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Article

# Unfolding Nostalgia: Spatial Visualization, Nostalgia and Wellbeing

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## Abstract

Research has shown that nostalgia can have psychological benefits, for example, by recreating comforting memories from the past. These memories often unfold in mental space, where one recreates events, people, objects, etc. Therefore, individual differences in nostalgic experience may relate with ability to process spatial information. The aim of the current study was to investigate the links among spatial ability, imagery, nostalgia and wellbeing. 521 participants (Mage 27.7 years; SD = 12.14; 400 women) had completed the following measures: Well-Being Inventory (WHO5), Neuroticism scale from BFI-2-S, Generalized Anxiety Disorder Inventory (GAD7), Southampton Nostalgia Proneness test, Nostalgia content test and Paper folding – a spatial visualization test (SV). SV did not correlate with nostalgia proneness. However, when only spatially-related items were selected from Nostalgia content questionnaire, “Spatial Nostalgia Score” was positively linked with SV and nostalgia proneness. This measure also positively linked with wellbeing after controlling for anxiety (but not neuroticism). The current study provided new insights into the links between nostalgia and wellbeing by incorporating spatial visualisation as an important element of nostalgia. Taken together the results suggest that individual differences in SV may be linked to spatial aspects of nostalgic experiences. The study identified directions for further measurement development and future experimental studies.

**Keywords:** Nostalgia proneness; spatial visualisation; wellbeing; anxiety; neuroticism

## 1. Introduction

Nostalgia is defined as an emotionally charged experience and is linked with temporal retrospect - with memories and past events (Batcho, 2013). Nostalgia is often associated with past time, with most research in nostalgia concerning memories of past events (see some discussion in (Wilson, 2015)). However, nostalgia also unfolds in space - even the origin of the term “nostalgia” is related to homesickness (Greek nostos – homecoming, and algos – sadness) and was first used to describe the anxieties shown by Swiss mercenaries fighting far from home (Fuentenebro De Diego & Valiente Ots, 2014). Recent research also suggests a paradoxical link between nostalgia and wellbeing. On the one hand, it can have positive effects on wellbeing via improving of emotional regulation, empowering feelings of connection and protecting against feeling of loneliness by recreating some comforting memories from the past (Sedikides & Wildschut, 2019; Van Tilburg et al., 2019). On the other hand, nostalgia is weakly and positively correlated with neuroticism and anxiety (Dai et al., 2024; Seehusen et al., 2013; Tullett et al., 2015). The current study investigates the links among nostalgia experiences, spatial cognition and wellbeing.

### 1.1. Nostalgia and Space

Nostalgia is often spatial in nature, with memories of the past directly linked to particular spatial locations and involving spatial visualization. It is possible that different people are more prone to spatial vs. other types (e.g., verbal) of nostalgizing. Indeed, previous research suggested that triggers and contents of nostalgia might be either qualitatively (e.g., different sensory triggers “activating” nostalgia) or quantitatively different (e.g., same triggers being more or less important for some people but not for other) for different clusters of people (e.g., (Hepper et al., 2014)). Research assessing the content of nostalgic memories ((Batcho, 1995) (Hepper et al., 2014; Wildschut et al., 2006)) showed that home and other important places were frequent content of nostalgia, alongside past friends, toys, and loved ones. Moreover, participants, on average, evaluate the world in the past “as a better place” compared to the present and future.

Neuroscientific research shows that nostalgia activates multiple brain regions, including areas associated with self-reflection (medial prefrontal cortex, posterior cingulate cortex, and precuneus), emotion regulation (anterior cingulate cortex and medial prefrontal cortex) and reward processing (striatum, substantia nigra, ventral tegmental area, and ventromedial prefrontal cortex) (see (Yang et al., 2022) or review (Yang et al., 2023)). In addition, these studies showed that nostalgia is linked with hippocampus, medial prefrontal cortex, posterior cingulate cortex, and precuneus, areas associated with autobiographical/episodic memory (Maguire et al., 2000) (Gilboa, 2004). In turn, this type of memory is related to personal experience for events in a spatio-temporal context (Tulving, 1983).

In particular, the involvement of hippocampus in nostalgia may explain why place and time is intertwined in nostalgia. Research converges on the crucial role of hippocampus (and its different parts) in spatial and topographic memory (Abrahams et al., 1999; Maguire et al., 1996, 1998; Maguire & Mummery, 1999; Spiers et al., 2001; Vargha-Khadem et al., 1997) (O’Keefe & Nadel, 1978). Both behavioral and neurological data converge on a shared basis of spatial and episodic memories, with spatial context acting as a scaffolding structure for individual past events (Robin, 2018). In addition, hippocampus plays a role in encoding emotional memories (Robin et al., 2018) and encodes temporal information (coming to them from the frontal lobes), serving as a timestamp for when the individual visited this location. For example, one recent study has linked an entorhinal cortex – a part of hippocampus which is a key area in spatial orientation and navigation (Fyhn et al., 2004; Hafting et al., 2005; Sargolini et al., 2006), to time perception (Tsao et al., 2018). Tsao et al., suggested that representation of time divided into episodes is integrated with spatial information recorded in the middle entorhinal cortex in the hippocampus, which allows the hippocampus to store a single representation of what, where, and when. Consistent with this, research has shown that impairments in both spatial and episodic memory are often the first symptoms of Alzheimer’s disease (e.g., (Kolb & Whishaw, 1996)).

Further, Rubin and colleagues have outlined a *multiple-systems model* of autobiographical memory in which autobiographical memories consist of a number of components that are behaviorally and neuropsychologically distinct, including sensory imagery, emotion, and narrative coherence (Rubin, 2006) – similarly to nostalgic experience that also includes such components (e.g. (Yang et al., 2023)).

In particular, research suggests that visual imagery has a fundamental role for autobiographical memory (Greenberg & Knowlton, 2014), distinguishing two types of imagery: visual-object imagery - visualizing pictorial appearances of objects and scenes in terms of their shape, color, brightness, and texture; and visual-spatial imagery - visualizing spatial relations and movements of objects and their parts, and spatial transformations (Blajenkova et al., 2006). These two types of imagery correlate to a degree and have a partially overlapping neural network composed of occipitotemporal (ventral “visual-object” pathway) and occipitoparietal (dorsal “visual-spatial” pathway) regions and also by a set of frontal regions (related to memory) ((Mazard et al., 2004) (Blazhenkova, 2016; Blazhenkova et al., 2025) (Kozhevnikov et al., 2005)).

### 1.2. *Nostalgia and Individual Differences in Spatial Ability*

Since space is so fundamental to nostalgia, it is possible that individual differences in spatial ability are linked to individual differences in nostalgic experiences. Spatial ability (or spatial abilities; see some discussion on spatial ability structure (M. Likhanov et al., 2022; Lohman, 1979; Uttal et al., 2013)) is an ability to process information about place and space (Lohman, 1996). In particular, people with greater spatial abilities might have better visual imagery, more detailed episodic/autobiographical memory (see reviews; (Burgess et al., 2002; Moscovitch et al., 2006; Stella et al., 2012)), and therefore have more proneness to experience nostalgia and/or more vivid nostalgic experience. Indeed, previous research showed that details of a memory unravel in space (Maguire et al., 2016) and that richer spatial context at encoding may lead to more vivid, long-lasting recall (Chang et al., 2024). It is also possible, that people with higher spatial ability will benefit more from nostalgia experiences (in terms of wellbeing gains or reductions in anxiety; (Frankenbach et al., 2021; Leunissen et al., 2021); Authors, in review).

In this context, a parallel can also be drawn with the mechanisms proposed to explain the link between individual differences in mathematical and spatial abilities. One of the potential causes of this link is that spatial visualization could act as the “mental blackboard” on which calculations take place (“mental simulation”) (Hawes & Ansari, 2020; M. Likhanov, Wang, et al., 2024). It is possible that spatial abilities act as the same mental space “in which” nostalgic experiences unfold.

### 1.3. *Nostalgia and Wellbeing*

Research has shown that nostalgia is positively correlated with subjective well-being (Luo et al., 2019) and this relationship with well-being is strengthened once neuroticism was controlled for. The same study also demonstrated that individuals carrying the short allele of the 5-HTTLPR gene, which is associated with heightened sensitivity to negative experiences, exhibited greater nostalgia proneness, with neuroticism mediating this relationship. Therefore, the positive effects of nostalgia on wellbeing could be masked by greater frequency of nostalgiazing in people with higher neuroticism. Consistent with this, a recent meta-analysis, which encompassed data from 2,556 participants, found that individuals with both high and low levels of neuroticism are similarly likely to experience psychological benefits from engaging in nostalgic reverie (Frankenbach et al., 2021).

In contrast, some research indicated that individuals with a habitual tendency to worry may experience heightened anxiety and depression when engaging in nostalgic reminiscence, potentially leading to rumination and distress (Verplanken, 2012). In addition, research has shown that nostalgia can have negative consequences for wellbeing in displaced populations, probably because it undermines optimism for the future ((Agha, 2019)(Wildschut et al., 2019)). It remains unclear whether neuroticism can indeed interfere with certain psychological benefits derived from nostalgia.

### 1.4. *The Current Study*

The current study is the first to investigate the link between spatial ability (spatial visualization) and nostalgia experiences from individual differences perspective. The three main aims are: 1) to identify nostalgia types according to predominant nostalgia triggers and content (spatial vs. other); 2) to investigate whether higher spatial ability is associated with greater nostalgia and wellbeing; and 3) to investigate nostalgia-wellbeing link: whether neuroticism and anxiety may modulate the positive effects of nostalgia on wellbeing.

In order to investigate this, we used a new instrument that aimed to tap into content of nostalgia experiences (visual images, tastes, scents, etc.); triggers of nostalgia (specific places, tastes, sounds, images, or sadness) and presence of other people (friends, family, etc.; see more information in (Alenina et al., 2023).

We then conducted Latent Class Analysis (Slominski et al., 2024), that allows to infer profiles from categorical/nominative data (see a growing body of research in the area of motivation; e.g., (Fieve et al., 2025)), to investigate whether there are any groups of participants that share similar

nostalgia experiences. For example, whether a spatial visualization class could be inferred that is different from other specific sensory class (auditory or odor based; e.g., (Reid et al., 2015)) or classes in which nostalgia is triggered by meetings with friends or just feeling sad (Sedikides & Wildschut, 2022; Wildschut et al., 2006).

After that, we investigated whether these profiles could be used to predict spatial visualization ability (measured with a Paper folding test; (Rimfeld et al., 2017)) and nostalgia proneness. Our expectation was that participants that endorse a particular class could demonstrate higher or lower spatial ability, nostalgia proneness and wellbeing.

In addition, we selected all items that concerned spaces, places or images from Nostalgia content questionnaire and created a new "Spatial nostalgia scale" by summing up these items. We then performed correlational analysis, with and without controlling for neuroticism and anxiety (see e.g., (Luo et al., 2019)), to see whether people who are "spatially-oriented" are more prone to nostalgia, have higher spatial ability and wellbeing; and lower anxiety.

## 2. Materials and Methods

### 2.1. Participants

521 participants (mean age 27.7 years; standard deviation 12.14 years; 400 women) took part in the study. Participants (mostly students) were recruited via Saint Petersburg State University research participation scheme and social networks advertising.

### 2.2. Procedure

Participants used their individual laptops and smartphones to complete 6 psychological measures as a part of a larger online data collection.

The study was approved by Ethics Committee of Saint Petersburg State University (Date: 06.07.2023 and number of approval: 24), and informed consent was obtained through an information sheet and signed consent form from all participants.

### 2.3. Measures

#### 2.3.1. Nostalgia content questionnaire

The measure was developed by authors based on Vividness of visual experiences scale (Marks, 1973) and previous research into triggers and content of nostalgia (Sedikides & Wildschut, 2022; Wildschut et al., 2006). The 13 questions covered triggers of nostalgia (e.g., specific places, tastes, sounds, images or sadness; content (e.g., people, objects, places, etc.) and vividness of experience (colors, modalities, etc.). Most of the items of the questionnaire were binary, i.e., participants were to answer Yes or No. Example item: "I usually experience nostalgic memories when I smell something from the past". Full list of items is available in Table 1. The validation information is available in (Alenina et al., 2023).

**Table 1.** Nostalgia content questionnaire.

No	Question	Response Options	Coding in SNS*
Nost 2	The last time I indulged in nostalgic memories	a – never / a long time ago b – a month ago c – a week ago d – a couple of days ago e – today	
Nost_3	<b>The objects in my nostalgic memories usually...</b>	<b>a – Cannot be clearly described</b>	<b>0</b> <b>1</b>

		<b>b – Have some form and shape</b>	<b>2</b>
		<b>c – Have a clear form and shape</b>	
		a – Black and white	
		b – Colored	
Nost_4	The surrounding environment in my nostalgic memories is usually...	If you selected this option, the question Nost4_2 will be presented	
		a – Warm colors	
		b – Cold colors	
Nost_4_2	The colors in my nostalgic memories are...	c – As they were in reality	
		d – Vary from time to time	
		a – I smell something from the past	
		b – I hear sounds that remind me of the past	
		<b>c – I see familiar images</b>	<b>1</b>
Nost_5	I usually experience nostalgic memories when... (choose all that apply)	d – I feel special touches from the past	
		e – I taste something that triggers memories	
		f – I feel sad	
		<b>g – I return to places tied to memories</b>	<b>1</b>
		a – Smell something (e.g., baked goods)	
		b – Hear something (e.g., a voice)	
Nost_6	<b>Most often during nostalgic memories, I... (choose all that apply)</b>	<b>c – Imagine only visual images</b>	<b>1</b>
		d – Feel touch (e.g., a person, breeze)	
		e – Other (please specify)	
Nost_7	<b>In my nostalgic memories, I return...</b>	<b>a – Mostly to the same place</b>	<b>1</b>
		<b>b – Mostly to different places</b>	<b>2</b>
Nost_8	In my nostalgic memories, I am usually...	a – Alone	
		b – With someone else	
	For those who selected 'with someone else' in Nost_8	a – Family members	
		b – Friends	
Nost_8_2	The people usually present in my nostalgic memories are... (choose all that apply)	c – Neighbors	
		d – Stranger	
		e – Pets	
		f – Other (please specify)	
		<b>a – Move around dynamically (e.g., inside a house)</b>	<b>1</b>
		<b>b – Move objects in space</b>	<b>1</b>
Nost_9	<b>In my nostalgic memories, I...</b>	c – Mostly observe passively without moving	
		<b>d – The space or objects move around me</b>	<b>1</b>
Nost_10		a – Alone	

	I most often engage in nostalgic memories...	b – In conversation with someone	
		a – Speak words (out loud or to myself)	
Nost_11	<b>In my nostalgic memories, I usually...</b>	<b>b – Visualize something without speaking</b>	<b>1/0</b>
<hr/> Note: *the formula for calculating Spatial Nostalgia Score (SNS) was as follows: Nost_3 +Nost5c+ Nost7 + Nost_9a+Nost_9b+Nost_9d+ Nost_11b; questions and response options included in the SNS are in bold <hr/>			

In addition, the following 5 established measures were used: Short Well-Being Inventory (WHO5), Big Five Inventory (BFI), Generalized Anxiety Disorder Inventory (GAD7), Nostalgia Proneness Questionnaire and the Spatial Visualization Ability Test: Paper Folding.

### 2.3.2. Proneness to Nostalgia

The 7-item questionnaire (Routledge et al., 2008) is designed to measure participants' proneness to nostalgic experiences of the past and the value of these nostalgic experiences. The participants are instructed to rate the items on a scale from 1 ('never') to 7 ('very often'). Example item: 'How often do you experience feelings of nostalgia?'. The questionnaire was adapted to Russian (Authors, in preparation) and demonstrated good validity (Chronbach's Alpha = .90).

### 2.3.3. Neuroticism Scale from Big Five Inventory

Big Five Inventory (BFI (John et al., 2008)) assesses the following personality traits: extraversion, neuroticism, openness to experience, helpfulness and conscientiousness. Russian adaptation the short second version of BFI (BFI-2-S) was used (Mishkevich et al., 2022). The questionnaire consists of 30 questions. Participants are asked to select the most appropriate statement by marking their level of agreement on a scale from 1 (strongly disagree) to 5 (strongly agree). Only questions related to neuroticism scale were used in the current study. Example item: 'I can be tense' (neuroticism). The scale demonstrated high internal consistency in previous research in Russian samples, as evidenced by high test-retest reliability and Cronbach's alpha of above .65 (Mishkevich et al., 2022).

### 2.3.4. Generalized Anxiety Disorder (GAD7)

GAD-7 (Spitzer et al., 2006) is a seven-item self-report instrument designed to assess the presence of GAD symptoms. Participants are instructed to evaluate the extent to which the following items have reflected their experiences over the past two weeks, responding to the prompt: "How often were you bothered by the following problems in the last two weeks?". Example items include 'Feeling nervous, anxious, or on edge' and 'Trouble relaxing'. Responses are scored on a scale from 0 ("not at all") to 3 ("almost every day"). The sum of all items was used as a total score. The GAD-7 has demonstrated high internal consistency (.85). We used Russian adaptation of this instrument, which showed high internal consistency (.85) in a large sample of adolescents (M. Likhanov, Alenina, et al., 2024).

### 2.3.5. Wellbeing - WHO5

The 5-item World Health Organization Well-Being Index (WHO-5) is a short scale measuring subjective wellbeing (Bech et al., 1996). The WHO-5 items are: (1) 'I have felt cheerful and in good spirits', (2) 'I have felt calm and relaxed', (3) 'I have felt active and vigorous', (4) 'I woke up feeling fresh and rested' and (5) 'My daily life has been filled with things that interest me'. Participants rated how well each of the 5 statements applies to them when considering the past two weeks. Each of the 5 items is scored from 5 (all of the time) to 0 (none of the time). The raw score therefore theoretically ranges from 0 (absence of well-being) to 25 (maximal well-being). The questionnaire demonstrated high validity in the current sample as evidenced by Cronbach's alpha of 0.86.

### 2.3.6. Spatial Visualization Ability Test - Paper Folding

This test aimed to assess spatial ability (Ekstrom et al., 1976). In each trial participants saw a screen where a piece of 2D square paper was folded and a hole was punched at the locations indicated by an arrow. Participants needed to select one of the 4 options, which corresponded to the unfolded paper sheet. The task featured 15 items with 20 sec time limit for each item. The task was adapted from (Rimfeld et al., 2017) and showed high validity in previous studies in Russian samples, with Split-half reliability equal to .85 (M. V. Likhanov et al., 2018).

### 2.4. Statistical Approach

Outliers were deleted using the interquartile range (IQR), i.e., [25th percentile] -  $1.5 \times$  IQR and [75th percentile] +  $1.5 \times$  IQR (McGill et al., 1978). The number of outliers was very small (less than 1%), with 2 outliers deleted from GAD-7 and 1 from Nostalgia proneness. Due to missing data, the number of participants varied for different traits, with Ns ranging from 440 (GAD7) to 474 (WHO5).

We employed Latent Class Analysis (LCA) to identify subgroups of respondents based on binary and categorical survey items. LCA is a clustering technique that groups individuals with similar response patterns, thereby modeling unobserved heterogeneity in the population (Slominski et al., 2024). This approach is especially appropriate for binary or categorical data, as LCA treats the observed survey responses as categorical indicators of latent classes (in contrast to latent profile analysis, which is used for continuous indicators; (Sinha et al., 2021). We fitted a series of LCA models using maximum-likelihood estimation and evaluated solutions with varying numbers of classes. The optimal number of latent classes was determined by comparing goodness-of-fit indices – including the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and sample-size adjusted BIC, as well as likelihood ratio tests (e.g., Vuong–Lo–Mendell–Rubin and bootstrap LRT). In line with recent recommendations (Slominski et al., 2024), when fit indices provided conflicting conclusions, we prioritized the model that offered interpretable and theoretically meaningful classes.

Four one-way ANOVAs were computed to assess the effect of nostalgia content profiles determined via LCA (IV) on 4 DVs: nostalgia proneness, wellbeing, GAD7 and spatial ability.

We conducted additional analysis focusing only on items indicating spatial content from Nostalgia content questionnaire, creating Spatial Nostalgia Score (SNS). Using Partial Spearman's rho (as SNS score was bimodal and violated normality assumption) correlations were investigated links between spatial content and nostalgia proneness, well-being, anxiety, and spatial ability.

## 3. Results

### 3.1. Descriptive Statistics

Descriptive statistics for nostalgia proneness, Neuroticism, WHO5, Paper folding and GAD7 are presented in Table 2.

**Table 2.** Descriptive Statistics.

	<b>BFI: Neuroticism</b>	<b>GAD 7</b>	Nostalgia proneness	WHO 5	Spatial ability
<b>Valid</b>	<b>473</b>	<b>440</b>	486	474	445
Mean	2.811	7.314	29.893	13.751	7.265
Std. Deviation	0.889	4.936	9.338	4.845	3.459
Skewness	0.120	0.980	-0.454	-0.178	0.280
Kurtosis	-0.749	0.417	-0.315	-0.562	-0.911
Minimum	1.000	1.000	1.920	2.000	1.000
Maximum	5.000	21.81 7	48.000	25.000	15.000

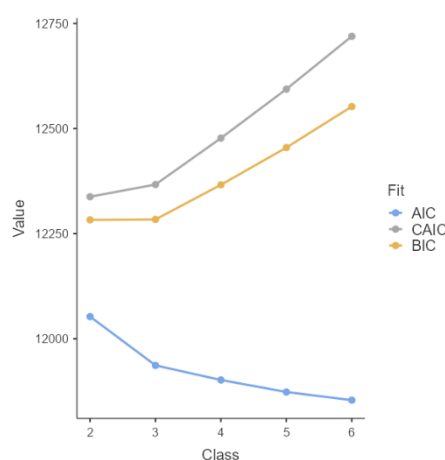
### 3.2. Nostalgia Content Profiles

Frequencies for each item of Nostalgia content questionnaire are presented in Table S1 in SOM. Some items demonstrated little variability. For example, Strangers were almost never present in nostalgic experiences (6.7 %); and nostalgic experiences were mostly colored (91.7%). Other items showed almost equal distributions for different options. For example, N% participants perceived sounds as triggers of nostalgia, whereas N% did not select this option.

#### 3.2.1. Latent Class Analysis

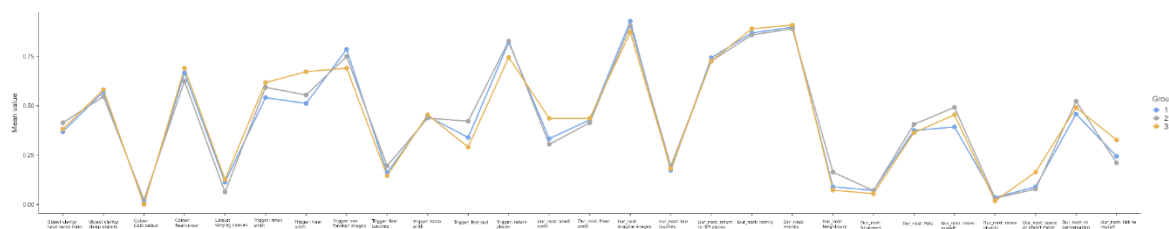
For Latent Class Analysis we excluded variable Nost\_4 ("The surrounding environment in my nostalgic memories is usually: black and white") and Nost\_8 ("In my nostalgic memories, I am usually with: someone else") because they partly overlapped in terms of content with adjacent variables (and were conditional on them) – variable Nost\_4\_2 ("The colors in my nostalgic memories are: warm") and Nost\_8\_2 ("The people usually present in my nostalgic memories are: family or friends"), respectively; which violated the analysis assumptions. We also excluded the first question from Nostalgia content questionnaire as it overlapped substantially with frequency of nostalgia experiences and correlated quite highly with nostalgia proneness questionnaire.

The elbow plot showed that the optimal number of classes is three, with increasing number of classes leading to the fit indices become better indefinitely (i.e., demonstrate overfit). See Figure 1.



**Figure 1.** Elbow plot for model selection. Note: Model with 3 classes demonstrated the following fit indices: log-likelihood = - 5885; AIC = 11937, CAIC =12367, BIC=12284; Entropy 0.769 and df = 400.

The resulting profile plot (See Figure 2) demonstrated no clear separation among the three classes in terms of nostalgia experiences. There were few small differences in mean scores among the three profiles for some items: “I usually experience nostalgic memories when: I hear sounds that remind me of the past”; “I taste something that triggers memories”; “Most often during nostalgic memories, I smell something (e.g., baked goods)”; “In my nostalgic memories: I move around dynamically (e.g., inside a house)” and “The space or objects move around me”). No “spatial” or other intuitively meaningful profile emerged.



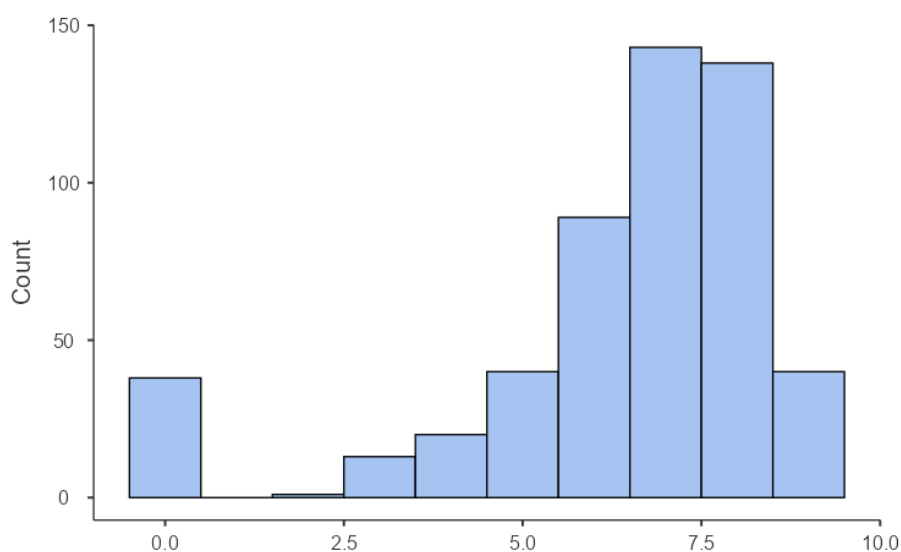
**Figure 2.** Latent profile analysis results. Note: dots on the graph illustrate the mean value of each item for a particular class.

### 3.2.2. Profile Effects on Anxiety, Wellbeing, Nostalgia Proneness and Spatial Ability

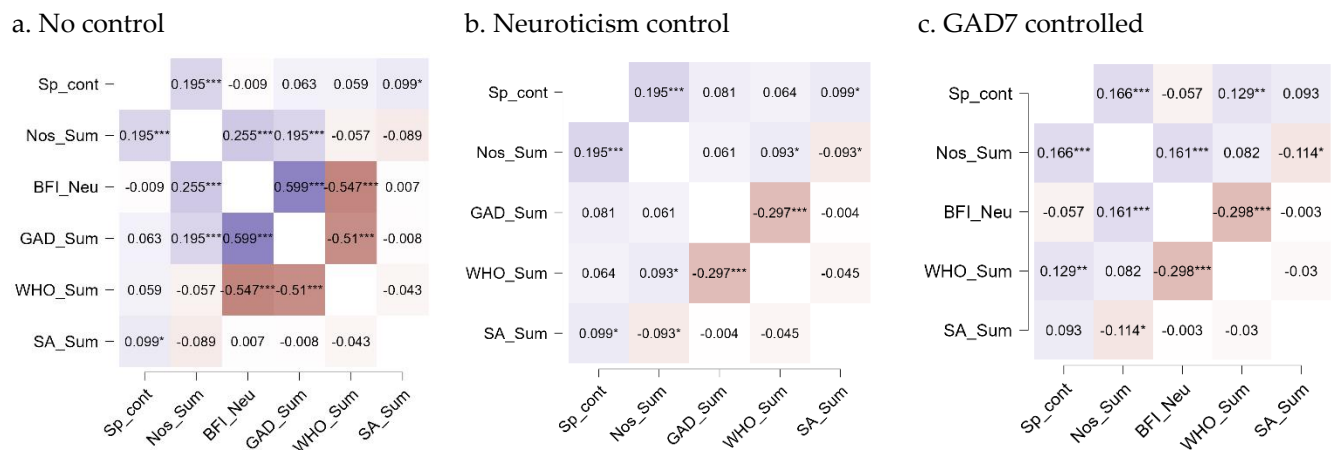
In order to test the differences between the three profiles in anxiety, WHO5 scores, nostalgia proneness or spatial ability, we run 4 one-way ANOVAs with profiles as IVs (see Table S2 in SOM). The results showed no group differences by profile ( $p < 0.05$ ).

### 3.3. Spatial Nostalgia Score

To further investigate links between nostalgia content and spatial ability, we recoded all the relevant items from Nostalgia content questionnaire into dummy variables and summed up all questions related to space and/or moving in space (9 items marked in Table 1 and in bold), and created a new scale – Spatial Nostalgia Score. The resulted score varied from 0 to 12, with larger scores reflecting more preferences to space-related triggers and experiences. The score was bimodal (see Figure 3), with most people selecting around 3 items and a small group of participants characterized by zero spatial triggers or content. The correlation analysis showed a small but positive link between spatial visualization score and this spatial content scale (Spearman’s  $\rho = .099$ ,  $p < .05$ ; see Figure 4).



**Figure 3.** Distribution of SNS.



**Figure 4.** Heatmaps for the links. Note: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ; Sp\_cont - Spatial Nostalgia experiences scale; Nos\_Sum - nostalgia proneness; BFI-Neu - Neuroticism scale from BFI; GAD\_Sum - Generalised Anxiety Disorder; WHO\_Sum - WHO5 questionnaire; SA\_Sum - Spatial ability measure - Paper folding.

### 3.4. Nostalgia and Wellbeing

Nostalgia proneness did not show correlations with WHO5, but showed a modest positive correlation with neuroticism (Spearman's  $\rho = .25$ ,  $p < .001$ ) and GAD7 (.19,  $p < .001$ ), with greater neuroticism and anxiety linked with more nostalgia. After partialling out Neuroticism (following (Luo et al., 2019)), a modest positive correlation (.09,  $p < 0.05$ ) between Nostalgia proneness and WHO5 emerged - with greater wellbeing associating with more nostalgia. After partialling out GAD7, Nostalgia proneness showed weaker correlations with Neuroticism but no correlation with WHO5.

In addition, we computed correlations between Spatial Nostalgia Scale and other study variables. Significant modest positive correlations emerged with nostalgia proneness (Spearman's  $\rho = .19$ ,  $p < .001$ ) and spatial ability ( $\rho = .09$ ,  $p < 0.05$ ). No correlations emerged with WHO5, Neuroticism and GAD7. These results did not change when we partialled out neuroticism. However, when we partialled out GAD7, we found a positive correlation between Spatial Nostalgia Scale and WHO5 ( $\rho = .12$ ,  $p < .01$ ).

Contrary to our hypothesis, spatial ability did not correlate with nostalgia proneness; and showed a negative weak correlation with it after controlling for Neuroticism ( $-.09$ ,  $p < .05$ ) and GAD7 ( $-.12$ ,  $p < .05$ ). All correlations with and without controlling for neuroticism/anxiety are presented in Figure 4.

## 4. Discussion

The current study provided new insights into the links between nostalgia and wellbeing by incorporating spatial visualisation as an important element of nostalgia; and testing whether spatial ability can modulate nostalgia-wellbeing links. The study identified directions for further measurement development and future experimental studies.

### 4.1. Profiles of Nostalgia Experiences

The first aim of our study was to identify nostalgia types according to predominant nostalgia triggers and content (spatial vs. other). The analysis of the nostalgia content questionnaire data demonstrated no meaningful profiles. Although three profiles emerged, they were not clearly separated in terms of modality, location, presence of others, etc.; or in terms anxiety, wellbeing, nostalgia proneness and spatial ability.

One possible explanation for no clear profiles emerging from Nostalgia Content questionnaire in Latent Class analysis is that each person's recollections are highly idiosyncratic: there are "marked interindividual differences in the quantity and quality" of personal memories (Palombo et al., 2018).

Moreover, people tend to have stable but unique retrieval styles. For example, one study showed that features of memory recall (such as visual imagery, emotional intensity, coherence, etc.) are extremely consistent within individuals across time (Rubin, 2021). However, different sensory or contextual cues may dominate for different people. Some studies, for instance, find that odor cues produce especially rich, vivid childhood memories (the classic “Proust effect”; (De Bruijn & Bender, 2018), whereas other work shows that the familiarity of a spatial context determines whether a memory is recalled in general vs. highly detailed form (Robin et al., 2019). This suggests that one person might be most driven by smells when remembering, another by spatial or visual cues, and so on. Because these cue–memory relationships vary continuously across individuals (rather than splitting neatly into groups), applying a latent-class or clustering analysis to the questionnaire will simply recover a diffuse, overlapping set of cases.

Another possible explanation is that the questionnaire itself may not cleanly separate distinct experience-trigger profiles. Such results were also observed even for standardised self-report instruments of autobiographical memory – probably due to such methods often show overlapping scales. For instance, the Survey of Autobiographical Memory (SAM) – a widely used questionnaire – was found to have “mixed” subscale independence: its episodic and semantic memory items did not load cleanly onto separate factors and “are not independent” measures of those constructs (Setton et al., 2022). Likewise, self-report ratings tend to capture only a fraction of the variability in actual recollection: one study reported that metacognitive memory ratings explained only 34% of the variance in recalled memory vividness (Aytürk et al., 2024). Such measurement limitations mean that clustering (latent class analysis in this case) has trouble finding robust groupings – noise and construct overlap wash out any clear profiles of cue-trigger or content patterns.

#### 4.2. *Nostalgia and Spatial Ability*

The second aim was to investigate whether higher spatial ability is associated with greater nostalgia. As nostalgia is inherently spatial, we assumed that individual differences in ability related to spatial process will underly individual differences in nostalgia proneness. Contrary to our expectations, our spatial ability measure (Paper folding) did not correlate with nostalgia proneness. However, our data showed that when only spatially-related items were selected from Nostalgia content questionnaire, the resulting score of “Spatial Nostalgia” experiences was positively linked with spatial ability, and nostalgia proneness. Taken together these results suggest that individual differences in spatial ability may be specifically linked to spatial aspects of nostalgic experiences.

The results are consistent with the view that nostalgic recollections draw on the same episodic-memory and scene-construction systems that underlie spatial memory. And indeed, neuroimaging studies show that retrieving personal nostalgic events engages hippocampal and default-mode regions (e.g. precuneus) involved in reconstructing past scenes (Oba et al., 2016). People who more spontaneously retrieve spatial information may have faster, richer recollection (Hebscher et al., 2018). Similarly, adults with stronger spatial memory or mental imagery may be able to “place” themselves more fully in a remembered scene, yielding more vivid, coherent nostalgic episodes. Indeed, those lacking visual imagery report fewer episodic details and weaker hippocampal engagement during recall (Monzel et al., 2024). Overall, our data showed that spatial ability could be involved in nostalgic experiences, probably as a mental black-board where nostalgia experiences unravel (analogous to one of the accounts of maths - spatial ability links; (Hawes & Ansari, 2020)).

#### 4.3. *Nostalgia and Wellbeing*

The third aim was to investigate nostalgia-wellbeing link. Specifically, we expected that nostalgia is negatively associated with wellbeing, but this negative association may mask the positive effect of nostalgia on wellbeing. This is because people turn to nostalgia to buffer anxiety. In other words, neuroticism and anxiety may modulate the positive effects of nostalgia on well-being. Our data showed that nostalgia proneness did not correlate with WHO5, but correlated positively with neuroticism and anxiety. As expected after partialling out Neuroticism, it correlated positively with

wellbeing. In addition, when we partialled out anxiety, a positive correlation between Spatial Nostalgia experiences scale and wellbeing emerged. This is consistent with the suggestion that more detailed nostalgic memories could lead people to turn to nostalgia more often and could amplify nostalgia's emotional payoffs (i.e., higher wellbeing in those who demonstrated higher spatial content scores).

Interestingly, it was GAD-7, but not neuroticism (shown in previous studies; (Luo et al., 2019); but see a meta-analysis; (Frankenbach et al., 2021)) that modulated the link between nostalgia and wellbeing. One explanation could be that hypervigilance and intolerance of uncertainty that are at the core of anxiety (Carleton, 2016), may interfere with the reflective and meaning-making processes inherent in nostalgia. Moreover, preoccupation with threat and difficulty disengaging from worry-based cognition in high anxious individuals (Eysenck et al., 2007) may preclude nostalgia-triggered self-continuity, social connectedness, and meaning in life (Routledge et al., 2008, 2011). It should be noted, that in our study the measures of anxiety and neuroticism showed a substantial correlation (.6), with previous research demonstrating the two sharing many behavioural outcomes, such as general reactivity to stress, a tendency to feel tension and inability to relax (Gomez & Francis, 2003; Hale et al., 2010; Papageorgiou et al., 2025). However, despite this overlap, neuroticism and anxiety showed different patterns in relation to nostalgia, calling for further research into role of individual differences in nostalgia-wellbeing links.

## 5. Conclusions and Future Directions

The current study provided some evidence on spatial ability role in nostalgia experiences and its connections to wellbeing. However, to gain further insights into these relationships experimental studies are needed. For example, such studies can test whether nostalgiazing is impacted by concurrent spatial task (e.g., by storage of conflicting or irrelevant spatial information that was suggested by researcher before nostalgia induction (Viviani et al., 2023)). In addition, studies can test whether people with higher spatial ability or imagery may benefit from nostalgia interventions more than people with lower abilities. This could be tested by incorporating spatial ability measures into nostalgic experiments.

Further, future research can investigate whether "spatialised" nostalgia inductions – e.g., prompting participants to recollect more spatial details, such as places, locations of objects - would lead to more psychological benefits. This spatial elements could be added to existing nostalgia manipulations, such as inducing nostalgia with a vivid recall of past experiences vs. presenting sensory stimuli to elucidate nostalgic feelings (Wildschut & Sedikides, 2024).

Moreover, more research is needed whether nostalgia is differentially related to different facets of spatial ability. In the current study we selected Paper folding as a proxy for spatial ability, as this measure shows good psychometric properties and captures much common variance among different SA facets (M. Likhanov et al., 2022; M. Likhanov, Wang, et al., 2024). However, previous research also showed that the general spatial ability factor explains around 40% of the variance, with much unique variance for each spatial ability measure (M. V. Likhanov et al., 2018; Rimfeld et al., 2017).

The current study also showed that more work is needed to further improve nostalgia experience scales. In particular, new instruments should systematically probe events cued by visual, auditory, olfactory, gustatory, etc., triggers – as different senses evoke memories with different qualities (Lopis et al., 2021)(Schlinter et al., 2023). For example, odors tend to elicit older, more emotional childhood memories (Lopis et al., 2021). The new instruments should use 5- to 7-point Likert scales so participants can rate phenomenological features (vividness, emotion, trigger intensity, or frequency of experience etc.) – similar to existing measures of autobiographical memory (e.g. (Rubin et al., 2003)). Such comprehensive measures will allow to further investigate nostalgia profiles, for example, whether triggers and content of nostalgic experience are in some way matched. It could be that people whose nostalgia is often triggered by a particular modality (e.g., taste), will experience more nostalgia or more vivid nostalgia in this modality. For example, research showed that matching a smell at recall with the memory's original context yields higher vividness than a

mismatched cue (Chu & Downes, 2002). In addition, our analysis showed that some items should be dropped from the new instrument as they showed little variance in responses. For example, >90% of respondents selected coloured vs. black-white option in “The surrounding environment in my nostalgic memories is usually...” question.

**Supplementary Materials:** The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

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