Changes in noise structure by learning a simple balancing tasks

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Since Bernstein´s ((Bernstein, 1967)) pioneering research in movement regulation, motor control processes are often described in terms of regularity ((e.g. Hausdorff et al., 1996)), complexity ((e.g. Kay, 1988)), and variability ((e.g. Riley & Turvey, 2002)). Thereby, different analysis methods have been developed including traditional statistical methods and nonlinear tools. Cordier ((Cordier, Mendez-Sanchez, Pailhous, & Bolon, 1994)) was first off the mark who applied entropy analysis to learning processes in a climbing task. He concluded that the entropy value of a special climbing trajectory indicates the climber`s level of expertise that happens on different time scales.

In the following pilot study, we analyzed structural changes of sway variability in a balancing task. Five subjects had to create a COP-circle by moving their body under visual control of their COP. Meanwhile, circle amplitude and movement velocity were controlled visually forcing a special frequency of 0.1 Hz. Subjects made 20 trials over 3 cycles resting 30 sec. between the trials. The instructions were to move the body with ankle strategy, arms hanging beside the body, and closed feet. Before and after these trials, a modified Romberg test of 20 sec. duration with open and closed eyes had to be absolved. Statistical analysis of the sway structure included sample entropy ((Richman & Moorman, 2000)), cross entropy of consecutive trials, and mean displacements to the given circle. The Romberg balance test was evaluated by Random Walk Analysis ((Collins & De Luca, 1993)).

Random Walk Analysis of the balance test showed a significant increase in short-term diffusion coefficients from pretest to posttest in x- ($p<0.05$) and y- ($p<0.01$) direction. Considering the 20 circle-trials, we did not find any clear trend neither in sample and cross entropy values nor in mean displacements that could indicate a consistent learning process. However, we found significant ($p<0.01$) correlations between cross entropy values and mean displacements. We suppose that cross entropy, which represents the information transfer, could predict the learning progress or performance. Concerning the missing learning trend we believe that the balance task was too difficult to be learned in 20 trials.

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