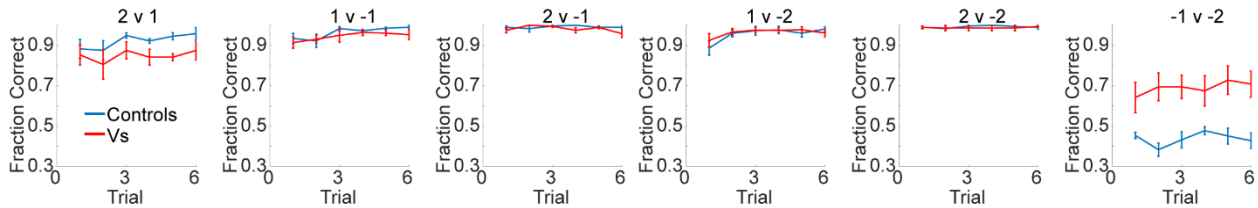**Supplement data**

Fig. S1 Familiar Blocks Deterministic Reinforcement Learning of Stimulus-Outcome Associations

In the familiar blocks (Fig. S1), there were differences in performance across conditions despite the extensive experience the animals had with all cues (Condition; $F_{(5,34)} = 182.0$, $p < 0.001$). There were also differences between the groups across conditions (Group x Condition; $F_{(5,26)} = 14.8$, $p < 0.001$). To examine this effect, we tested each condition separately. (All condition effects are reported uncorrected, but we only state effects as significant that would survive Bonferroni correction for number of conditions.) The only condition that showed a significant difference between the groups was the -1 v -2 condition ($F_{(1,5)} = 18.55$, $p = 0.008$). When we examined the average fraction correct in this condition we found that the monkeys did not do better than chance ($t(6) = 0.8$, $p = 0.452$). In addition, when we looked at both groups individually we found that neither group learned to choose the smaller loss at above chance levels (Control: $t(3) = -2.9$, $p = 0.058$), VS: $t(2) = 3.2$, $p = 0.087$). Overall, the VS animals performed slightly above chance, and the control animals performed slightly below chance, driving the group difference, but not leading to significant learning in either group.
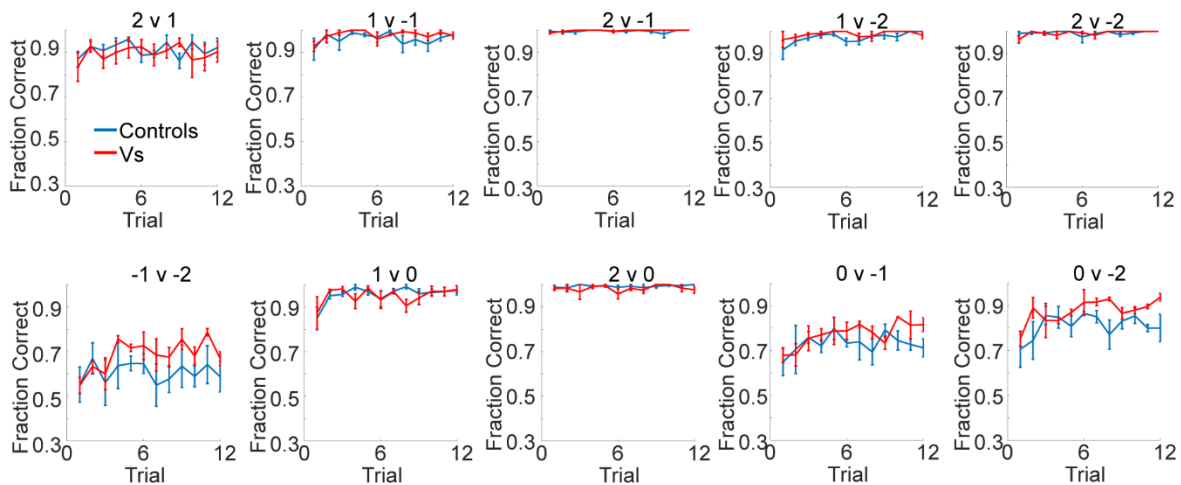

Fig. S2 Familiar Blocks Deterministic Reinforcement Learning Augmented by a Null Cue

In the familiar blocks (Fig. S2), there were differences across conditions (Condition; $F_{(9,50)} = 53.9$, $p < 0.001$). There was also an effect of group (Group; $F_{(1,20)} = 7.8$, $p = 0.011$), but no effect of group by condition (Group x Condition; $F_{(9,41)} = 0.8$, $p = 0.580$). Because of the ceiling performance, some

conditions had low variance (e.g. 2 v 0, 2 v -1 and 2 v -2), which may have been driving the group differences. In the familiar blocks, the animals performance in the condition in which they had to choose between the two loss cues was above chance (t(6) = 3.5, p = 0.012). When we tested the groups separately we found that only the VS animals reached significance (Controls: t(3) = 1.6, p = 0.198; VS: (t(2) = 6.6, p = 0.022). All the animals and both groups chose between the 0 and -1 cue above chance (All animals: t(6) = 11.5, p < 0.001; Controls: t(3) = 7.3, p = 0.005; VS: t(2) = 10.1, p = 0.009). This was also the case for choosing between the 0 and -2 cue (All animals: t(6) = 13.9, p < 0.001; Controls: t(3) = 8.5, p = 0.003; VS: t(2) = 19.5, p < 0.002).
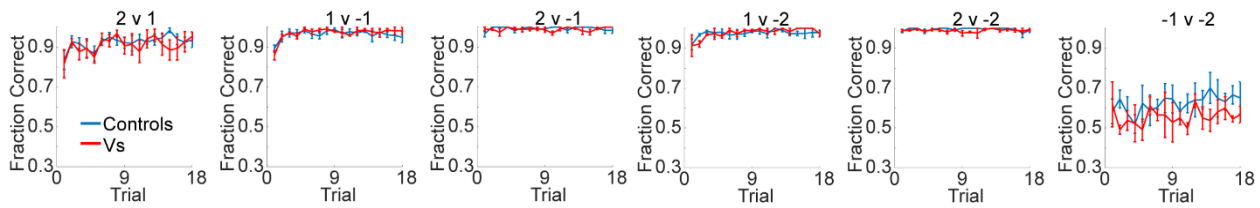

Fig. S3 Familiar Blocks Stochastic Reinforcement Learning

Performance in the familiar blocks was similar to performance in the other tasks. Consistent with the previous experiments, there was a difference in performance across conditions (Conditions; F(5,38) = 539.0, p < 0.001). There was also a difference between groups (Group; F(1,32) = 8.2, p = 0.007), but no difference in groups by condition (Group x Condition; F(5,35) = 1.5, p = 0.249). The animals learned in the -1 v -2 condition (t(6) = 2.7, p = 0.032). However, when we examined each group separately, neither group reached significance alone (Controls: t(3) = 2.4, p = 0.095; VS: t(2) = 2.9, p = 0.101).
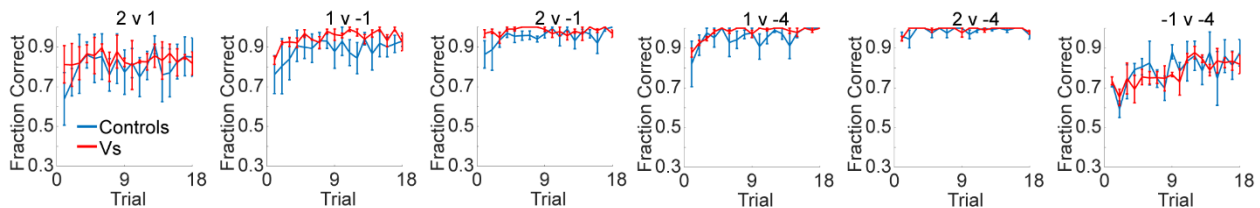

Fig. S4 Familiar Blocks Deterministic Reinforcement Learning with a Large Loss

In the familiar condition there were differences in performance across conditions (Fig. 8B; Condition; F(5,24) = 29.9, p < 0.001). There was also an effect of group (F(1,40)= 6.1, p = 0.017), but no group by condition effect (Group x Condition; F(5,17) = 0.2, p = 0.955). Similar to the novel data the animals were able to pick the smaller of the two losses more often than chance (t(5) = 13.9, p < 0.001). When we examined the groups individually we found that both groups chose the smaller loss (Controls; t(2) = 6.7, p = 0.022, VS; t(2) = 21.9, p = 0.002).
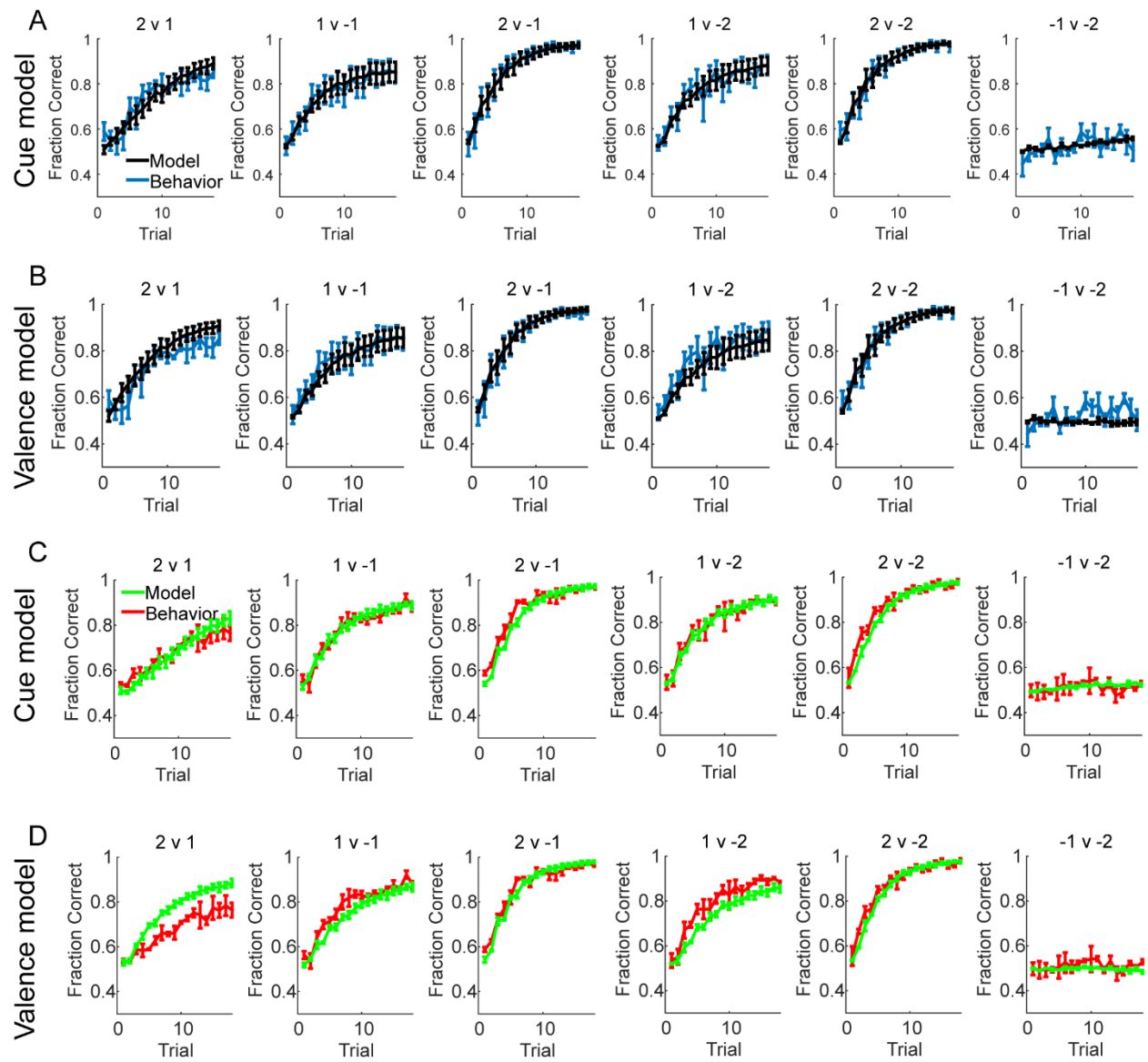
Figure S5. Fits of CUE and VALENCE models overlaid on choice behavior for both groups for task 3, which used stochastic feedback. Error bars are +/- s.e.m. with N = number of animals.
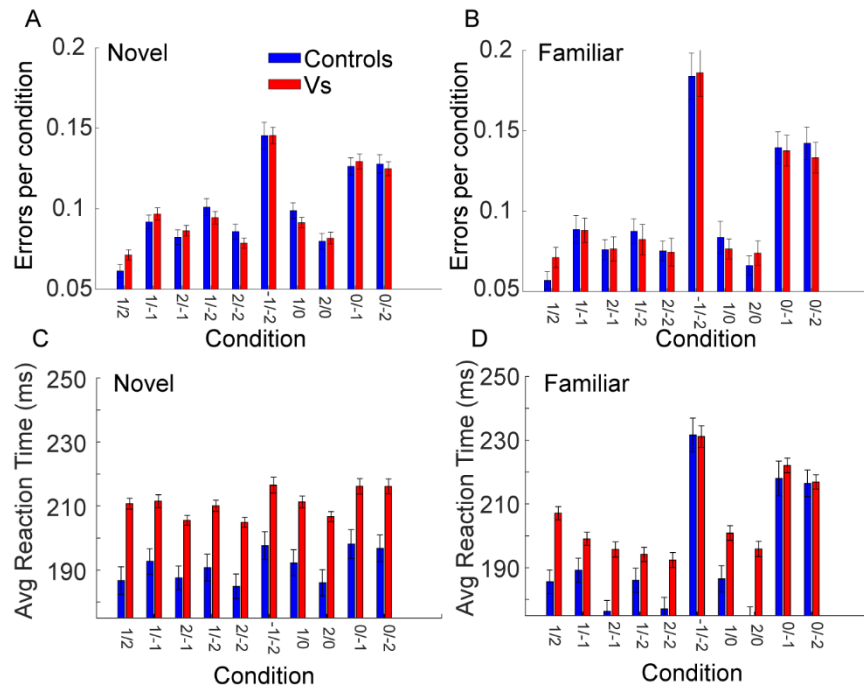
Fig. S6 Aborted trials and reaction times in the familiar and novel blocks of the Null token experiment. A. Aborted trials in each condition in the novel blocks. B. Same as A for familiar. C. Reaction times for the novel conditions. D. Same as C for the familiar condition.