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The human cerebellum and temporal information processing – results from a PET experiment

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CHANGES of cerebellar blood flow were studied in normal humans using positron emission tomography (PET). A motor driven peg marked pairs of lines on subjects' right hands at different velocities. Subjects had to decide whether the second line was marked slower or faster than the first. Estimation of velocity (compared with control, i.e. presentation of lines at constant velocity) led to increases of regional cerebral blood flow (rCBF) in the left cerebellar hemisphere and vermis. Presentation of lines at constant velocity (compared with rest) activated the right cerebellar hemisphere. We conclude that the cerebellum is involved in temporal information processing even in the absence of motor output. This process can be separated from mere presentation of somatosensory stimuli.

Key Words: Cerebellum; Humans; PET; Sensory functions

Introduction

For many decades, the cerebellum has been thought to exert an exclusive role in motor control.[1,2] Many recent investigations, however, have shown cerebellar involvement in non-motor tasks such as motor learning, classical conditioning, cognitive functions and even mental activity.[3,4] Evidence for cerebellar involvement in temporal information processing are derived from a number of different experiments. Flament and Hore demonstrated that hypermetria in humans and monkeys, one of the cardinal signs of neocerebellar lesions, might result from the delayed onset of antagonist muscle activity.[5] In animal experiments, temporary cooling of cerebellar nuclei resulted in smaller magnitudes of acceleration and larger magnitudes of deceleration.[5] These studies lead to the suggestion that the cerebellum might be involved in the fine tuning of the temporal pattern of movement parameters.

Ivry *et al*[6] investigated repetitive finger movements in normal subjects and patients with cerebellar lesions. Subjects had to maintain a constant rhythm of tapping. During the first trials, the frequency of tapping was determined by a metronome which was stopped after 13 trials. Their analysis was able to separate the timing aspects of movement from the motor execution part. Patients with a lower vermal or anterior lobe lesion due to chronic alcoholism had a normal timing function. Patients with lesions confined to the cerebellar hemispheres had normal motor implementation but disturbances in the timing mechanism. Thus timing and motor functions could be separated in the same subjects.

In a recent experiment using positron emission tomography (PET) we demonstrated that the estimation of time differences was associated with an increase of regional cerebral blood flow (rCBF) in the cerebellar vermis and adjacent cerebellar hemispheres in normal volunteers.[7] The increase of rCBF in the cerebellum was clearly separable from rCBF increases due to movement execution.

The present study was planned as a follow-up experiment to test whether cerebellar involvement in temporal information processing can be demonstrated after presentation of somatosensory stimuli, whether (within the cerebellum) this process can be separated from activations elicited by mere presentation of somatosensory stimuli, whether a perceptive task only activates the cerebellum when it is coupled to a motor task and whether the functional cerebellar anatomy of this perceptive process differs from the previous experiment in which presentation of acoustic stimuli was used.

Materials and Methods

Regional cerebral blood flow (rCBF) was examined in six healthy volunteers aged 21–31 years (mean 25 years) using PET. None of the subjects had a history of neurological or psychiatric disease; none took any medications. Approximately 30 min prior to scanning subjects performed 8–10 test trials on each experimental condition. All subjects gave written informed consent after the purpose and the procedure of the examination had been fully explained to them. The study was approved by the