The influence of motivation onto movement precision: A computational approach

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A foundation of behaviour is reward prospect: we move to attain valuable states. However, moving towards those states implies investing a certain amount of effort and deploying motor strategies that demand specific parameters. Although the relationship between reward, motivation and behaviour has been extensively studied, the specifics of how motivation relates to motor generation, whether and how it considers effort, how this may influence the selection of movement parameters, it all remains largely controversial. For example, it has been often assumed that the activation of motor neurons is unrelated of the intended movement, which is at odds with experimental evidence showing that cortical activity reflects costs associated to intended movements well before movement onset.

To investigate whether and how motor parameters and decisions between movements were influenced by differentially induced motivated states, we performed a decision-making paradigm where healthy human participants, under different movement control conditions, had to make choices between reaching movements. Their goal was to accumulate reward by selecting one of two reaching movements of opposite biomechanical cost, and to perform their selected reaching towards the target. Maximum reward was contingent on the movement entering the centre of the target, and decreased proportionally with error. All trials had fixed duration to prevent the participants from maximizing reward by minimizing temporal discount.

We manipulated the participants' motivated state via social pressure. Each experimental session was composed of six blocks, during which subjects could either play alone or accompanied by another simulated player. Within this illusion, the amount of reward obtained by the participant and by his/her companion was reported at the end of each trial. The previous ten trial ranking for the two players was shown briefly every nine trials. However, no specific mention to competition was ever made to the subjects in the instruction, and any such assumption reported by the player was immediately rejected by the experimenter.

The results show that despite the experimenter's denial on competition, the subjects end-point error diminished proportionally to the skill of the accompanying player, meaning that although not consciously, subjects cared about their own performance. The main behavioural result was an increase of the time to peak velocity and global movement time between the baseline (play alone) condition and any accompanying condition, irrespective of the opponent's skill. This could be viewed as a simple adaptive process of trade-off between precision and time, however, other effects on the movement amplitude became significant when the skill of the companion player was clearly unattainable, such as a reduction of

the amplitude, therefore escaping the traditional context of the speed-accuracy trade-off.

To further investigate the dynamics of adaptation under baseline and motivated conditions, we developed a generative computational model of decision-making and motor control, based on the optimization of the trade-off between the benefits and costs associated to a movement. Remarkably, the predictions of this model show that this optimization depends on the motivational context where the movements and the choices between them are performed. Although further research remains to be performed to understand the specific intricacies of this relationship between motor control theory and motivated states, this suggests that this inter-relation between internal physiological dynamics and motor behaviour is more than a simple modulation of the vigour of movement.

This is a joint work wit Gustavo Deco.