Bimanual Coordination, Inter-Personal Coordination, and Time Scales

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Bimanual coordination possesses macroscopic properties (preferred coordination modes, critical fluctuations, phase transition) that have been successfully accounted for by the HKB model [1]. This model considers the effectors as self-sustained oscillators, and coupling is performed by a continuous function.

Schmidt et al. [2] showed that interpersonal coordination presented identical macroscopic properties, and supposed that such coordinated behavior could be sustained by similar processes. We applied Detrended Cross-Correlation Analysis to period series collected (1) in a bimanual coordination task and (2) in an inter-personal coordination task. Results are illustrated in Figure 1 (left column). In both cases we observed a strong convergence of DFA and DCCA slopes in the long term, and long-term DFA exponents were closely correlated (bimanual coordination: r = 0.999; inter-personal coordination: r = 0.999). On the short-term, however, cross-covariance was lower in interpersonal coordination. Short-term DFA exponents remained closely correlated in bimanual coordination: r = 0.929, but were not significantly correlated in inter-personal coordination: r = 0.410).

We simulated effectors series by means of the HKB model, and we obtained DCCA results quite similar to that obtained from experimental series (Figure 1, right column, top graph). Correlations between DFA exponents were r = 0.998 on the long term, and r = 0.973 on the short term.

We tried to model interpersonal results with an auto-regressive corrective model, based on the three previous asynchronies (*ASYN*):

$$x(t) = x_{int}(t) + \delta_{1x}ASYN_x(t\text{-}1) + \delta_{2x}ASYN_x(t\text{-}2) + \delta_{3x}ASYN_x(t\text{-}3) + \eta\varepsilon_x(t)$$
$$y(t) = y_{int}(t) + \delta_{1y}ASYN_y(t\text{-}1) + \delta_{2y}ASYN_y(t\text{-}2) + \delta_{3y}ASYN_y(t\text{-}3) + \eta\varepsilon_y(t)$$

where $x_{int}(t)$ and $y_{int}(t)$ represent the intrinsic fluctuations of the two effectors. DCCA results are reported in Figure 1 (right column, bottom graph), and were similar to those obtained from experimental series. Correlations between DFA exponents were 0.987 on the long term, ad 0.756 on the short term.

These results suggest that coupling, in these two situations, work following different time scales. Bimanual coordination has been modeled through the well-known HKB model, which supposes a continuous coupling between effectors. This kind of coupling could explain the strong matching of exponents observed even on short scales. The results obtained for interpersonal coordination suggest in contrast a discrete form of coupling, which could occur at the time scale of a complete oscillation.

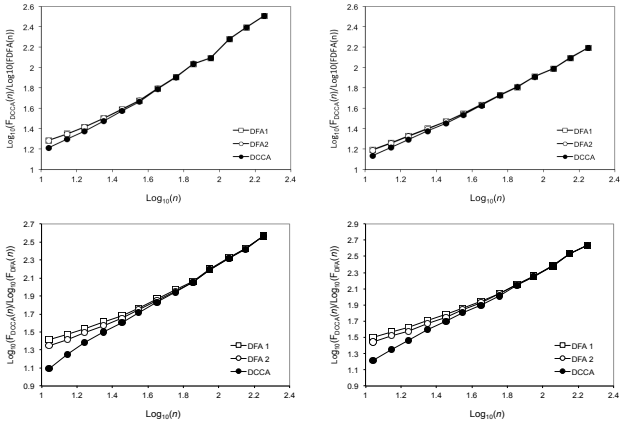

Figure 1: DFA and DCCA results. Top raw: Bimanual coordination. Bottom raw: Interpersonal coordination. Left column: experimental data, Right column: simulated data.

References

[1] H. Haken, J. Kelso, H. Bunz, A Theoretical-Model of Phase-Transitions in Human Hand Movements, Biological Cybernetics. 51, 347–356, 1985.

[2] R.C. Schmidt, C. Carello, M.T. Turvey, Phase transitions and critical fluctuations in the visual coordination of rhythmic movements between people., Journal of Experimental Psychology. Human Perception and Performance, 16, 227–47, 1990.