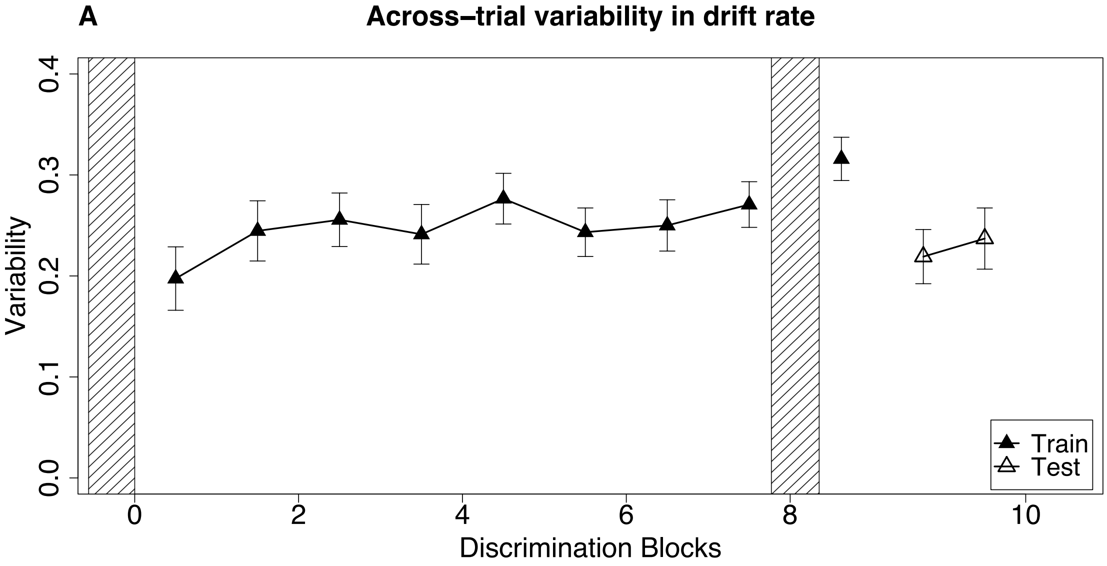
Supplementary material for "Dissociable perceptual learning mechanisms revealed by diffusion model analysis" by Petrov, Van Horn, & Ratcliff, to be published in *Psychonomic Bulletin & Review*, February 2011.

ADDITIONAL DETAILS ON THE MODEL FITS

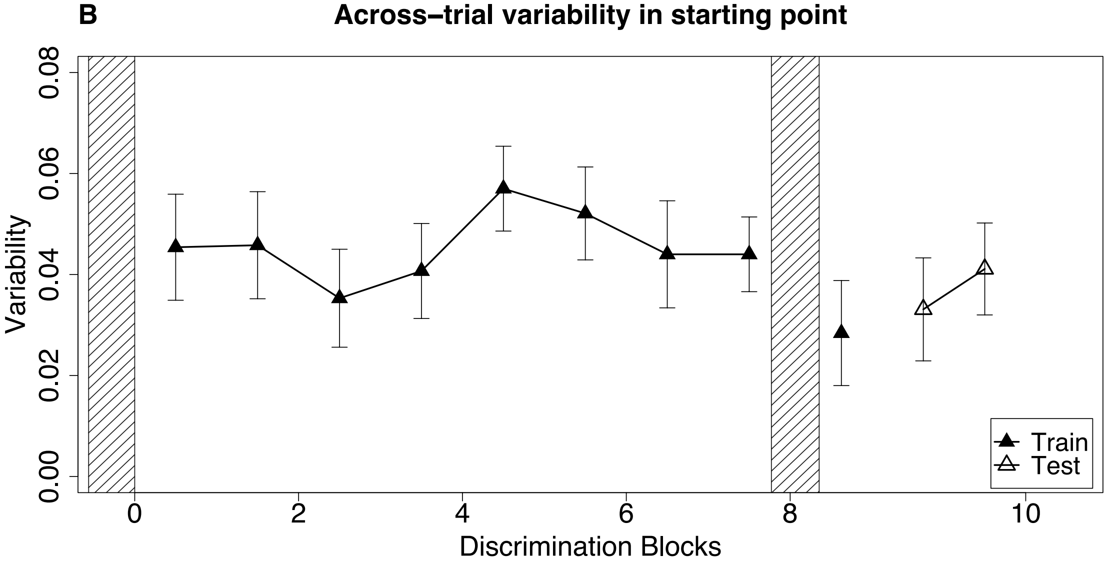
As stated in the main text, the diffusion model (DM) was fitted individually for each observer and each block. There were 297 fits (= 27 observers x 11 blocks, including the "mini-block" after the motion-aftereffect session). The parameter-search algorithm minimized the χ^2 discrepancy between predicted and observed quantile RTs (Ratcliff & Tuerlinckx, 2002). The distribution of the 297 individual χ^2 values had a mean of 23.6 (median=20.2, standard deviation=17.5, upper quartile=27.9, max=147). More than 69% of the values were less than the critical χ^2=25.0 (*df*=15, *p*<.05). That is, the model did not deviate significantly from the data in two thirds of the cases. The deviations in the remaining cases, though statistically significant, were small and unsystematic as evident from Figures 4 and 5. The deviating cases were spread approximately uniformly across blocks and participants. It should also be noted that for sample sizes such as ours, "χ^2 often indicates significant deviations from a model, when in fact, none exist" (Van Zandt, 2000, p. 452). In conclusion, the diffusion model seems to track our data to a sufficiently good approximation so that the model parameters are valid measures of the underlying cognitive processes.

Figure S1 plots the learning curves for two DM parameters: across-trial standard deviation η in the mean drift rates (top panel) and the across-trial variability s_z in starting point (bottom panel). The upward linear trend in η was statistically significant but the effect size was small (Table 1: $F(1,182)=6.0$, $p<.02$, $\eta_p^2=.08$). This increase in η probably stems from the large increase in the mean drift rates themselves (see Figure 3C in the main text).

Figure S1. Learning profiles for two diffusion-model parameters: across-trial variability in drift rate (A) and in starting point (B). The data format is as in Figure 3 in the main text. The observers practiced motion-direction discrimination for 8 blocks (black symbols) and then were tested on the same task at the orthogonal direction (open symbols). The error bars are 90% within-subject confidence intervals. Shaded areas mark two additional sessions of motion-aftereffect measurements.



A **Across–trial variability in drift rate**



B **Across–trial variability in starting point**

There were no significant learning trends for the starting-point variability s_z (F(1,182)=0.37 for the linear and 0.20 for the quadratic contrasts, respectively). This is consistent with the synchronization hypothesis and suggests that the diffusion process was rarely gated too early even during the very early blocks. In other words, the large variability in nondecision times s_t in Figure 3F apparently reflects instances in which the diffusion process started too late rather than too early. When the diffusion process starts too late, we expect a decrease in drift rates because useful sensory evidence is missed. By contrast, when the diffusion process starts too early, we expect an increase in starting-point variability because noise is accumulated in the absence of evidence. In other words, the synchronization hypothesis includes two distinct scenarios. In the first scenario, the initial blocks contain many trials on which the diffusion process starts too late. As these long nondecision times are shortened with practice, the drift rates improve, the nondecision variability s_t decreases, and the starting-point variability s_z stays the same. The available data seem to show this pattern. In the second scenario, the initial blocks contain many trials on which the diffusion process starts too early. If such short nondecision times were prolonged with practice, s_z would have increased. The apparent lack of such increase makes the second scenario unlikely.

MOTION AFTEREFFECT

The experiment contained two additional sessions that measured the motion aftereffect (MAE; Mather, Verstraten, & Anstis, 1998) in the trained, test, and two control directions. The MAE data address a research question that is independent of our current focus and will be published separately. The presence of these MAE sessions does not affect the interpretation of the discrimination data reported in the main text. This appendix outlines the MAE procedure and explains why the two data sets can be treated separately.

MAE Procedure

The MAE sessions occurred on two separate days marked by the shaded areas in Figure 3. There were 81 trials per session. Each trial began with a beep and consisted of three phases: adaptation, MAE measurement, and reset. The adaptation duration was 10 s, the MAE duration was the dependent variable, and the reset duration was adjusted to make the trial total exactly 30 s. The adapting stimuli were the same as in the discrimination sessions, except that they moved for 10 s rather than 397 ms. Then a (freshly generated) static[1] texture filled the aperture. It appeared to move due to the aftereffect. The participants were asked to press a key when the apparent motion stopped. The reset phase presented random dynamic noise within the aperture for the remainder of the trial. It minimized any residual carry-over to the next trial (von Grünau, 2002). A red fixation dot was visible in the aperture center at all times. A simple attentional task controlled for fixation during the adaptation phase. The direction of motion changed by ±3° at random intervals and the participants pressed a key whenever they detected a change. Several such changes occurred on a trial, and bonus points (visible onscreen) were scored for detecting them.

Discussion

It is extremely unlikely that the motion-aftereffect task can affect the interpretation of the discrimination data because the two tasks are very different. Moreover, our main finding – dissociable learning mechanisms – hinges on the concept of stimulus specificity, which in turn is defined with respect to two directions: training and test. All MAE blocks contained a counterbalanced, randomized mixture of both.[2] The MAE protocol was not contingent on what direction had been practiced during the discrimination sessions. Furthermore, the MAE data showed no statistically significant effects of the direction of the adapting stimulus.

The last experimental session began with a "mini-block" in the trained direction. It is shown in Figure 3 in the main text as an isolated point with the same symbol as the points on the main learning curve (blocks 1-8). The purpose of this mini-block was to absorb the disruptive influence of the MAE posttest and transition back to the discrimination task. The small drop in all performance measures in Figure 3 is typical of the switch cost that occurs in perceptual discrimination upon any change of the experimental situation (e.g., Petrov, Dosher, & Lu, 2005). In this case, the switch cost reflects the task transition. Critically, the motion-direction switch in block 9 causes a further drop (particularly in the drift rates in Fig. 3C). This further drop cannot be attributed to the MAE.

References

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Endnotes

[1] This measured the *static MAE* (Verstraten et al., 1999). For 11 of the 27 observers, the test stimulus on half the trials was dynamic noise that measured the *dynamic MAE*.

[2] For 16 observers, the MAE was also measured in the two opposite directions.