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Research Report

Neural correlates of impaired emotional face recognition in cerebellar lesions

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ABSTRACT

Clinical and neuroimaging data indicate a cerebellar contribution to emotional processing, which may account for affective-behavioral disturbances in patients with cerebellar lesions. We studied the neurophysiology of cerebellar involvement in recognition of emotional facial expression. Participants comprised eight patients with discrete ischemic cerebellar lesions and eight control patients without any cerebrovascular stroke. Event-related potentials (ERP) were used to measure responses to faces from the Karolinska Directed Emotional Faces Database (KDEF), interspersed in a stream of images with salient contents. Images of faces augmented N170 in both groups, but increased late positive potential (LPP) only in control patients without brain lesions. Dipole anaylsis revealed

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altered activation patterns for negative emotions in patients with cerebellar lesions, including activation of the left inferior prefrontal area to images of faces showing fear, contralateral to controls. Correlation analysis indicated that lesions of cerebellar area Crus I contribute to ERP deviations. Overall, our results implicate the cerebellum in integrating emotional information at different higher order stages, suggesting distinct cerebellar contributions to the proposed large-scale cerebral network of emotional face recognition.

1. Introduction

The cerebellum has a role in affective regulation and behavior. Reports in patients with cerebellar lesions have noted affective blunting, disinhibition or lability, even with little cognitive or other behavioral change (Schmahmann and Sherman, 1998). Neurofunctional research has identified neuroanatomical connections between the cerebellum and circumscribed cerebral areas, subserving distinct cognitive and affective processes (Habas et al., 2009; Strick et al., 2009). In topographic analyses, the posterior lobes of the cerebellum are involved in both cognitive and emotional processing, particularly lobule VI, vermal lobule VII implicated in cerebellar-limbic circuits, and Crus I (Stoodley and Schmahmann, 2009).

Emotional recognition of facial expression, highly relevant to social cognition and behavioral responses, is an important topic in contemporary neuroscience research. One area of interest understands how emotional processing is involved in simple and complex motor tasks, as well as higher order cognitive decision tasks (Adolphs, 2004). Neuroanatomical and functional neuroimaging data suggest that evolution has favoured development of complex visual strategies that recruit large-scale networks of the brain, though details of the supratentorial brain pathways involved remain uncertain (Fusar-Poli et al., 2009; Pessoa, 2008).

Whilst the subordinate role of the cerebellum in motor task execution is well recognized, reviews of clinical and functional imaging studies indicate little is known about cerebellar involvement in processing emotional components to support behavioral and motor responses (Leiner et al., 1989; Stoodley and Schmahmann, 2009; Strick et al., 2009; Timmann et al., 2009). Several reports have identified the cerebellum as recognizing and discriminating emotional facial expressions, in particular for negative emotions (Turner et al., 2007; Fusar-Poli et al., 2009; Ferrucci et al., 2012; Adamaszek et al., 2014). These observations suggest that in addition to its recognized motor tasks, the cerebellum is involved in the integration of emotional responses in social behaviors. In spite of neuroimaging observations outlining topographical aspects of cerebellar contributions to emotional face recognition (Fusar-Poli et al., 2009), its temporal characteristics are less defined. In healthy subjects, several studies of event-related potentials (ERP) have indicated that perception of faces *per se* occurs early, manifested in an augmented N170, whereas the later processing of specific face details such as emotional expressions usually displays augmented late positive potentials (LPP), indicating that higher order neocortical pathways are tasked with analyzing the details of facial cues and selection of adaptive behavioral responses (Eimer and Holmes, 2007).

The present study investigated disturbances of emotional processing in patients suffering from ischemic cerebellar lesions. We aimed to evaluate whether patients suffering an ischemic cerebellar lesion, compared to controls, show specific impairments in their ability to comprehend facially communicated emotion as indexed by ERP. We hypothezised that patients with a cerebellar lesion would show reduced amplitudes of late positive potentials, the neurophysiological correlate of deficient recognition of the emotional information in facial expressions. Further, that dipole analysis of the ERP would clarify topographical regions of the cerebellum that are supporting generators of the ERP and therefore involved in the cerebral network for recognition of emotional facial expressions. We also administered the Tübingen Affect Battery, a standardised tool for assessing recognition and discrimination of emotional facial expressions, to study any correspondence between observed ERP differences and clinically obtained neuropsychological impairments.

2. Results

2.1. Patient sample

The cerebellar lesion group had only slight to moderate ataxia or dysarthria, and none of the patients had disturbances of ocular movement. Thus, movement or ocular gaze disturbance interfering with the performance of the patients in our tasks were not likely. All participants were right-handed. The lesion volumes of the cerebellar infarctions were small to moderate (mean 16.9 cm^3, SD 9.5). The cerebellar lesion and control groups did not differ in sex [cerebellar group mean=1.11, SD=0.33, control group mean=1.25, SD=0.46, $t(15)=-0.716$, $p=0.485$], age [cerebellar group mean=57.22, SD=15.67, control group mean=66.00, SD=10.07, $t(15)=-1.389$, $p=0.196$] or years of education [cerebellar group mean=12.22, SD=1.39, control group mean=11.75, SD=1.16, $t(15)=0.760$, $p=0.464$]. No cases of concurrent ICD10 depressive disorder were found at a clinical screening interview.

2.2. Tuebingen affect battery

Compared to previously published normative data (Bowers et al., 1999), both cerebellar lesion and control groups showed high rates for discriminating the identity of non-emotional faces as probed by subtest 1, with no significant difference between