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

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Abstract

Formal modeling of cognitive bistability (e.g.[1][2]) is an interesting problem because a constant stimulus (e.g. the Necker cube) excites quasi periodic alternations between only two well defined perception states. 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) dynamics model [7][8] (similar to [1]) support this finding and show that the measured R vs. t_{off}-time characteristics can be fitted with only few model parameters: attention (= adaptive feedback gain) fatigue time constant = 1 – 2 s, feedback delay T = 40 ms, gain-noise power J_{ω}. Synchronisation of attention fatigue induced self-oscillations (yielding inter-stimulus transition time $T_{Tr} \approx$ 4 – 5 T) with stimulus-onset induced percept bifurcation appears to determine the reversal rates and the t_{off}-value at R_{max}. A linear approximation allows for an estimate of the cognitive damping time constant ($\tau_v \approx 1$ s) which by use of the Fluctuation-Dissipation theorem via J_{ω} defines an index of cognitive inertia (suggested in [8]) as crucial parameter of the simulated dynamics.

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Formal modeling of cognitive bistability (e.g.[1][2]) is an interesting problem because a constant stimulus (e.g. the Necker cube) excites quasi periodic alternations between only two well defined perception states. Periodic stimulus–off switching (toff < 1 s, ton = 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 Rmax = 36 1/min and toff ca. 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) dynamics model [7] (similar to [1]) support this finding and show that the measured R vs. toff-time characteristics can be fitted with basically three parameters: attention fatigue (= adaptive feedback gain) time constant of 1 – 2 s, feedback delay T ca. 40 ms, gain-noise power J. Synchronisation of attention fatigue induced self-oscillations (yielding inter-stimulus transition time ca. 4 – 5 T) with stimulus-onset induced percept bifurcation appears to determine the reversal rates and the toff-value at Rmax. A linear approximation allows for an estimate of the cognitive damping time constant (ca. 1 s) which by use of the Fluctuation-Dissipation theorem via noise power J defines an index of cognitive inertia (suggested in [8]) as crucial parameter of the simulated dynamics.