



## Event-related potentials indicating impaired emotional attention in cerebellar stroke—A case study

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### HIGHLIGHTS

- Cerebellum contributes to emotional processing.
- We examined a patient of cerebellar infarction to visual attention of emotional cues at two long distant time points.
- Precise ERP analysis outlined the prefrontal cortex as vicarious in face of cerebellar disconnections.
- Disturbed visual attention to emotional cues is crucial in cerebellar behavior disturbance.

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### ABSTRACT

The cerebellum has been implicated in affective and attentional processes, but little is known about corresponding neural signatures. We investigated early and late components of event-related potentials (ERPs) to emotionally arousing pictures, with and without competing attentional tasks, in a patient with an ischemic right posterior cerebellar infarction, at two months post infarct and two year follow-up. The early posterior negativity (EPN) response to highly arousing emotional cues in the competing visual attention condition revealed that the augmentation over occipital areas, as typically seen in normals, was absent post-infarct but was restored after two years. The late positive potentials (LPP) response to highly arousing emotional cues showed augmentation over frontal areas post-infarct, and over centro-parietal regions after two years. These ERP findings suggest a specific pattern of disruption of neural function associated with emotional-behavioral disturbances following cerebellar lesions, which can revert to normal with long term recovery.

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### 1. Introduction

Cognitive dysfunctions, such as impairments of high order attention and visuospatial organization due to cerebellar lesions, have been a focus of research in recent years [4,12,23,26]. Cerebellar involvement in affective regulation has also been recognized

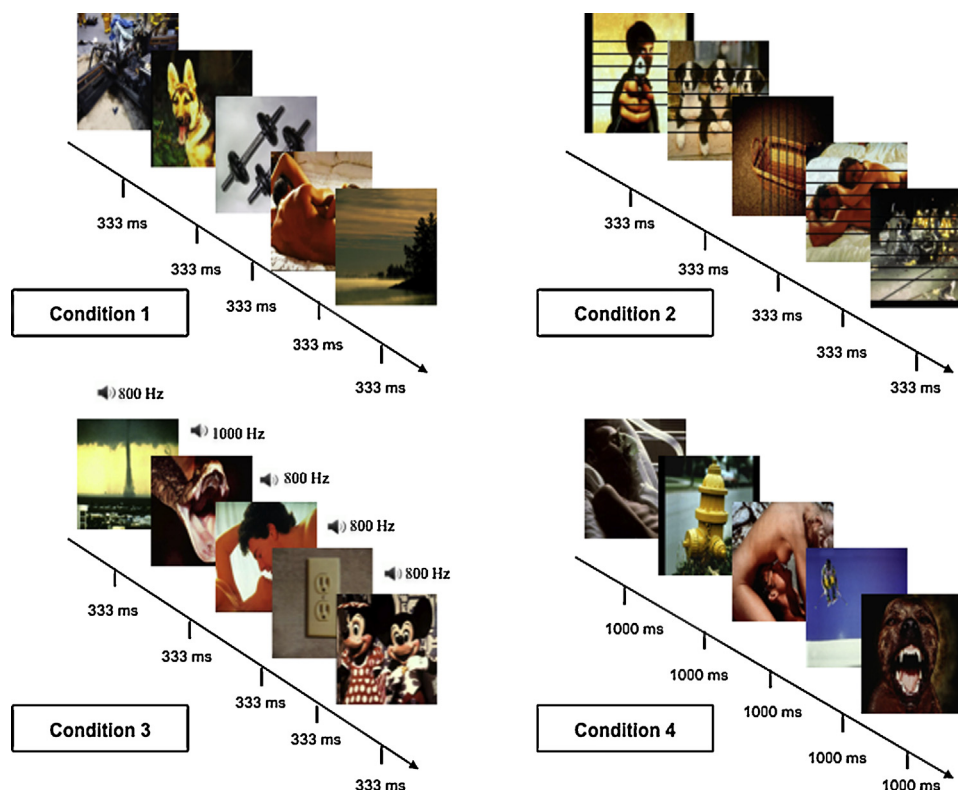
but has rarely been evaluated in detail. Clinical reports have noted affective dysregulation such as blunted affect or disinhibited behavior among patients with cerebellar lesions, but adequate explanations of these at times challenging clinical features require further investigation [6,18,23].

Functional neuroimaging procedures such as MRI or PET have identified the posterior lobes and in particular the dentate nucleus as the main topographical area of the cerebellum involved in processing cognitive and emotional cues [9,23,24]. Event-related potentials (ERPs) with their precise time resolution of neurofunctional processes have revealed increased latency or reduction of amplitude of the P300 in cerebellar lesions, a marker of disturbed information processing [25]. However, there are no substantial reports of ERP recordings studying emotional attention and, in particular, the neural signature of impaired emotional processing in patients with cerebellar lesions.

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**Fig. 1.** Four conditions probing the EPN and LPP of emotional attention and the influence of cognitive distractions, were performed. In condition 1, the patient viewed IAPS images changed at 333 ms intervals. In condition 2, each image was overlaid by horizontal or vertical lines, and in condition 3 accompanied by two different tones. In condition 4, images changed at longer intervals of 1000 ms to capture LPP.

We investigated the neurophysiological profile of emotional attention in a patient with a cerebellar stroke, based on two ERP components, early posterior negativity (EPN) and late positive potentials (LPP). EPN is a marker of early attention [19], and LPP a marker of the forwarding of emotional cues for further evaluation within cerebral networks [20]. We hypothesized that the clinical observations of affective dysregulation and disturbed social behavior in cerebellar lesions would be associated with abnormal ERP responses to certain conditions of emotional attention. We repeated recordings of the EPN and LPP at two year follow up, to ascertain changes associated with recovery processes.

## 2. Materials and methods

### 2.1. Clinical description

A sixty three year old right-handed man suffering from an acute right hemisphere cerebellar stroke due to atrial fibrillation was admitted to our Stroke Unit. The neurological examination of coordination abilities revealed a slight right sided hemiataxia, bradydiadochokinesia of the right hand, and a slight dysarthria. At the behavioral level the patient had reduced impulse control such as an urge to talk, answering and acting impulsively, also a tendency to resignation if facing barriers to action. The patient was mostly aware of these inappropriate behaviors afterwards, but could not control these premature actions.

On investigation, magnetic resonance imaging (MRI) showed an infarction of the supply area of the posterior inferior cerebellar artery (PICA). Single photon emission computer tomography (SPECT) revealed decreased perfusion, predominantly in the central portion of the right cerebellar hemisphere. After acute stroke

management, the patient was transferred to a professional Neurologic Rehabilitation Center for intensive coordinative training.

### 2.2. Neuropsychological testing and description of ERP procedures

The patient was examined for memory capacities (short memory span; verbal memory and learning skills; figural memory), executive functions (planning; problem solving; set shifting; divergent thinking), different attention functions, spatial constructive and intellectual ability, and visual neglect. The clinical assessment of behavior and affect modulation as well as conducting the standardized neuropsychological tests was performed by an approved neuropsychologist.

Event related potentials (ERPs) were recorded to capture the signaling of early and late stages of emotional attention to pictures from the International Affective Picture System (IAPS) [10]. The protocol was adapted from a study by Schupp et al., who demonstrated differential effects on early and late ERP processing stages of emotion potentiated attention in healthy volunteers [19]. Based on standardized ratings of arousal, IAPS pictures vary in emotional arousal. We chose pictures containing examples of: highly arousing categories with very pleasant (e.g. erotica) and very unpleasant contents (e.g. mutilations); low arousing categories with pleasant (e.g. family scenes) and unpleasant (e.g. pollution) pictures; and a very low arousing category depicting neutral contents (e.g. household objects). All pictures were depicted in random sequences, constructed as a movie for each run of picture presentations (see Fig. 1).

Four experimental conditions, each a movie containing various examples of the IAPS, were administered. Conditions 1–3 each presented 702 pictures with a duration of 333 ms per image, condition 4 presented 699 pictures with a duration of 1000 ms per image, drawn from a random order. Condition 1 was 'viewing only' fixating

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