The Effect of Loneliness on SPL-FPC versus aMPFC-FPC Connectivity

To test whether participants who scored higher on the NIH Toolbox Loneliness Scale would show neural markers of increased engagement with the external environment (cf. Cacioppo et al., 2015; Qualter et al., 2015), we ran a multivariate HLM analysis predicting relative activity in the SPL versus the aMPFC seed (see Results in the main report) from FPC brain scores and loneliness scores. Results of this analysis revealed that higher loneliness scorers evidenced a neural pattern of DAN functional dominance, $b = .011$, $SE = .003$, $t(13604) = 4.08$, $p < .001$, which was due to the stronger SPL-FPC coupling they demonstrated, $b = .036$, $SE = .008$, $t(13604) = 4.74$, $p < .001$. No significant effects of loneliness of aMPFC-FPC coupling were observed ($p > .29$). Taken together, these findings suggest that loneliness is associated with neural markers of greater externally oriented attention, a pattern that is opposite to the one observed and suggested by previous research (cf. Harmon-Jones et al., 2010) to be associated with sadness.

Replication of the DAN versus DMN Functional Dominance Patterns as a function of Emotion in the R-L and L-R Datasets

To verify that the pattern of results obtained with the aggregated R-L and L-R connectivity metrics replicates in the individual datasets, we followed a procedure similar to the one reported in the main body of text. Specifically, we standardized the FPC brain scores as well as the aMPFC and SPL signal values in both datasets, then added a constant to render positive the value of all scrutinized brain variables. Finally, we computed a ratio of a ratio of SPL to aMPFC activity, where higher positive values indicate relatively greater SPL, rather than aMPFC, activity.

A regression analysis predicting the relative activity of the SPL versus the aMPFC seed as a function of FPC engagement and scores on negative emotion experience, as well as the DSM-oriented scales in each of the two datasets provided evidence that the results based on the individual R-L and L-R datasets converged with the ones obtained with the combined R-L and L-R data. Specifically, we found that

(1) greater sadness was linked to weaker DAN functional dominance, in both the R-L, b = -.031, SE = .010, t(13596) = -3.20, p < .01, and L-R, b = -.028, SE = .010, t(13596) = -2.79, p < .01, datasets

(2) greater anger was linked to greater DAN functional dominance, in both the R-L, b = .018, SE = .011, t(13596) = 1.67, p = .094, and L-R, b = .068, SE = .011, t(13596) = 6.39, p < .001, datasets

(3) greater DSM depressive symptoms were linked to weaker DAN functional dominance, in both the R-L, b = -.088, SE = .012, t(13596) = -7.39, p < .001, and L-R, b = -.078, SE = .012, t(13596) = -6.42, p < .001, datasets, and

(4) greater DSM anxiety symptoms were linked to greater DAN functional dominance, in both the R-L, $b = .090$, $SE = .012$, $t(13596) = 7.41$, $p < .001$, and L-R, $b = .74$ $SE = .013$, $t(13596) = 5.77$, $p < .001$, datasets

Post-Hoc Analyses Including General Cognitive Function, Positive Affect, and the Big Five Personality Factors as Additional Control Variables

We verified that all the reported effects remained significant after controlling for general cognitive status (i.e., scores on the Mini-Mental State Exam [MMSE], Folstein, 1975), positive affect (assessed with the NIH Toolbox), which is a factor included in most wellbeing scales, and personality (assessed with the Neuroticism/Extroversion/ Openness Five Factor Inventory [NEO-FFI], McCrae & Costa, 2004).

To this end, we ran a multivariate HLM model predicting relative activity in the SPL versus the aMPFC from FPC brain scores as a function of currently experiences levels of sadness, anger, fear, as well as scores on the MMSE, positive affect, neuroticism, extraversion, openness to experience, agreeableness and conscientiousness. Results of this analysis confirmed that the effects of sadness, b = -.009, SE = .004, t(13582) = -2.45, p = .01, anger, b = .008, SE = .004, t(13582) = 2.05, p = .04, depressive, b = -.025, SE = .005, t(13582) = -5.13, p < .001, and anxiety symptoms, b = .016, SE = .005, t(13582) = 3.49, p < .001, on DAN functional dominance remained unchanged from the ones reported in the main text.

A second multivariate HLM analysis predicting activity in the SPL from FPC brain scores as a function of the same predictors used in the HLM analysis, detailed above, also replicated the results reported in the main text for sadness, b = -.025, SE = .010, t(13582) = -2.50, p = .01, anger, b = .032, SE = .011, t(13582) = 2.86, p < .01, depressive, b = -.103, SE = .013, t(13582) = -7.68, p < .001, and anxiety symptoms, b = .027, SE = .013, t(13582) = 2.16, p = .03.

Finally, a third multivariate HLM analysis predicting activity in the aMPFC from FPC brain scores as a function of the same set of predictors replicated the negative association between DSM anxiety symptoms and aMPFC-FPC connectivity, b = -.046, SE = .012, t(13582) = -3.95, p < .001.

NIH Toolbox Emotional Health	
NIH TB Anger-Affect CAT Age 18+	
Context	In the past 7 days:
Response Options	1=Never; 2=Rarely; 3=Sometimes; 4=Often; 5=Always
Items	
Anger30	When I was frustrated, I let it show.
Anger31	I was irritated more than people knew.
Anger32	I felt envious of others.
Anger33	I disagreed with people.
Anger34	I made myself angry about something just by thinking about it.
Anger35	I tried to get even when I was angry with someone.
Anger36	I felt angry.
Anger37	When I was mad at someone, I gave them the silent treatment.
Anger38	I felt like breaking things.
Anger39	I felt like I was ready to explode.
Anger40	When I was angry, I sulked.
Anger41	I felt resentful when I didn't get my way.

Anger42	I felt guilty about my anger.
Anger43	I felt bitter about things.
Anger44	I felt that people were trying to anger me.
Anger45	I stayed angry for hours.
Anger46	I held grudges towards others.
Anger47	I felt angrier than I thought I should.
Anger48	I was grouchy.
Anger49	I was stubborn with others.
Anger50	I felt annoyed.
Anger51	I had a bad temper.
Anger52	I had trouble controlling my temper.
Anger53	I was angry when I was delayed.
Anger54	Even after I expressed my anger, I had trouble forgetting about it.
Anger55	I felt like I needed help for my anger.
Anger56	I was angry when something blocked my plans.
Anger57	I felt like yelling at someone.
Anger58	Just being around people irritated me. Response options: 1=Not at all; 2=A little bit; 3=Somewhat;4=Quite a bit; 5=Very much

NIH Toolbox Emotional Health	
NIH TB Fear-Affect CAT Age 18+	
Context	**In the past 7 days:**
Response Options	1= Never; 2= Rarely; 3=Sometimes; 4=Often; 5=Always
Items	
Anxiety 36	I felt fearful.
Anxiety 37	I felt frightened.
Anxiety 38	It scared me when I felt nervous.
Anxiety 39	I felt anxious.
Anxiety 40	I felt like I needed help for my anxiety.
Anxiety 41	I was concerned about my mental health.
Anxiety 42	I felt upset.
Anxiety 43	I had a racing or pounding heart.
Anxiety 44	I was anxious if my normal routine was disturbed.
Anxiety 45	I had sudden feelings of panic.
Anxiety 46	I was easily startled.
Anxiety 47	I had trouble paying attention.
Anxiety 48	I avoided public places or activities.
Anxiety 49	I felt fidgety.

Anxiety 50	I felt something awful would happen.
Anxiety 51	I felt worried.
Anxiety 52	I felt terrified.
Anxiety 53	I worried about other people's reactions to me.
Anxiety 54	I found it hard to focus on anything other than my anxiety.
Anxiety 55	I found it hard to focus on anything other than my anxiety.
Anxiety 56	I had twitching or trembling muscles.
Anxiety 57	I felt nervous.
Anxiety 58	I felt indecisive.
Anxiety 59	Many situations made me worry.
Anxiety 60	I had difficulty sleeping.
Anxiety 61	I had trouble relaxing.
Anxiety 62	I felt uneasy.
Anxiety 63	I felt tense.
Anxiety 64	I had difficulty calming down.

NIH Toolbox Emotion	
NIH TB Sadness CAT Age 18+	
Context	In the past 7 days:
Response Options	1=Never; 2=Rarely; 3=Sometimes; 4=Often; 5=Always
Items	
Depression30	I felt worthless.
Depression31	I felt that I had nothing to look forward to.
Depression32	I felt helpless.
Depression33	I withdrew from other people.
Depression34	I felt that nothing could cheer me up.
Depression35	I felt that I was not as good as other people.
Depression36	I felt sad.
Depression37	I felt that I wanted to give up on everything.
Depression38	I felt that I was to blame for things.
Depression39	I felt like a failure.
Depression40	I had trouble feeling close to people.
Depression41	I felt disappointed in myself.
Depression42	I felt that I was not needed.
Depression43	I felt lonely.

NIH TB Positive Sadness CAT Age 18+

Depression44	I felt depressed.
Depression45	I had trouble making decisions.
Depression46	I felt discouraged about the future.
Depression47	I found that things in my life were overwhelming.
Depression48	I felt unhappy.
Depression49	I felt I had no reason for living.
Depression51	I felt ignored by people.
Depression52	I felt upset for no reason.
Depression53	I felt that nothing was interesting.
Depression54	I felt pessimistic.
Depression55	I felt that my life was empty.
Depression56	I felt guilty.
Depression57	I felt emotionally exhausted.

NIH Toolbox Emotion	
NIH TB Loneliness SF Age 18+	
Context	In the past month, please describe how often…
Response Options	1= Never; 2= Rarely; 3=Sometimes; 4=Usually; 5=Always
Items	
SOC253	I feel alone and apart from others.
SOC254	I feel left out.
SOC255	I feel that I am no longer close to anyone.
SOC260	I feel alone.
SOC261	I feel lonely.