

Supplemental material to manuscript titled Affective and neural mechanisms of how identity dysfunction in borderline personality disorder may interfere with building positive relationships.

Supplemental material

Data acquisition and analysis

Mood responses. In model 1 and 2 the intermediate feedback was set as the reference category to compare to the negative and positive feedback. In model 2 the intermediate member was set as the reference category to compare to the predominantly negative and positive member. In the analysis of model 1 and 2, six participants were not included. Two NCC and three BPD participants were excluded due to no or insufficient ($> 50\%$ missing) responses to applicability of traits and one BPD participant was excluded from analysis due to flat responses to the task (i.e., variance in mood responses equals 0) resulting in $N = 63$.

Affiliation responses. In model 3 the intermediate member was set as the reference level to compare to the positive and negative member. No participants were excluded from analysis of model 3 (i.e., $N = 69$). In model 4, the mediation analysis, two NCC participants had missing data on the fearful attachment rating (i.e., $N = 67$).

Bold responses. Three participants were excluded from MRI analysis. One NCC participant and two BPD participants showed acquisition issues or a structural deviation that excluded them from analysis. Furthermore, for one NCC and one BPD participant only the first half of the scan was used due to movement larger than 3mm in the second half. The number of volumes ($M = 527.34$, $SD = 66.95$) acquired was variable due to the self-paced nature of the task. The BPD ($M = 539.68$, $SD = 73.94$) and NCC ($M = 515.37$, $SD = 57.95$) group did not differ in number of volumes acquired ($t(67) = 1.52$, $p = 0.133$).

Power and sensitivity analysis

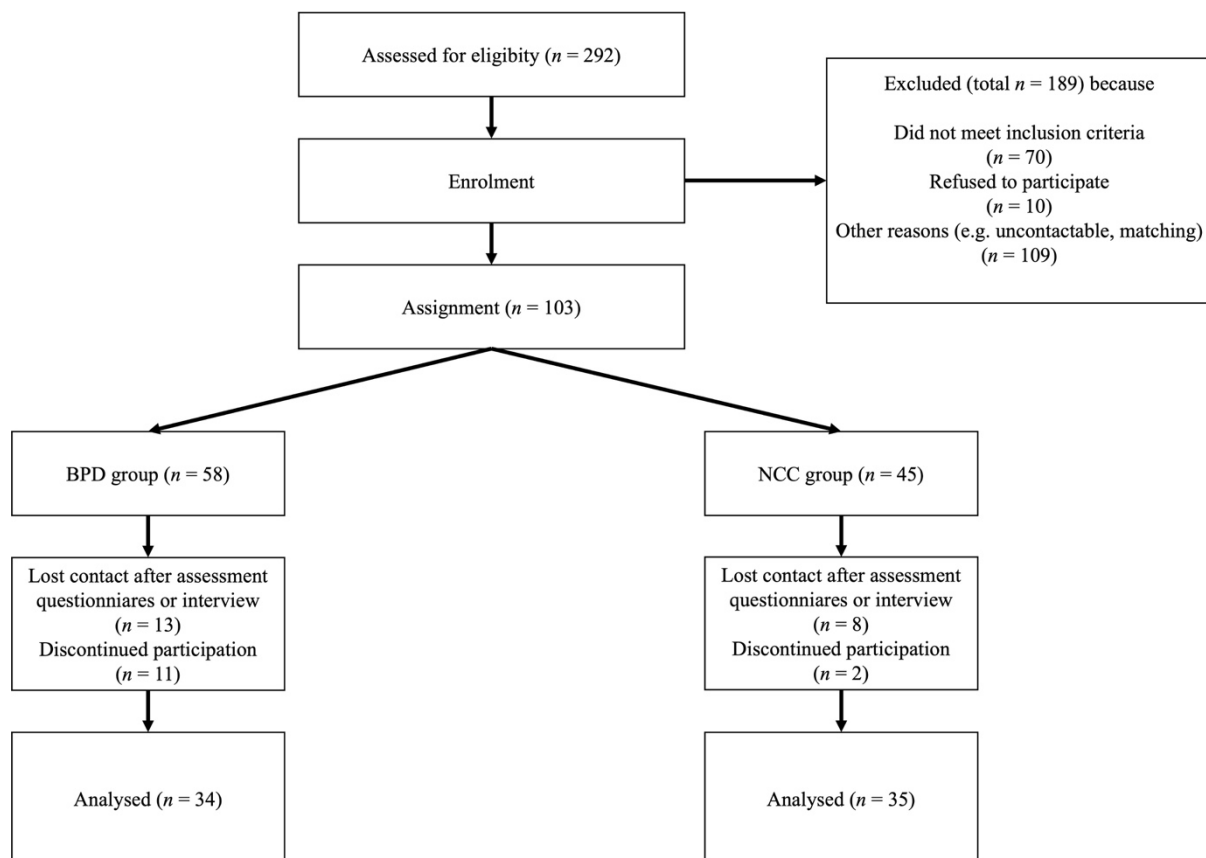
Power calculations were based on previous studies in the field. Previous fMRI studies into emotion regulation comparing participants with BPD to a non-clinical control group

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usually recruited less than 20 participants per group and had only sufficient power to detect large effects (van Zutphen et al., 2015). A recent neuroimaging study investigating self-relevancy in people diagnosed with BPD as compared to a control group included 23 participants per group and could detect group differences in regions of interests but not whole brain analyses (Orth et al., 2020). In our previous work, we detected group differences with 26 participants in the group with BPD and 32 participants in the non-clinical control group (van Schie et al., 2020). Based on the current literature, we hold that for this study, a minimum of 25 participants per group is needed to detect group differences on a whole brain level and when numbers are closer to 40 participants per group, it would allow for detecting smaller effects.

We estimated the power of the current study to detect mood and affiliation effects based on the effects found in previous studies and the current sample size using the `ep_Ftest` function in the `fabs` package (`github\jbiesanz\fabs`). To calculate the estimated power for the two-way interaction of group*valence on mood, we used the two-way interactions effects of group*valence found in van Schie et al. (2020) and negative self-views*valence found in van Schie et al. (2024). The mood analysis in the current study had $N = 63$ participants with 2813 mood measurements. With these number of measurements, the estimated power was between 0.97 and 0.99 to be able to detect two-way interactions between group and valence on mood. To calculate the estimated power for the two-way interaction of group*panel member on affiliation, we use the two-way interaction effect of negative self-view*panel member found in van Schie et al. (2024). The affiliation analysis in the current study had $N = 69$ participants with 819 ratings of closeness. With these number of measurements, the estimated power was 0.77 to detect two-way interactions on affiliation.

Supplemental Figure 1
Participant flow chart



Supplemental Table 1
Trait words used in the feedback task.

Negative	Intermediate	Positive
Nasty	Chaotic	Friendly
Selfish	Critical	Confident
Arrogant	Slow	Healthy
Mean	Clumsy	Funny
Unreliable	Strict	Smart
Stupid	Nervous	Respectful
Lazy	Anxious	Kind
Cold	Weird	Grateful
Cowardly	Reserved	Honest
Harsh	Competitive	Courageous
Bossy	Serious	Warm
Pesky	Quiet	Generous
Boring	Talkative	Loyal
Stubborn	Neat	Sincere
Rigid	Agreeable	Caring

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Supplemental Table 2

Distribution in percentage of positive, intermediate, and negative feedback among the three panel members.

	Predominantly negative member	Intermediate member	Predominantly positive member
Negative feedback	67.96	18.76	13.30
Intermediate feedback	18.70	62.59	18.74
Positive feedback	13.34	18.66	67.96

Supplemental Table 3

Model parameters for the model where applicability of traits is predicted by valence and group membership. Significant effects are printed in bold.

Outcome: Applicability	Estimate	Std. Error	<i>t</i> value	95% CI		Std. <i>b</i>	Std. <i>se</i>
				Lower bound	Upper bound		
Intermediate valence (Intercept)	4.03	0.11	38.12	3.81	4.23	0.00	0.00
Negative valence	-1.58	0.11	-14.19	-1.81	-1.36	-0.34	0.02
Positive valence	2.23	0.11	19.97	2.01	2.45	0.47	0.02
BPD group	0.93	0.15	6.09	0.63	1.23	0.21	0.03
BPD group*Negative valence	0.41	0.16	2.56	0.10	0.73	0.07	0.03
BPD group*Positive valence	-1.38	0.16	-8.60	-1.70	-1.07	-0.23	0.03

Supplemental Table 4

Model parameters for the model where mood is predicted by valence, applicability, and panel member. Significant effects are printed in bold.

Outcome: Mood	Estimate	Std. Error	<i>t</i> value	95% CI		Std. <i>b</i>	Std. <i>se</i>
				Lower bound	Upper bound		
Intermediate valence (Intercept)	4.56	0.16	29.36	4.25	4.87	0.00	0.00
Negative valence	-0.64	0.13	-4.97	-0.88	-0.39	-0.17	0.03
Positive valence	0.94	0.20	4.80	0.57	1.32	0.25	0.05
Applicability	0.16	0.02	8.06	0.12	0.20	0.20	0.03
Negative member	-0.13	0.06	-1.99	-0.26	0.00	-0.03	0.02
Positive member	0.01	0.06	0.23	-0.11	0.14	0.00	0.02
Negative valence*Applicability	-0.04	0.03	-1.32	-0.10	0.02	-0.04	0.03
Positive valence*Applicability	0.00	0.03	-0.11	-0.07	0.06	-0.01	0.06

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Supplemental Table 5

Model parameters for the model where mood is predicted by valence, applicability, panel member and group. Significant effects are printed in bold.

Outcome: Mood	Estimate	Std. Error	t value	95% CI		Std.b	Std.se
				Lower bound	Upper bound		
Intermediate valence (Intercept)	4.98	0.18	27.56	4.63	5.34	0.00	0.00
Negative valence	-0.64	0.13	-4.79	-0.89	-0.38	-0.17	0.03
Positive valence	0.69	0.21	3.33	0.29	1.10	0.18	0.05
Applicability	0.19	0.02	7.82	0.14	0.23	0.23	0.03
BPD group	-0.96	0.25	-3.82	-1.46	-0.49	-0.27	0.07
Negative member	-0.07	0.09	-0.83	-0.25	0.11	-0.02	0.02
Positive member	-0.03	0.09	-0.35	-0.21	0.14	-0.01	0.02
Negative valence*Applicability	-0.02	0.03	-0.59	-0.08	0.04	-0.02	0.03
Positive valence*Applicability	0.00	0.03	0.00	-0.06	0.06	0.00	0.06
Negative valence*BPD group	-0.11	0.14	-0.76	-0.38	0.16	-0.02	0.03
Positive valence*BPD group	0.42	0.14	3.06	0.15	0.69	0.08	0.03
BPD group*Negative member	-0.11	0.13	-0.84	-0.36	0.14	-0.02	0.03
BPD group*Positive member	0.10	0.13	0.82	-0.14	0.36	0.02	0.03
Applicability*BPD group	-0.03	0.03	-1.28	-0.09	0.02	-0.05	0.04

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Supplemental Table 6

Model parameters for the model where affiliation is predicted by panel member and group. Significant effects are printed in bold.

Affiliation				95% CI			
Outcome: Closeness	Estimate	Std. Error	t value	Lower bound	Upper bound	std.b	std.se
Intermediate member (Intercept)	4.24	0.23	18.10	3.78	4.71	0.00	0.00
Negative member	-0.57	0.14	-4.15	-0.84	-0.30	-0.14	0.03
Positive member	0.56	0.14	4.04	0.29	0.82	0.14	0.03
BPD Group	-1.22	0.33	-3.66	-1.89	-0.57	-0.33	0.09
BPD group*Negative member	0.08	0.20	0.38	-0.31	0.47	0.01	0.04
BPD group*Positive member	-0.43	0.20	-2.17	-0.81	-0.04	-0.08	0.04
				95% CI			
Outcome: Trust	Estimate	Std. Error	t value	Lower bound	Upper bound	std.b	std.se
Intermediate member (Intercept)	5.04	0.22	22.81	4.60	5.47	0.00	0.00
Negative member	-0.61	0.16	-3.82	-0.93	-0.29	-0.21	0.04
Positive member	0.46	0.16	2.87	0.14	0.76	0.17	0.04
BPD Group	-1.41	0.32	-4.48	-2.02	-0.79	-0.22	0.08
BPD group*Negative member	0.04	0.23	0.16	-0.43	0.49	0.02	0.05
BPD group*Positive member	-0.37	0.23	-1.64	-0.84	0.06	-0.06	0.05
				95% CI			
Outcome: Liking	Estimate	Std. Error	t value	Lower bound	Upper bound	std.b	std.se
Intermediate member (Intercept)	5.49	0.20	27.13	5.09	5.88	0.00	0.00
Negative member	-0.84	0.17	-4.83	-1.18	-0.50	-0.21	0.04
Positive member	0.69	0.17	4.00	0.35	1.03	0.17	0.04
BPD Group	-0.81	0.29	-2.79	-1.38	-0.26	-0.22	0.08
BPD group*Negative member	0.08	0.25	0.34	-0.41	0.58	0.02	0.05
BPD group*Positive member	-0.32	0.25	-1.31	-0.81	0.17	-0.06	0.05

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Supplemental Table 7

Model parameters for the model where closeness is predicted by panel member, group and fearful attachment indicating mediation. Significant effects are printed in bold.

Outcome: Closeness	Estimate	Std. Error	t value	95% CI		std.b	std.se
				Lower bound	Upper bound		
Intermediate member (Intercept)	4.38	0.28	15.91	3.83	4.92	0.00	0.00
Negative member	-0.49	0.17	-2.82	-0.82	-0.14	-0.13	0.05
Positive member	0.79	0.17	4.55	0.45	1.13	0.21	0.05
Fearful attachment	-0.01	0.01	-1.55	-0.02	0.002	-0.17	0.11
BPD Group	-0.73	0.40	-1.82	-1.51	0.04	-0.20	0.11
Fearful attachment*Negative member	-0.004	0.003	-1.13	-0.01	0.003	-0.07	0.06
Fearful attachment*Positive member	-0.007	0.003	-2.15	-0.01	-0.001	-0.13	0.06
BPD group*Negative member	0.29	0.25	1.13	-0.22	0.79	0.06	0.05
BPD group*Positive member	-0.11	0.25	-0.45	-0.62	0.39	-0.02	0.05

Supplemental Table 8

Model parameters when believing or not believing the set-up of the study is included in the models predicting mood and closeness. Significant effects are printed in bold

Outcome: Mood	Estimate	Std. Error	t value	95% CI		Std.b	Std.se
				Lower bound	Upper bound		
Intermediate valence (Intercept)	5.12	0.26	20.06	4.63	5.62	0.00	5.12
Negative valence	-0.64	0.13	-4.79	-0.88	-0.38	-0.17	-0.64
Positive valence	0.69	0.21	3.33	0.29	1.10	0.18	0.69
Applicability	0.19	0.02	7.82	0.14	0.24	0.23	0.19
BPD group	-0.96	0.25	-3.82	-1.46	-0.47	-0.27	-0.96
Negative member	-0.07	0.09	-0.83	-0.25	0.10	-0.02	-0.07
Positive member	-0.03	0.09	-0.35	-0.21	0.14	-0.01	-0.03
Believing SFT	-0.19	0.24	-0.78	-0.65	0.27	-0.04	-0.19
Negative valence*Applicability	-0.02	0.03	-0.59	-0.08	0.04	-0.02	-0.02
Positive valence*Applicability	0.00	0.03	-0.01	-0.07	0.06	0.00	0.00
Negative valence*BPD group	-0.11	0.14	-0.76	-0.38	0.16	-0.02	-0.11
Positive valence*BPD group	0.42	0.14	3.06	0.15	0.69	0.08	0.42
BPD group*Negative member	-0.11	0.13	-0.84	-0.35	0.14	-0.02	-0.11
BPD group*Positive member	0.10	0.13	0.82	-0.15	0.36	0.02	0.10
Applicability*BPD group	-0.03	0.03	-1.28	-0.09	0.02	-0.05	-0.03

Outcome: Closeness	Estimate	Std. Error	t value	95% CI		std.b	std.se
				Lower bound	Upper bound		
Intermediate member (Intercept)	4.13	0.36	11.55	3.43	4.83	0.00	4.13
Negative member	-0.57	0.14	-4.15	-0.86	-0.30	-0.14	-0.57
Positive member	0.56	0.14	4.04	0.28	0.83	0.14	0.56

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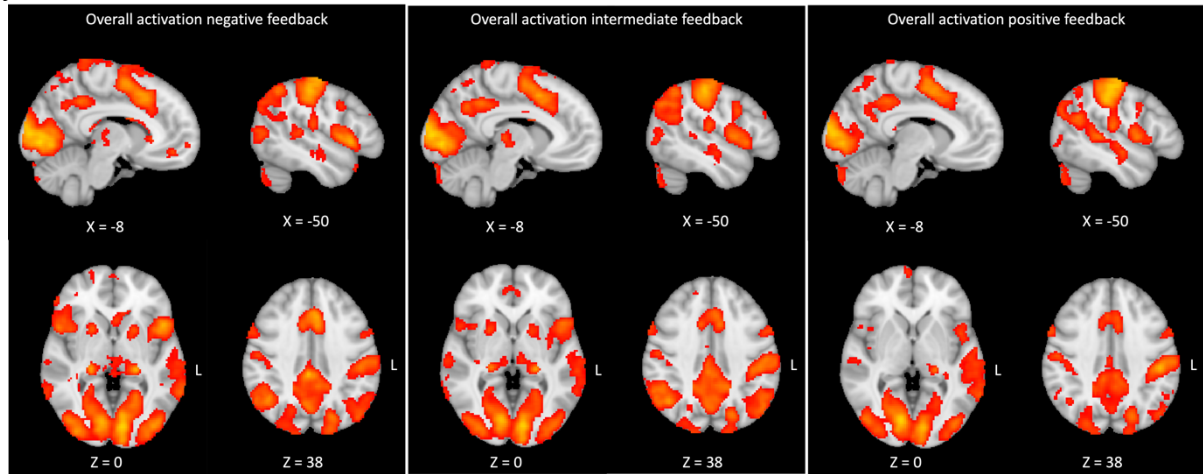
BPD Group	-1.23	0.33	-3.67	-1.89	-0.60	-0.33	-1.23
Believing SFT	0.15	0.36	0.41	-0.54	0.85	0.03	0.15
BPD group*Negative member	0.08	0.20	0.38	-0.31	0.46	0.01	0.08
BPD group*Positive member	-0.43	0.20	-2.17	-0.82	-0.04	-0.08	-0.43

Note. Adding believing status did not significantly improve the model with mood as outcome ($\chi^2(1) = 0.6, p = 0.434$) or the model with closeness as outcome ($\chi^2(1) = 0.2, p = 0.682$).

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Supplemental Figure 2

F-test on NCC and BPD mean of activation during negative, intermediate, and positive feedback.



Supplemental Table 9

Peak coordinates for F-test of NCC and BPD mean on negative, intermediate, and positive feedback.

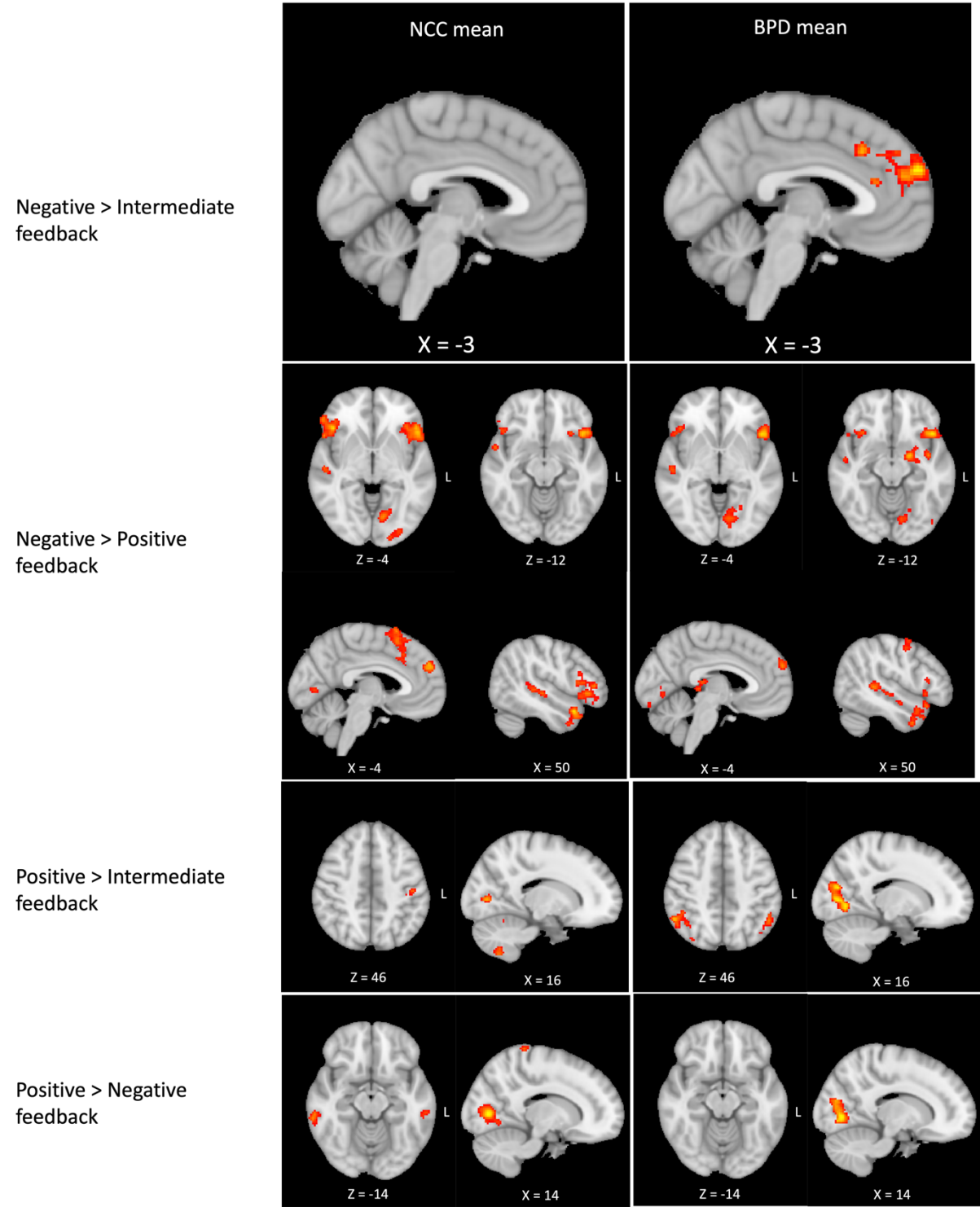
Brain regions	MNI Coordinates			Voxel test value	Cluster p-value	Cluster size
Negative feedback (F-test)	x	y	z	Z		
Occipital pole, lingual gyrus	10	-86	4	9.39	<0.001	37795
PCC	4	-34	38	7.67	<0.001	4429
Angular gyrus, extending into TPJp	-50	-56	48	5.95	<0.001	3964
IFG, Insula, orbitofrontal cortex	-48	14	0	7.43	<0.001	2120
Angular gyrus, TPJp	42	-58	38	6.58	<0.001	1954
Caudate nucleus	-18	-10	26	6.51	<0.001	1468
Thalamus	-22	-30	0	7.41	<0.001	651
Frontal Pole	-30	46	24	6.96	<0.001	630
Cerebellum: Left crus I	-44	-70	-36	5.54	<0.001	343
Putamen	-18	10	6	5.19	<0.001	320
Superior frontal gyrus, middle frontal gyrus	28	32	54	5.92	<0.001	313
Frontal medial cortex	-8	46	-12	4.97	0.001	267
Temporal pole	48	20	-30	4.88	0.001	260
Putamen	20	10	4	5.59	0.003	211
Frontal Pole	20	60	4	4.51	0.007	185
Superior frontal gyrus, middle frontal gyrus	-26	32	52	4.40	0.018	150
Cerebellum: Right crus II	40	-66	-50	4.41	0.018	150
Thalamus	22	-28	0	6.97	0.025	140

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Intermediate feedback (F-test)	x	y	z	Z	Cluster p-value	Cluster size
Occipital pole, Lingual gyrus, extending into precuneus	14	-92	16	9.22	<0.001	33619
Caudate	18	-4	28	6.35	<0.001	5266
Angular gyrus, TPJp	-40	-58	24	6.46	<0.001	3947
Angular gyrus, TPJp	42	-62	38	6.68	<0.001	2492
Insula	-44	-2	16	7.13	<0.001	2293
MTG	62	-36	-6	5.31	<0.001	1745
Cerebellum: Left crus I	-42	-80	-36	6.20	<0.001	1025
Middle frontal gyrus	32	30	52	5.42	<0.001	570
Frontal Pole	-30	44	28	5.50	<0.001	520
Thalamus	-22	-30	0	6.87	<0.001	435
ACC	8	46	-4	4.86	<0.001	411
Thalamus	20	-28	2	6.27	0.003	221
Cerebellum: Right VIIa	28	-60	-50	4.59	0.009	179
Positive feedback (F-test)	x	y	z	Z	Cluster p-value	Cluster size
Occipital pole, Lingual gyrus, extending into precuneus	12	-86	4	9.09	<0.001	31927
Superior Temporal gyrus, TPJa	-54	-36	6	6.77	<0.001	8435
Insula	-42	-2	14	7.32	<0.001	1322
Cerebellum: left crus I	-46	-72	-38	5.40	<0.001	1258
IFG	60	10	26	6.52	<0.001	1046
precuneus, postcentral gyrus	0	-44	76	5.48	<0.001	755
MTG	60	-6	-12	4.58	<0.001	619
Angula gyrus TPJp	42	-52	28	4.37	<0.001	477
Cerebellum: right VIIb	16	-60	-44	5.80	<0.001	439
Frontal pole, middle frontal gyrus	-30	44	28	4.49	0.003	216
Cerebellum: right crus I	48	-72	-26	4.82	0.003	209
Thalamus	-22	-30	0	5.68	0.009	173
Frontal pole	8	68	-2	4.53	0.017	150

Supplemental Figure 3

NCC and BPD mean activation on T-contrasts comparing negative, intermediate and positive feedback.



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Supplemental Table 10

Peak coordinates of NCC and BPD mean on t-contrasts comparing negative, intermediate and positive feedback.

Brain regions	MNI Coordinates			Voxel test value	Cluster	Cluster
	x	y	z	Z	p-value	size
Negative > Intermediate feedback (t-test)						
NCC mean						
No clusters						
BPD mean						
Frontal pole, superior frontal gyrus, ACC	-4	60	26	4.75	<0.001	930
Precentral gyrus	50	-2	48	3.76	0.023	138
Negative > Positive feedback (t-test)						
	x	y	z	Z	Cluster p-value	Cluster size
NCC mean						
Orbitofrontal cortex, IFG, insula	44	26	-4	5.11	<0.001	983
Orbitofrontal cortex, IFG, insula	-50	22	-6	5.19	<0.001	770
Superior frontal gyrus	6	18	64	5.50	<0.001	689
Lingual gyrus	-10	-76	2	4.80	<0.001	469
Cerebellum: Left crus I, left crus II	-20	-82	-32	5.50	<0.001	286
Temporal pole	50	12	-22	5.18	0.001	262
Superior frontal gyrus, frontal pole	-4	52	30	4.76	0.010	164
Superior temporal gyrus, TPJa	52	-22	-2	4.15	0.018	146
Cerebellum: Left crus I	-38	-64	-24	4.59	0.048	116
Occipital pole	-20	-94	-6	3.90	0.050	115
BPD mean						
Orbitofrontal cortex, IFG, insula	-46	20	-2	5.64	<0.001	856
Lingual gyrus, cuneus	-10	-84	12	4.48	<0.001	763
Temporal pole	54	10	-24	4.35	<0.001	706
Cerebellum: Left crus I, left crus II	-20	-82	-32	5.61	<0.001	696
Cerebellum: Right crus I, right crus II	22	-80	-32	5.25	<0.001	381
Amygdala	-20	-4	-12	4.97	<0.001	335
Middle temporal gyrus, TPJa	50	-38	4	4.53	<0.001	300
Superior frontal gyrus, frontal pole	-4	60	28	4.42	0.002	214
Middle temporal gyrus, TPJp	-60	-58	12	4.45	0.004	198
Thalamus	4	-22	14	4.36	0.008	174
Precentral gyrus	54	0	48	4.01	0.028	132
Positive > Intermediate feedback (t-test)						
	x	y	z	Z	Cluster p-value	Cluster size
NCC mean						
Postcentral gyrus	-34	-30	64	5.32	<0.001	949
Lingual gyrus	16	-76	4	4.62	0.002	233

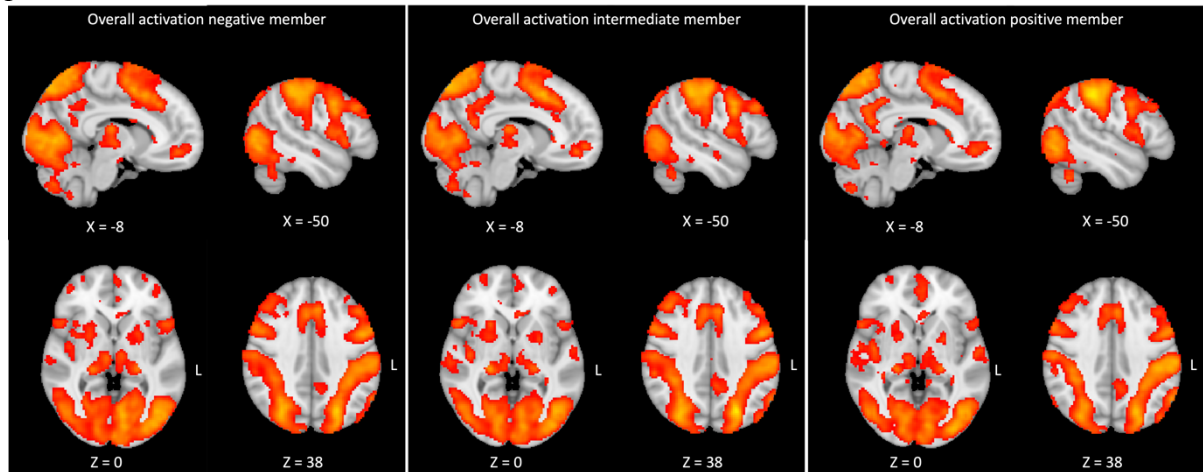
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Cerebellum: right VIIIa, right VIIIb	18	-62	-56	4.35	0.005	193
Temporal occipital fusiform cortex	22	-60	-12	4.23	0.014	156
BPD mean						
Lateral occipital cortex, Angular gyrus, TPJp	46	-56	54	4.51	<0.001	737
Lingual gyrus	14	-76	18	4.59	<0.001	537
Angular gyrus	-50	-54	46	3.86	0.029	133
Positive > Negative feedback						
(t-test)	x	y	z	Z	Cluster p-value	Cluster size
NCC mean						
Lingual gyrus	14	-76	4	5.43	<0.001	544
Precentral gyrus	0	-22	62	5.00	<0.001	451
Postcentral gyrus	-32	-30	64	4.21	0.001	234
Lateral occipital cortex, angular gyrus	36	-60	46	4.21	0.007	177
Middle temporal gyrus	-66	-38	-10	4.28	0.008	171
Central opercular cortex, insula	-38	-10	20	4.44	0.015	152
Lateral occipital cortex	46	-66	8	4.98	0.019	144
MTG	64	-36	-14	4.38	0.027	133
BPD mean						
Lingual gyrus	12	-76	-2	4.39	<0.001	404
Supramarginal gyrs, angular gyrus	40	-42	40	3.82	0.010	167

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Supplemental Figure 4

Activation for F-test on NCC and BPD mean on affiliating to the negative, intermediate, and positive member.



Supplemental Table 11

Peak coordinates for F-test of NCC and BPD mean for rating affiliation to negative, intermediate, and positive panel member.

Brain regions	MNI Coordinates			Voxel test value	Cluster p-value	Cluster size
Affiliation negative member (F-test)	x	y	z	Z		
Lateral occipital cortex, precuneus	-20	-62	56	10.60	<0.001	75301
Insula	40	6	-14	7.80	<0.001	1702
Thalamus	-16	-26	14	8.09	<0.001	1670
vmPFC, ACC	-8	48	-10	5.97	<0.001	808
Hippocampus	-18	-26	-14	5.54	<0.001	477
Angular gyrus, TPJp	-58	-58	38	6.28	<0.001	420
Precuneus, PCC	-4	-60	26	4.95	<0.001	289
NA	-6	2	18	4.60	0.002	211
Insula	-40	4	-14	5.53	0.008	169
Superior frontal gyrus, Middle temporal gyrus	-54	-14	-8	4.53	0.020	139
Affiliation intermediate member (F-test)	x	y	z	Z	Cluster p-value	Cluster size
Lateral occipital cortex, precuneus	18	-64	60	10.10	<0.001	68949
Insula, Temporal pole	40	8	-16	7.12	<0.001	2334
Thalamus	-12	-22	14	7.30	<0.001	1972
Insula, Temporal pole	-40	4	-16	6.77	<0.001	1497
Precuneus, PCC	-6	-56	20	5.84	<0.001	1094
vmPFC, ACC	-8	46	-10	6.03	<0.001	894
Angular gyrus, TPJp	-58	-60	38	6.36	<0.001	698
Cerebellum: right crus I, right crus II	30	-80	-34	4.68	<0.001	290
Cerebellum: left crus I, left crus II	-26	-80	-34	5.50	0.001	237

Supplemental material to manuscript titled Affective and neural mechanisms of how identity dysfunction in borderline personality disorder may interfere with building positive relationships.

Affiliation positive member (F-test)	x	y	z	Z	Cluster p-value	Cluster size
Lateral occipital cortex, precuneus	18	-64	60	9.69	<0.001	63192
Insula	40	6	-14	7.16	<0.001	3241
Frontal pole, middle frontal gyrus	40	38	30	7.35	<0.001	1774
vmPFC, ACC	-6	46	-8	5.70	<0.001	1721
Insula	-40	4	-14	7.15	<0.001	1491
Precuneus, PCC	-8	-56	20	6.11	<0.001	968
Angular gyrus, TPJp	-58	-60	38	6.78	<0.001	828
Superior frontal gyrus, Middle temporal gyrus	-62	-10	-2	6.18	<0.001	407
Putamen	-24	2	2	5.24	<0.001	336
Cerebellum: right crus I, right crus II	28	-78	-34	4.66	0.006	183
Angular gyrus, TPJp	58	-60	40	4.40	0.013	155
Cerebellum: left crus I, left crus II	-22	-80	-32	5.78	0.019	143
Precuneus, PCC	26	-48	12	5.22	0.026	134
Affiliation negative member > positive member (t-test)	x	y	z	Z	Cluster p-value	Cluster size
NCC mean						
Lingual gyrus, cuneus, precuneus	-16	-72	-4	5.16	<0.001	1561
BPD mean						
no clusters						