Fig. 6. Histogram showing the distribution of reward prediction error (PE) values. The two outliers (PE values less than -80) were excluded from analyses presented in the text.

Fig. 7. Time course of reward PE. When the logarithm of the absolute value of PE is plotted against trial number, a significant regression was found ($r = -0.217, P = 0.03, n = 100$), indicating learning by the patient over time.
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Fig. 8. Amplitudes and phase-locking values recorded at channel 1. (a) Mean instantaneous amplitude of field potentials on channel 1 (n = 91). D-1 to D-6 correspond to decomposition levels of the discrete wavelet transform. 0 on the x axis represents the time of punishment delivery (or "Wait" cue delivery in nonpunished trials). Roughly, D-1 to D-3 correspond to gamma, D-4 corresponds to beta, D-5 corresponds to alpha, and D-6 corresponds to theta frequency bands. Note the clear increase of amplitude in alpha and theta bands at 200-600 msec. (B) Phase-locking values (PLV) of field potentials on channel 1 (n = 91). Significant phase concentration occurred in the alpha and theta frequency range from 200-500 msec. For this calculation, zero phase-shift windowed FIR (finite impulse response) band-pass filters of order 100 with center frequency 1 to 20 Hz (1-Hz steps) were applied to the ERP data.

Fig. 9. Relationship between prediction error (PE) and alpha-band ERP amplitude. (a) For trials corresponding to choices from risky decks, there was a correlation between PE and ERP amplitude only for that subset in which no punishment was actually obtained (red), but not that subset in which punishment was given (blue). (b) PE versus alpha-band ERP amplitude for choices from safe decks, for that subset in which no punishment was given (blue) and that subset in which punishment was given (black); neither showed a significant correlation.
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Fig. 10. Analyses of action values ($Q$). (a) Action values were significantly larger for choices from the risky decks than for choices from the safe decks ($t(89) = 6.2, P < 0.001, n = 91$). Error bars are ±1 SEM. Relationship between PE and alpha-band ERP amplitude (alpha rms value) for those trials that showed large $Q$ values (b) did not correlate, whereas PE and ERP amplitude were correlated for those trials that showed negative $Q$ values (c).

Fig. 11. Log-likelihood maps for various parameter combinations, verifying that a global minimum was achieved. We held either $\tau$ or $\sigma$ fixed and plot the values of the other two parameters. $\tau$, temperature parameter; $\beta$, step-size parameter; and $\sigma$, sensitivity to punishment. Color encodes log-likelihood of the model.