

Right-frontal cortical asymmetry predicts increased proneness to nostalgia

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Abstract

Nostalgia is often triggered by feelings—such as sadness, loneliness, or meaninglessness—that are typically associated with withdrawal motivation. Here, we examined whether a trait tendency to experience withdrawal motivation is associated with nostalgia proneness. Past work indicates that baseline right-frontal cortical asymmetry is a neural correlate of withdrawal-related motivation. We therefore hypothesized that higher baseline levels of right-frontal asymmetry would predict increased proneness to nostalgia. We assessed participants' baseline levels of frontal cortical activity using EEG. Results supported the hypothesis and demonstrated that the association between relative right-frontal asymmetry and increased nostalgia remained significant when controlling for the Big Five personality traits. Overall, these findings indicate that individuals with a stronger dispositional tendency to experience withdrawal-related motivation are more prone to nostalgia.

Descriptors: Nostalgia, Frontal EEG asymmetry, Approach and withdrawal, Motivation, Emotion

Some people prefer not to dwell on the past. Others, however, contemplate the past often. They reflect on meaningful experiences, construct personal narratives, and indulge in nostalgia. This discrepancy raises a question: Why are some people more nostalgic than others? An understanding of the emotional and motivational states that trigger nostalgia may provide a useful starting point for answering this question. Evidence suggests that episodes of nostalgia are triggered by withdrawal-related motivational states (Pierro, Pica, Klein, Kruglanski, & Higgins, 2013; Sedikides et al., 2015; Stephan et al., 2014). For example, people are more likely to slip into nostalgic reflection when feeling sad than when feeling happy or angry. This reasoning gives rise to the hypothesis, tested here, that individuals who are dispositionally prone to withdrawal motivation will be more nostalgic.

Past work has demonstrated that approach and withdrawal motivation are associated with asymmetries in frontal cortical activity as assessed with EEG. Frontal cortical asymmetry refers to the relative level of neural activity in the left and right prefrontal cortices (Davidson, 1992). Neural activity is assessed by computing the inverse of alpha activity—a putative metric of cortical inhibition—across frontal regions and comparing the levels at homologous sites on opposite sides of the scalp (e.g., F8 and F7; Lindsley & Wicke, 1974). This work has shown that approach motivation is associated with greater relative left-frontal cortical asymmetry, whereas with-

drawal motivation is associated with greater relative right-frontal asymmetry (Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997). Baseline measures of frontal asymmetry provide an indication of dispositional tendencies to experience approach and withdrawal motivation (Tomarken, Davidson, Wheeler, & Kinney, 1992; Wheeler, Davidson, & Tomarken, 1993). We examined the motivational precursors of nostalgia by testing its relation with baseline frontal cortical asymmetry.

Nostalgia

Contemporary perspectives define nostalgia as an emotion (Sedikides, Wildschut, Arndt, & Routledge, 2006), and describe it as “a sentimental longing or wistful affection for the past” (*The New Oxford Dictionary of English*, p. 1266). Although early views characterized nostalgia as pathological (for reviews, see Batcho, 2013; Sedikides, Wildschut, & Baden, 2004; Sedikides et al., 2015), recent research suggests that such conceptualizations neglect its psychological benefits. For example, nostalgia boosts self-esteem, optimism, and perceptions of psychological growth (Baldwin & Landau, 2014; Cheung et al., 2013; Hepper, Ritchie, Sedikides, & Wildschut, 2012), increases social connectedness and support (i.e., a sense of acceptance or belongingness; Wildschut, Sedikides, Arndt, & Routledge, 2006; Wildschut, Sedikides, Routledge, Arndt, & Cordaro, 2010; Zhou, Sedikides, Wildschut, & Gao, 2008), and promotes prosocial behavior (Turner, Wildschut, & Sedikides, 2012; Turner, Wildschut, Sedikides, & Gheorghiu, 2013; Zhou, Wildschut, Sedikides, Shi, & Feng, 2012). Furthermore, nostalgic engagement is an effective way to reinforce a sense

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of meaning in life and thereby evade existential threat (Routledge, Arndt, Sedikides, & Wildschut, 2008; Routledge et al., 2011; Routledge, Sedikides, Wildschut, & Juhl, 2013). In all, nostalgic reflection contributes to psychological equanimity (Routledge, Wildschut, Sedikides, & Juhl, 2013; Sedikides, Wildschut, Arndt, & Routledge, 2008; Van Dijke, Wildschut, Leunissen, & Sedikides, 2015).

Nostalgia is regarded as a bittersweet or ambivalent emotion, involving mostly happiness but also a tinge of sadness (Batcho, 2007; Hepper et al., 2012, 2014; Wildschut et al., 2006). For example, individuals are more likely to describe a song as nostalgic when it evokes positive and negative emotions concurrently (Barrett et al., 2010). When people are given the opportunity to write nostalgic narratives, they report both positive and negative affect, although positive affect predominates (Abeyta, Routledge, Sedikides, & Wildschut, 2014; Wildschut et al., 2006). Thus, the affective signature of nostalgia is complex, involving mostly positive, but also negative, emotions.

Other studies have investigated the triggers of nostalgia. These findings indicate that nostalgia is often triggered by aversive states, even though the emotion itself is largely positive. In particular, nostalgia is elicited by negative mood (Barrett et al., 2010; Wildschut et al., 2006), loneliness (Wildschut et al., 2006; Zhou et al., 2008), social exclusion (Seehusen et al., 2013; Wildschut et al., 2010), boredom (Van Tilburg, Igou, & Sedikides, 2013), and meaninglessness (Routledge et al., 2011, 2012). Stephan et al. (2014) proposed that these aversive states are specific instances of withdrawal motivation. They showed that withdrawal motivation (as assessed with the Behavioral Inhibition System [BIS] scale; Carver & White, 1994) was positively associated with nostalgia proneness. Furthermore, an experimental induction of withdrawal motivation increased state nostalgia.

Consistent with these ideas, work on self-regulation suggests an association between withdrawal motivation and nostalgia. Regulatory mode theory proposes two orthogonal modes of self-regulation: assessment and locomotion. Assessment is associated with evaluation and shows conceptual overlap with withdrawal motivation, whereas locomotion is associated with goal progress and shows conceptual overlap with approach motivation (Higgins, Kruglanski, & Pierro, 2003; Wildschut et al., 2000). Individuals who are dispositionally higher on assessment and lower on locomotion score higher on nostalgia proneness. Furthermore, when these modes are experimentally manipulated, individuals in assessment mode show higher levels of state nostalgia than those in locomotion mode (Pierro et al., 2013). To the extent that there are parallels between assessment mode and withdrawal motivation, these findings provide further evidence for a link between withdrawal motivation and nostalgia proneness.

Frontal EEG Asymmetry

If nostalgia is triggered by withdrawal-related motivation, dispositional variation on this dimension should provide an indication of an individual's propensity to engage in nostalgic reverie. One way to assess such dispositional variation is by focusing on frontal cortical asymmetry. Initial research in this area demonstrated that individuals with greater relative left-frontal asymmetry experience more positive affect and less negative affect, and are also less likely to become depressed (Jacobs & Snyder, 1996; Nusslock et al., 2011; Tomarken et al., 1992; Wheeler et al., 1993). Tests of the reliability of asymmetry scores over time demonstrate that these scores are relatively stable, lending credence

to the idea that left frontal asymmetry might be a biological substrate of a positive affective style (Allen, Urry, Hitt, & Coan, 2004; Coan, Allen, & Harmon-Jones, 2001; Tomarken et al., 1992; Wheeler et al., 1993).

More recently, the motivational direction model has added nuance to these initial findings, and has implicated left-frontal asymmetry in approach motivation and right-frontal asymmetry in withdrawal motivation (Davidson, 1995; Harmon-Jones, 2004; Harmon-Jones, Gable, & Peterson, 2010; van Honk & Schutter, 2006). Approach motivation prompts individuals to pursue desired goals and rewards, whereas withdrawal motivation ensures that they evade punishment and threat (Gray & McNaughton, 2000; Sutton & Davidson, 1997). Left-frontal asymmetry is linked with emotions such as happiness and anger that promote approach behaviors (Coan et al., 2001; Davidson, Schaffer, & Saron, 1985; Harmon-Jones & Allen, 1998). Meanwhile, right-frontal asymmetry is associated with emotions such as sadness, fear, and disgust that facilitate withdrawal behaviors (Coan et al., 2001; Dawson, Panagiotides, Klinger, & Hill, 1992). Although the evidence linking frontal EEG asymmetry and motivational style is not without inconsistencies (Hewig, Hagemann, Seifert, Naumann, & Bartussek, 2004, 2006), frontal EEG asymmetry has more established construct validity than any other psychophysiological measure of motivational style (Allen, 2004).

The evidence that nostalgia is often elicited by withdrawal-related feelings, such as sadness, loneliness, and meaninglessness, suggests that individuals who feel these emotions more often might be more prone to nostalgia (Barrett et al., 2010; Stephan et al., 2014; Wildschut et al., 2006). A similar account has been proposed for findings linking right-frontal asymmetry and empathic concern (Tullett, Harmon-Jones, & Inzlicht, 2012). In particular, susceptibility to sadness and distress can increase the degree to which individuals engage in the ambivalent process of empathizing. Given that relative right-frontal asymmetry provides an indication of trait withdrawal motivation, observing an association between this neural measure and nostalgia proneness would provide support for the theoretical account that nostalgia is triggered by withdrawal motivation. To test this idea, we examined the association between baseline frontal EEG asymmetry and two trait measures assessing the tendency to engage in nostalgia.

In addition, we assessed the Big Five personality traits (Costa & McCrae, 1992; Goldberg, 1981). The Big Five has been found to provide a relatively comprehensive account of human personality, and as such it explains a large amount of variation in traits across people (John & Srivastava, 1999). For this reason, from an exploratory standpoint we considered it important to include this measure in order to find out whether any observed relation between frontal cortical asymmetry and nostalgia could be explained by basic personality traits. Broadly, two potential results could be informative. First, if Big Five traits accounted for the association, this finding could shed light on the nature of the relation. Alternatively, if the association were independent of the Big Five, this finding would suggest that the construct underlying the association is distinct from these dimensions of personality.

Method

We report how we determined our sample size, all data exclusions, and all manipulations. We present all measures within the text or in Footnote 2.

Participants

We recruited 69 University of Toronto Scarborough undergraduate students who took part for course credit. We excluded 13 participants prior to data analysis, because they did not complete the nostalgia measures ($n = 4$) or because of excessive numbers of artifacts ($n = 9$).¹ Thus, we analyzed data for 56 participants (32 females; $M_{\text{age}} = 19.84$ years, $SD_{\text{age}} = 3.79$). We decided a priori to collect data until the end of the semester provided we had at least 60 participants.

Procedure

To begin, participants were fitted with an EEG cap. Baseline EEG was recorded while participants sat still with their eyes alternately open and closed for four blocks of 30 s each. Participants then completed three go/no-go tasks that were not relevant to the present research. Next, they responded to a series of questionnaires and demographic items including the Nostalgia Inventory (NI; Batcho, 1995), the Southampton Nostalgia Scale (SNS; Barrett et al., 2010; Routledge et al., 2008), and the Big Five Inventory (BFI; John, Naumann, & Soto, 2008; John & Srivastava, 1999).² Debriefing concluded the experimental session.

Self-Report Measures

NI. The NI is an 18-item scale that measures degree of nostalgia toward various aspects of one's past ($\alpha = .76$). Participants are instructed to indicate the degree of nostalgia they feel toward a list of items (e.g., "music," "someone you loved," "the way people were") using a 5-point scale (1 = *not at all nostalgic*, 5 = *very nostalgic*). The NI has strong test-retest reliability ($r = .84$), supporting its use as a measure of trait proneness to nostalgia (Batcho, 1995). Individuals who score higher on the NI perceive the past more favorably relative to those who score lower (Batcho, 1995).

SNS. The SNS is a 7-item scale that measures subjective importance and frequency of nostalgic engagement ($\alpha = .91$). Participants respond to questions such as "How valuable is nostalgia for you?" and "How often do you experience nostalgia?" (1 = *not at all or very rarely*, 7 = *very much or very frequently*). Past work has demonstrated that the SNS has high internal consistency and predicts the degree to which emotional cues, such as music, elicit nostalgic recollections (Barrett et al., 2010; Routledge et al., 2008).

BFI. The BFI is a 48-item scale that measures the Big Five traits: extraversion ($\alpha = .83$), agreeableness ($\alpha = .76$), conscientiousness ($\alpha = .72$), neuroticism ($\alpha = .81$), and openness to experience ($\alpha = .65$). Participants respond to items on a 5-point scale (1 = *strongly disagree*, 5 = *strongly agree*). A review of previous research using the BFI notes that the internal reliabilities of the subscales are typically around .80, with test-retest reliabilities around .85 (John & Srivastava, 1999). The BFI has high convergent and divergent

Table 1. Correlations Between Frontal EEG Asymmetry and Nostalgia

	SNS	Composite	F4F3	F8F7	FC4FC3	CP4CP3	P4P3
NI	.53**	.88**	-.09	-.25†	.14	.05	.12
SNS	–	.88**	-.09	-.27*	-.02	-.09	.12
Composite	–	–	-.10	-.30*	.07	-.02	.14
F4F3	–	–	–	.22†	.02	-.07	-.49**
F8F7	–	–	–	–	-.11	-.03	-.22
FC4FC3	–	–	–	–	–	-.02	-.13
CP4CP3	–	–	–	–	–	–	.56**

** $p < .01$. * $p < .05$. † $p < .1$.

validity with other Big Five instruments and peer ratings (John & Srivastava, 1999).

EEG Recording and Processing

We recorded EEG with a stretch Lycra cap containing 32 tin electrodes. As a reference, we used a digital average of all electrodes. Data were acquired from electrodes Fp1, Fpz, Fp2, FCz, F7, F3, Fz, F4, F8, FT7, FC3, FC4, FT8, T3, C3, Cz, C4, T4, TP7, CP3, CP4, TP8, T5, P3, Pz, P4, T6, CPz, O1, Oz, and O2. Electrode impedances were below 10 k Ω . Vertical eye movements were recorded to facilitate artifact identification. Recordings were digitized at 1,024 Hz using ASA acquisition software (Advanced Neuro Technology, Enschede, The Netherlands). We analyzed the data offline using BrainVision Analyzer software (Brain Products, Gilching, Germany). First, we rereferenced EEG to the average of both earlobes, and then we digitally filtered it between .01 and 15 Hz, and corrected for vertical electrooculogram artifacts (Gratton, Coles, & Donchin, 1983). We detected and rejected artifacts with an automatic procedure that used the following criteria: a voltage step of more than 25 μV between sample points, a voltage difference of 150 μV within 150-ms intervals, voltages above 85 μV and below -85 μV , and a maximum voltage difference of less than 0.50 μV within 100-ms intervals. We rejected such intervals from individual channels. We extracted artifact-free 2-s epochs through a Hamming window (75% overlap) and submitted to fast Fourier transform. We averaged alpha power (8–12 Hz) at each electrode across the 2 min of baseline recording, then log-transformed these values and calculated asymmetry scores by subtracting left- from right-sided alpha at homologous sites. We took asymmetry scores at F8F7 and F4F3 as indices of frontal asymmetry, and we used scores at FC4FC3, CP4CP3, and P4P3 as nonfrontal control values. Given that alpha power is inversely related to cortical activity (Lindsley & Wicke, 1974), higher values on our difference score indicate greater relative left hemisphere activity. Thus, negative correlations will indicate a positive relation between relative right-frontal asymmetry and the variable of interest.

Results

To examine the relation between cortical EEG asymmetry and nostalgia, we ran a series of correlations (Table 1). As in previous research (Routledge et al., 2008; Stephan et al., 2014; Zhou et al., 2008), the two nostalgia scales were significantly correlated, $r(54) = .53$, $p < .001$. This correlation is similar to that observed in other studies (e.g., $r = .40$; Routledge et al., 2008) and indicates a relatively strong relation between the two scales, despite distinct ways of assessing individual differences in nostalgia proneness. We therefore created a composite nostalgia index by standardizing

1. The somewhat high number of participants excluded due to poor EEG recording quality was attributed to the recording amplifier experiencing technical difficulties. These exclusions were made a priori (i.e., before data analysis).

2. Participants also completed the need for structure scale, the free will and determinism scale, and the uncertainty response scale, as well as questions assessing their beliefs about God, beliefs about the government, ethnicity, religious affiliation, years speaking English, and years lived in Canada. We do not discuss these measures, because they are irrelevant to the purposes of this study.

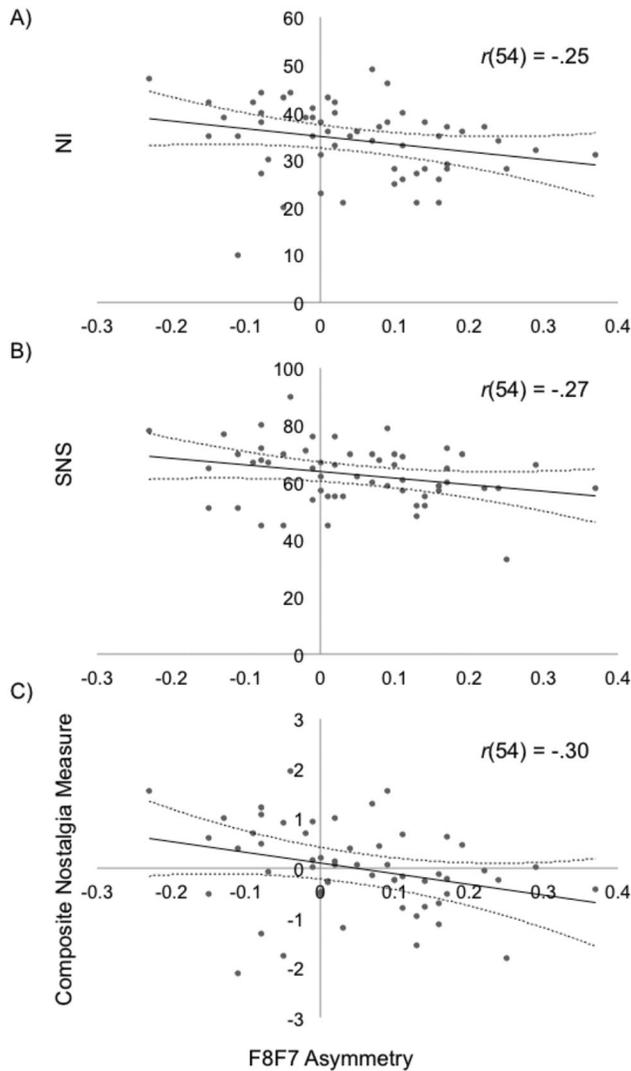


Figure 1. Scatter plot depicting the relation between frontal EEG asymmetry at F8F7 electrode sites and (A) scores on the NI, (B) scores on the SNS, and (C) scores on the composite nostalgia measure. Dotted lines represent the 95% CI of the regression line.

each scale and then averaging them ($\alpha = .89$, using Nunnally & Bernstein's, 1994, formula for the reliability of linear combinations of scales). In addition to analyzing the two nostalgia measures independently, we report results for this composite index (Table 2). As hypothesized, we found that asymmetry at F8F7 was negatively correlated with scores on the NI, $r(54) = -.25, p = .059, 95\% \text{ CI} [-.49, .01]$, the SNS, $r(54) = -.27, p = .047, 95\% \text{ CI} [-.50, .00]$, and the composite index, $r(54) = -.30, p = .026, 95\% \text{ CI} [-.52, -.04]$ (Figure 1). Asymmetry scores at F4F3 were not significantly correlated with scores on any of the nostalgia measures, $r_s < |.15|, p_s > .4$. Nevertheless, the correlations at F4F3 are in the same direction as those at F8F7, and a composite score combining F8F7 and F4F3 is significantly correlated with the composite nostalgia index, $r(54) = -.27, p = .047, 95\% \text{ CI} [-.50, .00]$

If the relation between EEG asymmetry and nostalgia were specific to frontal regions, we would not expect to find significant correlations between nostalgia scores and electrodes in central or parietal areas. Consistent with this expectation, asymmetry scores at FP4FP3, CP4CP3, and P4P3 were not significantly correlated

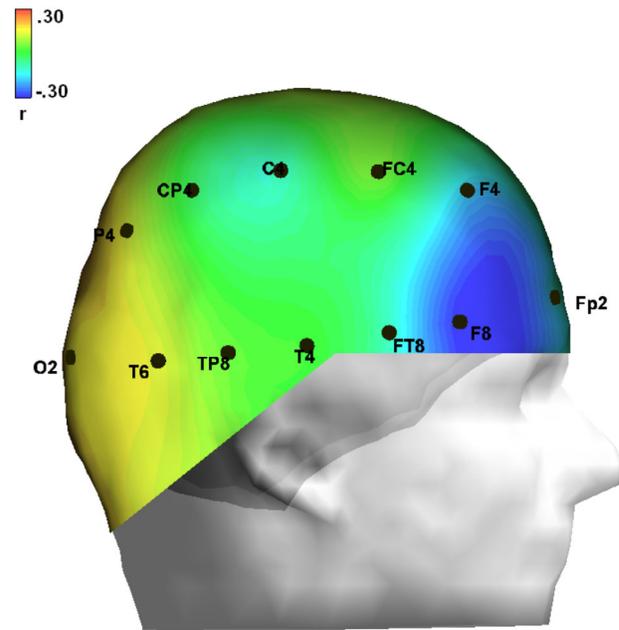


Figure 2. Topographic map of correlations between asymmetry scores, $[\log(\text{right}) - \log(\text{left})]$, and the composite nostalgia index. Correlations depicted across colored area of the scalp are interpolated from measured correlations at electrode sites. Blue values indicate a negative relation between left-frontal asymmetry and nostalgia (i.e., a positive relation between right-frontal asymmetry and nostalgia), whereas red values indicate a positive relation.

with any of the nostalgia measures, $r_s < |.15|, p_s > .3$ (Figure 2). These results suggest that at F8F7 sites greater relative right-frontal asymmetry is associated with higher scores on both measures of nostalgia as well as the composite index. Furthermore, the results are specific to frontal regions.

To test whether the relation between nostalgia and asymmetry scores at F8F7 is accounted for by overlap with Big Five traits, we ran a series of partial correlations (Table 3). Partial correlations revealed that the relations between frontal EEG asymmetry and the nostalgia measures were largely unaffected by controlling for any of the Big Five traits. When we controlled for all the Big Five simultaneously, the relation between asymmetry at F8F7 and the NI was no longer statistically significant, $r(49) = -.21, p = .136, 95\% \text{ CI} [-.46, .07]$. The relation between asymmetry at F8F7 and the SNS, however, remained significant, $r(49) = -.30, p = .032, 95\% \text{ CI} [-.53, -.03]$. The same held for the relation between

Table 2. Correlations Between Frontal EEG Asymmetry, Nostalgia, and the Big Five Personality Traits

	NI	SNS	Composite	E	A	C	N	O
F8F7	-.25†	-.27*	-.30*	-.03	.20	-.04	-.16	-.07
NI	—	.53**	.88**	.08	-.02	.03	.35**	.25†
SNS	—	—	.88**	.09	.24†	.11	.14	.22
Composite	—	—	—	.10	.13	.08	.28*	.27*
E	—	—	—	—	.12	-.05	-.21	.24†
A	—	—	—	—	—	.04	-.22	.04
C	—	—	—	—	—	—	-.08	.07
N	—	—	—	—	—	—	—	-.04

Note. E = extraversion, A = agreeableness, C = conscientiousness, N = neuroticism, O = openness to experience.

** $p < .01$. * $p < .05$. † $p < .1$.

Table 3. Partial Correlations Between Frontal EEG Asymmetry and Nostalgia, Controlling for Big Five Personality Traits

	NI	SNS	Composite
F8F7			
Controlling for:			
Extraversion	-.25 [†]	-.27*	-.30*
Agreeableness	-.26 [†]	-.33*	-.33*
Conscientiousness	-.25 [†]	-.26 [†]	-.30*
Neuroticism	-.21	-.25 [†]	-.27*
Openness	-.25 [†]	-.26 [†]	-.29*
Total BFI	-.21	-.30*	-.30*

** $p < .01$. * $p < .05$. [†] $p < .1$.

asymmetry at F8F7 and the composite nostalgia index, $r(49) = -.30$, $p = .034$, 95% CI $[-.53, -.03]$.

Discussion

Participants who showed greater relative right-frontal EEG asymmetry, a pattern of neural activity indicative of dispositional withdrawal-related motivation, were more prone to nostalgia. Given prior evidence that nostalgia is often triggered by withdrawal-related emotions (Pierro et al., 2013; Sedikides et al., 2015; Stephan et al., 2014), our results are consistent with a process in which individuals with greater relative right-frontal activity are more likely to experience these emotions, and thus are more likely to engage in nostalgia. For instance, these individuals might be more prone to feelings of loneliness or sadness, and might have more nostalgic recollections as a result.

Our findings, which specifically address trait nostalgia, raise several questions about the relation between state measures of nostalgia and cortical asymmetry. Although the triggers of nostalgia that have been identified are consistently associated with withdrawal motivation, the experience of nostalgia often involves approach-related emotions such as joy (Stephan et al., 2014; Wildschut et al., 2006). For this reason, one might expect state nostalgia to be correlated with relative left frontal asymmetry, consistent with the idea that nostalgia serves to shift people into a more approach-oriented state. This question of whether nostalgia may function to offset withdrawal motivation by fostering approach motivation and increasing relative right frontal cortical asymmetry is an important question for future research.

The findings reported here build on previous research suggesting a positive side to dispositional relative right-frontal asymmetry (Eslinger et al., 2007; Shamay-Tsoory, Tomer, Berger, Goldsher, & Aharon-Peretz, 2005; Tullett et al., 2012). Baseline levels of right-frontal asymmetry are associated with a propensity to engage in nostalgia and empathy, both of which are linked to beneficial outcomes (Eisenberg & Miller, 1987; Sedikides et al., 2015; Zhou et al., 2012). Thus, although greater relative right-frontal asymmetry is associated with depression and negative affect, it may sometimes be associated with positive emotional experiences. This may be particularly so for emotional states, such as empathic concern and nostalgia, which have a “bittersweet” affective signature (Barrett et al., 2010; Wildschut et al., 2006).

One alternative interpretation of our findings is that negative emotions, rather than withdrawal-related emotions, account for the relation between relative right-frontal asymmetry and nostalgia. Although our results cannot rule out this possibility, we think that

withdrawal-related emotions provide a more plausible mechanism than negative emotions. Relative right-frontal asymmetry is not categorically associated with all negative emotions; for instance, anger is a negative emotion that is linked with relative left-frontal asymmetry (Harmon-Jones & Allen, 1998). Thus, the category of “negative emotions” includes emotions—like anger—that are unlikely to explain our findings. Nevertheless, there may be withdrawal-related emotions (perhaps negatively valenced ones) that help to account for this relation. Future research may help to clarify the specific emotional states that account for this association.

Another model of asymmetrical frontal cortical activation that should be considered in interpreting our results is the hemispheric encoding/retrieval asymmetry model (Habib, Nyberg, & Tulving, 2003). This model posits that the left prefrontal cortex is more involved than the right prefrontal cortex in episodic memory encoding, whereas the opposite pattern is found for episodic memory retrieval. These findings have been obtained by measuring state neural activity during encoding and retrieval tasks, and thus little is known about how resting or trait patterns of asymmetrical frontal cortical activation, like those measured here, might predict individual differences in encoding and retrieval. Nevertheless, the obvious connections between episodic memory retrieval and nostalgia suggest this may be a productive direction for future investigations.

The positive association between relative right-frontal asymmetry and nostalgia was statistically significant at F8F7 electrode sites, but not at F4F3 sites. Previous research on frontal EEG asymmetry has often examined both regions, with some studies finding them to be similarly related to other variables (e.g., Coan & Allen, 2003) and others studies finding them to be differentially related to other variables (e.g., Jacobs & Snyder, 1996). In a meta-analysis on depression, anxiety, and frontal EEG asymmetry, F4F3 and F8F7 sites showed minimal overlap in their relations to various affect and mood measures (Thibodeau, Jorgenson, & Kim, 2006). Here, although the magnitudes of the correlation coefficients appear different, the correlations between the nostalgia measures and F8F7 are not significantly higher than those with F4F3, $ts(53) < 1.5$, $ps > .2$. Further research is needed to clarify whether there is a dissociation between F8F7 and F4F3 regions in predicting nostalgia.

We also tested whether the relation between frontal EEG asymmetry and nostalgia is accounted for by overlap between these measures and basic personality traits. Our results suggest that this is not the case, as the relations between F8F7 asymmetry scores and nostalgia measures were largely unaffected by controlling for any of the Big Five traits individually. One trait that warrants specific attention is neuroticism, which has been conceptually and empirically linked with withdrawal motivation (Gray, 1981; Zelenski & Larsen, 1999). Given that neuroticism and withdrawal motivation are related but distinct, we anticipated that neuroticism would not be able to fully account for the relation between frontal asymmetry and nostalgia. Nevertheless, we would expect that neuroticism would show at least weak correlations with relative right-frontal asymmetry and nostalgia. Indeed, we find that the relation between neuroticism and nostalgia in our sample is significant, $r(54) = .28$, $p = .04$, and the relation between neuroticism and F8F7 asymmetry is in the predicted direction, $r(54) = -.16$, $p = .26$, albeit not significant. These associations converge with previous work demonstrating an association between nostalgia and BIS (Stephan et al., 2014) and are consistent with our conclusion that individuals with a stronger dispositional tendency to experience withdrawal motivation are more prone to nostalgia.

Conclusion

Our results demonstrate a link between baseline right frontal EEG asymmetry and nostalgia. Foundational research on asymmetrical cortical activity has implicated right-frontal asymmetry in withdrawal-related affect and depression (Jacobs & Snyder, 1996; Nusslock et al., 2011; Tomarken et al., 1992; Wheeler et al., 1993). Intriguingly, the findings suggest that this increased susceptibility to sadness and distress may facilitate nostalgia, an emotion associated predominantly with joy. Past work linking

right-frontal asymmetry with empathic concern identified sadness as a mediator, suggesting that an increased propensity or willingness to experience sadness might enhance the degree to which an individual reflects on the sadness of others (Tullett et al., 2012). Our findings are consistent with this line of reasoning. Individuals who are more prone to withdrawal-related motivation are more likely to reflect on past experiences, thus risking a wistful sentiment but also generating social connectedness, empathy, and meaning in the process.

References

- Abeyta, A., Routledge, C., Sedikides, C., & Wildschut, R. T. (2014). Attachment-related avoidance and the social content of nostalgic memories. *Journal of Social and Personal Relationships*. Advance online publication. doi: 10.1177/0265407514533770
- Allen, J. J. B. (2004). Frontal EEG asymmetry, emotion, and psychopathology: The first, and the next 25 years. *Biological Psychology*, *67*, 1–5.
- Allen, J. J. B., Urry, H. L., Hitt, S. K., & Coan, J. A. (2004). The stability of resting frontal electroencephalographic asymmetry in depression. *Psychophysiology*, *41*, 269–280. doi: 10.1111/j.1469-8986.2003.00149.x
- Baldwin, M., & Landau, M. J. (2014). Exploring nostalgia's influence on psychological growth. *Self and Identity*, *13*, 162–177. doi: 10/1080/15298868.2013.772320
- Barrett, F. S., Grimm, K. J., Robins, R. W., Wildschut, T., Sedikides, C., & Janata, P. (2010). Music-evoked nostalgia: Affect, memory, and personality. *Emotion*, *10*, 390–403. doi: 10.1037/a0019006
- Batcho, K. I. (1995). Nostalgia: A psychological perspective. *Perceptual and Motor Skills*, *80*, 131–143. doi: 10.2466/pms.1995.80.1.131
- Batcho, K. I. (2007). Nostalgia and the emotional tone and content of song lyrics. *American Journal of Psychology*, *120*, 361–381.
- Batcho, K. I. (2013). Nostalgia: The bittersweet history of a psychological concept. *History of Psychology*, *16*, 165–176. doi: 10.1037/a0032427
- Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology*, *67*, 319–333. doi: 10.1037/0022-3514.67.2.319
- Cheung, W.-Y., Wildschut, T., Sedikides, C., Hepper, E. G., Arndt, J., & Vingerhoets, A. J. J. M. (2013). Back to the future: Nostalgia increases optimism. *Personality and Social Psychology Bulletin*, *39*, 1484–1496. doi: 10.1177/0146167213499187
- Coan, J. A., & Allen, J. J. B. (2003). Frontal EEG asymmetry and the behavioral activation and inhibition systems. *Psychophysiology*, *40*, 106–114. doi: 10.1111/1469-8986.00011
- Coan, J. A., Allen, J. J. B., & Harmon-Jones, E. (2001). Voluntary facial expressions and hemispheric asymmetry over the frontal cortex. *Psychophysiology*, *38*, 912–925. doi: 10.1111/1469-8986.3860912
- Costa, P. T., & McCrae, R. R. (1992). 'Normal' personality inventories in clinical assessment: General requirements and the potential for using the NEO Personality Inventory: Reply. *Psychological Assessment*, *4*, 20–22. doi: 10.1037/1040-3590.4.1.20
- Davidson, R. J. (1992). Anterior cerebral asymmetry and the nature of emotion. *Brain and Cognition*, *20*, 125–151. doi: 10.1016/0278-2626(92)90065-T
- Davidson, R. J. (1995). Cerebral asymmetry, emotion, and affective style. In R. J. Davidson & K. Hugdahl (Eds.), *Brain asymmetry* (pp. 361–387). Cambridge, MA: MIT Press.
- Davidson, R. J., Schaffer, C. E., & Saron, C. (1985). Effects of lateralized presentations of faces on self-reports of emotion and EEG asymmetry in depressed and non-depressed subjects. *Psychophysiology*, *22*, 353–364. doi: 10.1111/j.1469-8986.1985.tb01615.x
- Dawson, G., Panagiotides, H., Klinger, L. G., & Hill, D. (1992). The role of frontal lobe functioning in the development of infant self-regulatory behavior. *Brain and Cognition*, *20*, 152–175. doi: 10.1016/0278-2626(92)90066-U
- Eisenberg, N., & Miller, P. A. (1987). The relation of empathy to prosocial and related behaviors. *Psychological Bulletin*, *101*, 91–119. doi: 10.1037/0033-2909.101.1.91
- Eslinger, P. J., Moore, P., Troiani, V., Antani, S., Cross, K., Kwok, S., & Grossman, M. (2007). Oops! Resolving social dilemmas in fronto-temporal dementia. *Journal of Neurology, Neurosurgery and Psychiatry*, *78*, 457–460. doi: 10.1136/jnnp.2006.098228
- Goldberg, L. R. (1981). Language and individual differences: The search for universals in personality lexicons. In L. Wheeler (Ed.), *Review of personality and social psychology*, (Vol. 2, pp. 141–165). Beverly Hills, CA: Sage.
- Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology*, *55*, 458–484. doi: 10.1016/0013-4694(83)90135-9
- Gray, J. A. (1981). A critique of Eysenck's theory of personality. In H. J. Eysenck (Ed.), *A model for personality* (pp. 246–276). New York, NY: Springer-Verlag.
- Gray, J. A., & McNaughton, N. (2000). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system*. New York, NY: Oxford Press.
- Habib, R., Nyberg, L., & Tulving, E. (2003). Hemispheric asymmetries of memory: The HERA model revisited. *Trends in Cognitive Sciences*, *7*, 241–245. doi: 10.1016/S1364-6613(03)00110-4
- Harmon-Jones, E. (2004). Contributions from research on anger and cognitive dissonance to understanding the motivational functions of asymmetric frontal brain activity. *Biological Psychology*, *67*, 51–76. doi: 10.1016/j.biopsycho.2004.03.003
- Harmon-Jones, E., & Allen, J. B. (1997). Behavioral activation sensitivity and resting frontal EEG asymmetry: Covariation of putative indicators related to risk for mood disorders. *Journal of Abnormal Psychology*, *106*, 159–163. doi: 10.1037/0021-843X.106.1.159
- Harmon-Jones, E., & Allen, J. J. B. (1998). Anger and frontal brain activity: EEG asymmetry consistent with approach motivation despite negative affective valence. *Journal of Personality and Social Psychology*, *74*, 1310–1316. doi: 10.1037/0022-3514.74.5.1310
- Harmon-Jones, E., Gable, P. A., & Peterson, C. K. (2010). The role of asymmetric frontal cortical activity in emotion-related phenomena: A review and update. *Biological Psychology*, *84*, 451–462. doi: 10.1016/j.biopsycho.2009.08.010
- Hepper, E. G., Ritchie, T. D., Sedikides, C., & Wildschut, T. (2012). Odyssey's end: Lay conceptions of nostalgia reflect its original Homeric meaning. *Emotion*, *12*, 102–119. doi: 10.1037/a0025167
- Hepper, E. G., Wildschut, T., Sedikides, C., Ritchie, T. D., Yung, Y.-F., Hansen, N., ... Zhou, X. (2014). Pancultural nostalgia: Prototypical conceptions across cultures. *Emotion*, *14*, 733–747. doi: 10.1037/a0036790
- Hewig, J., Hagemann, D., Seifert, J., Naumann, E., & Bartussek, D. (2004). On the selective relation of frontal cortical asymmetry and anger-out versus anger-control. *Journal of Personality and Social Psychology*, *87*, 926–939.
- Hewig, J., Hagemann, D., Seifert, J., Naumann, E., & Bartussek, D. (2006). The relation of cortical activity and BIS/BAS on the trait level. *Biological Psychology*, *71*, 42–53.
- Higgins, E., Kruglanski, A., & Pierro, A. (2003). Regulatory mode: Locomotion and assessment as distinct orientations. *Advances in Experimental Social Psychology*, *35*, 293–344. doi: 10.1016/S0065-2601(03)01005-0
- Jacobs, G. D., & Snyder, D. (1996). Frontal brain asymmetry predicts affective style in men. *Behavioral Neuroscience*, *110*, 3–6. doi: 10.1037/0735-7044.110.1.3

- John, O. P., Naumann, L. P., & Soto, C. J. (2008). Paradigm shift to the integrative Big-Five trait taxonomy: History, measurement, and conceptual issues. In O. P. John, R. W. Robins, & L. A. Pervin (Eds.), *Handbook of personality: Theory and research* (pp. 114–158). New York, NY: Guilford Press.
- John, O. P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. In L. A. Pervin & O. P. John (Eds.), *Handbook of personality: Theory and research* (2nd ed., pp.102–138). New York, NY: Guilford Press.
- Kruglanski, A. W., Thompson, E. P., Higgins, E. T., Atash, M. N., Pierro, A., Shah, J. Y., & Spiegel, S. (2000). To do the right thing! or to just do it!: Locomotion and assessment as distinct self-regulatory imperatives. *Journal of Personality and Social Psychology*, *79*, 793–815. doi: 10.1037/1A1022-3514.79.5.793
- Lindsley, D. B., & Wicke, J. D. (1974). The electroencephalogram: Autonomous electrical activity in man and animals. In R. Thompson & N. Patterson (Eds.), *Bioelectric recording techniques* (pp. 3–79). New York, NY: Academic Press.
- Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory* (3rd ed.). New York, NY: McGraw-Hill.
- Nusslock, R., Shackman, A. J., Harmon-Jones, E., Alloy, L. B., Coan, J. A., & Abramson, L. Y. (2011). Cognitive vulnerability and frontal brain asymmetry: Common predictors of first prospective depressive episode. *Journal of Abnormal Psychology*, *120*, 497–503. doi: 10.1037/a0022940
- Pierro, A., Pica, G., Klein, K., Kruglanski, A. W., & Higgins, E. T. (2013). Looking back or moving on: How regulatory modes affect nostalgia. *Motivation and Emotion*, *37*, 653–660. doi: 10.1007/s11031-013-9350-9
- Routledge, C., Arndt, J., Sedikides, C., & Wildschut, T. (2008). A blast from the past: The terror management function of nostalgia. *Journal of Experimental Social Psychology*, *44*, 132–140. doi: 10.1016/j.jesp.2006.11.001
- Routledge, C., Arndt, J., Wildschut, T., Sedikides, C., Hart, C., Juhl, J., ... Scholtz, W. (2011). The past makes the present meaningful: Nostalgia as an existential resource. *Journal of Personality and Social Psychology*, *101*, 638–652. doi: 10.1037/a0024292
- Routledge, C., Sedikides, C., Wildschut, T., & Juhl, J. (2013). Finding meaning in the past: Nostalgia as an existential resource. In K. Markman, T. Proulx, & M. Lindberg (Eds.), *The psychology of meaning* (pp. 297–316). Washington, DC: American Psychological Association.
- Routledge, C., Wildschut, T., Sedikides, C., & Juhl, J. (2013). Nostalgia as a resource for psychological health and well-being. *Social and Personality Psychology Compass*, *7*, 808–818. doi: 10.1111/spc3.12070
- Routledge, C., Wildschut, T., Sedikides, C., Juhl, J., & Arndt, J. (2012). The power of the past: Nostalgia as a meaning-making resource. *Memory*, *20*, 452–460. doi: 10.1080/09658211.2012.677452
- Sedikides, C., Wildschut, T., Arndt, J., & Routledge, C. (2006). Affect and the self. In J. P. Forgas (Ed.), *Affect in social thinking and behavior: Frontiers in social psychology* (pp. 197–215). New York, NY: Psychology Press.
- Sedikides, C., Wildschut, T., Arndt, J., & Routledge, C. (2008). Nostalgia: Past, present, and future. *Current Directions in Psychological Science*, *17*, 304–307. doi: 10.1111/j.1467-8721.2008.00595.x
- Sedikides, C., Wildschut, T., & Baden, D. (2004). Nostalgia: Conceptual issues and existential functions. In J. Greenberg, S. Koole, & T. Pyszczynski (Eds.), *Handbook of experimental existential psychology* (pp. 200–214). New York, NY: Guilford Press.
- Sedikides, C., Wildschut, T., Routledge, C., Arndt, J., Hepper, E. G., & Zhou, X. (2015). To nostalgize: Mixing memory with affect and desire. *Advances in Experimental Social Psychology*, *51*, 189–273. doi: 10.1016/bs.aesp.2014.10.001
- Seehusen, J., Cordaro, F., Wildschut, T., Sedikides, C., Routledge, C., Blackhart, G. C., ... Vingerhoets, A. J. J. M. (2013). Individual differences in nostalgia proneness: The integrating role of the need to belong. *Personality and Individual Differences*, *55*, 904–908. doi: 10.1016/j.paid.2013.07.020
- Shamay-Tsoory, S. G., Tomer, R., Berger, B. D., Goldsher, D., & Aharon-Peretz, J. (2005). Impaired “affective theory of mind” is associated with right ventromedial prefrontal damage. *Cognitive and Behavioral Neurology*, *18*, 55–67. doi: 10.1097/01.wnn.0000152228.90129.99
- Stephan, E., Wildschut, T., Sedikides, C., Zhou, X., He, W., Routledge, C., ... Vingerhoets, A. J. J. M. (2014). The mnemonic mover: Nostalgia regulates avoidance and approach motivation. *Emotion*, *14*, 545–561. doi: 10.1037/a0035673
- Sutton, S. K., & Davidson, R. J. (1997). Prefrontal brain asymmetry: A biological substrate of the behavioral approach and inhibition systems. *Psychological Science*, *8*, 204–210. doi: 10.1111/j.1467-9280.1997.tb00413.x
- Thibodeau, R., Jorgenson, R. S., & Kim, S. (2006). Depression, anxiety, and resting frontal EEG asymmetry: A meta-analytic review. *Journal of Abnormal Psychology*, *115*, 715–729. doi: 10.1037/0021-843X.115.4.715
- Tomarken, A. J., Davidson, R. J., Wheeler, R. E., & Kinney, L. (1992). Psychometric properties of resting anterior EEG asymmetry: Temporal stability and internal consistency. *Psychophysiology*, *29*, 576–592. doi: 10.1111/j.1469-8986.1992.tb02034.x
- Tullett, A. M., Harmon-Jones, E., & Inzlicht, M. (2012). Right frontal cortical asymmetry predicts empathic reactions: Support for a link between withdrawal motivation and empathy. *Psychophysiology*, *49*, 1145–1153. doi: 10.1111/j.1469-8986.2012.01395.x
- Turner, R. N., Wildschut, T., & Sedikides, C. (2012). Dropping the weight stigma: Nostalgia improves attitudes toward persons who are overweight. *Journal of Experimental Social Psychology*, *48*, 130–137. doi: 10.1016/j.jesp.2011.09.007
- Turner, R. N., Wildschut, T., Sedikides, C., & Gheorghiu, M. (2013). Combating the mental health stigma with nostalgia. *European Journal of Social Psychology*, *43*, 413–422. doi: 10.1002/ejsp.1952
- Van Dijke, M., Wildschut, T., Leunissen, J., & Sedikides, C. (2015). Nostalgia buffers the negative impact of low procedural injustice on cooperation. *Organizational Behavior and Human Decision Processes*, *127*, 15–29.
- van Honk, J., & Schutter, D. J. L. G. (2006). From affective valence to motivational direction: The frontal asymmetry of emotion revisited. *Psychological Science*, *17*, 963–965. doi: 10.1111/j.1467-9280.2006.01813.x
- Van Tilburg, W. A. P., Igou, E. R., & Sedikides, C. (2013). In search of meaningfulness: Nostalgia as an antidote to boredom. *Emotion*, *13*, 450–461. doi: 10.1037/a0030442
- Wheeler, R. E., Davidson, R. J., & Tomarken, A. J. (1993). Frontal brain asymmetry and emotional reactivity: A biological substrate of affective style. *Psychophysiology*, *30*, 82–89. doi: 10.1111/j.1469-8986.1993.tb03207.x
- Wildschut, T., Sedikides, C., Arndt, J., & Routledge, C. (2006). Nostalgia: Content, triggers, functions. *Journal of Personality and Social Psychology*, *91*, 975–993. doi: 10.1037/0022-3514.91.5.975
- Wildschut, T., Sedikides, C., Routledge, C., Arndt, J., & Cordaro, P. (2010). Nostalgia as a repository of social connectedness: The role of attachment-related avoidance. *Journal of Personality and Social Psychology*, *98*, 573–586. doi: 10.1037/a0017597
- Zelenski, J. M., & Larsen, R. J. (1999). Susceptibility to affect: A comparison of three personality taxonomies. *Journal of Personality*, *67*, 761–791.
- Zhou, X., Sedikides, C., Wildschut, T., & Gao, D.-G. (2008). Counteracting loneliness: On the restorative function of nostalgia. *Psychological Science*, *19*, 1023–1029. doi: 10.1111/j.1467-9280.2008.02194.x
- Zhou, X., Wildschut, C., Sedikides, C., Shi, K., & Feng, C. (2012). Nostalgia: The gift that keeps on giving. *Journal of Consumer Research*, *39*, S300–S311. doi: 10.1086/662199

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