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Conflicts as Signals in Cognitive Systems

Hopfield Energy as a Measure of Conflict Predicts Late Negativity during Nonword Processing

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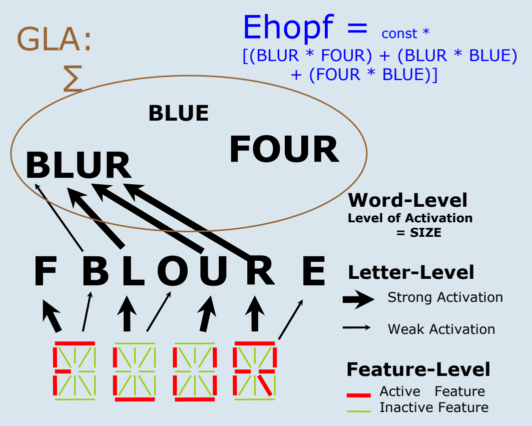

Fig. 1. The difference between the GLA as the sum of activations of all active word nodes in contrast to Ehopf as a direct measure of conflict

Braun et al. (2006) used the total sum of word node activations (Global Lexical Activation, **GLA**) of the Multiple Read Out Model including phonological representations (MROM, Grainger and Jacobs, 1996;implementation of Jacobs et al., 1998; cf. **Fig 1**) to predict behavioral and electrophysiological measures in a lexical decision task. Larger N5 Amplitudes and longer response times (**RTs**) have been observed with increasing levels of GLA in nonwords (**NW**).

Hypothesis: The larger N5-amplitudes and longer RTs to increasing GLA reflect an intralexical conflict between the activated word nodes!

Simulation: To test whether a large **GLA** is accompanied by larger conflict, we implemented the **Hopfield Energy (Ehopf)** into the MROM as a **measure of conflict between activated word nodes** (cf. Botvinick et al., 2001, see **Fig.1**).

In comparison to the mean activation of all words of the MROM's lexicon (see **Fig.2**; solid line) NWs (dashed and dotted lines) revealed a larger conflict.

-> The hypothesis that larger GLA is accompanied by larger Ehopf was confirmed (see Fig.2).

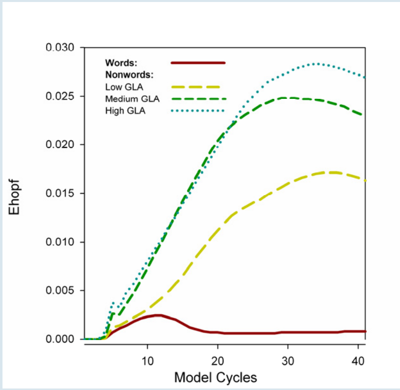

Fig. 2. Time Course of Ehopf as a measure of conflict

In a replication study of Braun et al. (2006) we obtained a highly reliable **ERP**-effect of **Ehopf**

($F(1.4) = 5.3$, $p = 0.01$, Greenh. Geisser corr.)

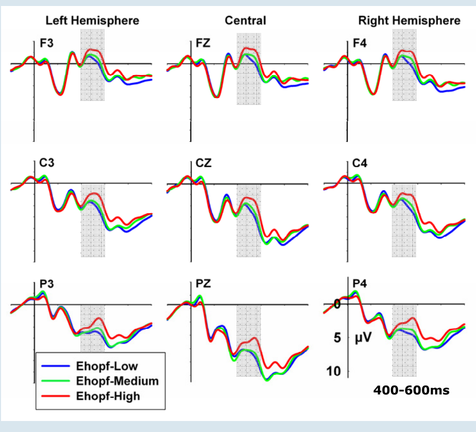

Fig. 3. ERPs for 3 categories of increasing Ehopf

The **rostral cingulate zone** was the most likely source of the **Ehopf**-effect

(max t-& p-scores: a) & b) t's>5.4, p's=0.002, c) t=3.2, p=0.09)

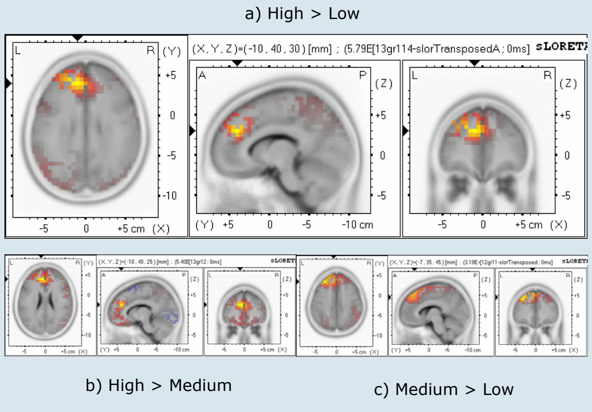

Fig 4. sLORETA revealed the **Medial Frontal Gyrus** including the **Anterior Cingulate Cortex** and the left **Superior Frontal Gyrus** as the most likely sources of the effect.

Log Ehopf accounted for 11% of the N5 ($F(1, 204) = 25$) and 15% of the RT Variance ($F = 34$)

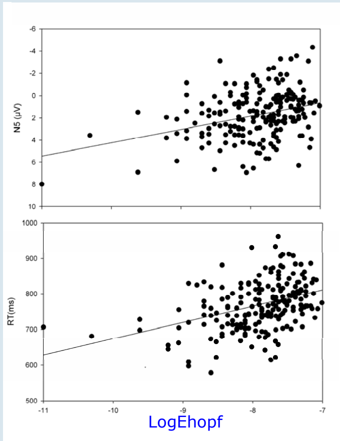

Fig. 5. Log Ehopf predicts RTs and N5.

Because Ehopf accounted for more variance of the electrophysiological and behavioral data than GLA ($R^2 = 0.08$, $F = 13$, and $R^2 = 0.10$, $F = 22$) **and the effect was likely to be localized in the rostral cingulate zone, we propose that conflict is a more general account than lexical activation (GLA) for the N5 and RT effects observed by Braun et al. (2006).**

Method: Braun et al.'s stimuli were presented to **14 subjects** performing a **Lexical Decision Task**. Electrophysiological responses were derived from **26 electrodes**. After artifact rejection (manually and ICA) NWs were sorted due to Ehopf and segmented into three equally sized Ehopf categories à 100 NW (Ehopf: High, Medium, Low). **Averages** were computed **across all channels** for the time frame of **400 to 600ms**. For **item analysis**, each item for which at least 10 observations remained after error and artifact rejection were included in the analysis (N=207). The mean Ehopf scores of the cycles 2-7 have been log-transformed, as well as the GLA 2-7 values.

References: Botvinick, Braver, Barch, Carter, & Cohen, 2001, *Psychological Review.* Braun, Jacobs, Ricker Hofmann, & Hutzler, 2006, *Brain Research*. Grainger, & Jacobs, 1996, *Psychological Review*; Jacobs, Rey, Ziegler, & Grainger, 1998, pp 147-88, in: Localist connectionist approaches to human cognition, Grainger & Jacobs (Eds.).