Basal ganglia lesions compromise temporal prediction in audition

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Introduction
Adequate timing, defined as the ability to be in the right place at the right time, requires continuous adaptation to the formal and temporal structure of an ever-changing environment. However, adequate timing implies not only reactive but also predictive adaptation of cognitive and motor behavior, which, in order to be efficient, has to take advantage of (perceived) regularity in temporal structure.

As an integral part of extensive subcortico-cortical processing loops, the basal ganglia engage in attention-dependent temporal processing, thereby generating an internal representation of temporal structure (Buhusi and Meck, 2005). In the current experiment, we use event-related potentials of the Electroencephalogram (EEG) and systematical variation of temporal (inter-stimulus-intervals) and formal (frequency) regularity to investigate (1) whether both types of regularity interact early on, and (2) whether damage to the basal ganglia affects the ability to exploit temporal regularity.

Methods

Participants
- 23 Healthy Controls (matched in terms of age, gender, handedness, education)
- 23 Patients with focal basal ganglia lesions
  - 7 female, mean age 51.8 years (SD 12.8)
  - Lesions: 6 right-sided, 16 left-sided, 1 bilateral; green shades: maximal lesion overlap

Paradigm
- Stimuli: Sequences consisting of 360 standard (600 Hz) and 90 deviant (660 Hz) equidurational (300 ms) sinusoidal tones – formal structure
- Conditions: (1) Isochronous (fixed inter-stimulus-intervals (ISIs), 600 ms; (2) Random (random ISIs 200 - 1000 ms) – temporal structure
- Task: Silent counting of deviants (attentive listening)

EEG Recording / Analysis
- 32 electrodes, 500 Hz sampling rate, ground: sternum, reference: linked mastoids
- 5-75 Hz bandpass filter, automatic and manual rejection, -75 ms pre-stimulus baseline

Results

The results suggest that mid-latency auditory evoked responses do not differ as a function of temporal regularity in patients with basal ganglia lesions.

This finding may be interpreted as a difficulty to evaluate the temporal structure of the stimulus sequence as a basis for predictive adaptation and the dynamic allocation of attention in time.

In contrast to later stages of attentive deviant processing (P300, Schwartze et al., 2011), formal and temporal structure do not interact in earlier stages.

In a dedicated integrative subcortico-cortical temporal processing network (Schwartze et al., 2012), the cerebellum encodes a precise event-based representation of temporal structure and directs a „wake-up call“ (Sherman, 2001) for attention towards the cortex (possibly represented in P50).

The evaluation of temporal inter-event relations then recruits cortico-striatal loops. Damage to the basal ganglia should affect the use of this information in predictive adaptation, e.g. the allocation of attention in time.

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Summary and Discussion

- The results suggest that mid-latency auditory evoked responses do not differ as a function of temporal regularity in patients with basal ganglia lesions

References