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RESEARCH PAPER

Nostalgia and Satisfaction with Life: A Behavioral Genetic Analysis

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Abstract
Nostalgia, a bittersweet but predominantly positive emotion, arises from self-relevant and social memories. Evidence suggests that nostalgia is a potential source of happiness. Indeed, at the phenotypic level, this relation appears to be positive albeit tenuous. At the etiologic level, the relation is unknown. To fill this knowledge gap, we investigated the phenotypic and genetic association between nostalgia and satisfaction with life (SWL). We assessed nostalgia and SWL in 464 twin siblings, including 117 monozygotic twin pairs and 115 dizygotic twin pairs. By comparing monozygotic twins to dizygotic twins, we analyzed the genetic and environmental effects on nostalgia and SWL simultaneously. We observed a small positive association between nostalgia and SWL ($r_{phenotypic}=0.12$), with this association being strengthened after neuroticism was partialled out ($r_{phenotypic}=0.17$). More importantly, nostalgia and SWL shared some environmental (but not genetic) sources ($r_{non\text{-}shared\ environment}=0.21$), which accounted for the majority (88%) of their phenotypic association. Taken together, the findings support a positive relation between nostalgia and SWL, and further uncover the bases underlying this relation. The study adds to the burgeoning literature on nostalgia and well-being.

Keywords Nostalgia · Satisfaction with life · Well-being · Neuroticism · Behavioral genetics · Twin study

1 Introduction

Happiness matters. How to sustain and promote happiness has captured the fascination of the public (https://positivepsychology.com/best-happiness-books/) and academics (Diener et al., 1999; Lyubomirsky, 2007) alike. Some research suggests that people can derive happiness from nostalgia (Routledge et al., 2013; Sedikides et al., 2015). In this article, we

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address the relation between nostalgia and happiness at the phenotypic level and, more importantly, at the etiologic level.

1.1 Nostalgia and Subjective Well-Being

Nostalgia is a bittersweet but predominantly positive emotion that originates in self-relevant and social memories. In particular, the emotion arises when people reflect on their fond and meaningful autobiographical memories (Hepper et al., 2014; Madoglou et al., 2017; Wildschut et al., 2006) or are reminded incidentally of them (e.g., via music or scents; Reid et al., 2015; Routledge et al., 2011; Sedikides et al., 2021). The emotion has been conceptualized as a discrete or transient state, and also as a stable or enduring trait reflecting dispositional proneness to nostalgizing about one's past and to valuing doing so (Barrett et al., 2010; Juhl et al., 2020; Routledge et al., 2008).

In contrast to the early view of nostalgia as a psychological illness (for reviews, see Batcho, 2013; Sedikides et al., 2004), the construct is now largely rehabilitated and established as a psychological resource (Sedikides & Wildschut, 2016, 2019; Sedikides et al., 2015; Wildschut & Sedikides, 2020). Specifically, nostalgia fosters subjective well-being, which involves satisfaction with life (SWL) and experiencing more positive but less negative affect (Busseri & Sadava, 2011; Diener et al., 2002). Evidence indicates that experimentally induced nostalgia increases SWL (Cox et al., 2015, Study 1; Zhou et al., 2021, Studies 4–6) and raises positive affect (Frankenbach et al., 2021; Ismail et al., 2020; Leunissen et al., 2021). Further, a weekly nostalgia intervention yielded increases in SWL and positive affect over a 3-month (but not 6-month) period (Layous et al., 2021). However, a naturalistic assessment of nostalgia (i.e., nostalgia as a state in daily life) evinced a positive association with subjective well-being at a later moment in the day, but was inversely linked to subjective well-being on the following day (Newman et al., 2020, Studies 3–4). So far, research has identified a generally positive but occasionally inconsistent relation between nostalgia and well-being at the state level.

1.2 Nostalgia and Satisfaction with Life at the Phenotypic Level

Investigations of nostalgia and SWL as traits are more relevant to the objectives of this article. One study found that nostalgia was positively related to well-being, including SWL, while controlling for positive and negative affect as well as the Big Five ($r = 0.25$, $p = 0.001$; Baldwin et al., 2015, Study 7). Nevertheless, because that study treated SWL along with other measures of well-being as a composite, it did not inform on the magnitude of the relation between nostalgia and SWL per se. Another study administered two convergent measures of nostalgia and found that one was positively, but marginally, associated with SWL ($r = 0.13$, $p < 0.10$), whereas the other was unassociated with it ($r = 0.02$, $p > 0.10$; Newman et al., 2020, Study 2). In summary, the relation between trait-like nostalgia and SWL appears to be tenuous. Therefore, we re-examined the phenotypic relation between nostalgia and SWL, expecting it to be positive.

1.3 Nostalgia and Satisfaction with Life at the Etiologic Level

Finding a phenotypic link between trait-like nostalgia and SWL indicates that the two variables covary on a long-term basis. This link, however, does not inform on the origins of the

association between these two variables. Does this association arise from genes or environments that influence both nostalgia and SWL? Addressing this question can improve understanding of the mechanisms through which nostalgia contributes to happiness, with implications for leveraging nostalgia to promote happiness. Hence, our main objective was to address the relation between nostalgia and SWL at the etiologic level.

A twin study has shown that nostalgia is heritable, with approximately 30% of its variance attributed to genetic factors and the remaining variance attributed to non-shared environmental factors, which refer to environments that are not shared by family members. (Luo et al., 2016). An example of non-shared environmental factors is romantic relationships. At the same time, previous twin studies have demonstrated the heritability of SWL in various populations, with genetic factors accounting for 30–40% of individual differences in SWL, according to meta-analyses (Bartels et al., 2015; Nes & Røysamb, 2015). In addition, the environmental effects on SWL are mainly attributed to non-shared environmental factors, which explain more than half of the variation in SWL. However, it is unknown whether any genetic and/or environmental sources contribute to nostalgia and SWL simultaneously.

We attempted to fill this knowledge gap in the current study. Given that phenotypic covariance usually indicates etiological similarity (Knopik et al., 2017), once the postulated relation between nostalgia and SWL is established at a phenotypic level, we would expect some genetic and/or environmental overlap between nostalgia and SWL.

1.4 A Potential Confounder of the Nostalgia–SWL Link

The potential link between nostalgia and SWL may be confounded by a third variable—neuroticism. Neuroticism reflects a dispositional proclivity to experience unstable mood and negative emotions. Neuroticism is positively associated with nostalgia (Barrett et al., 2010; Seehusen et al., 2013). This association arises not because nostalgia engenders emotional negativity, but rather because nostalgia is implemented as a coping mechanism to sooth worries and re-establish the sense of belongingness—deficits often experienced by highly neurotic persons (Frankenbach et al., 2021; Seehusen et al., 2013; Wildschut & Sedikides, 2022). Meanwhile, given its link to discomforting emotions, especially depression, neuroticism is negatively related to SWL (Hahn et al., 2013; Schimmack et al., 2004). Thus, although nostalgia may be positively associated with SWL, nostalgia also covaries with neuroticism, which is inversely related to SWL. In this way, neuroticism may obscure the potentially positive relation between nostalgia and SWL at the phenotypic level.

Moreover, neuroticism may confound the potential etiological overlap between nostalgia and SWL. For one thing, the same genetic variant is associated with both nostalgia and neuroticism (Luo et al., 2019; Sen et al., 2004). For another, SWL and neuroticism share a substantial portion of genetic sources, which function in opposite directions for the two traits (e.g., promoting SWL but deflating neuroticism; Baselmans et al., 2019; Turley et al., 2018). In addition, a number of environmental factors underlying neuroticism also contribute to individual differences in SWL (Hahn et al., 2013). Hence, these genetic and environmental bases shared between neuroticism and nostalgia or SWL may interfere with the examination of the etiologic overlap between nostalgia and SWL. Therefore, we needed to rule out the confounding influence of neuroticism when assessing the correlations between nostalgia and SWL at both phenotypic and etiologic levels. We expected that the association between nostalgia and SWL would be strengthened when neuroticism was partialled out.

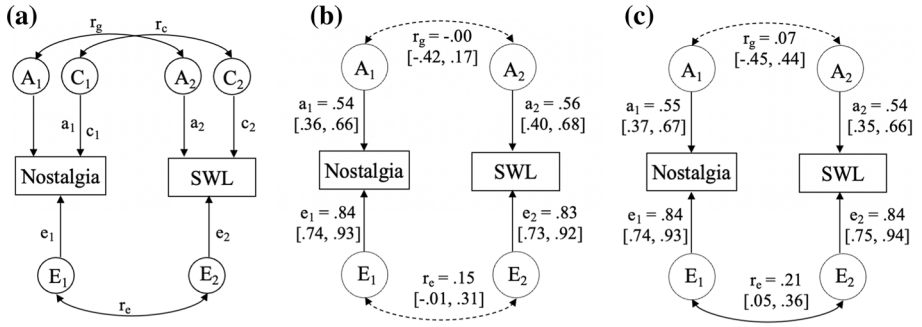

Fig. 1 Genetic Modelling for Nostalgia and Satisfaction With Life (SWL). *Note*. This path diagram illustrates the full ACE model (**a**; left panel), the best-fitting AE model based on variables adjusted for age and sex (**b**; middle panel), and the best-fitting AE model based on variables adjusted for age, sex, and neuroticism (**c**; right panel). Measured variables are depicted in rectangles. Latent factors A (genetic factor), C (shared environmental factor), and E (non-shared environmental factor) are presented in circles. r_g = genetic correlation; r_c = shared environmental correlation; r_e = non-shared environmental correlation. All the path estimates, standardized but unsquared, are obtained from the best-fitting model, with 95% confidence intervals (CIs) in brackets. A non-significant path is denoted by a dashed line

2 Method

2.1 Participants and Procedure

We recruited participants from the Beijing Twin Study (BeTwiSt), a twin registry in Beijing. Twins in the BeTwiSt are socio-demographically representative of their Beijing peers (Chen et al., 2013). For 88% of the same-sex twin pairs in the BeTwiSt, zygosity was assigned by DNA testing, with classification accuracy approximating 100%; for the remaining pairs, zygosity was determined by a combination of parent-reports and children's self-reports about co-twin physical similarities and frequency of confusion, with a predictive accuracy of 91% (Chen et al., 2013). We sent invitations to twins who had finished middle school by the time of testing, and received responses from 464 of them (response rate: 77%; sex: 265 women, 199 men; age in years: *Range* = 17–25, $M = 20.26$, $SD = 1.86$). The sample involved 117 monozygotic (MZ) pairs and 115 dizygotic (DZ; 68 same-sex, 47 opposite-sex) pairs.

We implemented power analyses via the package 'pwr' (Version 1.2.0) in R (Champely, 2018). As we gauged the relation between nostalgia and SWL on both phenotypic and etiologic levels, we conducted power analyses corresponding to the two levels respectively. On the phenotypic level, the current sample ($N = 464$) afforded power of a conventional level (80%) to detect a correlation of no less than 0.13 at $\alpha = 0.05$. On the etiologic level, given a sample size of $N = 232$ (the total number of twin pairs), $\alpha = 0.10$, $df = 1$ (estimating one effect each time), and power at 80%, we could detect genetic and environmental effects whose size was no less than 0.16. (cf. Luo et al., 2020).[1] Stated otherwise, if the standardized estimate of a path parameter in the genetic model (e.g., a_1 in Fig. 1) was no less than

[1] For power analyses of twin models, Verhulst (2017) recommended setting the Type I Error rate as .10 to address a complex situation involving multiple chi-square distributions with different *df*s. Such a solution is adequate for a 1 *df* test.

0.16, we would have sufficient power to examine the corresponding genetic or environmental effect.

Participants completed measures of nostalgia, neuroticism, and SWL (along with measures irrelevant to the objectives of this research[2]) on personal computers in private rooms. Measures were translated into Chinese, and then back-translated, by a committee of bilinguals (Brislin, 1980).

2.2 Measures

2.2.1 Nostalgia

We assessed nostalgia with the Southampton Nostalgia Scale (SNS; Sedikides et al., 2015; for validational information, see Wildschut & Sedikides, in press). The SNS consists of seven items. Three of them measure the degree to which participants find nostalgia important, significant, or valuable (1 = *not at all*, 7 = *very much*). The remaining four items measure the extent to which participants are prone to nostalgizing (e.g., 'How prone are you to feeling nostalgic'; 1 = *not at all*, 7 = *very much*) or the frequency of their nostalgizing (e.g., 'Generally speaking, how often do you bring to mind nostalgic experiences?'; 1 = *very rarely*, 7 = *very frequently*). We averaged responses to form a nostalgia score ($\alpha = 0.84$; $M = 4.53$, $SD = 1.18$).

2.2.2 Satisfaction with Life

We administered the 5-item Satisfaction with Life Scale (Diener et al., 1985). A sample item is: 'I am satisfied with my life' (1 = *strongly disagree*, 7 = *strongly agree*). We calculated a SWL score by averaging across responses ($\alpha = 0.86$, $M = 4.57$, $SD = 1.08$).

2.2.3 Neuroticism

We assessed neuroticism with 10 items from the 50-item International Personality Item Pool version of the Big Five Markers (Goldberg, 1992). A sample item is: 'I get stressed out easily' (1 = *strongly disagree*, 6 = *strongly agree*). We reverse-scored three items indicating emotional stability, and averaged scores to create a neuroticism score ($\alpha = 0.84$; $M = 3.46$, $SD = 0.76$).

2.3 Data Analysis

We examined the relation between nostalgia and SWL in three steps: zero-order correlations, hierarchical linear modelling (HLM), and genetic modelling. Participants were nested within twin pairs. This might introduce bias in many parametric analyses by violating the common assumption of independence. To control for this, we conducted HLM analyses. First, we regressed SWL on nostalgia, while controlling for sex (1 = *male*, 2 = *female*) and age (Table 1, Model 1). Then, to partial out the confounding effect of neuroticism, we

[2] The other measures pertained to gender-science stereotypes, racial attitudes, self-esteem, self-enhancement, emotion, essentialism, individualism and collectivism, and online behaviors.

Table 1 HLM analyses predicting satisfaction with life (SWL) from nostalgia while controlling for age, sex, and neuroticism

Predictor	*B* (*SE*)	95% CI	*df*	*t*	*p*	*r*
Model 1						
Age	0.00 (.03)	[– 0.06, 0.06]	227.83	0.14	0.887	0.009
Sex	0.05 (.11)	[– 0.16, 0.26]	403.54	0.44	0.662	0.022
Nostalgia	0.11 (.04)	[0.02, 0.19]	458.99	2.48	0.013	0.115
Model 2						
Age	0.00 (.03)	[– 0.06, 0.06]	226.68	0.01	0.992	0.001
Sex	0.13 (.10)	[– 0.07, 0.33]	398.36	1.28	0.203	0.064
Nostalgia	0.15 (.04)	[0.07, 0.23]	458.90	3.73	<0.001	0.172
Neuroticism	– 0.43 (0.06)	[– 0.56, – 0.30]	458.91	– 6.70	<0.001	– 0.299

B represents unstandardized regression coefficients, with standard errors (*SE*) in parentheses and 95% confidence intervals (CI) in brackets; *df*: degrees of freedom. Sex was coded as 1 = *male* and 2 = *female*

included neuroticism as another predictor variable (Table 1, Model 2). We implemented the analyses using the MIXED procedure in SPSS 26.0 (REML as estimation method, compound symmetry as covariance structure). This procedure estimates non-independence within dyads as a covariance (Kenny et al., 2006). We computed effect sizes in the metric of Pearson's *r* using the formula $r = \sqrt{t^2/(t^2 + df)}$.

Next, we delineate the procedure for genetic modelling. Twin siblings are identical on age, and approximately 80% of twin pairs were same-sex. If age and/or sex have some effect on a phenotype, similarity in age and sex may result in overestimation of the twin intraclass correlation, and thus should be controlled for (McGue & Bouchard, 1984). For these reasons, we regressed each of nostalgia and SWL on age and sex, and saved the standardized residuals for genetic analyses.

As mentioned above, neuroticism may confound the relation between nostalgia and SWL at the etiological level. Thus, we planned to run another set of genetic modelling with neuroticism being controlled for. Given that we had only moderate statistical power in assessing genetic and environmental effects (i.e., 80% power for detecting a medium effect; Gignac & Szodorai, 2016), we employed a bivariate genetic model so as to focus on the covariation between nostalgia and SWL. Hence, we regressed each of nostalgia and SWL on neuroticism, age, and sex, and saved the standardized residuals for genetic modelling.

The logic underlying genetic modelling relies on the comparison of similarity between MZ twins and DZ twins. MZ twins are 100% genetically identical, whereas DZ twins are on average 50% identical for additive genetic effects. A shared environment contributes to the similarity of twins growing up in the same family. A non-shared environment is unique to each individual (this component also includes measurement error). In the usual case where twins are reared together, greater resemblance between MZ twins than between DZ twins indicates that the trait is heritable.

The genetic modelling for nostalgia and SWL employed a correlated factors model based on the Cholesky decomposition (Loehlin, 1996). (We present the Cholesky decomposition for the full ACE model and the best-fitting sub-models in Fig. S1 of Supplementary Information.) In this model, each variable is separately decomposed into its additive genetic (A), shared environmental (C), and non-shared environmental (E) components at the same time that the correlations across these components are estimated (Fig. 1a). The

additive genetic correlation indexes the extent to which additive genetic influences on nostalgia and SWL overlap. Their overlap in either shared or non-shared environmental influences is indicated by shared or non-shared environmental correlation, respectively. We examined the full ACE model first, and then tested sub-models (AE, CE, and E models) nested within the full model by removing systematically one or two component(s) of variance. We applied this series of models to the measured variables, respectively, before and after neuroticism being controlled for.

We used the change in chi-square (χ^2) and the Akaike Information Criterion (AIC; Akaike, 1987) as model-fitting indices. A lower AIC value indicates better fit. Comparing the full model and a sub-model, a significant chi-square difference suggests that the nested model fits significantly worse than the full model, and thus the full model should be chosen; otherwise, the nested model with fewer parameters should be considered in terms of the parsimony principle (Kline, 1998). We carried out genetic modelling using R version 4.0.0 (R Core Team, 2020) and the OpenMx package (Boker et al., 2012).

3 Results

3.1 Zero-Order Correlations

Nostalgia was positively and significantly related to SWL ($r = 0.10$, $p = 0.032$). In contrast, neuroticism was negatively related to SWL ($r = –0.28$, $p < 0.001$). Neuroticism and nostalgia were positively related ($r = 0.17$, $p < 0.001$).

3.2 Hierarchical Linear Modelling

In line with the zero-order correlation, nostalgia was a positive predictor of SWL (Table 1, Model 1). Moreover, the relation between nostalgia and SWL increased when neuroticism, a negative predictor of SWL, was statistically controlled (Table 1, Model 2). We tested whether this increase was statistically significant by using MLmed, a computational macro for multilevel mediational analysis in SPSS (Hayes & Rockwood, 2020). The absolute change in the relation between nostalgia and SWL when controlling for neuroticism is mathematically equivalent to the indirect or mediated 'effect' of nostalgia on SWL via neuroticism. The analysis revealed that this indirect 'effect', or to say, the change in the relation between nostalgia and SWL, was significant ($B = – 0.05$, $SE = 0.02$, $Z = – 2.39$, $p = 0.017$, 95% CI based on 10,000 Monte Carlo samples = [– 0.09, – 0.01]). To summarize, results indicated a positive relation between nostalgia and SWL, which was significantly strengthened when neuroticism was partialled out.

3.3 Genetic Modelling

We sought to ascertain the genetic and environmental architecture underlying the relation between nostalgia and SWL. We carried out two sets of genetic analyses. For the first set, to control for similarity in age and sex between twin siblings, we regressed nostalgia and SWL each on age and sex, and saved the standardized residuals for further analyses. For the second set, we further ruled out confounding influences from neuroticism to the potential genetic or environmental overlap between nostalgia and SWL, by regressing each variable on age, sex, and neuroticism. As before, we saved standardized residuals for

Table 2 Twin Intraclass Correlations

	MZ	DZ
Nostalgia[a]	0.46 [0.22, 0.62]	0.29 [– 0.02, 0.51]
SWL[a]	0.43 [0.18, 0.60]	0.40 [0.13, 0.58]
Nostalgia[b]	0.46 [0.22, 0.63]	0.30 [– 0.01, 0.52]
SWL[b]	0.41 [0.15, 0.59]	0.34 [0.04, 0.54]

SWL = Satisfaction with Life. DZ = dizygotic twins; MZ = monozygotic twins. 95% CIs are presented in brackets

[a]Age and sex were partialled out from nostalgia and SWL scores

[b]Age, sex, and neuroticism were partialled out from nostalgia and SWL scores

twin-correlation estimation and genetic modelling. For both nostalgia and SWL, identical twin correlations were greater than fraternal twin correlations, suggesting genetic influence (Table 2). This pattern upheld regardless of whether neuroticism was controlled for.

As a complement, we performed univariate genetic modelling to replicate previous findings about genetic and environmental effects on nostalgia and SWL each. For nostalgia, similar to a previous finding (Luo et al., 2016), our results showed considerable genetic and non-shared environmental effects but trivial shared environmental effects. Controlling for neuroticism introduced little variation to the estimates (Table S1, Supplementary Information). For SWL, we found modest genetic and shared-environmental effects but substantial non-shared environmental effects (Table S1, Supplementary Information). The estimate for genetic effect increased, whereas that for shared-environmental effect decreased, when neuroticism was partialled out. These results were consistent with previous findings (Bartels, 2015; Hahn et al., 2013). Notably, we conducted post-hoc power analysis following Verhulst's (2017) formula, which is implemented through an online tool (https://shiny.cnsgenomics.com/TwinPower/). Results showed that the achieved power was much lower than desirable levels (10%–33%) for detecting either genetic or shared-environmental effects on nostalgia and SWL each.

Next, we used a correlated factors model to analyze genetic and environmental effects on nostalgia and SWL concurrently. We tested the full ACE model first. The model fit the data well, as evidenced by its model fit being comparable to that of a saturated model (which estimated only the means, variances, and covariance for all the variables): (1) neuroticism not partialled out, $\chi^2(5) = 8.58$, $p = 0.13$; (2) neuroticism partialled out, $\chi^2(5) = 9.00$, $p = 0.11$. According to the full ACE model, neither the genetic effects nor the shared environmental effects on nostalgia and SWL were correlated (Table 3). This held true regardless of whether neuroticism was controlled for. The non-shared environmental effects on nostalgia and SWL overlapped marginally, when neuroticism was not partialled out (Table 3). When neuroticism was partialled out, the non-shared environmental correlation between nostalgia and SWL was significant and larger.

As previous findings have shown that shared environmental influence is small for both nostalgia and SWL (Luo et al., 2016, 2020), we excluded shared environmental components and tested the AE model (Table 4). We also tested the CE and E models, for comparison purposes. Relative to the full model, the AE model fit the data equally well and had the lowest AIC value. Hence, the AE model was optimal. This was the case for analyses using variables both with and without neuroticism being controlled for. When neuroticism was not adjusted, according to the best-fitting AE model, neither the genetic nor the non-shared environmental correlation between nostalgia and SWL was significant (Fig. 1b).

Table 3 Estimates for Genetic and Environmental Effects in the Full ACE Model

	Additive genes	Shared environments	Non-shared environments
Path			
Nostalgia[a]	0.52 [0.00, 0.66]	0.14 [0.00, 0.56]	0.84 [0.75, 0.94]
SWL[a]	0.38 [0.00, 0.67]	0.38 [0.00, 0.60]	0.84 [0.74, 0.93]
r^a	0.08 [– 1.00, 1.00]	– 0.36 [– 1.00, 1.00]	0.15 [– 0.02, 0.32]
Nostalgia[b]	0.52 [0.00, 0.67]	0.15 [0.00, 0.56]	0.84 [0.74, 0.94]
SWL[b]	0.44 [0.00, 0.66]	0.28 [0.00, 0.57]	0.85 [0.75, 0.95]
r^b	0.05 [– 1.00, 1.00]	– 0.11 [– 1.00, 1.00]	0.21 [0.04, 0.37]
Proportion			
Nostalgia[a]	0.27 [0.00, 0.44]	0.02 [0.00, 0.31]	0.70 [0.56, 0.89]
SWL[a]	0.14 [0.00, 0.45]	0.15 [0.00, 0.36]	0.71 [0.55, 0.87]
Nostalgia[b]	0.27 [0.00, 0.45]	0.02 [0.00, 0.32]	0.70 [0.55, 0.89]
SWL[b]	0.19 [0.00, 0.43]	0.08 [0.00, 0.33]	0.73 [0.57, 0.90]

SWL = Satisfaction with Life. A path estimate squared equals the corresponding proportion of genetic or environmental effect. All estimates are standardized, with 95% CIs in brackets

[a]Age and sex were partialled out from nostalgia and SWL scores

[b]Age, sex, and neuroticism were partialled out from nostalgia and SWL scores

Table 4 Genetic Model-Fitting Statistics

Model	– 2LL	*df*	AIC	Change from Full Model		
				$\Delta\chi^2$	Δdf	*p*
Nostalgia and SWL Adjusted for Age and Sex						
ACE	2593.47	917	759.47			
AE	2594.16	920	754.16	0.69	3	0.88
CE	2595.06	920	755.06	1.59	3	0.66
E	2622.55	923	776.55	29.07	6	< 0.001
Nostalgia and SWL Adjusted for Age, Sex, and Neuroticism						
ACE	2586.75	917	752.75			
AE	2586.94	920	746.94	0.19	3	0.98
CE	2588.71	920	748.71	1.96	3	0.58
E	2613.04	923	767.04	26.28	6	< 0.001

SWL = SWL = Satisfaction with Life. -2LL = twice the negative log-likelihood; AIC = Akaike's Information Criterion; $\Delta\chi^2$ = change in chi-square; Δdf = change in degrees of freedom (*df*); A = genetic factor; C = shared environmental factor; E = non-shared environmental factor. E, CE, and AE models are nested within the ACE model. The best-fitting model is underlined

However, when neuroticism was controlled for, the AE model identified a significant non-shared environmental correlation (0.21), but still a non-significant genetic correlation (0.07), between nostalgia and SWL (Fig. 1c). Based on these coefficients and the formula $e_1 \times r_e \times e_2 / (a_1 \times r_g \times a_2 + e_1 \times r_e \times e_2)$, we further estimated that non-shared environments accounted for 88% of the phenotypic correlation between nostalgia and SWL. The remaining 12% of the phenotypic correlation was explained by genetic factors, as estimated by

$a_1 \times r_a \times a_2 / (a_1 \times r_g \times a_2 + e_1 \times r_e \times e_2)$. However, given that the genetic correlation was not significant, the genetic contribution to the phenotypic correlation should be regarded as null.

4 Discussion

We investigated the relation between trait nostalgia and SWL at two levels, phenotypic and etiologic. At the phenotypic level, nostalgia and SWL were positively associated, and this association became significantly stronger after we controlled for neuroticism. At the etiologic level, non-shared environmental influences on nostalgia and SWL overlapped modestly and marginally. This environmental overlap became significant and larger when neuroticism was partialled out. Consistent with our reasoning, these findings indicate that (1) nostalgia and SWL are associated at both phenotypic and etiologic levels, and (2) neuroticism obscures this association.

4.1 Implications

First, we identified a positive connection between nostalgia and SWL, which reinforces previous findings (Baldwin et al., 2015; Newman et al., 2019). The relation between nostalgia and SWL was numerically small, even after partialling out neuroticism ($r = 0.17$). This effect size, however, was close to the average effect size ($r = 0.19$) of personality studies (Gignac & Szodorai, 2016). In addition, this effect size was no less or even larger than the average effect size ($d = 0.22$, equivalent to $r = 0.11$) of experimentally induced nostalgia on well-being (e.g., positive affect; Frankenbach et al., 2021). Moreover, although small effects may be inconsequential on a single occasion, their influence tends to cumulate and become consequential over a relatively short time period (e.g., one month), and such accumulation of small effects over time is especially evident for stable traits, such as nostalgia and SWL in our case (Funder & Ozer, 2019; Götz et al., 2022).

We also demonstrated that the naturalistic connection between nostalgia and SWL is overshadowed by neuroticism. Nevertheless, a recent meta-analysis illustrated that the psychological benefits of momentarily-induced nostalgia are unmoderated by neuroticism (Frankenbach et al., 2021). The discrepancies between these findings and ours may be due to the different time scales used. The meta-analytic findings pertained to fleeting effects of nostalgia, whereas our findings pertained to its long-term influence. It follows that researchers would do well to control for neuroticism when examining how nostalgia contributes to subjective well-being in the long run (i.e., weeks, months, or years; Wildschut & Sedikides, in press), but such adjustment may not be necessary when testing the effect of nostalgia in the short run (i.e., within minutes or hours).

More importantly, we uncovered the etiologic bases underlying the phenotypic association between nostalgia and SWL. That is, some environmental conditions that are unique to each individual contribute to nostalgia and SWL in the same direction. A possible candidate is romantic relationships. As an environment not shared by even identical twins, a good romantic relationship can promote social emotions (e.g., nostalgia) and well-being (e.g., SWL) simultaneously, whereas a bad one can deter both. Future twin studies can test the role of romantic relationships in shaping the connection between nostalgia and well-being. For example, can the quality of romantic relationships moderate the non-shared environmental (and/or genetic) overlap between nostalgia and SWL?

Furthermore, although both nostalgia and SWL were evidently heritable, we found that their association was mainly shaped by environments rather than genes (88% vs. 12%). This contrasts with the relation between nostalgia and self-enhancement, which is predominantly shaped by genes (90%; Luo et al., 2016). Such difference can only be observed on the etiologic level but not on the phenotypic level, as the phenotypic correlation between nostalgia and SWL ($r = 0.17$) and that between nostalgia and self-enhancement ($r = 0.16$–0.18) were of similar effect size. Put together, these findings suggest that different etiologic mechanisms underlie the relations between nostalgia and different psychological constructs, although the strength of these relations may be similar at the phenotypic level. Thus, to improve understanding of nostalgia and its psychological correlates, etiological studies are necessary.

Our sample consisted of younger persons (age: *Range* = 17–25, $M = 20.26$). Nostalgia is common among both younger and older persons (Hepper et al., 2021; Madoglou et al., 2017; Sedikides et al., 2015). A previous study reported a positive association between nostalgia and subjective well-being in a sample of adults that were older than those in our sample ($M_{age} = 37$ years; Baldwin et al., 2015, Study 7). Then, the positive link between nostalgia and subjective well-being may uphold across ages, although more evidence is needed. However, the stability at phenotypic levels cannot inform whether the underlying environmental or genetic overlap also remains stable across ages. This presents an interesting question for follow-up studies.

4.2 Limitations and Future Research

The methodological or statistical implication of partitioning an already small correlation into separate genetic, shared environmental, and non-shared environmental components is that tests of each component are likely underpowered. Indeed, our study did not have sufficient power to detect both genetic and shared-environmental correlations between nostalgia and SWL (0.05/–0.11—lower than the threshold of 0.16), although we had sufficient power to detect the non-shared environmental correlation (0.21). We were also short of power to test reliably either genetic or shared-environmental effect on nostalgia and SWL each. Therefore, our findings concerning genetic and shared-environmental influences are preliminary. Replication studies with much larger sample sizes that provide desirable statistical power are warranted.

Researchers may also gain by exploring alternative SWL measures as a complementary strategy for increasing power. Ancillary analyses revealed that nostalgia was significantly and positively related to all items of the Satisfaction with Life Scale, except one (i.e., 'If I could live my life over, I would change almost nothing'; see Supplementary Information). This item may partly account for the modest phenotypic correlation between nostalgia and SWL. The item had the lowest factor loading and item-total correlation in the original scale development process (Diener et al., 1985). Also, the item captures the absence of regret in addition to life satisfaction, whereas nostalgia can entail regret (Gilovich et al., 1998; Hepper et al., 2012). Thus, the relation between nostalgia and this particular item was null. By using other and sound SWL measures, researchers may find a stronger phenotypic relation with nostalgia, which would create suitable conditions for conceptually replicating the demonstrated role of non-shared environmental sources. A stronger phenotypic relation, and the attendant increase in statistical power, would additionally set the stage for re-examining potential overlap of shared environmental and genetic components.

Another limitation of our research concerns the conceptualization of SWL. We treated SWL as a separate component of subjective well-being, which includes two other components—positive and negative affect. However, recent research has indicated that the three parts of subjective well-being are not simply bundled together; instead, various possibilities exist to account for the tripartite structure of subjective well-being (Busseri & Sadava, 2011). Particularly, SWL as well as positive and negative affect, are constructs under the umbrella of a larger general factor. Therefore, to extend this line of research on nostalgia and subjective well-being, follow-up studies need to assess all three constructs, conceptualizing well-being as a synthesis of them (Busseri, 2015).

4.3 Conclusion

We obtained a small positive relation between nostalgia and SWL, a relation that strengthened after we partialled out neuroticism. Moreover, we showed that nostalgia and SWL shared some environmental sources, which accounted for most of their phenotypic correlation. The findings add to the burgeoning literature on nostalgia and well-being.

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Author's Contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by YLLL. The first draft of the manuscript was written by YLLL and CS, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data Availability The data used for analyses can be found at https://osf.io/nb2fe/.

Declarations

Conflict of interests The authors have no competing interests to declare that are relevant to the content of this article.

Ethical Approval This study was part of a research program titled 'A Twin Study of the Self' (Protocol Number: PH13009), and was reviewed and approved by the Ethics Committee of Institute of Psychology, Chinese Academy of Sciences.

Informed Consent All participants or their parents provided written consent prior to the study.

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