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Simulating Bistable Perception with Interrupted Ambiguous Stimulus using Self-Oscillator Dynamics with Percept Choice Bifurcation

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A behavioral stochastic self-oscillator model with perception-attention coupling and re-entrant cognitive processing is used for simulating interrupted ambiguous stimulus induced percept reversals. The results provide further support for a dynamical systems foundation of cognitive and psychological problems as discussed in detail within the context of Gestalt psychology [1], and for coordination dynamics of the brain [2]. Periodic stimulus–off switching (t_{off} < 1 s, t_{on} = 300 ms) was introduced by Orbach et al. [3] as experimental paradigm to get more insight into the underlying perceptual dynamics. Their Necker cube experiments showed a maximum of the percept reversal rate R at $R_{max} \approx 36\ min^{-1}$ and $t_{off} \approx 200$ ms which was confirmed by recent experiments [4]. Noest et al. [5] demonstrated with a low level neural activation model [6] that a bifurcation of the percept choice dynamics during the ambiguous-stimulus on-off switching dominates the statistics of the reversal time series. Our simulations based on a macroscopic (behavioral) nonlinear dynamics model [7][8] (similar to [9]) support this finding. They show that the measured R vs. t_{off}-time characteristics can be fitted with only a few model parameters: Thalamo-cortical reentrant delay T = 40 ms, attention fatigue (= adaptive feedback gain) time constant = 1 – 2 s, feedback-gain noise power J_{ω}. Synchronisation of attention fatigue induced self-oscillations (yielding inter-stimulus transition time $T_{Tr} \approx$ 4 – 5 T) in combination with stimulus-onset induced percept choice bifurcation appears to determine the percept-reversal rates and the t_{off}-value at R_{max}. A linear approximation of the dynamical equations allows for an analytical estimate of the reversal frequency and the cognitive damping time constant ($\tau_v \approx 1$ s). By use of the Fluctuation-Dissipation theorem via noise power J_{ω} it defines an index of cognitive inertia (as suggested in [10]) as crucial parameter of the simulated dynamics.

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