nature human behaviour

Registered Report

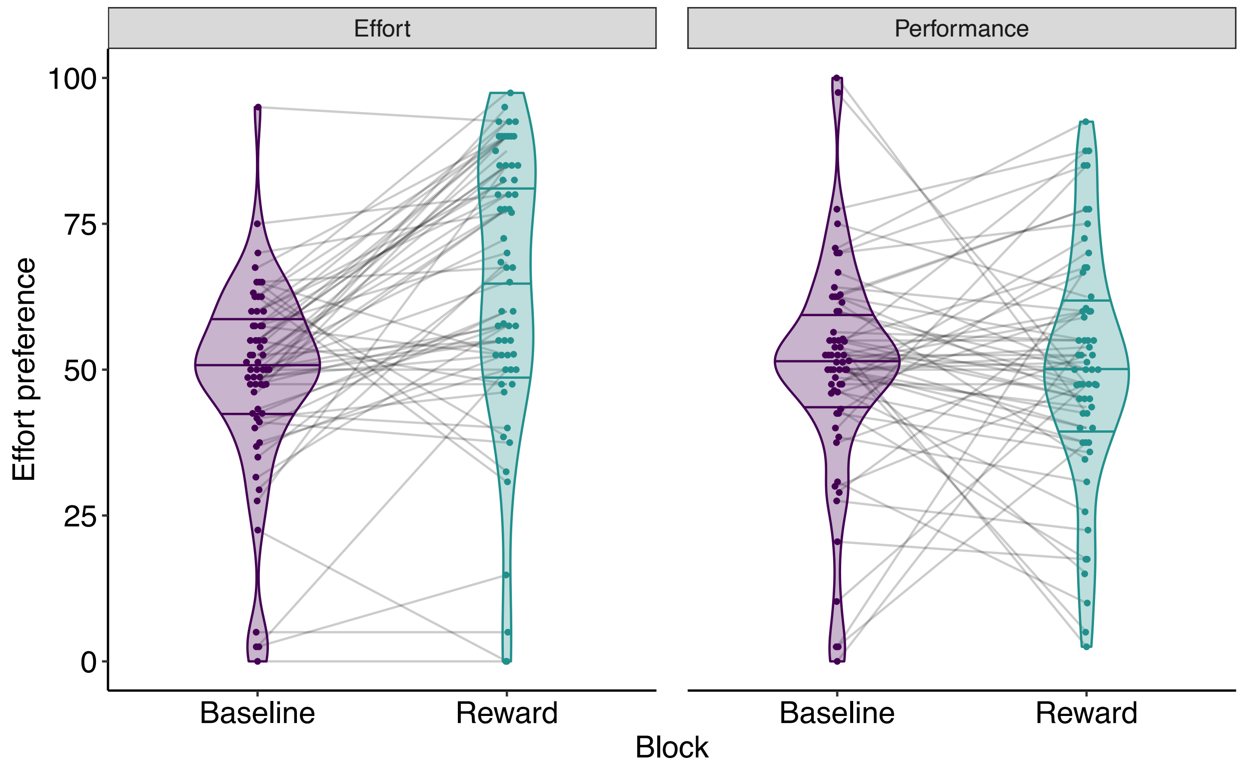
https://doi.org/10.1038/s41562-024-01842-7

An experimental manipulation of the value of effort

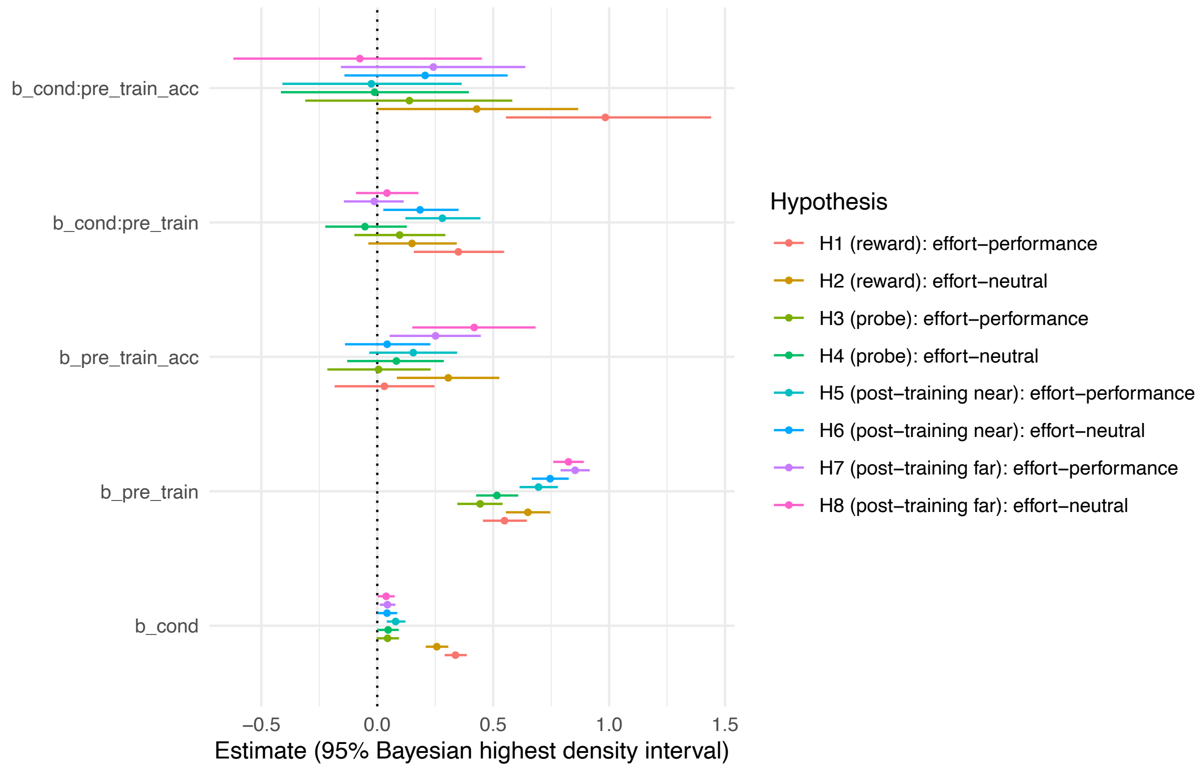
In the format provided by the authors and unedited

In the pilot study, participants were randomly assigned to either the effort or performance condition (Supplementary Fig. 1). Each participant first completed a baseline block (40 trials) where no rewards were offered. On each trial, they chose to perform the easy or hard version of the dot-motion inhibition task (equivalent to Block 1 in Fig. 1a). They then completed a reward block (40 rewarded trials) where they saw the reward trial cue and feedback (Fig. 1b) on every trial. Those in the effort condition experienced only the reward-effort value function (Fig. 1c, left panel), whereas those in the performance condition experienced only the reward-performance value function (Fig. 1c, right panel).

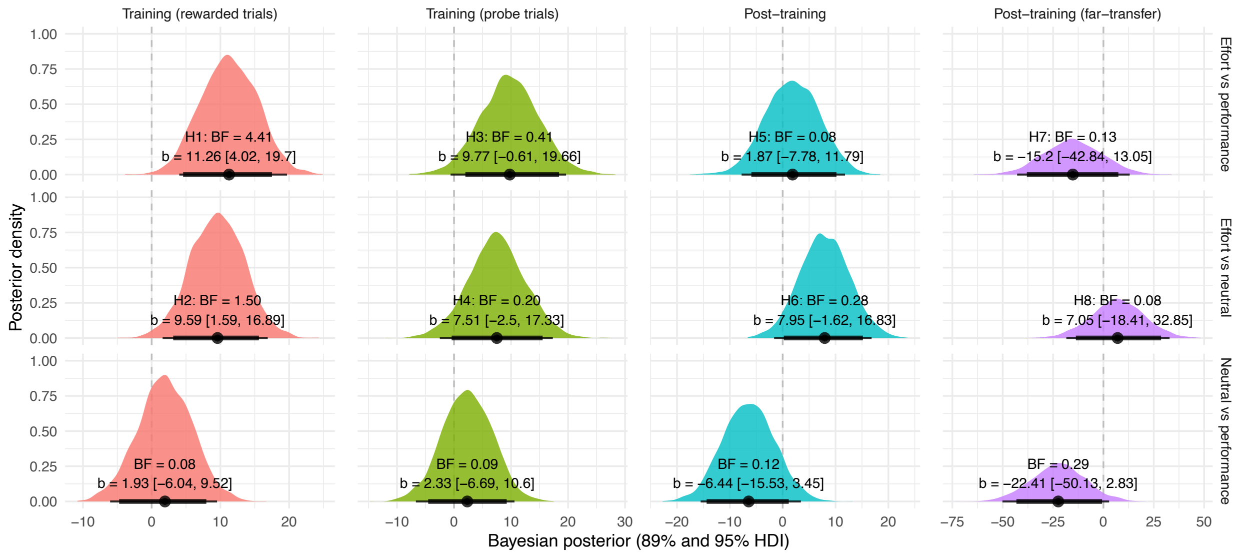
In the main text (Pilot data section), we reported that effort preferences in the reward block were higher in the effort than performance condition, demonstrating the feasibility of the proposed paradigm. Below, we report the results from additional models. When we include effort preferences in the baseline as a covariate in our model, we found strong evidence for the effect of condition, $b = 14.64$, 95% HPD = [7.28, 22.33], $d = 0.73$, BF = 144.02 ($p < .001$). When we modeled effort preferences as a change score (reward block minus baseline block), the results were similar, $b = 15.45$, 95% HPD = [7.54, 23.72], $d = 0.70$, BF = 107.86 ($p < .001$), indicating the robustness of the condition manipulation. We also modeled effort preferences as a function of condition, block, and condition-block interaction. There was an interaction effect, $b = 15.39$, 95% HPD = [5.29, 25.19], $d = 0.38$, BF = 10.14 ($p = .005$), which was driven by an increased in effort preferences across blocks in the effort condition, $b = 15.64$, 95% HPD = [7.64, 23.21], $d = 0.75$, BF = 225.90 ($p < .001$), but no change in effort preferences in the performance condition, $b = 0.13$, 95% HPD = [-6.56, 7.57], $d = 0.01$, BF = 0.19 ($p = .971$). This null effect suggests the performance condition serves as a good control or baseline condition because, overall, the manipulation does not increase or decrease effort preferences.



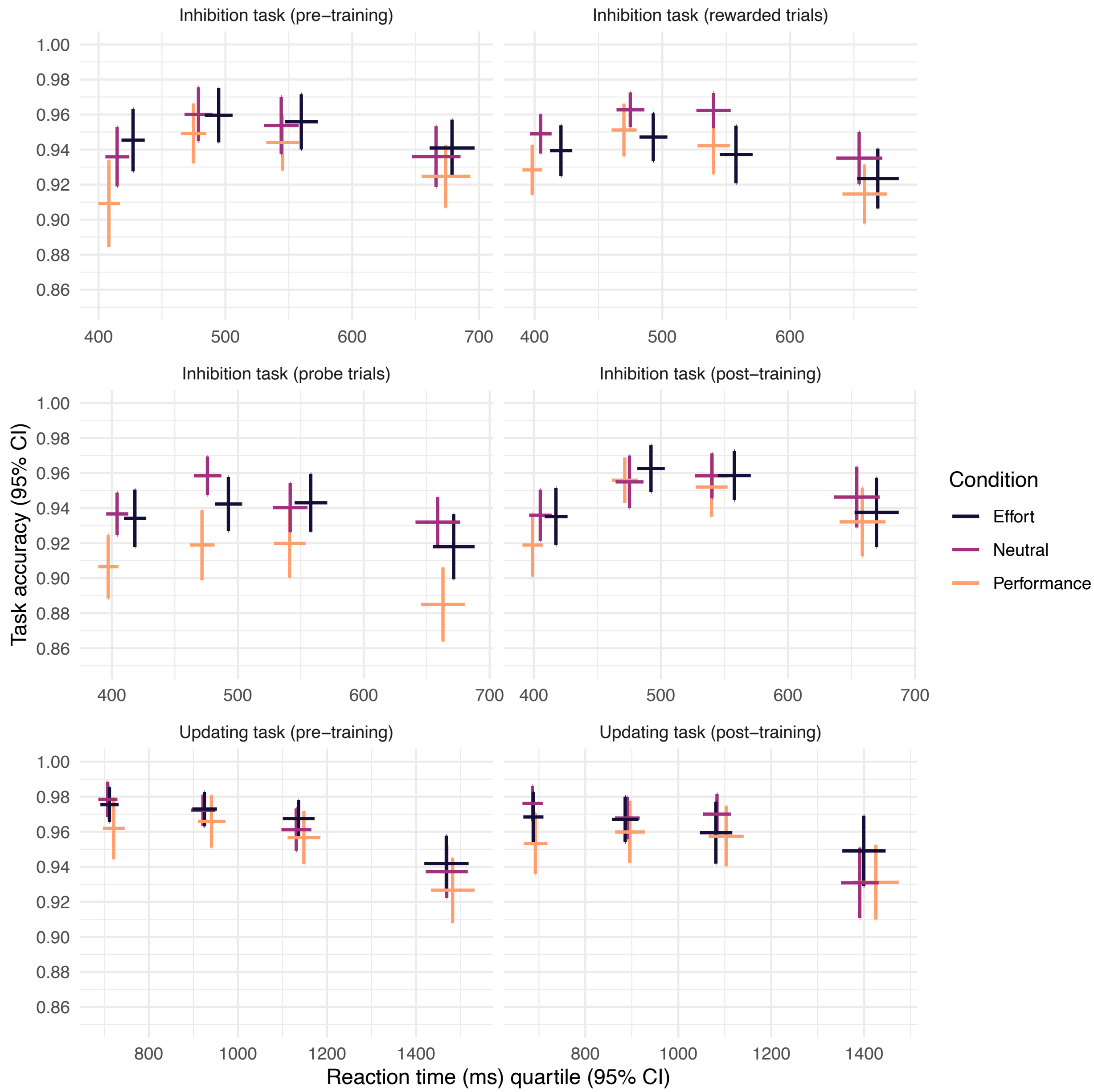
Supplementary Figure 1 | Pilot results. Participants were randomly assigned to either the effort (left panel) or performance (right panel) condition. They first completed a baseline block (dot-motion inhibition task) where no rewards were offered before completing a reward block where rewards were delivered at the end of each trial. In the reward block, those in the effort condition experienced only the reward-effort value function, whereas those in the performance condition experienced only the reward-performance value function. Effort preference (proportion of choices whereby participants chose the hard task) in the reward block was higher for the effort than performance condition. Each dot is one participant. The three horizontal lines in each violin plot are the 0.25, 0.50, and 0.75 quantiles. Each grey line connects the baseline and reward blocks' effort preferences for one participant: Positive and negative slopes indicate that the condition manipulation increased and decreased effort preferences, respectively.



Supplementary Figure 2 | Bayesian posterior estimates for models predicting effort preference and controlling for pre-training effort preference and pre-training task accuracy. Positive condition ("cond") estimates are hypothesis-consistent results (i.e., higher effort preference in the effort than the other condition). Model specification: effort preference ~ condition * (pre-training baseline + pre-training task accuracy). Posterior means and 95% highest-posterior-density intervals are shown.



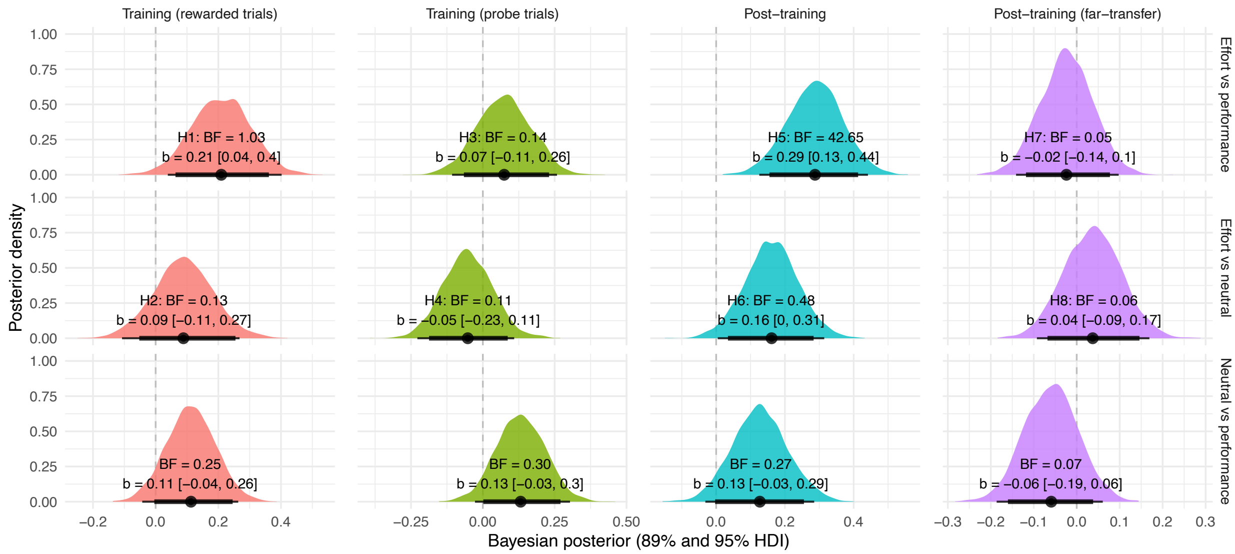
Supplementary Figure 3 | Exploratory analyses and Bayesian posterior densities for the effect of condition on task reaction time. Positive Bayesian posterior estimates indicate longer reaction times in the effort than the other condition. Model specification: reaction time ~ condition + pre-training baseline reaction time + objective task difficulty. Posterior means and highest-posterior-density intervals (95% and 89%) are shown.



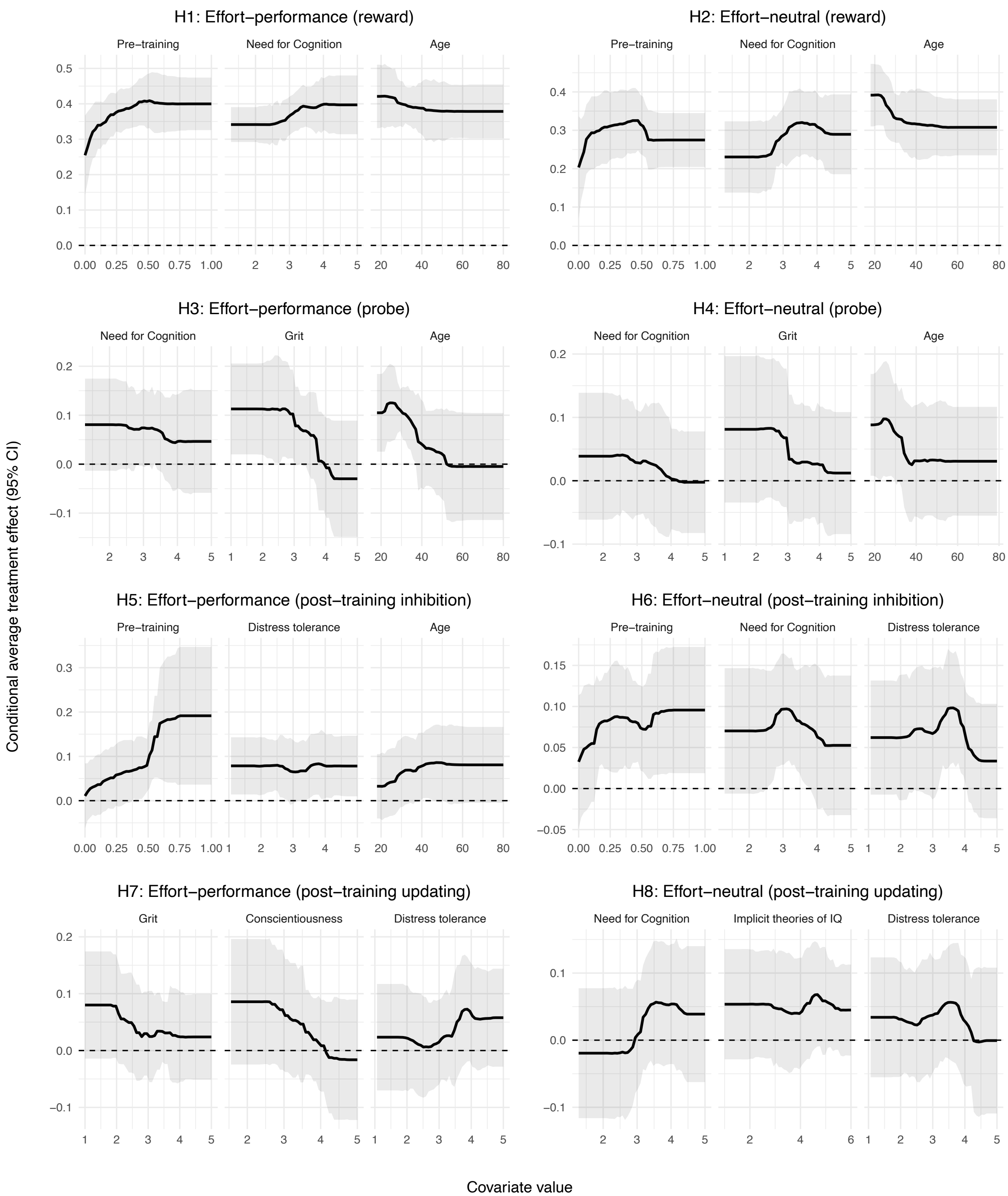
Supplementary Figure 4 | Task accuracy for reaction time quartiles. Task accuracy for easy and hard tasks. Mean and 95% CI are shown for both the y-axis (task accuracy) and x-axis (reaction time quartile). The y-axis is truncated and begins at 0.85 because mean accuracies were very high across all quartiles. n = 254, 252, and 255 participants were included the effort, neutral, and performance conditions respectively. See Supplementary Table 1 for trial numbers.

Supplementary Table 1. Sum and mean of trial numbers for each task, trial type, and reaction time quartile

			Effort (n = 254)		Neutral (n = 252)		Performance (n = 255)	
Task	Type	RT quartile	Sum	Mean	Sum	Mean	Sum	Mean
Inhibition	Pre-training	1	4650	18.38	3451	14.09	3171	13.27
Inhibition	Pre-training	2	6579	25.90	5759	22.85	5564	21.91
Inhibition	Pre-training	3	7987	31.44	8250	32.74	8598	33.72
Inhibition	Pre-training	4	9259	36.45	10322	40.96	10835	42.49
Inhibition	Reward	1	8020	31.57	9530	37.82	10417	40.85
Inhibition	Reward	2	7655	30.14	8103	32.15	8209	32.19
Inhibition	Reward	3	7080	27.87	6445	25.58	6094	23.90
Inhibition	Reward	4	6192	24.38	4971	19.73	4557	17.87
Inhibition	Probe	1	4336	17.07	4133	16.40	3978	15.60
Inhibition	Probe	2	3527	13.89	3662	14.53	3639	14.27
Inhibition	Probe	3	3222	12.74	3198	12.69	3341	13.10
Inhibition	Probe	4	3092	12.17	3040	12.06	3153	12.41
Inhibition	Post-training	1	4822	18.98	4479	17.77	4290	16.96
Inhibition	Post-training	2	3780	14.94	3801	15.20	4122	16.23
Inhibition	Post-training	3	3251	12.80	3352	13.35	3506	13.80
Inhibition	Post-training	4	2755	10.89	2782	11.13	2813	11.16
Updating	Pre-training	1	2515	9.90	2497	9.91	2518	9.87
Updating	Pre-training	2	2436	9.59	2394	9.50	2414	9.50
Updating	Pre-training	3	2489	9.80	2445	9.70	2470	9.72
Updating	Pre-training	4	2350	9.25	2307	9.15	2336	9.20
Updating	Post-training	1	1269	5.00	1260	5.00	1269	4.98
Updating	Post-training	2	1235	4.86	1225	4.86	1237	4.85
Updating	Post-training	3	1261	4.96	1243	4.93	1256	4.94
Updating	Post-training	4	1159	4.56	1152	4.57	1179	4.64



Supplementary Figure 5 | Exploratory analyses and Bayesian posterior densities for the interaction effect between condition and pre-training effort preference. Positive Bayesian posterior estimates indicate that the effect of condition on effort preference is stronger for participants with higher pre-training effort preference. Posterior means and highest-posterior-density intervals (95% and 89%) are shown.



Supplementary Figure 6 | Casual forests examining heterogeneous treatment effects. Predicted conditional average treatment effects for each hypothesis plotted against values of covariates while holding constant the other two covariates at their mean values. Mean predicted effects and 95% CI are shown.