# Separate processing of movement and harvest times in a foraging-like task in humans.

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**Résumé**

**Introduction**

Time and effort are thought to influence both decision-making and movement through their direct contribution to the utility of goal-oriented behaviors (Shadmehr et al. 2016). This theory suggests that the speeds of movement and decision-making are governed and regulated in an interdependent manner through the maximization of the utility, described as the subjective value resulting from the balance between the costs associated with time, effort and the rewards harvested (Yoon et al. 2018). However, the co-regulation of movement and decision-making remains debated and could be task-dependent. Hence, the purpose of this study is to investigate the time-effort trade-off in a foraging-like task that allows comparable manipulations of these two costs.

**Methods**

Forty-four healthy volunteers were required to collect as many points as possible during multiple 5-min blocks under different time and effort conditions. To do this, they had to move a cursor towards a target by pushing against a robotic interface (HRX-1 HumanRobotiX), then stay in the target while withstanding a force field in order to harvest points. Variations in effort and waiting time (delays) were introduced during movement and harvest. Changes in terms of movement and harvest durations were systematically assessed. The predictions made by the utility model were compared to an alternative model relying on a separate regulation of movement and harvest durations. Based on this model, the durations would be determined by minimizing an increasing cost of time and a task-specific cost decreasing over time.

**Results**

At the behavioral level, the results showed that delays mostly affected harvest durations, without affecting movement durations. Conversely, variations in effort had a predominant effect on movement durations. High inter-individual stability was observed between movement durations, such that the fastest participants in one condition were also the fastest in another. The same phenomenon was observed for harvest durations, but no relationship could be established between movement and harvest durations, thereby suggesting a separation between the movement and harvest phases of the task. This was confirmed with the alternative model providing a more accurate prediction of the participants' behavior than the utility model, with a residual sum of squares of 0.052 $sec^2$ compared to 0.41 $sec^2$ for the

*Intervenant

utility model.

**Discussion**

Overall, the results suggest that movement and harvest can also be regulated in a decoupled manner, highlighting the need to refine the theoretical framework of the utility to add more flexibility in the link between movement and harvest. Hence, we propose here a simplified model suggesting that the durations of these two phases are determined separately by the nervous system, yet based on similar principles involving a cost on time. It is interesting to note that, as with movement vigor (Labaune et al. 2020), the inter-individual stability observed for harvest durations seems to point towards an individual trait related to decision-making speed.

**Conclusion / Perspectives**

This study provides new insights into the factors influencing motor behavior in humans, but it is also of interest for the study of foraging behavior in a more ecological scenario. In addition, some neurological disorders associated with basal ganglia dysfunction (Parkinson's disease, depression) are also characterized behaviorally by an altered sensitivity to time and effort (Mazzoni et al. 2012). This study is therefore of direct interest for understanding the behavioral consequences of these pathologies in terms of movement and decision-making.

**References**

*(Original article:)*

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