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Mercredi 15 Juin 2005
Conférence Géométrie Différentielle

16h30 – 17h15

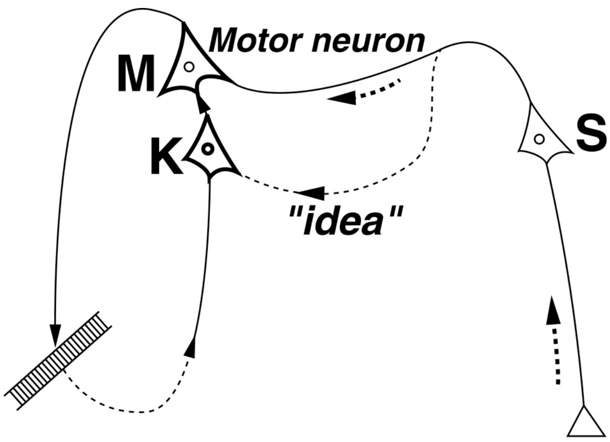
On the formation and representation of complex movements

Motor production is analysed on several levels involving movement kinematics, dynamics and muscle activations. In recent years, new experimental methods and different mathematical models have provided insights into the neural control of complex movements. For example, the observed invariants and kinematic features of complex upper limb movements have revealed the general strategies and the coordinate frames that underlie motion planning. To address the question of what rules govern the selection of particular movements among the desired ones, optimization models based on different alternative objective functions were developed. In particular, earlier studies have suggested that a fundamental principle in motion planning is the wish to maximize motion smoothness, expressed as the wish to minimize higher time derivatives of position (e.g., jerk). Other motion planning models were based on empirically observed local relationships among, for example, the path curvature and velocity (e.g., the two-thirds power law) suggesting that complicated movements are composed of elementary strokes. This apparent segmentation, however, might be an epi -phenomena of smoothness maximization (joint work with Richardson).

Recently, a new mathematical framework, based on the use of differential geometry, Lie group theory and Cartan's moving frame method was developed. Inquiring into the nature of the metrics subserving motor representation (joint work with Handzel), we found that the 2/3 power law is compatible with the movements being generated at a piecewise constant affine velocity. Equi-affine differential invariants were calculated for 2D drawing movements and movement segmentation and classification were examined. The significance and computational benefits of using the equi-affine metrics in both motion production and perception as indicated in motion perception studies (joint work with Levit-Binnun and Schectman) will be discussed. The equi-affine analysis was also extended to 3D hand trajectories leading to the formulation of a new power-law relationships between Euclidean torsion, curvature and speed (joint work with Pollick, Giblin, Sapiro, Maoz and Berthoz).

An important issue concerning trajectory formation is the existence and nature of the underlying motion primitives. To address these issues, both Euclidean and equi-affine analysis of monkey and human scribbling and drawing movements were performed (joint work with Polyakov and Abeles) focusing on issues of global versus piecemeal planning and the underlying neuronal coding

More recently (with Bennequin and Berthoz) the above work was extended in order to investigate whether global isochrony (the fact that movements with different amplitudes tend to have similar durations) can be accounted for by assuming that movements are represented in terms of affine rather than the equi-affine distance and that affine distance is proportional to the movement duration, allowing us to identify a global velocity gain factor which does not change between different local segments. The implications of this representation for motion planning and perception will be discussed.



(Figure from William JAMES)

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