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Performing without planning: De novo learning of a continuous tracking skill

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Classical theories suggested that movements needed to be constructed or "programmed" before they could be executed. However, in recent years it has become clear that movements are in fact prepared very rapidly – in as little as 150 ms after a movement goal is presented. This has led to a different understanding that movements are not "constructed" at all, but rather simply generated by invoking a pre-existing movement policy after a goal is specified.

It may be the case, however, that movements can only be prepared so rapidly in over-learned tasks. Time-consuming planning still appears to be necessary in less well practiced tasks. A wealth of work has shown that, when we learn to compensate for a visuomotor perturbation, such as a rotation of visual feedback, we do so in part by re-aiming our movement towards a different movement goal than the target location – which can be considered a form of planning.

Pre-movement planning of this kind, however, can only really occur in the context of discrete movements such as point-to-point reaching. For many real-world skill, such as riding a bicycle or juggling, there is no clear start and stop and instead we must continuously adjust our actions based on a constantly changing environment. In this context, the kind of time-consuming re-aiming strategy that people rely on when learning discrete tasks is likely to no longer be possible. It is not clear how people might be able to learn in such tasks, if at all.

I will present work (led by Chris Yang, with Noah Cowan) describing how participants are able to learn to track a moving target while also compensating for an imposed visuomotor perturbation – either a mirror reversal, or a 90 degree visuomotor rotation. Despite having no opportunity to implement time-consuming re-aiming, participants were able to counter the perturbation, at least partially. We analysed behaviour using linear system identification, which revealed two distinct components of learning: parametric adaptation of a baseline tracking policy, which exhibited aftereffects and occurred only in the rotation group, and formation of a de novo policy, which occurred in both groups. In neither case, however, did we find evidence that participants utilized a re-aiming strategy to counter the perturbation. Our findings demonstrate that participants can learn a new control policy that maps target motion to motor output, without having to rely on the kind of discrete re-aiming strategies that have been characterized in the context of discrete point-to-point tasks, exemplifying a form of de novo motor learning that has previously not been well characterized.