A Nonlinear Dynamics Model for Simulating Multistable Perception Using Reentrant Perception–Attention–Memory Coupling

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Simulation results of multistable perception due to ambiguous visual stimuli are presented which are obtained with a behavioral nonlinear dynamics (phase oscillator) model using perception–attention–memory coupling. As a kind of minimum architecture representing the Thalamo-Cortical and ventral ("what") V4–InferoTemporal–PraeFrontal–V4 loops the basic model couples the nonlinear dynamics of a macroscopic perception state order parameter with an adaptive attention (feedback gain) control parameter with reentrant delay T and additive band limited white noise (Fürstenau 2006, 2007). Quasiperiodic perceptual switching is induced by attention fatigue coupled to the perception state, with a perception bias which balances the relative duration of the alternative percepts, corresponding to the well known Synergetics model of Ditzinger and Haken (1989). As a new feature memory effects are introduced by allowing for the slow adaptation of the perception bias parameter via coupling to the perception state. The simulations exhibit long range correlations of the perceptual duration times in agreement with recent experimental results of Gao et al. (2006). They are determined by calculation of the self similarity (Hurst) parameter H of the reversal time series ($H > 0.5$). Deviations of the simulated reversal time statistics from the Γ-distribution as typically observed in experiments, increase with decreasing memory time constant and attention noise. Mean perceptual duration times of 2 – 5 s are predicted in agreement with experimental results reported in the literature, if a feedback delay T of 40 ms is assumed which is typical for cortical reentrant loops and the stimulus-V1 latency (Lamme 2003). Numerically determined perceptual transition times of 3 – 5 T are in reasonable agreement with stimulus–conscious perception delay of 150 – 200 ms. Initial periodic stimulus simulations yields the reversal rate variation as a function of stimulus off-time in surprisingly good quantitative agreement with experimental results of Orbach et.al.(1966) when selecting an adaptation (fatigue) time constant of 1 – 2 s. An explanation of the observed reversal rate maximum as a consequence of the perception–attention coupling dynamics is suggested.

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