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Promotionsverfahren von **Herrn M.Sc. Adam Michael Berlijn**
Auslage der Dissertation und Gutachten sowie Termin der mündlichen Prüfung
Anlage: Einseitige Zusammenfassung der Dissertation

Sehr geehrte Damen und Herren,

in dem oben genannten Promotionsverfahren wird die Annahme der Dissertation

Insights into the human cerebellum's contribution to reinforcement learning and error processing

von den Berichterstattenden Prof. Dr. C. Bellebaum und Prof. Dr. J. Peterburs beantragt. Sie kann zusammen mit den Gutachten in der Zeit

vom 02.08.2024 bis 19.08.2024

eingesehen werden. Bitte wenden Sie sich zur Einsicht an das Promotionsbüro (promotionmnf@hhu.de).

Einsprüche gegen diese Dissertation können nur zwei Tage nach der vorgenannten Frist geltend gemacht werden. Erfolgt kein Einspruch, so gilt die Dissertation als angenommen (§ 7 Ziffer (5) PO).

Sofern die Dissertation angenommen wird, findet die mündliche Prüfung am

22.08.2024 um 10:00 Uhr

im **Raum 23.02.00.63** statt. Als Prüferinnen bzw. Prüfer sind vorgesehen:
Prof. Dr. G. Jocham, Prof. Dr. T. Kalenscher und PD Dr. M. Minnerop.

Die Öffentlichkeit ist bei der Befragung zugelassen.

Mit freundlichen Grüßen
im Auftrag

Daniela Schleiffer

Insights into the human cerebellum's contribution to reinforcement learning and error processing

Adam Michael Berlijn

Over the last decades, the view on the cerebellum's functions has changed from a brain structure primarily involved in motor control towards an important hub for non-motor, cognitive functions. The goal of this dissertation was to understand the human cerebellum's contribution to reinforcement learning and the processing of errors which are both subfunctions of performance monitoring.

To understand the cerebellum's contributions to reinforcement learning through available feedback information, a systematic review was conducted in study 1 to review the literature on cerebellar patients and healthy participants conducting feedback-based learning tasks. After using an extensive search strategy and excluding abstracts that did not met our inclusion criteria, thirty-six studies were included. Results showed behavioral alterations in patients in about half of all studies. One study using electroencephalography (EEG) revealed alterations in the event-related potential (ERP) in patients suffering from cerebellar damage. Task-based functional magnetic resonance imaging (fMRI) revealed cerebellar activation patterns across the cerebellum, particularly in posterolateral regions, during feedback processing in healthy participants.

Study 2 investigated the cerebellum's involvement in error processing using a fast-paced Go/Nogo Flanker task to induce errors. EEG was recorded during the task, and single-pulse transcranial magnetic stimulation was applied in one session to the cerebellum and in another to an extra-cerebellar control region (vertex). Results revealed that error rates did not differ between the stimulation sites, while the ERP component error-related negativity (ERN/Ne) was reduced for cerebellar compared to vertex stimulation. These results point towards a direct contribution of the cerebellum to (cerebral) error processing.

Study 3 investigated the cerebellum's contributions to reinforcement learning and prediction error (PE) processing in patients with cerebellar degeneration and healthy controls. EEG was continuously measured while participants completed a feedback-based learning task that comprised both immediate and delayed feedback. The feedback-related negativity (FRN) and P3a/P3b ERP components were analyzed as indices of reinforcement learning. The PE was calculated for each trial using a Rescorla Wagner model. In addition, MRI data were acquired to characterize the cerebellar gray matter volume (GMV). The GMV was compared between patients and controls, and a multiple regression analysis was conducted to identify potential links between regional GMV reduction in the cerebellum and FRN alterations in patients. No group differences were found in learning performance (accuracy). Accuracy was generally higher for delayed compared to immediate feedback, and a reduction in choice switching over the course of the task was found across all participants. Importantly, coding of the unsigned PE in FRN, P3a and P3b was present in controls and absent in patients. Whole-brain and cerebellar VBM on the GMV demonstrated reduced GMV in widespread cerebellar regions including bilateral Crus I/ II and bilateral lobules I-IV in patients compared to controls. Multiple regression analysis linked reduced GMV in Crus I/ II with a blunting of the FRN.

Taken together, the present multimodal results provide insight into multifaceted contributions of the human cerebellum to reinforcement learning and error processing.