Effects of spatial and temporal constraints on thé dynamics of rhythmical aiming

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The relation between the time necessary to point at a target and the corresponding spatial variability is an important issue when trying to understand how humans control their movements. This issue has been extensively addressed via experimental manipulations of relative spatial or temporal constraints, but in relatively disjointed experimental and theoretical frameworks.

Using a spatially constrained paradigm, Fitts [1] showed that movement time (MT) increases as a linear function of the amount of information (labelled ID for index of difficulty) that specify the requested relative spatial accuracy. The so-called Fitts' law holds for discrete and rhythmical movements as well, but movement kinematics is far more influenced by task difficulty in rhythmical movements. When ID is raised, kinematics profiles gradually change from continuous oscillation towards a concatenation of discrete units, which provides important information about movement organisation [2].

Using a time constrained paradigm, Schmidt [3] showed that the effective index of difficulty increased with the imposed MT This result indicates that the informational logic of Fitts' law can hold in a time constrained paradigm, but detailed comparisons still lack to ensure that spatial or temporal constraints similarly influence movement organisation, especially at the level of movement kinematics. Participants were instructed to perform a reciprocal aiming task between two targets separated by 60° as fast and as accurately as possible. In a first session, we experimentally manipulated spatial constraints and measured the resulting movement time (i.e., target width of 15°, *7.5°* and 3.75° were imposed to participants). In a second session, we manipulated movement time and measured the resulting spatial accuracy (i.e., fast, medium and slow pace were imposed to participant). To allow comparison between the two sessions, MT measured in the first session were used to set the metronome in session 2.

As expected, MT linearly increased with the effective index of difficulty in both sessions. Kinematic analyses revealed that, as task difficulty or MT increased, movement continuity decreased, kinematic profiles gradually changed from continuous towards discrete in a very similar fashion: Velocity profiles became asymmetric with an earlier peak velocity and Hooke's portraits deviated from straight line, reflecting the influence of non-linear terms in limit cycle modelling of movement dynamics.

Taken together, these results show that manipulating spatial or temporal constraints lead to similar changes in kinematic profiles. This suggests that the dynamics that underwrite the spatially constrained or temporally constrained rhythmical aiming task was the same.

[1] Fitts, PM (1954). The information capacity of thé human motor system in controlling the amplitude of movement. Journal of Expérimental Psychology: Human Perception and Performance, 47, 381-391.
[2] Mottet, D, Bootsma, RJ (1999). The dynamics of goal-directed rhythmical aiming. Biological Cybernetics, 80, 235-245.
[3] Schmidt, RA, Zelaznick, HN, Hawkins, B, Frank, JS, Quinn, JT (1979). Motor output variability: a theory for thé accuracy of rapid motor acts. Psychological Review, 47, 415-451.