

Supplementary Material

The analyses presented in this document are exploratory to further delve into the effects of variability on task performance and see whether small effects were indeed present. The first set of analyses looked at variations of examining the learning effects in the test sessions while the second set of analyses looked at alternatives for evaluating the effect of intrinsic variability by analysing a subset of participants with the least and most intrinsic variability.

Task Performance

The analysis in the manuscript on task performance was performed on the mean absolute error of each test session, which might have clouded subtle effects of intrinsic variability. To examine whether small effects of variability on task performance exist, three additional analyses were conducted. The first analysis compared the first trial of pre-test, post-test and transfer, since the effect of intrinsic variability might be visible in the first trial after the learning session. The second analysis on the post-test and transfer-test sessions included trial number as a factor to see if differences emerged between different groups during the course of the test sessions. Lastly, we also examined whether performance on the post-test correlated with the intrinsic variability.

Analysis of First Trials of Test Session

We analysed the performance in the first trial of the pre-test, post-test and transfer-test instead of taking the means within each session to evaluate learning.

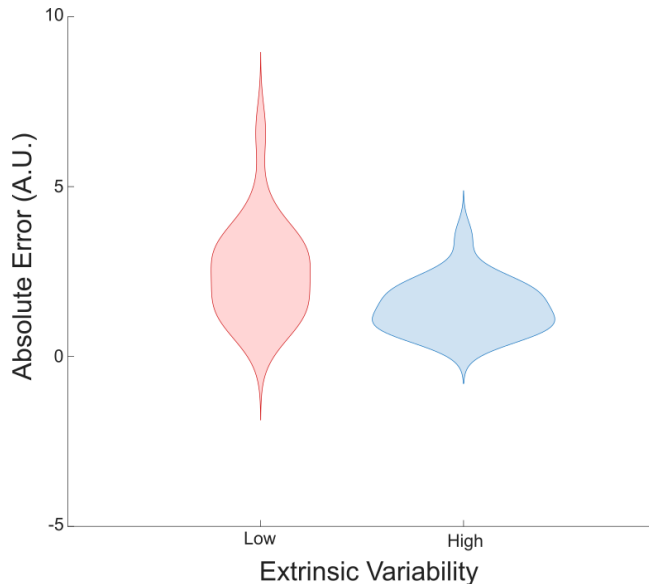
A mixed ANOVA was performed with Test Session as repeated measures and the between group measures were intrinsic and extrinsic variability. Only the main effect of test ($F(1,30)=50.52$, $p<0.001$, $\eta_G^2 = 0.39$) was significant. We did not find an effect of variability on the first trials of the test sessions which corroborated our results based on the mean absolute error.

Analysis on Post Test

The post test included one trial of each ball trajectory i.e 16 trials in total. To better understand the differences in learning among the groups, we looked at the differences in performance within the post test by including trial number as a factor.

We performed a Mixed ANOVA on absolute error with trial number as a repeated measure while intrinsic and extrinsic variability were between group measures. Only the main effect of extrinsic variability was significant ($F(1,33)=7.05$, $p=0.012$, $\eta_G^2 = 0.04$). The results

suggest that there were no differences in the performance across the trials of the post-test while the performance was significantly lower in high extrinsic variability groups compared to the low extrinsic variability (Fig. S1).



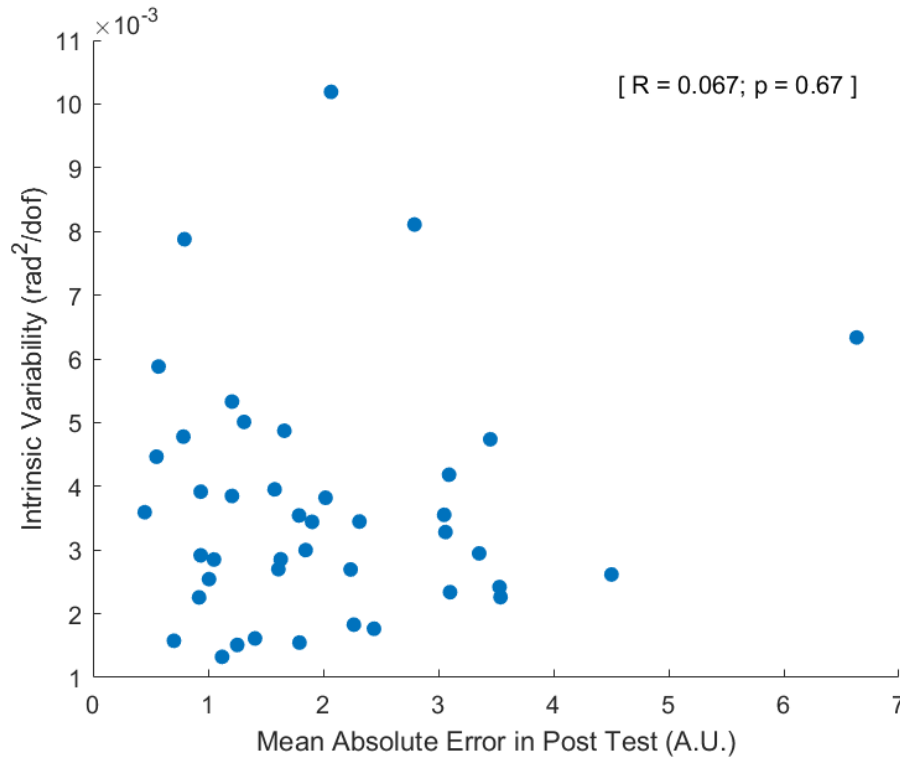
Supplementary Figure 1 (S1): Differences in the performance in post-test between the low and high extrinsic variability groups.

Analysis on Transfer Test

The transfer test included one trial of each ball trajectory i.e 16 trials in total. In these transfer trials different ball arrival positions than the ones the participants trained on, were used. We looked at the differences in performance within the transfer test by including trial number as a factor. We performed a Mixed ANOVA on absolute error with trial number as a repeated measure while intrinsic and extrinsic variability were between group measures. No significant effects were observed. There was no difference in performance between the different trials within the transfer test.

Correlation analysis between intrinsic variability and performance in post test

A correlation analysis was performed between the intrinsic variability measure and task performance in the post test. The results suggest that there is no trend in the comparison of these two measures (Fig.S2).

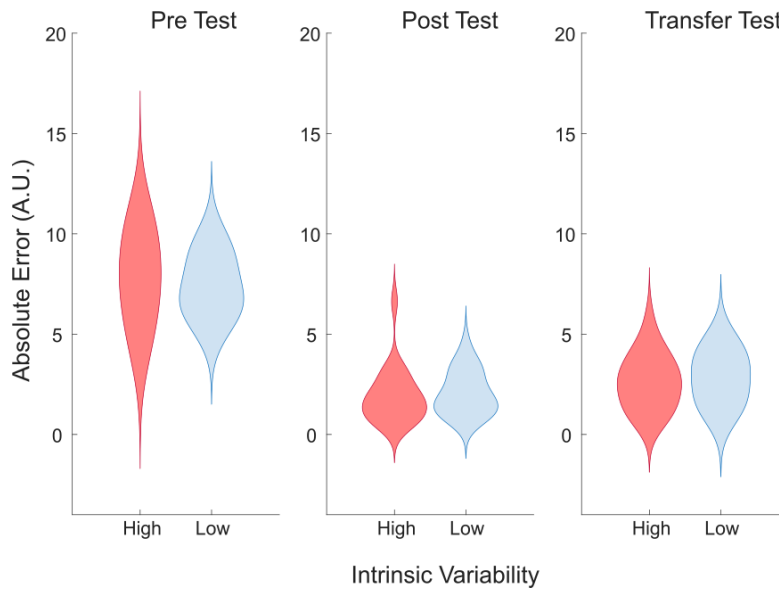


Supplementary Figure 2 (S2): Correlation between intrinsic variability and absolute error in post test

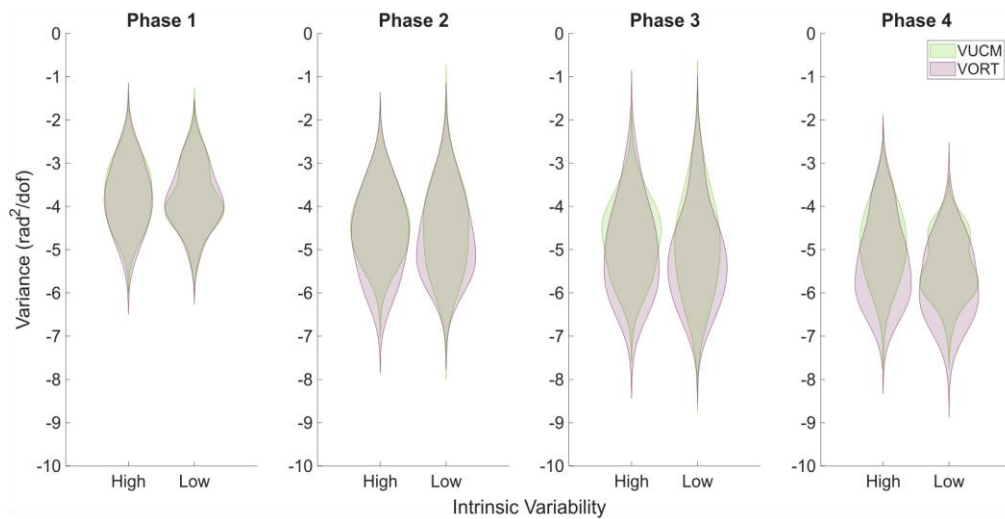
Overall, these exploratory analyses support our initial findings based on the mean performance in the test sessions. We do not find an effect of variability (extrinsic or intrinsic) on the task performance and learning.

Effect of Intrinsic Variability

Effects of intrinsic variability could not be observed either at the task level based on the performance in different test sessions (Fig. S3) nor at the degree of freedom level based on the uncontrolled manifold analysis (Fig.S4). Further, a set of exploratory analyses were carried out to establish the lack of effect due to intrinsic variability.



Supplementary Figure 3 (S3): Distribution of absolute error in different test sessions for the high and low intrinsic variability groups



Supplementary Figure 4 (S4): Distribution of variance (VUCM and VORT) for the different groups based on the intrinsic variability

Analysis on participants with least and most intrinsic variability

To better understand the effect of intrinsic variability on learning and synergy formation we ran a mixed ANOVA on a subset of total participants with the least and most amount of intrinsic variability. We selected 5 participants from each group such that the two groups with low intrinsic variability included participants with the lowest intrinsic variability while the participants in the high intrinsic variability group had participants with the highest intrinsic variability.

A 2-way mixed ANOVA was performed on absolute error with repeated measures as the test sessions and intrinsic variability as a between group measure. Due to the small sample size we only report the main effects. We found a significant effect of test ($F(1.23,22.16)=103.15$, $p<0.001$, $\eta_G^2 = 0.74$) but not of intrinsic variability ($F(1,18)=0.10$, $p=0.75$, $\eta_G^2 = 0.003$).

Another 3-way mixed ANOVA was performed on variance with repeated measures as the practice phase and variance type (VUCM and VORT) while intrinsic variability was a between group measure. Due to the small sample size we only report the main effects. We found a significant effect of variance type ($F(1,18)=13.21$, $p=0.002$, $\eta_G^2 = 0.02$) and phase ($F(2.88,51.80)=62.60$, $p<0.001$, $\eta_G^2 = 0.44$) but not of intrinsic variability ($F(1,18)=0.62$, $p=0.44$, $\eta_G^2 = 0.01$).

These results indicate that intrinsic variability had no effect on task performance and search behaviour, even for participants with the highest and lowest levels of intrinsic variability.