Supporting Information

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SI Results

Randomization Test. To confirm that our behavioral results on the undermining effect were not obtained by chance (e.g., preexisting heterogeneity of the groups), we conducted a randomization test (1) as an additional analysis (using a Monte Carlo simulation; N = 10,000). This test allows us to examine the probability of obtaining the observed between-group difference in the free-choice behavior under the null hypothesis when we use the random assignment procedure. The obtained P values were less than 0.05 ($P = 0.041$ for the first free-choice period and $P = 0.042$ for the second free-choice period), indicating that our behavioral results cannot be attributable to the accidental heterogeneity of the groups.

SW Task Performance. During the first session, SW task performance was significantly better in the reward group than in the control group ($t_{26} = 2.35$, $P < 0.05$; M = 13.07 and 17.79, SD = 5.28 and 5.34). In the second session, the difference became weaker and was no longer significant ($t_{26} = 1.72$, $P = 0.10$; M = 13.07 and 16.79, SD = 6.53 and 4.74), but there is still a trend that participants in the reward condition showed better performance in the SW task. A previous meta-analysis has shown that intrinsic motivation conferred an advantage only for complex, cognitive tasks, but not for simple, noncognitive tasks (2). Therefore, given that the SW task is a noncognitive, motor-response task, the results in the SW task performance are consistent with the previous observations. Indeed, the correlation between the SW task performance in the second session and the number of voluntary plays of the SW task (after the first session) was not significant in either of the groups ($r = -0.01$, $P = 0.98$ for the control group; $r = -0.09$, $P = 0.77$ for the reward group), suggesting that the SW task performance does not reflect participants' intrinsic motivation for the task.

It should also be noted that the skill acquired in motor-response tasks like the SW task is likely to be resistant to the loss (3, 4). This could explain why the participants in the reward group continued to show superior performance (although nonsignificant) in the SW task in the second session. In fact, the correlation between the SW task performance in the first and second sessions is very high ($r = 0.78$, $P < 0.0001$), suggesting the high stability of the SW task performance.

Sex Difference. In the behavioral analysis, we conducted a 2 (free-choice period: first or second time) × 2 (group: control or reward group) × 2 (sex: male or female) mixed ANOVA to investigate a possible sex difference in the behavioral undermining effect. None of the interactions involving sex was significant (P values > 0.20). In the fMRI analysis, we conducted a 2 (session: first or second session) × 2 (group: control or reward group) × 2 (sex: male or female) ANOVA to examine whether the session-by-group interaction (our primary effect of interest) was affected by sex ($P < 0.001$, uncorrected, $k > 5$ voxels). No significant three-way interaction (i.e., session × group × sex) was detected in the striatum, midbrain, or LPFC for the task cue or feedback period. These results, taken together, suggest that our behavioral and fMRI findings are not dependent on participants' sex, although our analyses may be underpowered as a result of the small sample size.

1. Edgington ES, Onghena P (2004) *Randomization Tests* (Chapman & Hall/CRC, Boca Raton, FL), 4th Ed.
2. Utman CH (1997) Performance effects of motivational state: a meta-analysis. *Pers Soc Psychol Rev* 1:170–182.
3. Eslinger PJ, Damasio AR (1986) Preserved motor learning in Alzheimer's disease: implications for anatomy and behavior. *J Neurosci* 6:3006–3009.
4. Doyon J, Ungerleider LG (2002) Functional anatomy of motor skill learning. *Neuropsychology of Memory*, eds Squire LR, Schacter DL (Guilford Press, New York), pp 225–238.

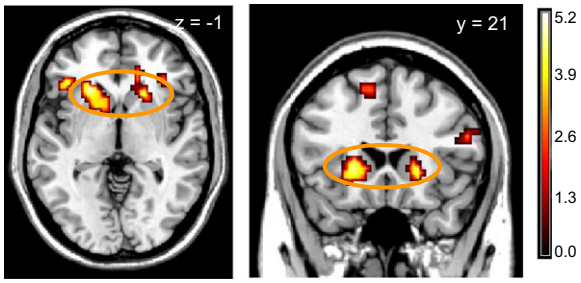

Fig. S1. Bilateral striatum activation (peaks at 21, 20, −2 and −21, 23, 1) detected in the session-by-group interaction during the feedback period (i.e., success trials minus failure trials; $P < 0.05$, small-volume-corrected; image is shown at $P < 0.001$, uncorrected). Neural responses are displayed in transaxial and coronal formats. Plot for the individual session/group is depicted in Fig. 2.

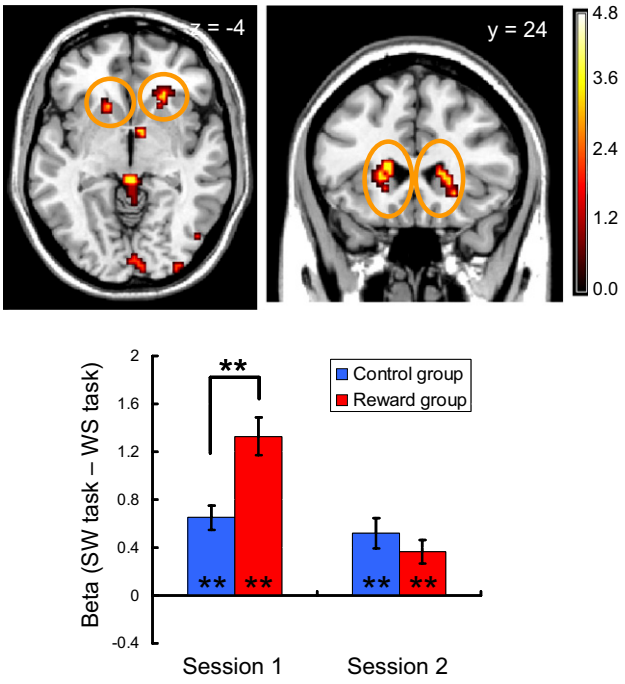

Fig. S2. Bilateral striatum activation (peaks at 15, 8, −11 and −18, 26, 10) showing a significant session-by-group interaction in response to the SW cues relative to the WS cues (image is shown at $P < 0.001$, uncorrected). Neural responses are displayed in transaxial and coronal formats. The pattern of striatal activation was different from that during the feedback period. The graph represents the averaged activation across both the right and left striatum. Asterisks represent the statistical significance of one-sample/two-sample *t* tests (**$P < 0.05$, *$P < 0.01$).

Table S1. Patterns of the session-by-group interaction during the feedback period in response to success (relative to failure) trials

Region	Peak MNI coordinates (x, y, z)			*z* value
$\underline{C_1} < \underline{R_1}$ and $\underline{C_2} > R_2$				
Right anterior striatum	21	20	−2	4.04
Left anterior striatum	−21	23	1	4.75
$\underline{C_1} < \underline{R_1}$ and $C_2 \approx R_2$				
Left inferior frontal gyrus	−42	29	−2	4.08
$C_1 < \underline{R_1}$ and $C_2 > \bar{R}_2$				
Right LPFC	57	32	19	3.79
Right inferior frontal gyrus	42	26	−11	3.52
Midbrain	−9	−7	−11	3.40
Left central OFC*	−24	35	−11	4.40
Presupplementary motor area	−12	20	52	3.63
Right inferior frontal gyrus	33	32	−2	3.38

All regions that showed a significant interaction effect ($P < 0.001$, uncorrected, $k > 5$ voxels) are categorized based on simple main effect analyses within each session. C_1, control group in the first session; R_1, reward group in the first session; C_2, control group in the second session; R_2, reward group in the second session; MNI, Montreal Neurological Institute; ≈, nonsignificant difference. Conditions that showed a significant positive activation (activation is significantly higher in responses to success trials than to failure trials) are underlined (e.g., $\underline{C_2}$). Conditions that showed a significant negative activation (activation is significantly smaller in responses to success trials than to failure trials) have a bar above them (e.g., $\bar{R}_2$).

*In the second session, a marginally significant positive activation was observed in the control group.

Table S2. Patterns of the session-by-group interaction during the task cue period in response to SW (relative to WS) trials

Region	Peak MNI coordinates (x, y, z)			*z* value
$\underline{C_1} < \underline{R_1}$ and $\underline{C_2} > R_2$				
Right LPFC	39	41	40	3.77
Cerebellum	−30	−79	−17	4.34
$\underline{C_1} < \underline{R_1}$ and $\underline{C_2} \approx \underline{R_2}$				
Right striatum	15	8	−11	3.55
Left anterior striatum	−18	26	10	3.75
Right globus pallidus	9	−1	−5	3.42
Presupplementary motor area	3	11	73	4.23
Supplementary motor area	6	−7	79	3.30
Anterior thalamus	−3	−4	7	3.25
$\underline{C_1} < \underline{R_1}$ and $C_2 \approx R_2$				
Right premotor cortex	33	−4	70	3.53
Left premotor cortex*	−30	−4	70	3.87
Right frontal pole	36	62	16	3.88
Parietal lobe†	12	−73	46	3.52
Right temporal lobe†	45	−31	−11	3.92
Left primary motor cortex	−30	−40	61	3.36
$C_1 < \underline{R_1}$ and $C_2 \approx R_2$				
Left primary motor cortex	−42	−34	61	3.52
Cerebellum	−51	−58	−20	3.47

All regions that showed a significant interaction effect ($P < 0.001$, uncorrected, $k > 5$ voxels) are categorized based on simple main effect analyses within each session. C_1, control group in the first session; R_1, reward group in the first session; C_2, control group in the second session; R_2, reward group in the second session; MNI, Montreal Neurological Institute; $\approx$, nonsignificant difference. Conditions that showed a significant positive activation (activation is significantly higher in responses to SW trials than to WS trials) are underlined (e.g., $\underline{C_2}$).

*In the second session, a significant positive activation was observed in the reward group.

†In the second session, a significant (or a marginally significant) positive effect was observed in the control group.