An Experimental Investigation of the Cognitive Noise Influence on the Bistable Visual Perception

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Abstract : The perception of visual signals in the brain was among the first issues discussed in terms of multistability which has been introduced to provide mechanisms for information processing in biological neural systems. In this work the influence of the cognitive noise on the visual perception of multistable pictures has been investigated. The study includes an experiment with the bistable Necker cube illusion and the theoretical background explaining the obtained experimental results. In our experiments Necker cubes with different wireframe contrast were demonstrated repeatedly to different people and the probability of the choice of one of the cubes projection was calculated for each picture. The Necker cube was placed at the middle of a computer screen as black lines on a white background. The contrast of the three middle lines centered in the left middle corner was used as one of the control parameter. Between two successive demonstrations of Necker cubes another picture was shown to distract attention and to make a perception of next Necker cube more independent from the previous one. Eleven subjects, male and female, of the ages 20 through 45 were studied. The choice of the Necker cube projection was detected with the Electroencephalograph-recorder Encephalan-EEGR-19/26, Medicom MTD. To treat the experimental results we carried out theoretical consideration using the simplest double-well potential model with the presence of noise that led to the Fokker-Planck equation for the probability density of the stochastic process. At the first time an analytical solution for the probability of the selection of one of the Necker cube projection for different values of wireframe contrast have been obtained. Furthermore, having used the results of the experimental measurements with the help of the method of least squares we have calculated the value of the parameter corresponding to the cognitive noise of the person being studied. The range of cognitive noise parameter values for studied subjects turned to be [0.08; 0.55]. It should be noted, that experimental results have a good reproducibility, the same person being studied repeatedly another day produces very similar data with very close levels of cognitive noise. We found an excellent agreement between analytically deduced probability and the results obtained in the experiment. A good qualitative agreement between theoretical and experimental results indicates that even such a simple model allows simulating brain cognitive dynamics and estimating important cognitive characteristic of the brain, such as brain noise.

Keywords : bistability, brain, noise, perception, stochastic processes