Preregistration

The Effect of Variance of an Applied Perturbation on Learning Rate, Generalisation and Washout in a Feedforward Experiment

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Study Information

Title	The Effect of Variance of an Applied Perturbation on Learning Rate, Generalisation and Washout in a Feedforward Experiment
Description	Does feedforward adaptation to a visuomotor perturbation follow a Bayesian framework? In their seminal paper Körding and Wolpert (2004) have shown that humans can learn a probability distribution of visuomotor perturbations as a prior and that this learning process is further affected by the amount of uncertainty of the visual input. However, as most of the following research, they have only shown that

this applies to the mean of a probability distribution and, so far, little is known about the question whether also additional information of the distribution of an imposed perturbation such as its variance is encoded and learned. An investigation specifically of the effect of variance of an imposed perturbation on learning would, however, be crucial for a better understanding of the Bayesian implementation of the brain in sensorimotor adaptation. The purpose of the present study is to investigate the effect of variance on learning, washout and generalisation to other targets in a feedforward experimental design.

Hypotheses

Learning: The effect of variance of a perturbation probability distribution on learning rate is still poorly studied. Fernandes et al. (2012) report lower variance leading to a higher and faster learning rate. However, a strong directional prediction would require a more solid basis of previous literature, especially considering paradigm differences. We, therefore, choose the more statistically conservative non-directional hypothesis, expecting the amount of variance leading to a difference in learning rate.

Washout: As is the case with learning, evidence of variance influencing washout is poor. Results of Canaveral et al. (2017) weakly suggest that training under a more variable perturbation schedule increases the uncertainty of the adapted forward model and lead to weaker retention. However, their chosen variances are first much smaller and second drawn from a multinomial as opposed to a normal distribution. Those changes in paradigm make predictions for this study even more unreliable. We, thus, also choose a non-directional hypothesis here, stating that a difference in variance influences washout rate.

Generalisation: Fernandes et al. (2012) reported no significant differences in generalisation width after manipulating the perturbation variance. Assuming that variance has an effect on learning rate we would, however, at least expect a different amplitude between different variance conditions. In line with the previous two hypotheses, our conservative non-directional hypothesis states that varying the amount of variance would result in a difference in generalisation.

Design Plan

Study type **Experiment**. A researcher randomly assigns treatments to study subjects, this includes field or lab experiments. This is also known as an intervention experiment and includes randomized controlled trials.

Blinding For studies that involve human subjects, they will not know the treatment group to which they have been assigned.

Study design The present study involves a between-subjects design with a factor rotation variance, i.e. the variance of the respectively imposed perturbation, with the three group levels 0°, 4° and 12° and the factor rotation direction with the two levels clockwise (CW) vs. counter clockwise (CCW).

Randomisation Participants will randomly be assigned to a rotation direction and a rotation variance group respectively. In order to ensure the same number of participants per group we will create a vector of 24 ones (CCW) and zeros (CW) respectively for rotation direction and another one with 16 zeros (0°), ones (4°) and twos (12°) respectively for the rotation variance. Subsequently, we pseudorandomised the resulting vectors using the `sample` function in R. The vector of participant indices (representing the order of their assignment to the experiment) will then be merged with those pseudorandomised rotation direction and rotation variance vectors.

Sampling Plan

Existing data **Registration prior to creation of data**. As of the date of submission of this research plan for preregistration, the data have not yet been collected, created, or realized.

Explanation of existing data	We don't have any existing data so far.
Data collection procedures	We will use the Macquarie University first year psychology SONA Participant Pool for recruitment. Participants will be rewarded with 4 credits after completion. Only right-hand dominant participants with normal or corrected to normal vision will be eligible for this study.
Sample size	Our minimum sample size consists of 27 participants, 9 per group. However, we will attempt to recruit 48 participants, 16 per group (see section sample size rationale below).
Sample size rationale	After running a power analysis in the free software program G*Power to reach a power of 0.95 with a significance level of alpha = 0.05 using a one-sided paired t-test we determined a minimum sample size of 9 participants per group. Based on the smallest reported effect size of Fernandes et al. (2012) the effect size was set to a decrease of 5.7° in the second group. However, as we are changing their within-subjects design to a between-subjects design this result should be treated with caution and, hence, we plan to recruit additional 7 subjects per group resulting in a total amount of 16 subjects per group. Participant numbers are consistent with field-standard conventions for studies of visuomotor adaptation and generalisation (Krakauer et al., 2000; Krakauer et al., 1999; Brayanov et al., 2012; Fernandez et al., 2012).
Stopping rule	As long as we haven't reached the total amount of 48 participants, we will continue posting weekly sign-up slots. All slots will be deleted as soon as 48 subjects participated in the study.

Variables

Manipulated variables	We manipulated two variables, rotation direction and rotation variance. Both variables are categorical with the factor levels clockwise (CW), counter clockwise (CCW) and 0°, 4° and 12° sd respectively.
Measured variables	**Outcome measure:** Our outcome measure will be the baseline corrected endpoint error (EE), i.e. the distance between the actual target location and the participants hand position when the threshold of 9cm is reached in degrees.
Indices	We will baseline correct EEs in adaptation and re-adaptation using the baseline trials with feedback and EEs in generalisation and washout using the baseline trials without feedback. For this purpose, the mean per target in the respective baseline block is computed over trials and subtracted from the respective EE in the adaptation, re-adaptation, generalisation and washout block.

Analysis Plan

Statistical models	...
Transformations	...
Inference criteria	...
Data exclusion	A participant's data will be excluded in the case of a participant not completing the whole experiment or if a participant's data will get corrupted in any possible manner. In those cases, this data will not be analysed and the respective number of new subjects will be recruited. In order to reduce explicit strategies, we will add a time constraint such that participants have a total time of 600ms to reach the target. Trials in which participants don't reach the 9cm threshold will be excluded.

Missing data	Missing trials due to a participant exceeding the time constraint will be treated in the following way: - If a subject's amount of missing values in at least one of the baseline, post-baseline, adaptation, re-adaptation or washout phase exceeds a 10% threshold respectively or in the case of less than 5 successful reaches per target in the generalisation phase the respective subject will be excluded from the analysis. - Otherwise, we will run a simulation to ensure that the threshold of 10% is appropriate. If yes, analyses will be conducted considering those trials as missing values. - If, however, the result of the simulation suggests that the threshold of 10% has been set too low and that a more restrictive threshold would be more appropriate for data analysis participants will be excluded according to the more appropriate threshold.
Exploratory analyses (optional)	**Initial prior:** We will analyse the pre-familiarisation data to investigate the prior based only on proprioception, i.e. the movements occluded participants conduct to reach to a specific target before any feedback and, thus, any prior is being imposed. Are there some systematic patterns? What is the participants initial prior when exposed to this new reaching task without the respective visual input? **Endpoint error (EE) vs. initial movement vector (IMV):** We are further interested in comparing EE to IMV. As the present stud design is meant to be a pure feedforward design, we expect no systematic difference between EE and IMV. The reason we chose EE as our dependent measure is due to the high amount of noise we found in the IMV of our pilot study. EE in contrast was much less noisy. We, however, decided to additionally include IMV to explore the relationship of those two measures in this feedforward design. **Implicit vs. explicit learning:** Previous literature suggests gaze as a way to distinguish between implicit and explicit strategies in sensorimotor adaptation (Anouk et al., 2018). Even though this relationship needs further research for better confirmation we are interested in this possible way of disentangling those two strategy types and, therefore, plan to analyse eye tracking data while participants perform the sensorimotor adaptation task. We assume that the implementation of explicit strategies would let the learning curve immediately increase at its maximum after only few trials as opposed to a gradual shift that would be expected in the implicit case.

We will further implement the questionnaire of Benson et al. (2011) at the end of the study to relate the eye tracking data to the conscient use of explicit strategies. This would allow us to investigate specific pattern differences in gaze and movement data between participants who learned only implicitly and those who additionally implemented explicit strategies.

Other

Other (Optional)	Enter your response here.

References