

Acute Nicotine Differentially Impacts Anticipatory Valence- and Magnitude-Related Striatal Activity

Supplemental Information

Table S1. Summary of the outcomes of analysis of Parrot mood questionnaire ratings: Controls vs. Smokers. Mean difference = pre-rating – post-rating.

Measure	Smokers (mean difference; SD) <i>n</i> = 28		Controls (mean difference; SD) <i>n</i> = 28		Contrasts			
	Session 1	Session 2	Session 1	Session 2	Group	Session	Time	Interactions
Parrot 1: Relaxed/Tense	40.43 (298.67)	35.00 (278.78)	-68.85 (326.74)	-35.57 (151.54)	$F_{(1, 54)} = 7.39$ $p = 0.009$	$F_{(1, 54)} = 5.50$ $p = 0.02$	NS	NS
Parrot 2: Calm/Nervous	19.71 (146.46)	12.71 (165.30)	-40.14 (310.38)	-35.86 (75.33)	NS	$F_{(1, 54)} = 5.35$ $p = 0.02$	NS	NS
Parrot 3: Tired/Energetic	-46.43 (127.32)	-47.43 (137.19)	-147.71 (207.46)	-28.14 (128.53)	NS	NS	$F_{(1, 54)} = 17.29$ $p < 0.001$	Session x Time: $F_{(1, 54)} = 5.52$ $p = 0.02$ Session x Time x Group: $F_{(1, 54)} = 5.70$ $p = 0.02$
Parrot 4: Drowsy/Alert	-77.29 (193.51)	-54.00 (182.55)	-76.14 (138.92)	-22.86 (133.19)	$F_{(1, 54)} = 4.49$ $p = 0.04$	NS	$F_{(1, 54)} = 13.14$ $p = 0.001$	NS
Parrot 5: Irritated/Contented	-70.57 (183.15)	-81.86 (174.14)	37.29 (122.98)	-34.57 (127.26)	NS	NS	$F_{(1, 54)} = 6.79$ $p = 0.01$	Time x Group: $F_{(1, 54)} = 7.29$ $p = 0.009$
Parrot 6: Dissatisfied/Satisfied	-53.71 (107.09)	-57.86 (117.15)	-8.28 (69.08)	17.43 (115.75)	NS	NS	$F_{(1, 54)} = 6.26$ $p = 0.01$	Time x Group: $F_{(1, 54)} = 8.69$ $p = 0.005$
Parrot 7: Distracted/Focused	-107.14 (155.13)	-90.43 (152.31)	-27.71 (111.53)	-28.43 (130.15)	NS	NS	$F_{(1, 54)} = 23.10$ $p < 0.001$	Time x Group: $F_{(1, 54)} = 7.18$ $p = 0.01$
Parrot 8: Depressed/Happy	-16.00 (77.03)	-43.43 (132.47)	28.14 (95.84)	-13.43 (69.24)	NS	NS	NS	Time x Group: $F_{(1, 54)} = 4.25$ $p = 0.04$
Parrot 9: Satiated/Hungry	59.57 (143.85)	56.29 (103.68)	74.14 (119.59)	62.71 (171.42)	NS	NS	$F_{(1, 54)} = 22.76$ $p < 0.001$	NS

NS, not significant.

Table S2. Summary of analysis of mood ratings (Parrot and TCQ) – Smokers only: Nicotine vs. Placebo. Mean difference = pre-rating – post-rating.

Measure	Nicotine (mean difference; SD)	Placebo (mean difference; SD)	Contrasts		
			Drug Condition	Time	Interactions
TCQ: Emotionality	-61.90 (198.71)	-87.13 (166.43)	NS	$F_{(1,27)} = 5.59$ $p = 0.02$	NS
TCQ: Expectancy	-60.24 (138.25)	-53.90 (173.19)	$F_{(1,27)} = 10.49$ $p = 0.003$	$F_{(1,27)} = 5.36$ $p = 0.03$	NS
TCQ: Compulsivity	-44.37 (160.24)	-49.13 (147.73)	NS	NS	NS
TCQ: Purposefulness	-47.56 (166.83)	-60.21 (141.07)	$F_{(1,27)} = 11.21$ $p = 0.002$	$F_{(1,27)} = 5.00$ $p = 0.03$	NS
Parrot 1: Relaxed/Tense	44.14 (270.56)	31.29 (306.02)	$F_{(1,27)} = 14.08$ $p = 0.001$	NS	NS
Parrot 2: Calm/Nervous	24.43 (147.35)	8.00 (164.16)	$F_{(1,27)} = 5.99$ $p = 0.03$	NS	NS
Parrot 3: Tired/Energetic	-29.86 (113.14)	-64.00 (147.07)	NS	$F_{(1,27)} = 5.62$ $p = 0.03$	NS
Parrot 4: Drowsy/Alert	-25.57 (179.40)	-105.71 (188.50)	NS	$F_{(1,27)} = 7.32$ $p = 0.01$	NS
Parrot 5: Irritated/Contented	-55.29 (155.72)	-97.14 (196.92)	$F_{(1,27)} = 9.08$ $p = 0.006$	$F_{(1,27)} = 9.70$ $p = 0.004$	NS
Parrot 6: Dissatisfied/Satisfied	-62.14 (102.26)	-49.43 (121.08)	NS	$F_{(1,27)} = 14.14$ $p = 0.001$	NS
Parrot 7: Distracted/Focused	-85.00 (111.75)	-112.57 (185.81)	$F_{(1,27)} = 6.87$ $p = 0.01$	$F_{(1,27)} = 24.26$ $p < 0.001$	NS
Parrot 8: Depressed/Happy	-39.00 (107.86)	-20.42 (109.81)	NS	$F_{(1,27)} = 4.89$ $p = 0.04$	NS
Parrot 9: Satiated/Hungry	74.86 (106.11)	41.00 (139.98)	NS	$F_{(1,27)} = 11.05$ $p = 0.003$	NS

NS, not significant; TCQ, Tobacco Craving Questionnaire.

Table S3. Summary of the analysis of characterization measures: Smokers vs. Controls.

Measure	Scale/Subscale	Smokers (mean (SD))	Controls (mean (SD))	Comparison (independent <i>t</i> -test)
Temperament and Character Inventory	Cooperativeness	33.72 (5.71)	34.91 (4.48)	NS
	Harm avoidance	10.58 (6.31)	9.18 (5.06)	NS
	Novelty seeking	18.46 (4.26)	19.55 (5.45)	NS
	Reward dependence	14.54 (4.64)	16.57 (4.66)	NS
	Persistence	5.04 (1.87)	5.61 (1.64)	NS
	Self-directedness	12.20 (6.58)	12.73 (5.34)	NS
	Self-transcendence	36.96 (5.51)	35.64 (4.58)	NS
Childhood Trauma Questionnaire	Emotional abuse	8.00 (5.49)	5.89 (2.34)	NS
	Physical abuse	6.22 (3.27)	5.51 (1.98)	NS
	Sexual abuse	6.15 (4.55)	5.70 (4.05)	NS
	Emotional neglect	10.29 (5.44)	7.74 (3.13)	NS
	Physical neglect	6.51 (3.96)	6.04 (2.28)	NS
	Minimization/denial	0.29 (0.72)	0.51 (0.94)	NS
Beck Depression Inventory	n/a	2.11 (2.49)	1.07 (2.16)	NS
Beck Anxiety Inventory	n/a	1.61 (2.48)	0.79 (1.52)	NS
Trails A	Time	27.29 (8.09)	26.78 (9.71)	NS
	Errors	0.14 (0.52)	0.04 (0.19)	NS
Trails B	Time	66.04 (29.85)	63.48 (29.89)	NS
	Errors	0.36 (1.03)	0.59 (0.89)	NS
Weschler Memory Scale	Spatial span	16.07 (2.78)	16.19 (3.79)	NS
	Digit span	19.11 (3.74)	19.04 (4.16)	NS
Lifetime Events Questionnaire	Last 6 months	1.23 (2.47)	1.25 (2.09)	NS
	Lifetime	4.88 (5.11)	2.96 (4.31)	NS
Positive and Negative Affect Scale	Negative affect	1.73 (1.66)	1.56 (2.29)	NS
	Positive affect	15.65 (2.96)	16.07 (4.15)	NS
K10	n/a	3.61 (3.37)	3.15 (3.51)	NS

K10, Kessler Psychological Distress Scale; n/a, not applicable; NS, not significant.

Table S4. Summary of the analysis of post session blood concentrations (ng/mL) of nicotine and its metabolites.

	Nicotine (mean; SD)	Placebo (mean; SD)	Comparison
Nicotine	24.1 (10.8)	3.0 (3.9)	$t_{(26)} = 11.95$ $p < 0.001$
Cotinine	308.1 (184.4)	235.3 (158.0)	$t_{(26)} = 3.92$ $p = 0.001$
OH-Cotinine	94.0 (64.9)	83.7 (43.1)	NS
Norcotinine	1.4 (2.1)	0.3 (0.6)	$t_{(26)} = 3.27$ $p = 0.003$

NS, not significant.

Table S5. Summary of behavioral outcomes on the MID-R - Smokers vs. Controls.

Measure	Smokers (mean; SD) <i>n</i> = 28		Controls (mean; SD) <i>n</i> = 28		Group	Session	Group x Session
	Session 1	Session 2	Session 1	Session 2			
MID-R: Final Monetary Gain (\$)	\$381.93 (\$73.98)	\$378.63 (\$61.02)	\$378.98 (\$57.85)	\$386.64 (\$62.27)	NS	NS	NS
MID-R: Reaction Time (ms)	276.14 (46.61)	262.65 (54.54)	276.26 (48.07)	267.27 (46.40)	NS	$F_{(1, 54)} = 13.09$ $p = 0.001$	NS
	Nicotine	Placebo			Condition		
MID-R: Final Monetary Gain (\$)	\$383.89 (\$66.86)	\$369.73 (\$96.76)	n/a	n/a	NS		
MID-R: Reaction Time (ms)	265.66 (49.40)	272.82 (53.67)	n/a	n/a	NS		

MID-R, revised monetary incentive delay task; NS, not significant.

Table S6. Summary of valence-related changes in activity in smokers. Note: all clusters and contrasts are significant at $p_{\text{CORRECTED}} < 0.05$.

Analysis	Region	Talairach Coordinates			K_E	Contrast
		<i>x</i>	<i>y</i>	<i>z</i>		
Valence (Prime 1) – Whole brain	R. Lingual gyrus	10.1	-73.3	4.6	1553	Gain >Loss
	L. Caudate	-12.6	10.1	0.2	912	Gain >Loss
	R. Inferior frontal gyrus	34.1	22.7	-2.9	744	Gain >Loss
	R. Caudate	8.5	12	1.8	695	Gain >Loss
	L. Middle occipital gyrus	-8.7	-89.7	14.6	414	Gain >Loss
	L. Lingual gyrus	-10.3	-82.2	4	382	Gain >Loss
Valence (Prime 1) – Small Volume Correction	R. Caudate	8.4	12	2	666	Gain >Loss
	L. Caudate	-12.8	10.3	0.8	661	Gain >Loss

L., left; R., right.

Table S7. Summary of magnitude-related changes in activity in smokers. All clusters and contrasts are significant at $p_{\text{CORRECTED}} < 0.05$;

Effect	Region	Talairach Coordinates			K_E	Contrast
		x	y	z		
Gain Magnitude†	R. Cuneus	2	-84	15	6032	Low < Medium; Low < High
	L. Cingulate gyrus & BA32	-3	24	32	1973	Low < Medium
	L. Insula & BA13	-39	18	-1	1818	Low < High
	R. Insula & BA13	34	20	0	1535	Low < High
	L. Caudate	-1	1	9	1377	Low < High
	L. BA19	-17	-52	-3	881	Low < High
	L. Cerebellar tonsil	-27	-55	-30	721	Low < High
	R. Declive	18	-69	-16	552	Low < High
	R. Inferior frontal gyrus	50	29	-2	372	Low < Medium
	L. Middle frontal gyrus & BA6	-7	-9	61	268	Low < High
Gain Magnitude‡	L. Cingulate gyrus & BA32	-3	19	33	450	Low < Medium; Low < High
	L. Putamen	-20	9	-3	416	Low < High
	L. Caudate	-11	5	10	303	Low < Medium; Low < High
	R. Caudate	8	3	10	205	Low < Medium; Low < High
	R. Caudate	8	13	1	104	Low < Medium; Low < High
	L. Cingulate gyrus & BA32	-5	36	26	49	Low < Medium
	L. Superior frontal gyrus & BA10	-21	61	-2	27	Medium < High
Loss Magnitude†	R. Cuneus & BA17	1	-85	8	1378	Low < High
	R. Lingual gyrus	9	-73	-7	396	Low < High
	R. Lingual gyrus & BA19	11	-55	2	307	Low < High

BA, Brodmann area; L., left; R., right.

†whole brain.

‡small volume correction.

Table S8. Summary of outcome-related changes in activity in smokers. Note: all clusters and contrasts are significant at $p_{\text{CORRECTED}} < 0.05$

Analysis	Region	Talairach Coordinates			K_E	Contrast
		x	y	z		
Outcome – whole brain	L. Thalamus	-2	-8	13	76156	Successful > Unsuccessful
	L. Precuneus & BA7	-2	-36	46	5912	Successful > Unsuccessful
	L. Cerebellar tonsil	-4	-52	-31	5024	Successful > Unsuccessful
	L. Superior frontal gyrus	-26	18	50	3936	Successful > Unsuccessful
	R. Precuneus	30	-72	35	3110	Successful > Unsuccessful
	R. Cerebellar tonsil	16	-36	-36	2003	Successful > Unsuccessful
	R. Cuneus & BA18	16	-99	8	1689	Successful > Unsuccessful
	L. Inferior semi-lunar lobule	-3	-70	-39	1368	Successful > Unsuccessful
	L. Cuneus	-17	-98	-1	1174	Successful > Unsuccessful
	L. Fusiform gyrus & BA19	-26	-83	-11	976	Successful > Unsuccessful
	R. Superior frontal gyrus	21	21	48	419	Successful > Unsuccessful
	R. Medial frontal gyrus & BA9	14	35	27	359	Successful > Unsuccessful
	R. Posterior Cingulate	9	-52	14	332	Successful > Unsuccessful
	Outcome - SVC	R. Putamen	18	7	2	7459
L. Putamen		-18	8	1	5946	Successful > Unsuccessful
L. Anterior cingulate & BA32		-5	42	5	1718	Successful > Unsuccessful
R. Anterior cingulate		6	43	8	1645	Successful > Unsuccessful
R. Superior frontal gyrus & BA10		21	66	2	506	Successful > Unsuccessful
R. Middle frontal gyrus & BA10		38	59	7	133	Successful > Unsuccessful
L. Cingulate Gyrus & BA32		-4	9	41	127	Successful > Unsuccessful
L. Caudate		-12	-4	19	103	Successful > Unsuccessful
L. Caudate		-17	-14	24	90	Successful > Unsuccessful
R. Superior frontal gyrus & BA10		9	62	22	84	Successful > Unsuccessful
L. Caudate		-13	5	16	61	Successful > Unsuccessful
L. Superior frontal gyrus		-23	59	-1	56	Successful > Unsuccessful
L. Middle frontal gyrus & BA10		-25	66	6	50	Successful > Unsuccessful
R. Superior frontal gyrus & BA10		25	54	0	49	Successful > Unsuccessful
L. Caudate		-17	-25	20	49	Successful > Unsuccessful
R. Middle frontal gyrus & BA10		44	44	12	47	Successful > Unsuccessful
R. Cingulate Gyrus & BA32		5	27	33	47	Successful > Unsuccessful
R. Middle frontal gyrus & BA10		45	45	20	40	Successful > Unsuccessful

	R. Anterior cingulate & BA10	19	47	-2	38	Successful > Unsuccessful
	R. Superior frontal gyrus & BA10	26	57	24	33	Successful > Unsuccessful
	L. Caudate	-21	-32	15	32	Successful > Unsuccessful
	L. Middle frontal gyrus	-26	49	-5	30	Successful > Unsuccessful
	R. Middle frontal gyrus & BA10	39	46	12	28	Successful > Unsuccessful

BA, Brodmann area; L., left; R., right; SVC, small volume correction.

Table S9. Summary of task-related changes in activity associated with the MID-R in healthy controls. All clusters and contrasts are significant at $p_{\text{CORRECTED}} < 0.05$.

Contrast	Region	Talairach Coordinates			K_E/mm^3	Contrast
		x	y	z		
Valence: Prime 1	L. Putamen†	-12	8	0	1429	Gain > Loss
	R. Caudate†	10	7	-1	1255	Gain > Loss
	R. Dentate †	5	-53	-25	937	Gain > Loss
	R. Lingual gyrus †	16	-62	5	916	Gain > Loss
	R. Mammillary body †	1	-14	-8	541	Gain > Loss
	L. Inferior semi-lunar lobule †	-32	-68	-48	371	Gain > Loss
	L. Lingual gyrus †	-18	-65	3	343	Gain > Loss
	R. Culmen †	14	-43	-6	291	Gain > Loss
	R. BA27 †	5	-27	-10	260	Gain > Loss
	R. Caudate ‡	8	10	0	582	Gain > Loss
	L. Putamen ‡	-17	10	-3	516	Gain > Loss
	L. Caudate ‡	-9	9	3	495	Gain > Loss
	R. Putamen ‡	15	7	-4	109	Gain > Loss
	L. Caudate ‡	-9	1	13	59	Gain > Loss
	R. Anterior cingulate/BA32 ‡	-9	36	19	40	Gain > Loss
	L. Medial frontal gyrus/BA10 ‡	-3	60	-5	31	Gain > Loss
	R. Medial frontal gyrus/BA10 ‡	4	60	-4	28	Gain > Loss
	VTA ‡	0	-15	-7	269	Gain > Loss
Gain Magnitude (Prime 2)	R. Cuneus †	4	-81	16	9747	Small < Large
	L. Thalamus †	-1	-4	11	7480	Small < Large
	L. Medial frontal gyrus/BA6 †	0	13	43	2305	Small < Large
	R. Declive †	17	-66	-19	2246	Small < Large
	L. Inferior frontal gyrus/BA47 †	-41	20	0	1983	Small < Medium
	L. Declive †	-29	-69	-20	1493	Small < Medium
	R. Inferior frontal gyrus/BA47 †	46	17	0	1171	Small < Medium
	R. BA47 †	31	24	-2	791	Small < Medium
	L. Lingual gyrus †	-20	-54	0	420	Small < Large & Medium
	R. Caudate ‡	9	8	8	1273	Small < Large & Medium
	L. Caudate ‡	-10	5	9	752	Small < Large
	L. Putamen ‡	-17	9	2	237	Small < Large & Medium

	R. Anterior cingulate/ BA32 ‡	4	19	35	132	Small < Large
	L. Anterior cingulate/BA32 ‡	-4	24	34	126	Small < Large
	L. Anterior cingulate/BA32 ‡	-4	9	41	118	Small < Large
	R. Putamen ‡	17	10	2	85	Small < Large
	L. Putamen ‡	-20	4	11	70	Small < Large
	R. Putamen ‡	30	-19	-1	60	Small < Large
	R. Caudate ‡	15	-10	19	46	Small < Large & Medium
	L. Superior frontal gyrus/BA10 ‡	-29	53	-3	27	-
Loss Magnitude (Prime 2)	R. Medial frontal gyrus/BA10 ‡	11	53	12	28	Medium > Large
Outcome	L. Caudate †	0	10	3	14457	Successful > Unsuccessful
	L. Anterior cingulate & BA32 †	-5	45	-4	781	Successful > Unsuccessful
	R. Cingulate gyrus †	12	-10	26	683	Successful > Unsuccessful
	L. Precuneus †	-23	-46	33	600	Successful > Unsuccessful
	R. Putamen ‡	17	10	0	3242	Successful > Unsuccessful
	L. Putamen ‡	-17	11	0	2674	Successful > Unsuccessful
	L. Putamen ‡	-28	-13	9	312	Successful > Unsuccessful
	L. Anterior cingulate/BA32 ‡	-4	46	-3	160	Successful > Unsuccessful

BA, Brodmann area; L., left; MID-R, revised monetary incentive delay task; R., right; VTA, ventral tegmental area.

†whole brain.

‡small volume correction.

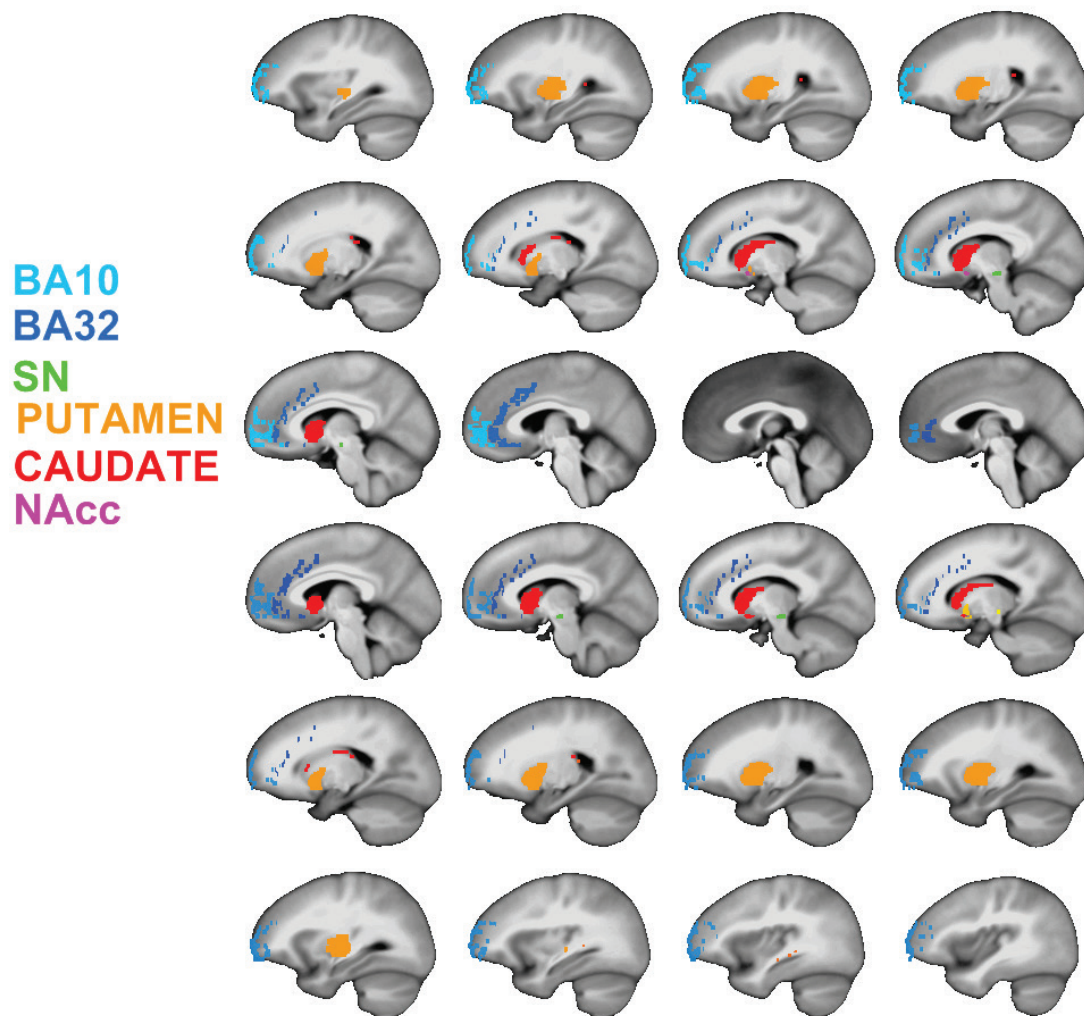


Figure S1. A priori anatomical small volume correction masks. BA, Brodmann area; SN, substantia nigra; NAcc, nucleus accumbens.

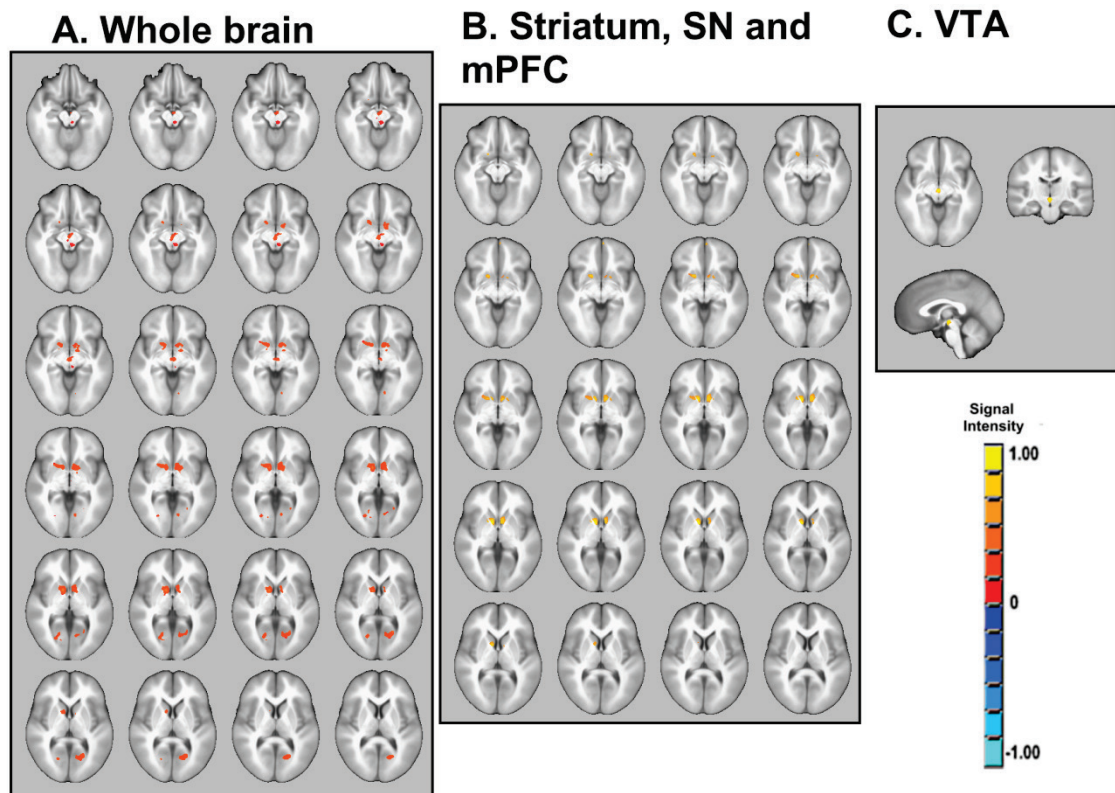


Figure S2. Main effect of valence (prime 1) in healthy controls. All clusters are significant at $p_{\text{CORRECTED}} < 0.05$. mPFC, medial prefrontal cortex; SN, substantia nigra; VTA, ventral tegmental area.

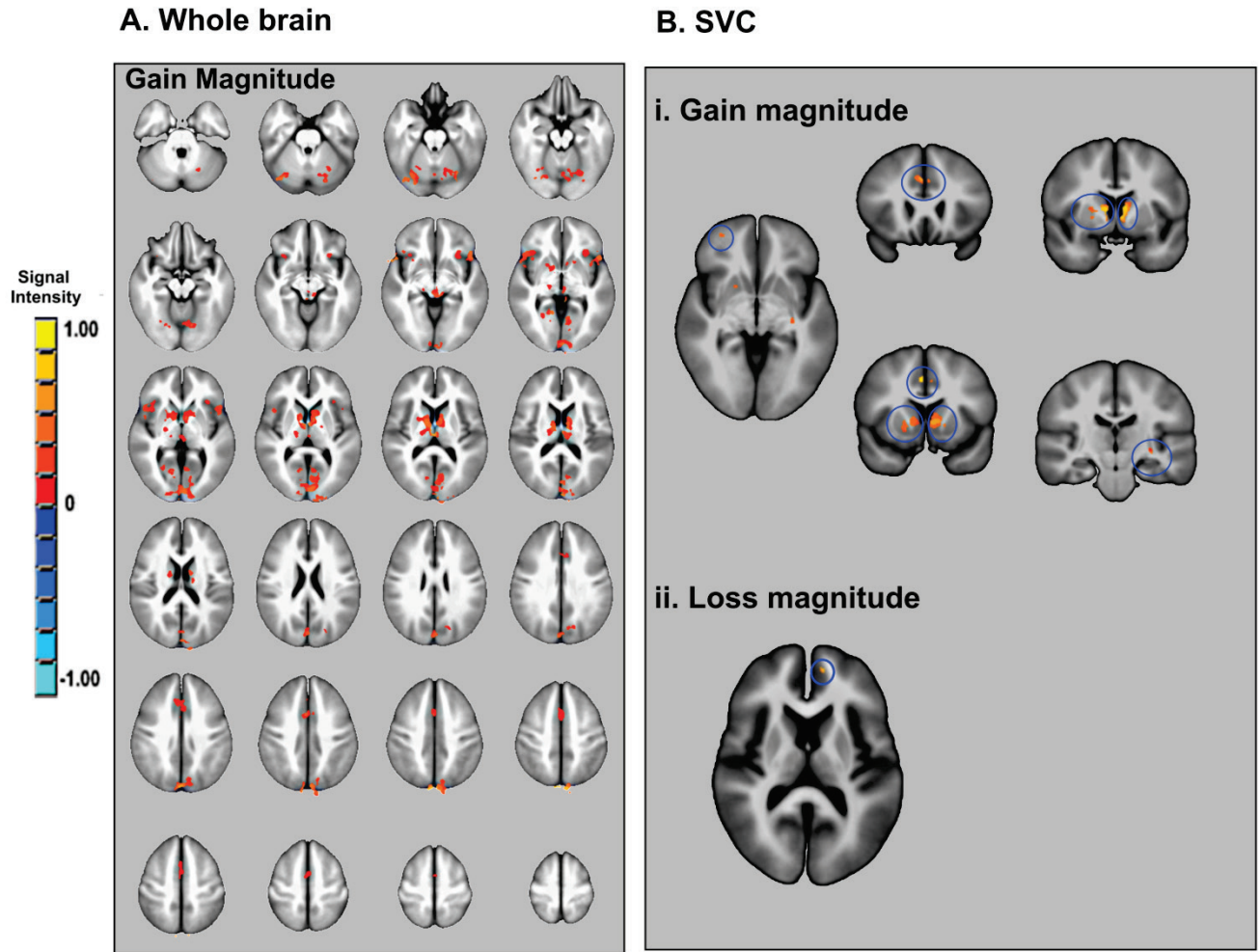


Figure S3. Main effect of magnitude (prime 2) in healthy controls. All clusters are significant at $p_{\text{CORRECTED}} < 0.05$. SVC, small volume correction.

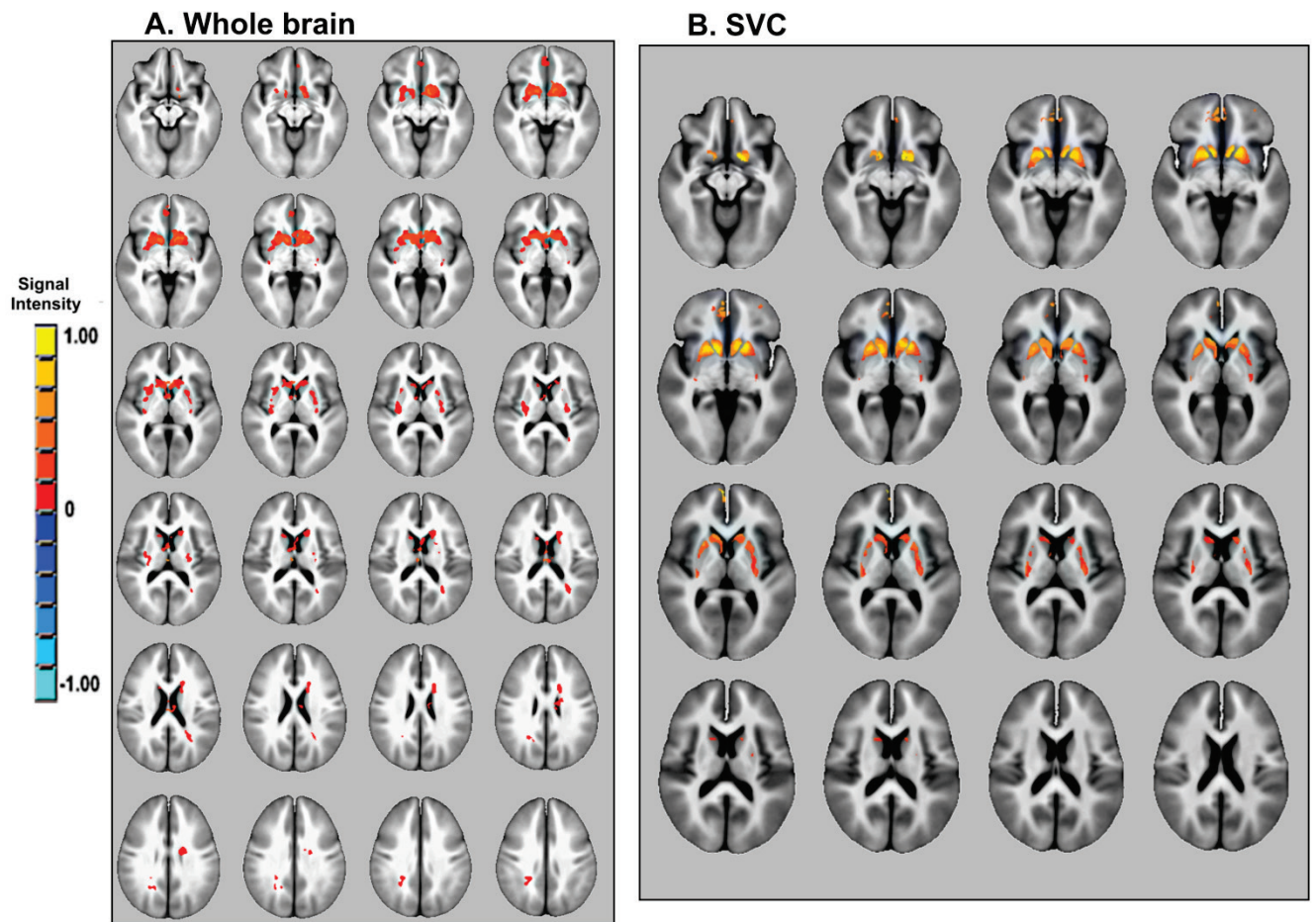


Figure S4. Main effect of outcome in healthy controls. All clusters are significant at $p_{\text{CORRECTED}} < 0.05$. SVC, small volume correction.

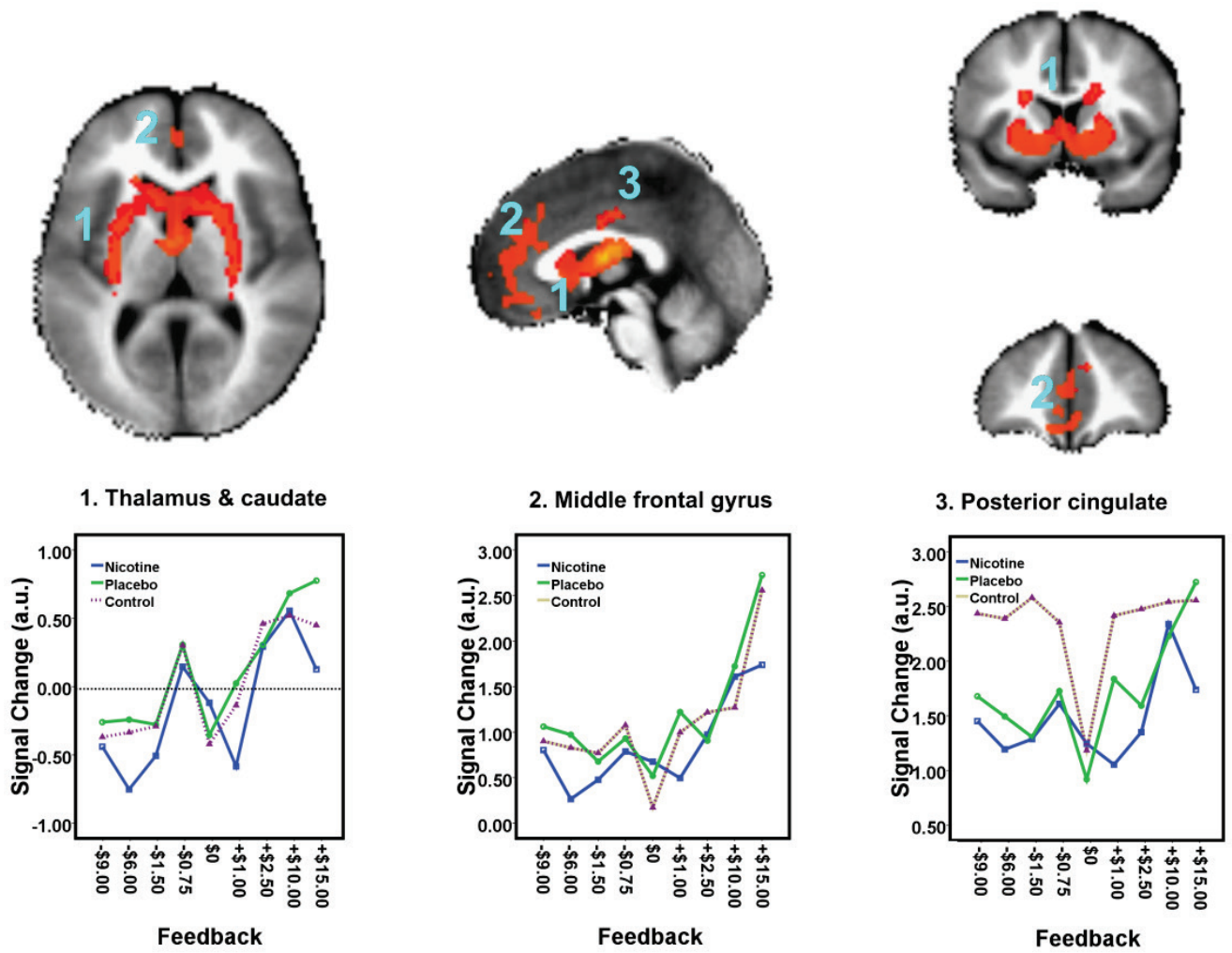


Figure S5. Main effect of all levels of feedback ($n = 9$) in whole brain analysis (smokers and controls). All clusters are significant at $p_{\text{CORRECTED}} < 0.05$.