Supplement Contents

Supplementary Results.

Region-of-interest (ROI) analyses at 6 s following cue. We examined percent signal change in the NAcc at 6 s following the cue to test whether activation during the cue or delay periods might differ from activation in response to cue onset (which we expected to peak at 4 s following cue onset; e.g., Handwerker et al., 2004). Since the targets appeared between 3.5 – 4.5 s following cue onset, activation at 6 s may also have included early response to the target itself or motor preparation for the target.

We analyzed activation in the uncertain trials (which were present in both contexts) for effects of available incentive set (UNC-ONLY or CERT-UNC), valence (gain or loss), and magnitude (high or low; see Table S1). Identical to the pattern at 4 s, there were significant main effects of set ($F(1,11) = 5.22$, $p_{H\text{-}F} < 0.05$) and magnitude ($F(1,11) = 11.25$, $p_{H\text{-}F} < 0.01$), a significant interaction between valence and magnitude ($F(1,11) = 18.30$, $p_{H\text{-}F} < 0.01$), and a significant three-way interaction of set, valence, and magnitude ($F(1,11) = 6.54$, $p_{H\text{-}F} < 0.05$).

We investigated the effect of available incentive set with planned *t*-tests between uncertain high-magnitude gains and losses in each set. Uncertain high-loss trials had a trend towards greater activation in the CERT-UNC than in the UNC-ONLY set ($t(11) = 2.06$, $p = 0.067$, two-tailed). Uncertain high-gain trials had no difference in activation between CERT-UNC and UNC-ONLY sets ($t(11) = 0.65$, *ns*).

As at 4 s, the valence by magnitude interaction was evident primarily in the UNC-ONLY set, where uncertain high-gain trials had greater activation than uncertain high-loss trials ($t(11) = 4.32$, $p < 0.01$). This difference was not present in the CERT-UNC set, where uncertain high-gain and uncertain high-loss trials did not significantly differ ($t(11) = 1.81$, *ns*). This pattern across sets accounted for the three-way interaction.

In summary, the primary difference between patterns at 4 s and 6 s was a weakening of the difference between sets for high-magnitude gain trials (and a smaller weakening of the difference for high-magnitude loss trials). From 4 s to 6 s, activation for all conditions rose (see Figure S2), and this rise was relatively larger for the uncertain high-gain conditions. One reason for this larger rise might be increased activation due to response to the target on high-magnitude trials, which might begin to wash out anticipatory activation. In general, anticipatory NAcc activation at 6 s following cue onset was similar to activation at 4 s following cue onset, with an identical pattern of main effects and interactions across factors.

ROI analyses of parameter estimates. To investigate a measure of activation incorporating multiple time points, we analyzed parameter estimates of the effects of each condition (i.e., beta weights) from the imaging model. These estimates were extracted for each condition in each participant's bilateral NAcc ROI, averaged across the NAcc ROI, and analyzed with repeated-measures ANOVA using available incentive set, valence, and magnitude as within-participant factors.

Parameter estimates had a similar pattern of results to the percent signal change analyses at 4 s and 6 s (Table S2). There were again main effects of set ($F(1,11) = 11.51$, $p_{H\text{-}F} < 0.01$) and magnitude ($F(1,11) = 10.82$, $p_{H\text{-}F} < 0.01$); there was also a significant interaction between set and magnitude ($F(1,11) = 7.41$, $p_{H\text{-}F} < 0.05$), a trend towards an interaction between valence and magnitude ($F(1,11) = 3.35$, $p_{H\text{-}F} < 0.1$), and a three-way interaction of set, valence, and magnitude ($F(1,11) = 8.03$, $p_{H\text{-}F} < 0.05$).

We examined the effects of incentive set with planned *t*-tests of uncertain high gains and losses between sets. Both conditions had greater activation in the CERT-UNC set (uncertain high losses: $t(11) = 5.64$, $p < 0.001$; uncertain high gains: $t(11) = 2.91$, $p < 0.05$). By contrast, low-magnitude gains and losses differed only slightly or not at all between sets (uncertain low losses: $t(11) = 0.82$, *ns*; uncertain low gains: $t(11) = 2.16$, $p < 0.06$). As in the earlier analyses, uncertain high-gain trials had greater activation than uncertain high-loss trials in the UNC-ONLY set ($t(11) = 2.64$, $p < 0.05$), but this difference was eliminated in the CERT-UNC set ($t(11) = 1.54$, *ns*), accounting for the three-way interaction.

In summary, parameter estimates provided a measure of activation that included the response over several timepoints; these estimates showed a similar pattern to the analyses of percent signal change at both 4 s and 6 s. NAcc activation for high-magnitude trials was greater in the CERT-UNC set, and the difference between high-magnitude gains and losses was eliminated.

Supplementary References

Handwerker, D.A., Ollinger, J.M., & D'Esposito, M. (2004) Variation of BOLD hemodynamic responses across subjects and brain regions and their effects on statistical analyses. NeuroImage, 21, 1639-51.

Table S1.

Nucleus accumbens activation by condition at 6 s following cue onset

Condition	Percent signal change (*SEM*)
UNC-ONLY	
Uncertain high-gain	0.064_{a} (0.04)
Uncertain low-gain	-0.21_{e} (0.04)
Uncertain low-loss	$-0.11_{b,c,d,e}$ (0.05)
Uncertain high-loss	$-0.070_{b,c,d,e}$ (0.04)
CERT-UNC	
Uncertain high-gain	0.10_{a} (0.06)
Uncertain low-gain	$-0.090_{c,d,e}$ (0.04)
Uncertain low-loss	-0.13_{d} (0.03)
Uncertain high-loss	$0.00_{a,b}$ (0.02)
Certain high-gain	$-0.025_{a,b,c}$ (0.03)
Certain low-gain	$-0.079_{c,d}$ (0.03)
Certain low-loss	$-0.14_{d,e}$ (0.04)
Certain high-loss	$-0.16_{d,e}$ (0.04)

Note. Data is activation in the nucleus accumbens 6 s following the cue for a condition, in units of percent signal change from the experiment mean in that region of interest. Standard errors of the mean (*SEM*) are calculated within condition. Data points that share subscripts do not differ at $p < 0.05$ (two-tailed).

Table S2.

Parameter estimates of nucleus accumbens activation in response to cues

Condition	Parameter estimate x 10^{-4} (*SEM*)
UNC-ONLY	
Uncertain high-gain	$-1.38_{c,e}$ (0.60)
Uncertain low-gain	-2.86_{f} (0.47)
Uncertain low-loss	$-2.47_{d,f}$ (0.56)
Uncertain high-loss	$-2.56_{d,f}$ (0.66)
CERT-UNC	
Uncertain high-gain	0.05_{a} (0.75)
Uncertain low-gain	$-1.63_{c,d,e,f}$ (0.63)
Uncertain low-loss	$-2.11_{c,d,e,f}$ (0.48)
Uncertain high-loss	$-0.56_{a,b}$ (0.62)
Certain high-gain	$-1.33_{b,c,d}$ (0.62)
Certain low-gain	$-1.50_{c,d}$ (0.59)
Certain low-loss	$-1.84_{b,c,d,e,f}$ (0.44)
Certain high-loss	$-2.31_{e,f}$ (0.49)

Note. Data is parameter estimates (i.e., beta weights) in the nucleus accumbens for activation in response to cues, using a gamma-function estimate of the hemodynamic response function. Standard errors of the mean (*SEM*) are calculated within condition. Data points that share subscripts do not differ at $p < 0.05$ (two-tailed).

Table S3

Significant differences in response to uncertain cues by condition in UNC-ONLY set

Region	Peak Z-Score	X	Y	Z	Cluster Size (Voxels)
Uncertain high-gain > uncertain low gain					
Dorsal Cingulate Gyrus	5.37	6	20	30	792
Dorsomedial PFC	4.42	2	6	48	[a]
Posterior Cingulate	5.03	4	-26	38	34
Postcentral Gyrus	4.47	-40	-30	66	60
Striatum	4.35	-8	12	-2	44
Inferior Frontal Gyrus	4.32	-40	26	0	69
Insula	3.81	-30	28	-6	[a]
Precuneus	4.31	8	-64	26	19
Insula	4.20	-40	8	14	25
Posterior Cingulate	4.10	-6	-44	18	46
Claustrum / Insula	4.01	38	12	-6	76
Middle Frontal Gyrus	4.00	-24	44	34	20
Post/precentral Gyrus	3.96	-40	-14	52	43
Ventromedial PFC	3.96	8	40	-14	37
Thalamus	3.96	10	-16	10	20
Anterior PFC	3.95	-28	46	26	42
Precentral Gyrus	3.95	-38	2	58	20
Anterior PFC	3.93	-34	50	14	54

Caudate	3.92	-18	16	8	20
Paracentral Lobule	3.91	-2	-36	60	92
Superior Parietal Lobule	3.91	-30	-44	70	19
Precuneus	3.86	8	-76	48	29
Ventromedial PFC	3.82	-4	54	-8	19
Dorsal Anterior Cingulate	3.79	-8	-18	28	23
Caudate	3.72	14	-10	24	19
Cuneus	3.68	18	-70	38	24
Superior Temporal Gyrus	3.67	56	8	-10	19
Precuneus	3.62	14	-38	52	17
Uncertain high-loss > uncertain low-loss					
Dorsal Cingulate Gyrus	4.40	12	10	44	44
Dorsomedial PFC	3.79	-4	8	50	[a]
Posterior Cingulate	4.34	-6	-20	48	28
Putamen	3.52	-16	6	4	25
Uncertain high-gain > uncertain high-loss					
Superior Parietal Lobule	3.86	-34	-44	66	25
Superior Temporal Gyrus	3.82	38	-50	20	30
Rostral Anterior Cingulate	3.78	6	44	10	19
Medial Superior PFC	3.55	-4	-10	56	17

Uncertain high-loss > uncertain high-gain

No clusters at this threshold.

Note. [a] indicates subpeaks within a cluster. PFC = prefrontal cortex. Activations in table were thresholded voxelwise at $p < 0.001$ and with a cluster size > 16 voxels (corresponding to a whole-brain threshold of $p < 0.05$). T-statistics were converted to Z-scores for reporting. Coordinates are reported in MNI/ICBM152 coordinates, as in SPM2. Resampled voxel size was 2 x 2 x 2 mm.

Table S4

Significant differences in response to uncertain cues by condition in CERT-UNC set

Region	Peak Z-Score	X	Y	Z	Cluster Size (Voxels)
Uncertain high-gain > uncertain low gain					
Dorsomedial PFC	4.62	-4	4	66	744
Dorsal Anterior Cingulate	4.37	-2	8	36	[a]
Inferior Frontal Gyrus	4.57	-58	12	6	38
Parahippocampal Gyrus	4.48	28	-58	6	185
Posterior Cingulate	3.96	22	-52	8	[a]
Putamen	4.47	24	-4	8	54
Precuneus	4.42	10	-66	24	66
Precentral Gyrus	4.42	-24	-16	54	120
Parahippocampal Gyrus	4.40	44	-50	-4	24
Globus Pallidus	4.36	-26	-20	-2	45
Caudate	4.34	10	6	10	146
Globus Pallidus	4.16	14	2	-2	[a]
Middle Frontal Gyrus	4.34	30	34	18	30
Cingulate Gyrus	4.34	-10	-10	38	53
Ventral Striatum	4.34	14	14	-12	24
Precentral Gyrus	4.33	-40	-10	60	63
Postcentral Gyrus	4.33	-34	-38	66	26
Dorsolateral PFC	4.29	-32	38	40	121
Precentral Gyrus	4.24	52	-8	54	20

Cuneus	4.20	-14	-84	32	25
Ventral Striatum	4.19	-4	14	-14	40
Middle Frontal Gyrus	4.15	42	2	52	18
Middle Frontal Gyrus	4.13	-28	2	48	45
Culmen	4.11	14	-48	-4	48
Superior Temporal Gyrus	3.99	-44	-50	20	23
Cuneus	3.94	4	-84	32	53
Thalamus	3.93	-4	-8	16	17
Inferior Parietal Lobule	3.90	58	-28	30	45
Culmen	3.89	-16	-54	-2	135
Claustrum	3.88	34	22	2	31
Precuneus / Cuneus	3.86	26	-72	24	56
Inferior Frontal Gyrus	3.84	30	36	-6	21
Precuneus	3.83	-16	-68	28	20
Parahippocampal Gyrus	3.80	36	-4	-22	19
Parahippocampal Gyrus	3.78	-10	-38	6	54
Precentral Gyrus	3.75	-38	-16	52	19
Middle Frontal Gyrus	3.73	34	4	60	42
Superior Temporal Gyrus	3.65	50	-36	0	35
Middle Occipital Gyrus	3.55	-30	-76	28	17
Thalamus	3.54	12	-20	0	25
Caudate	3.53	-16	-14	22	26
Claustrum / Insula	3.47	-34	2	-8	17

Uncertain high-loss > uncertain low-loss					
Dorsolateral PFC	4.38	-46	10	54	27
Posterior Cingulate	4.29	4	-34	42	24
Midbrain	4.14	-8	-24	-8	24
Ventrolateral PFC	3.96	-42	44	0	21
Superior Parietal Lobule	3.95	-28	-70	56	17
Middle Frontal Gyrus	3.89	-38	6	40	29
Precuneus	3.85	6	-72	44	98
Superior Parietal Lobule	3.82	-38	-62	56	27
Cuneus / Precuneus	3.79	6	-76	34	58
Ventral striatum	3.76	12	10	-4	69
Putamen	3.75	-20	0	6	18
Rostral Anterior Cingulate	3.72	-10	42	12	17
Superior Frontal Gyrus	3.71	-6	-4	60	29
Uncertain high-gain > uncertain high-loss					
Ventromedial PFC	4.31	-2	36	-18	24
Amygdala	4.16	34	-8	-26	40
Precentral Gyrus	3.64	24	-20	62	24
Uncertain high-loss > uncertain high-gain					
Superior Parietal Lobule	4.79	-30	-68	52	44

Middle Frontal Gyrus	4.50	-32	28	14	36
Middle Frontal Gyrus	4.21	54	30	22	19
Middle Frontal Gyrus	3.98	-54	16	26	48

Note. [a] indicates subpeaks within a cluster. PFC = prefrontal cortex. Activations in table were thresholded voxelwise at $p < 0.001$ and with a cluster size > 16 voxels (corresponding to a whole-brain threshold of $p < 0.05$). T-statistics were converted to Z-scores for reporting. Coordinates are reported in MNI/ICBM152 coordinates, as in SPM2. Resampled voxel size was 2 x 2 x 2 mm.

Table S5

Significant differences in response to uncertain high-magnitude cues by condition across incentive sets

Region	Peak Z-Score	X	Y	Z	Cluster Size (Voxels)
Uncertain high-gain: UNC-ONLY > CERT-UNC					
Anterior PFC	4.16	28	52	18	23
Temporal Pole	3.95	54	2	-22	19
Uncertain high-gain: CERT-UNC > UNC-ONLY					
Inferior Frontal Gyrus	3.81	30	32	-8	17
Uncertain high-loss: UNC-ONLY > CERT-UNC					
No clusters at this threshold.					
Uncertain high-loss: CERT-UNC > UNC-ONLY					
No clusters at this threshold.					

Note. PFC = prefrontal cortex. Activations in table were thresholded voxelwise at $p < 0.001$ and with a cluster size > 16 voxels (corresponding to a whole-brain threshold of $p < 0.05$). T-statistics were converted to Z-scores for reporting. Coordinates are reported in MNI/ICBM152 coordinates, as in SPM2. Resampled voxel size was 2 x 2 x 2 mm.

Supplementary Figure Captions

Figure S1. Individual nucleus accumbens region of interest. Figure shows a single participant's mask used for region of interest (ROI) analyses, superimposed on that participant's normalized high-resolution structural image (y = +12 mm). R indicates right. Each participant's data was extracted from individualized nucleus accumbens ROIs.

Figure S2. Timecourses of nucleus accumbens activation. Lines represent mean percent signal change from experiment mean in bilateral nucleus accumbens following cue onset (0 s). Error bars represent standard errors across participants. Significant differences not indicated.