Cerebellum and peripersonal defensive behavior

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Background

In the Sherringtonian model reflex responses provide a rapid, first line of defense, by adequately reacting to aversive stimuli and optimizing the chances of survival (Sherrington et al., 1906). Experiments on the attentional deficits of brain-damaged humans have corroborated the hypothesis of specialized attentional mechanisms for the peripersonal space. In humans, the specific role of the cerebellum in the defensive behavior within the peripersonal space has not been clearly defined so far.

Materials and Methods

tDCS was applied using a pair of electrodes in two saline-soaked synthetic sponges with a surface area of 25 cm^2. For cathodal stimulation the cathode was centered on the median line 2 cm below the inion, with its lateral borders about 1 cm medially to the mastoid apophysis, and the anode over the right shoulder. Direct current was applied for 20 minutes with an intensity of 1.5 mA. For the recording of HBR, electrical stimuli were delivered using a surface bipolar electrode placed on the median nerve at the wrist and EMG activity was recorded from the orbicularis oculi muscle, bilaterally, using pairs of surface electrodes with the active electrode over the mid-lower eyelid and the reference electrode a few centimeters laterally to the outer canthus. Depending on the hand position respective to the face, we explored four different conditions: "hand far", "hand near" (eyes open), "hand side", "hand near" (eyes closed).

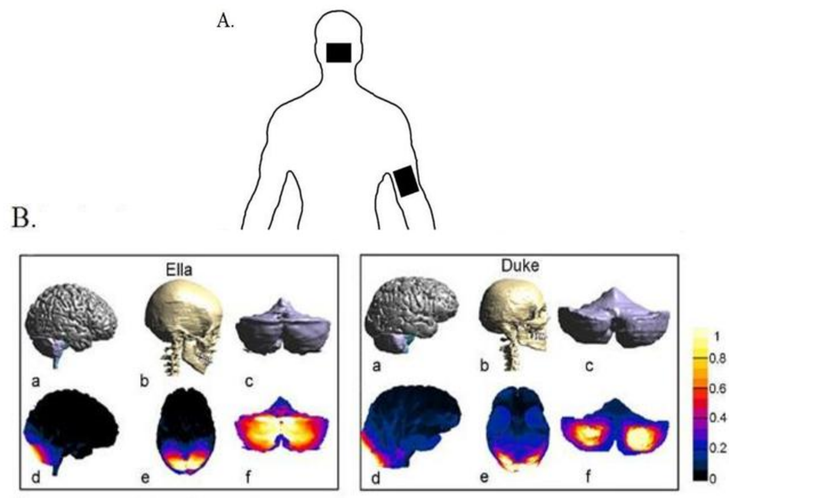
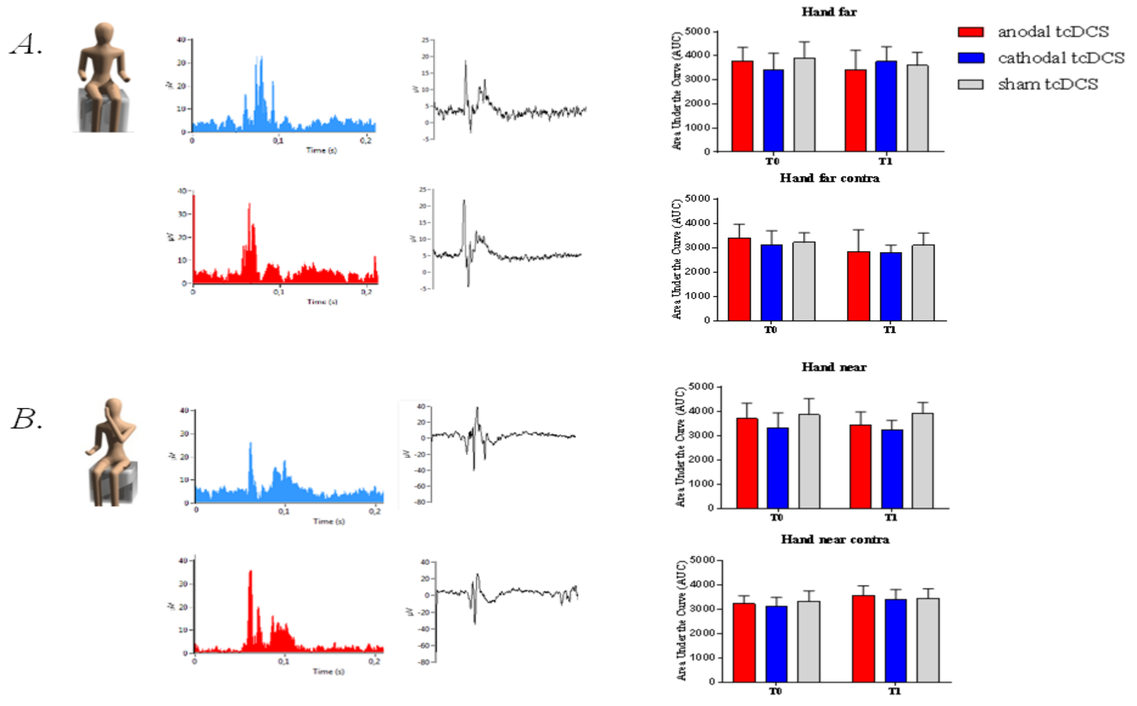


Figure 1 *– Current density generated by cerebellar transcranial direct current stimulation (cerebellar tDCS) in humans. (modified from Priori et al., J Physiol 2014, with permission)*

Results

Cerebellum



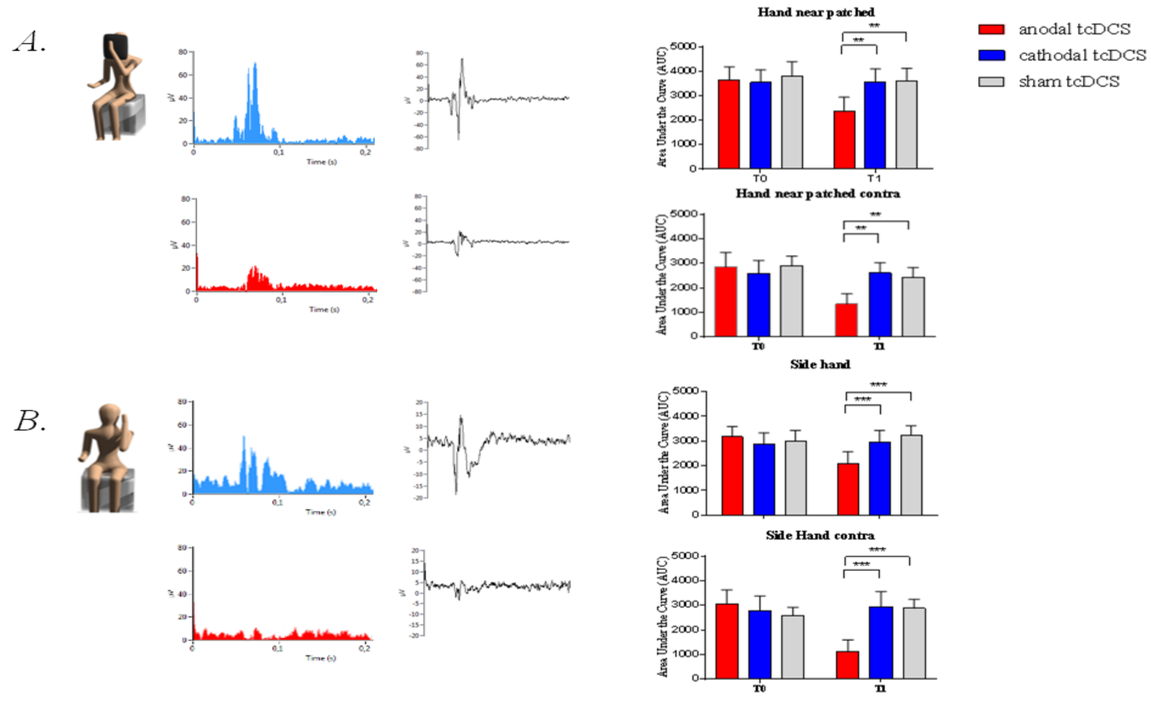
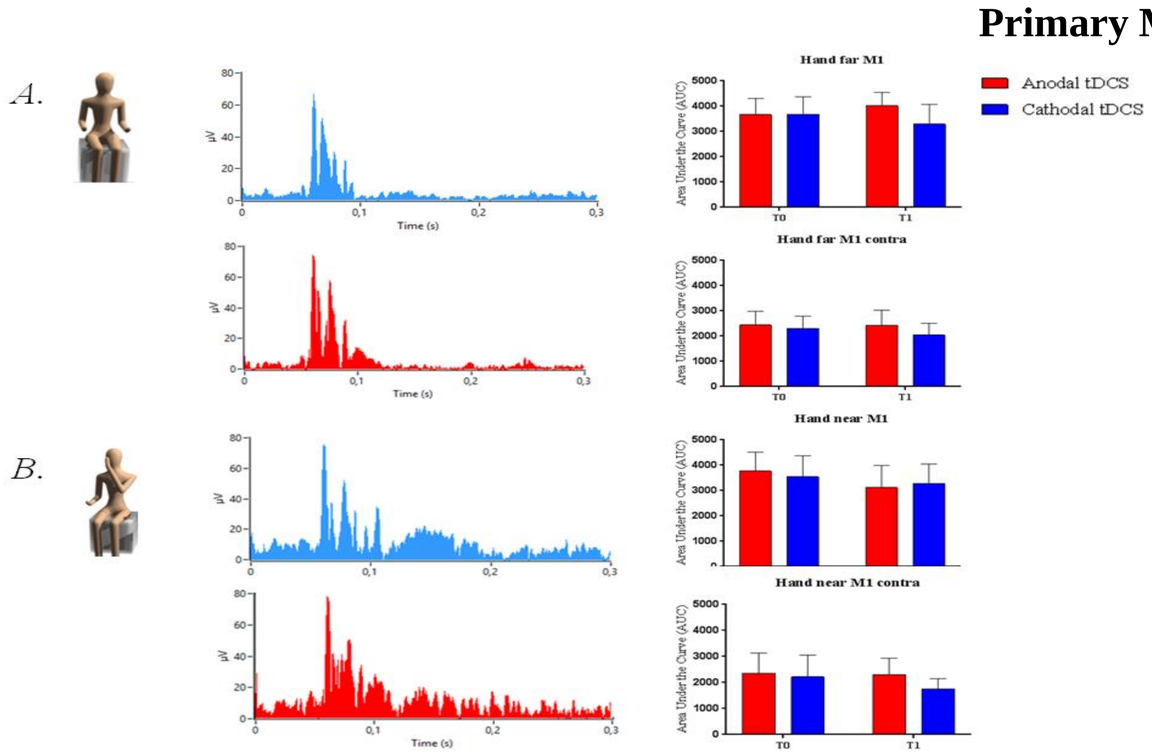
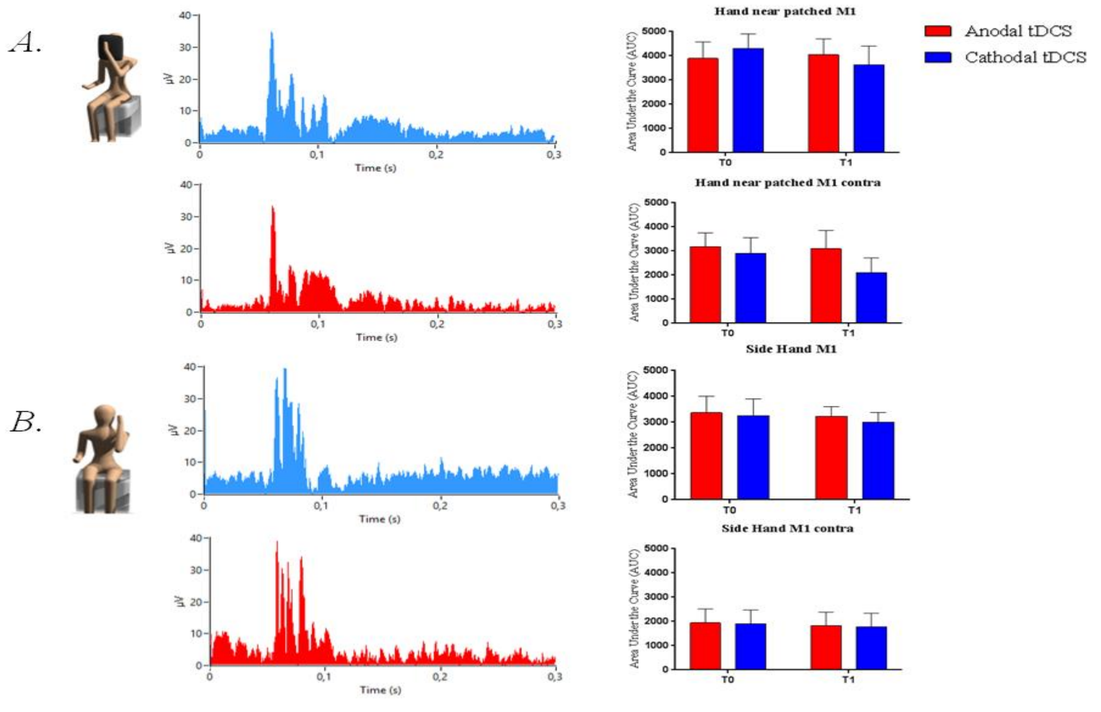


Figure 2 *– "Hand far" and "hand near". In the first two experimental conditions, no significant modification of HBR area appeared following either anodal or cathodal cerebellar/M1 polarization. At the left: ipsilateral traces at T1 were grand-averaged and rectified (blue: cathodal tDCS; red: anodal tDCS). At the middle: grand-average of the same traces immediately after tcDCS completion. At the right: histograms showing trend over time of AUC (blue: cathodal tcDCS; red: anodal tcDCS; grey: sham tcDCS).*

Figure 3 *– "Hand patched" and "side hand". Anodal stimulation significantly dampened HBR area compared both with sham and cathodal polarization (** $p < 0.01$; *** $p < 0.0001$), only when the cerebellum is stimulated. At the left: traces at T1 were grand-averaged and rectified (blue: cathodal tDCS; red: anodal tDCS). At the middle: grand-average of ipsilateral traces after tcDCS completion. At the right: histograms showing AUC changes following anodal, cathodal and sham stimulation.*

Primary Motor Area (M1)





Discussion and Conclusions

1. **Our results support a role of the cerebellum in the defensive responses within the peripersonal space, thus selectively modulating defensive behavior when the visual feedback is missing While anodal tDCS reduces AUC, cathodal polarization has not significant effects**
2. **From a functional point of view, our results could indicate that cerebellum is involved in visual-independent learning of defensive behavior**
3. **As the cerebellum interferes with reflex responses when the visual feed-back is lost, cerebellum may in part exert its role alone, independently from any cortical control**