Two-Rate Proprioception - How Quickly Does Proprioception Recalibrate And Is It Related To The Two-Rate Model Of Motor Learning

Jennifer E. Ruttle

Bernard Marius ’t Hart

Denise Y.P. Henriques

# Overview

We have previously found that proprioception recalibrates within 6 trials, whereas visuomotor adaptation takes longer to saturate [[1](#ref-Ruttle2016),[2](#ref-Ruttle2018)].

In this project we set out to investigate 1) exactly how quickly proprioception recalibrates, 2) to disentangle it from the updating of predicted sensory consequences, and 3) to see if it matches implicit learning that should follow the slow process [[3](#ref-McDougle2015)] in the two-rate model [[4](#ref-Smith2006)].

## Trial types

To do all this we use a trial-by-trial approach, that is: one reach-training trial is followed by one of various “measurement” trials: passive localization, active localization or no-cursor reaches (all of them explained below). As a control we also had people pause for a short bit instead. There wer four groups of participants and each did one of the four “measurement” trials exclusively. With one exception, the pause and no-cursor group also did a set of localization trials before and after the regular paradigm also done by the other groups.

* reach training
* passive localization (only proprioception)
* active localization (proprioception + prediction)
* no-cursor reach (classic measure of motor learning)
* pause (control)
* error-clamp

By comparing the trial-by-trial changes in the four paradigms, we can investigate the time-course of all these processes in more depth than we previously have.

## Figures

Here is a list of planned figures with their intended meaning:

* Fig 1: A) setup, B) reach training + targets, C) localization + points, D) no-cursor + targets (illustrate the hardware and trial types)
* Fig 2: paradigm, four phases (aligned, rotated, reversed, error-clamped), plus extra localization phases (illustrate the main paradigm… add expected model fit?)
* Fig 3: A,B,C,D) one subplot for each group showing reach deviations in the four main phases: individual traces, 95% confidence intervals, median (show quality of the data)
* Fig 4: A,B,C,D) one subplot for each group showing the median reach deviations in the four main phases, plus the two-rate model fit and it’s fast and slow process (show quality of the fits)
* Fig 5: comparing reach deviations over time, (show differences between the groups, or should this go in a previous figure? seems it would get cluttered)
* Fig 6: A) localization throughout for the two localization groups, B) localization shift in the pause and no-cursor group, C) speed of localization shift, D/E) localization shift with the two processes for each group (show the incredible speed of localization shifts and how non-matching the slow but also the fast process are)
* Fig 7: alternative models of localization? (20% model works reasonably well… even better than giving localization it’s own two- or one-rate model)
* Fig 8: A) time course of no-cursor changes (no-cursor could reflect a watered down version of the slow process?)

## Two-Rate model

In the two-rate model, the motor output X at trial t, is simply the added output of the slow and fast process at trial t:

The output of the slow process on the next trial (t+1) is determined by the error on the previous trial multiplied by a learning rate L, and the output on the previous trial multiplied by a retention rate R:

Similarly, the fast process has it’s own learning rate and retention rate:

The four parameters , , and will be fit to match the data optimally according to a least-squared error algorithm. They should each fall within the range [0,1]. To ensure that the fast process learns faster than the slow process but also forgets faster than the slow process the model is further constrained by requiring that and .

# References

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