ABSTRACT

In everyday life we make a variety of reaching movements. Most of these reaching movements have a clear objective of bringing the hand to the spatial location of the object of interest. Although we typically do not explicitly or at least are not aware of formulating a movement plan during reaching, a number of psychophysical studies on simple reaching movements highlight the notion that movement attributes and plans are likely to be represented/programmed in the central nervous system well before execution. In my thesis I have investigated the computational mechanisms underlying change of such movement plans.

I used a REDIRECT task in which targets occasionally changed their locations, to study the control of reaching movements. This task also gives a unique opportunity to address control before movement execution and while the movement is made. I used nine different race model architectures that can explain the redirect behavior of reaching movements. I showed that only the independent GO-STOP-GO model successfully explains the various behavioral measures. Second, using a particular outcome of the task called the hypometric response, EMG measurements and computational modelling I showed that redirecting a movement before initiation and during motor execution shared the same mechanisms.

Based on the race model framework developed in the previous chapter I next addressed whether and how kinematic plans maybe changed online. Reports from various studies suggest the kinematic representation constitutes an important aspect of motor planning. Unlike eye movements for which the kinematics are relatively fixed, hand movements exhibit a large scope for modification of the kinematics. I designed a novel velocity redirect task to understand the computational mechanisms behind the subject’s ability to change the speed of their movement. In two separate tasks the subjects either had to increase or decrease the speed of the movement according to the change in the target color. The applicability of different race model architectures to the velocity redirect task was assessed, similar to the position redirect task. I found that the GO-STOP-GO independent explained all aspects of behavior in the fast to slow velocity condition. The modeling results indicated a peculiar asymmetry in that while the FS model required inhibition, none of the GO-GO or GO-STOP models were able to explain the slow to fast velocity data. Interestingly, a vector averaging model was used to demonstrate the gradual merge of two kinematic plans in the SF task. Further, I undertook a novel approach to investigate the nature of kinematic planning borrowing from a well known paradigm in cognitive control called task switching. Using the logic of the task switch paradigm I showed the existence of a switch cost when subjects switched between slow and fast velocity movements indicating the existence of a kinematic plan well before the target onset, suggesting that such a plan may be part of a motor set. In summary, my work shows how a race model framework can provide a mechanistic understanding of motor control of different aspects of reach movement planning.