

COMPARING THE MENTAL RESTORATION OF FROZEN AND LIQUID WATERSCAPES: THE FROZEN WATER HYPOTHESIS

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Highlights:

- Mental restoration of frozen water is assessed by comparing to its liquid counterpart;
- Mental restoration of frozen water is significantly lower than that of liquid water;
- A new theory: the frozen water hypothesis.

Article History:

- received 10 March 2025
- accepted 15 December 2025

Abstract. In cold regions, outdoor water bodies undergo an annual phase shift from liquid to solid. Although waterscapes are widely recognized for their mental health benefits, the psychological impact of frozen water remains poorly understood. This study examined the mental restoration capacity of liquid water and frozen water using a comparative assessment. The findings demonstrate that the restorative potential of frozen water is significantly lower than that of its liquid counterpart. However, this disparity can be mitigated by enhancing the diversity of the surrounding landscape. Based on the study's findings and considering the close synchrony between the onset of Seasonal Affective Disorder (SAD) and the seasonal occurrence of frozen water in the environment, as well as the symptomatic overlap between SAD and high mental stress, this study puts forward the frozen water hypothesis, which posits that frozen water in the environment may contribute to the development of SAD.

Keywords: frozen water, mental restoration, comparative assessment, seasonal affective disorder, landscape management.

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1. Introduction

Mental health is defined as a state of well-being in which individuals can realize their own abilities, cope with the normal stresses of life, work productively and fruitfully, and make a contribution to their community (World Health Organization [WHO], 2001). To emphasize its critical role, WHO (2005) elevated this concept by declaring that there is “no health without mental health.” As a result, mental health promotion has emerged as a critical global health priority (Trautmann et al., 2016). However, despite great efforts paid to improve mental health, the prevalence of mental disorders has risen significantly in recent decades worldwide (Frankish et al., 2018; Wu et al., 2021), posing an urgent global health challenge (Lawrance et al., 2022; Sha et al., 2022).

Classic theories, such as Attention Restoration Theory (ART), (Kaplan & Kaplan, 1989), Stress Reduction Theory (SRT), (Ulrich et al., 1991) and Biophilia Hypothesis (Wilson, 1986), and numerous case studies (e.g., Tsunetsugu et al., 2007; Park et al., 2011; Li & Sullivan, 2016; Wang et al., 2018) have concluded that contact with nature could

reduce stress, thereby improving mental health. As a vital component of natural environments, water bodies play a significant role in promoting mental health across all age groups, including youth, adults (Baran et al., 2014), and older adults (Garrett et al., 2019). This positive impact is observed across diverse water body types, such as sea (White et al., 2013), freshwater (Pasanen et al., 2019; Nutsford et al., 2016) and artificial water features (Xie et al., 2021), and varying movement characteristics, ranging from fast- to slow-flowing water (Zhao et al., 2024a). Even the sound of water can alleviate the listeners' mental stress (Alvarsson et al., 2010; Zhao et al., 2018). McDougall et al. (2021) considered that waterscapes could offer superior restorative effects compared to green landscapes due to their multi-sensory stimulation, including the sound of flowing water, the visual complexity of reflections, and the tactile experience of proximity to water. The underlying mechanism include that the presence of water symbolizes the adequate resources to support various types of life, and can afford activities such as boating, sailing, swimming and fishing, which have positive effects on health physiologically and psychologically (Carr et al., 2009; Matsuda, 2006).

The freezing of water is a ubiquitous phenomenon during the transition from warm to cold seasons in mid- and high-latitude regions. However, existing research has predominantly equated “water” with its liquid form, largely overlooking the seasonal dynamics of water features (Zhou et al., 2022; Bell et al., 2017). Correspondingly, few studies have specifically examined the effects of frozen water features on mental health, and the available evidence remains inconsistent, resulting in a limited understanding of this issue. For example, a study in northern China found that residents reported low psychological restoration during winter, potentially due to the frozen water features (Yan et al., 2024). Conversely, Brooke and Williams (2021) suggested that ice’s reflective properties offered unique visual fascination.

Seasonal Affective Disorder (SAD) is a type of depression triggered by seasonal changes, typically occurring in winter, followed by remission of symptoms in other seasons (Praschak-Rieder & Willeit, 2003). The burden of SAD disproportionately affects populations living in mid- and high-latitude regions (Levitan, 2007). Traditionally, SAD has been primarily attributed to reduced exposure to natural light and limited outdoor activity during colder seasons (Partonen & Lönqvist, 1998). Therefore, light therapy becomes one of the prevalent treatments for mitigating the symptoms of SAD (Glod, 2017; Selman et al., 2025). However, the increasing prevalence of SAD highlights the necessity for new therapeutic methods. Natural environment exposure presents a promising avenue for alleviating SAD. For example, Zhao et al. (2024b) concluded that introducing evergreen trees to winter landscapes is a viable mitigation strategy, as evergreen trees addressed the lack of winter greenness, which was identified as a contributor to SAD in mid- and high-latitudes. In light of such findings, scholars have begun to challenge traditional interventions like light therapy. For example, Hidalgo (2021) considered that the presence of green landscapes in winter was better than the brightness treatment for relieving mental stress.

Given the prevalence of frozen water during cold seasons in mid- and high-latitude regions – a phenomenon that coincides with the occurrence of SAD – we hypothesize a potential association between frozen water and SAD. If frozen waterscapes are found to lack restorative benefits or stress-reducing capacity, they may inadvertently exacerbate SAD symptoms. This possibility is supported by the overlap between certain symptoms of SAD, such as depression, lack of vitality, and irritability (Iorio et al., 2024), and those observed in individuals under high mental stress, including low mood, loss of interest in activities, anxiety, and aggression (Jones et al., 2022; Spaan et al., 2024).

This study employed a comparative experimental design to assess the stress-reducing capacity of frozen versus liquid waterscapes. Participants evaluated and compared the mental restoration potential of both water types to determine which was more effective during cold seasons. Furthermore, the research examined the influence of participants’ socio-demographic characteristics and key

landscape features on the observed differences in restorative outcomes between frozen and liquid water.

2. Methods

2.1. Stimuli

Previous literature has emphasized the superiority of on-site evaluations over surrogate stimuli (e.g., static photographs) for capturing authentic human perception (Frantál et al., 2017). This advantage is largely attributed to the multisensory engagement facilitated by real-world environments, which enables a more comprehensive and immersive experience (Gao et al., 2019). However, on-site evaluations are susceptible to a range of confounding factors, such as ambient sounds, smells, wind speed, and air temperature, which can compromise the accuracy of the results (Cervén et al., 2016; Zhang et al., 2017; Cheung & Jim, 2018). The comparative assessment of frozen and liquid waterscapes from the same sites posed a major methodological challenge: on-site evaluation would inevitably involve confounding temperature effects. Therefore, the study utilized photographic representations in a laboratory setting, which enabled the restorative capacity of the waterscapes to be measured under controlled conditions. This approach has been widely employed in prior research, yielding reliable outcomes (e.g., Pflüger et al., 2010; Yao et al., 2012; Zhao et al., 2024b). Furthermore, it has been specifically validated as highly effective for comparative evaluations (Palmer & Hoffman, 2001).

Eleven aquatic sites were selected as study areas in Taiyuan, the capital city of Shanxi province. The city is located in northern China (Latitude 37°27' to 38°25' N, longitude 111°30' to 113°09' E) with a typical warm continental monsoon climate, characterized with a cold and long winter. The selected sites encompassed a variety of rivers and lakes with diverse surrounding environments, making them highly representative of local outdoor waterscapes (Figure 1). The photographs describing frozen waterscapes were taken during the coldest period of the year (January 2023) on clear or less cloudy days, from 10 a.m. to 3 p.m. to control for similar lighting conditions by the same person at eye level using the same digital camera (Canon EOS 60D). In early March 2023, after the ice had melted but before deciduous vegetation had begun to green, the same 11 sites were re-photographed using a consistent methodology to capture the liquid water phase. These photographs replicated the exact landscape compositions from those taken in January. This method created a direct contrast between frozen and liquid states while holding all other visual elements constant, thereby establishing that any difference in mental restoration is directly attributable to the conditions of waterscape.

2.2. Mental restoration measurement

Questionnaire surveys are widely used to measure mental restoration (Zhao & Gong, 2022; Park et al., 2011; Xu et al., 2023), as this method allows for the collection of

data from a large number of participants in a relatively short time and at a low cost. Therefore, this study used this method to measure the mental restoration of participants by comparing frozen and liquid waterscapes.

2.2.1. Mental restoration items

Based on the Short-version Revised Restoration Scale (SRRS), which comprises four dimensions with two items each (Han, 2003), Zhao and Gong (2022) developed a revised instrument by combining the two items in each dimension into a single statement. The revised SRRS comprises four items, each corresponding to one of the original dimensions: emotion, psychology, cognition, and behavior. This revised scale has been validated and demonstrated efficacy comparable to the original SRRS in measuring mental restoration capacity (Zhao & Gong, 2022).

2.2.2. Survey procedure

Palmer (1990) observed that participants rated summer scenes more favorably when evaluated in spring than in summer. This was attributed to a heightened desire for green scenery after a long, less green winter, thus demonstrating that the timing of evaluation can significantly influence perceptual outcomes. To avoid this influence, the mental restorative capacity of frozen and liquid waterscapes was measured in February 2024, which is generally in line with the period when the photographs were taken (January and March 2023). For each site, the frozen and liquid waterscape photographs were presented together on a slide at equal sizes. The two photographs, labeled A and B, were randomly assigned to represent either the frozen or liquid waterscape to mitigate order effects.

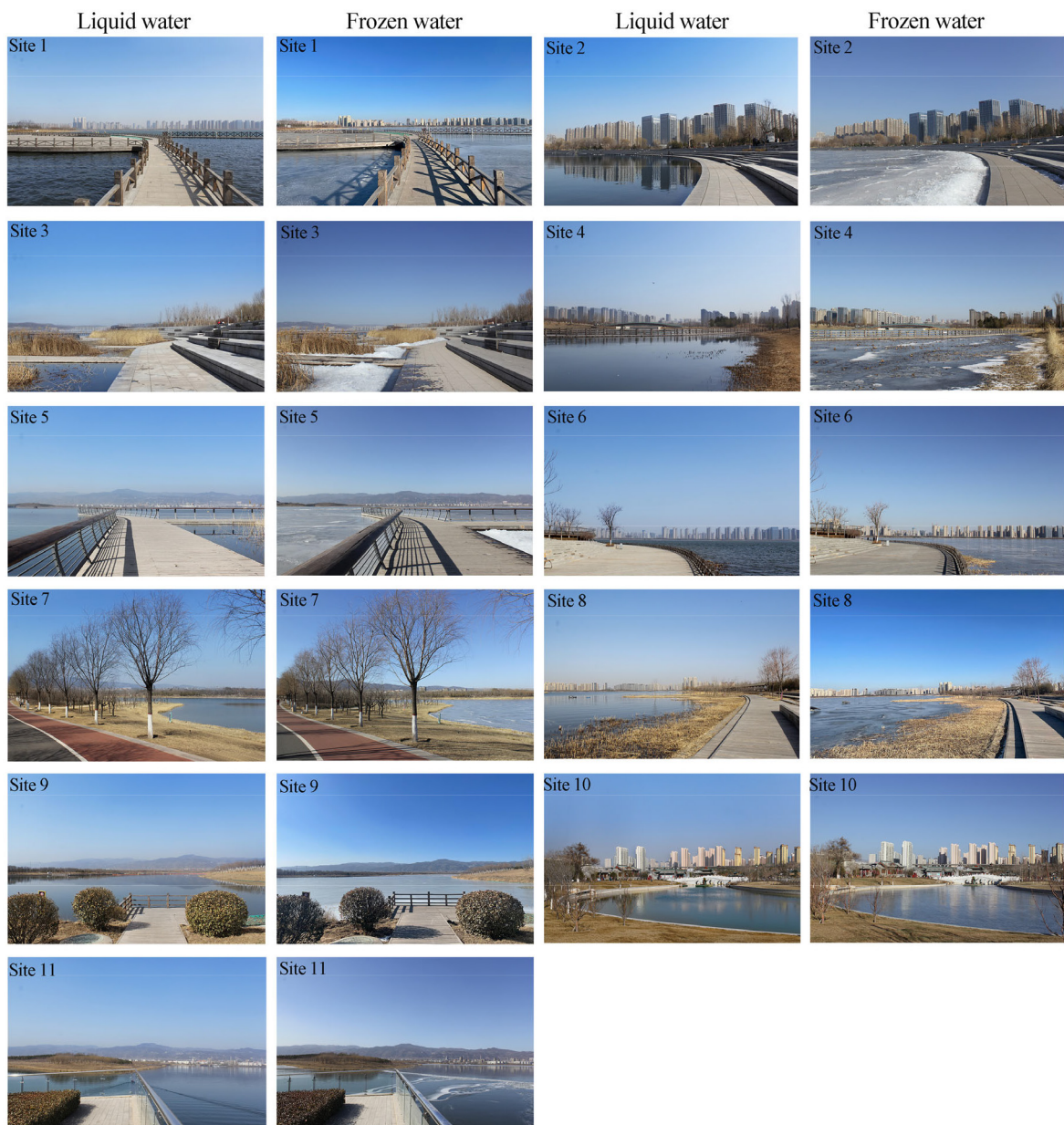


Figure 1. All photographs used in this study

The experiment was conducted in a standard classroom setting. Participants viewed each slide projected onto a white screen and were asked to answer the following four questions, each representing a key dimension of mental restoration:

- (1) Which scene makes you feel more pleasant and good-natured? (Emotion);
- (2) Which scene helps you better forget your daily worries? (Psychology);
- (3) Which scene holds your interest more strongly? (Cognition);
- (4) Which landscape would you prefer to visit? (Behavior).

Following this, participants completed a demographic section capturing information on gender (male or female),

age (under 18 years old, 18–35, 35–60, or more than 60), education level (primary school and below, junior high school, high school, college, or postgraduate), and the frequency of seeing frozen waterscapes in the past (never, occasionally, or regularly).

A total of 100 participants were recruited from the general public via WeChat, a widely used social media platform in China. Given that the classroom accommodates a maximum of 60 persons, the 100 participants were divided into two groups, each comprising 50 individuals. After the first group completed the surveys, the second group of participants was asked to evaluate these slides with the same manner. During the survey sessions, participants were instructed not to communicate with each other and to make independent judgments. If a photograph was

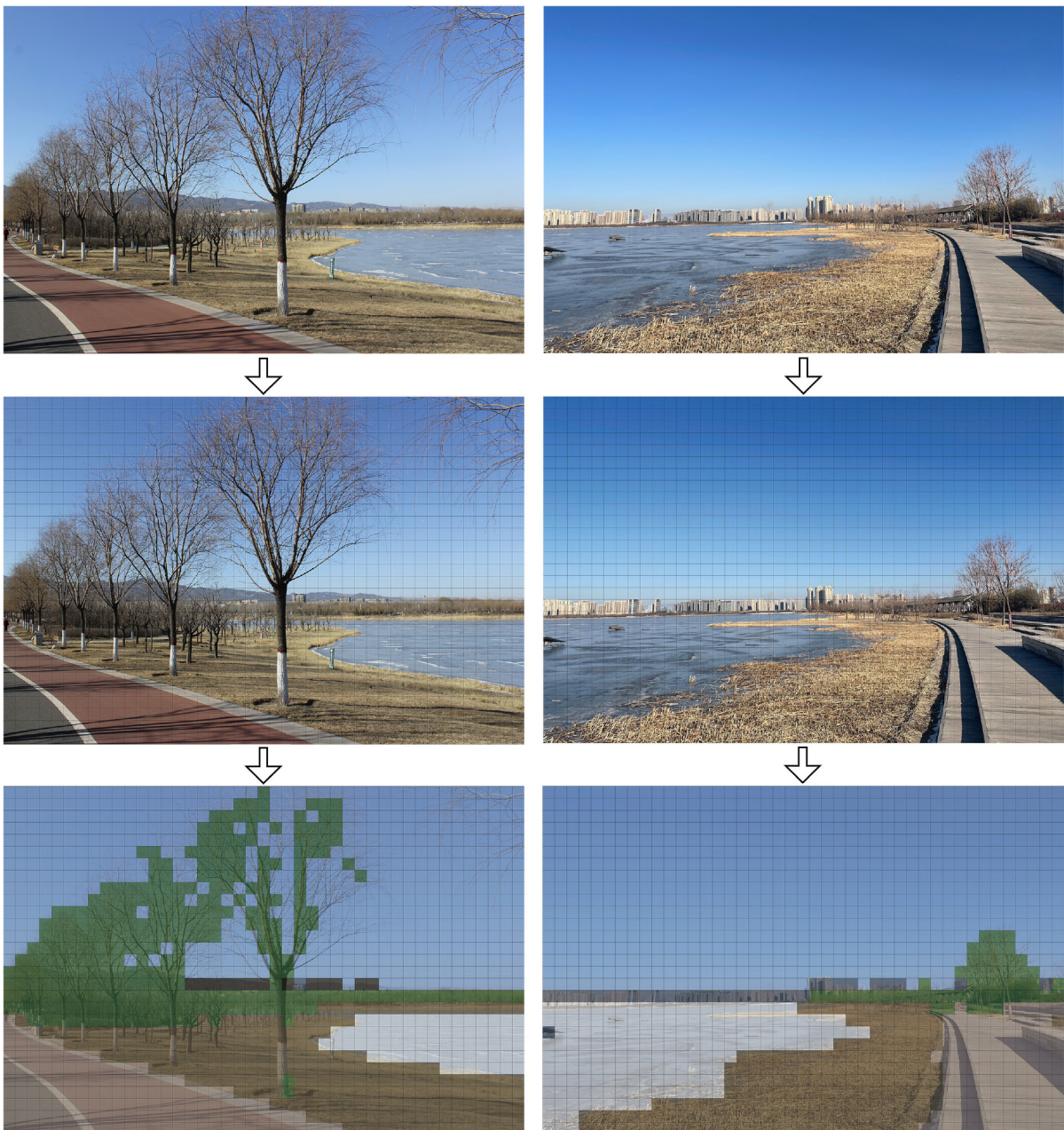


Figure 2. Two sample photographs describing the method of landscape characteristics measurement

selected in terms of an item, it was scored “1”, and the other photograph was scored “0”. The mental restoration capacity of a photograph was determined by the sum score of four items (questions), thus the score of mental restoration capacity of a photograph ranged from 0 to 4. After data cleaning, 84 valid questionnaires were retained for analysis. Invalid responses, which included incomplete submissions and those that failed an internal consistency check, were excluded. The consistency check involved verifying participants’ gender responses at both the beginning and end of the questionnaire, and any discrepancy led to exclusion.

2.3. Landscape characteristic measurements

Landscape perception is context dependent (Gobster et al., 2007). Therefore, the landscapes with different characteristics can influence mental restoration of frozen or liquid water. To examine the effects of various landscapes on restorative capacity and guide winter landscape design, six landscape characteristics were abstracted by analyzing the features of photographs studied and referring to the characteristics identified in previous works (Xu & Zhao, 2023; Nordh et al., 2009). These characteristics have been shown to be correlated with mental restoration capacity (Britton et al. 2018; Cao et al., 2024; Yao et al., 2024; Nordh et al., 2009). A grid ($29 \times 43 = 1247$ squares) was placed over the whole photograph with frozen water (Figure 2), and each square covered by more than 50% of a given characteristic was marked and counted (Nordh et al., 2009). Then the number of squares covered by a given characteristic was divided by the total number of squares (1247). Landscape diversity was calculated by Shannon-Wiener index (Table 1).

Table 1. Landscape characteristics measurement

Landscape characteristics	Calculation
Ratio of paved areas	$P_i = M_i/M,$ where P_i – ratio of i th characteristic; M_i – the number of squares covered by i th characteristic; M – the total number of squares on the photograph.
Ratio of sky	
Ratio of woody plants	
Ratio of grass	
Ratio of water bodies	
Landscape diversity	$H = - \sum_{i=1}^S \frac{N_i}{N} \log_2 \frac{N_i}{N}$ H – the value of landscape diversity; S – the number of landscape characteristics; N_i – the number of squares covered by the i th characteristic; N – the total number of squares covered by all characteristics.

2.4. Statistical analysis

First, the reliability of the mental restoration scores was assessed. Second, descriptive statistics were used to summarize participants’ socio-demographic profiles. Third, a

paired-samples t-test was employed to examine the significance of Mental Restoration Difference (MRD) between frozen and liquid waterscapes, where MRD was calculated as the liquid waterscape score minus the frozen waterscape score. Subsequently, correlation analysis explored the relationships between socio-demographic variables of participants and MRD. Finally, a set of two-layer hierarchical regression models was constructed to analyze the association between landscape characteristics and MRD after controlling for confounders. Model 1 included only socio-demographic variables, while Model 2 incorporated both these variables and the six landscape characteristics. To mitigate multicollinearity, variables with a Variance Inflation Factor (VIF) ≥ 4 were excluded (Xu et al., 2024).

3. Results

3.1. Reliability

The mental restoration scale demonstrated a good reliability (Cronbach’s $\alpha = 0.784$), surpassing the 0.701 threshold indicative of good internal consistency (Landis & Koch, 1977). The normal distribution of the data was examined using Kolmogorov-Smirnov test, returning p -values of $0.167 > 0.05$ for mental restoration scores. These results indicated that the data could be used with confidence.

3.2. Descriptive statistics of participants’ socio-demographic variables

The sample of 84 valid participants exhibited a relatively balanced gender distribution and comprised predominantly working-age individuals ($M = 36.21$, $SD = 9.75$) with high educational attainment (77.4% held a college degree or higher). Regarding past exposure, nearly half reported occasionally seeing frozen outdoor water, while 30.9% did so regularly, and 15.5% had never seen it. The details of participants’ socio-demographic variables are presented in Table 2.

Table 2. Socio-demographic characteristics of participants ($N = 84$)

Measures		Number	%
Gender	Male	41	48.8%
	Female	43	51.2%
Age (years old)	<18	3	3.6%
	18–35	45	53.6%
	35–60	29	34.5%
	>60	7	8.3%
Education level	Primary school and below	2	2.4%
	Junior high school	6	7.1%
	High school	11	13.1%
	College	43	51.2%
	Postgraduate	22	26.2%

End of Table 2

Measures		Number	%
The frequency of seeing frozen outdoor water in the past	Never	13	15.5%
	Occasionally (experienced at least once, but not yearly)	45	53.6%
	Regularly (encountered in virtually every year)	26	30.9%

3.3. Comparison in mental restoration between frozen and liquid waterscapes

The mean scores of mental restoration capacity of frozen and liquid waterscapes across 11 sample sites are shown in Figure 3. The scores of frozen waterscapes was found to be predominantly lower than those of liquid waterscapes across the study sites. The only notable exceptions were Sites 8 and 10, where the opposite was true. The paired-samples t-test revealed that liquid waterscapes promoted a significantly greater capacity for mental restoration than frozen waterscapes ($t = 4.493$, $p < 0.001$), with mean scores of 2.32 (SD = 0.40) and 1.68 (SD = 0.40), respectively.

3.4. Effects of participants' socio-demographic variables on mental restoration difference between frozen and liquid waterscapes

Participants' socio-demographic variables were coded for statistical analysis as follows: gender (male = 1; female = 2), age group (<18 years old = 1; 18–35 = 2; 36–60 = 3; >60 = 4), education level (primary school and below = 1; junior high school = 2; high school = 3; college = 4; postgraduate = 5), and past frequency of seeing frozen outdoor water (never = 1; occasionally = 2; regularly = 3).

Correlation analysis revealed that MRD was significantly and positively associated with education level and past frequency of seeing frozen water, but not with age or

gender (Table 3). Specifically, higher education levels were linked to greater restorative benefits from liquid (vs. frozen) waterscapes. Furthermore, individuals who regularly saw frozen waterscapes perceived a more pronounced contrast in mental restoration, favoring liquid over frozen water, compared to those with little or no prior exposure.

Table 3. Correlations between MRD and participants' socio-demographic variables (Spearman)

		MRD	Gender	Age	Education level
Gender	Coefficient	−0.015			
	Sig. (2-tailed)	0.742			
Age	Coefficient	−0.038	0.013		
	Sig. (2-tailed)	0.410	0.789		
Education level	Coefficient	0.122**	−0.038	−0.225***	
	Sig. (2-tailed)	0.009	0.416	< 0.001	
The frequency of seeing frozen outdoor water in the past	Coefficient	0.104*	0.097*	0.056	0.027
	Sig. (2-tailed)	0.026	0.037	0.233	0.558

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

3.5. Effects of landscape characteristics on mental restoration difference between frozen and liquid waterscapes after controlling for covariates

Since the socio-demographic variables of participants had significant impacts on MRD (Table 3), it is necessary to treat these variables as covariates when examining the effects of landscape characteristics on MRD. After controlling for these covariates, the results of hierarchical linear

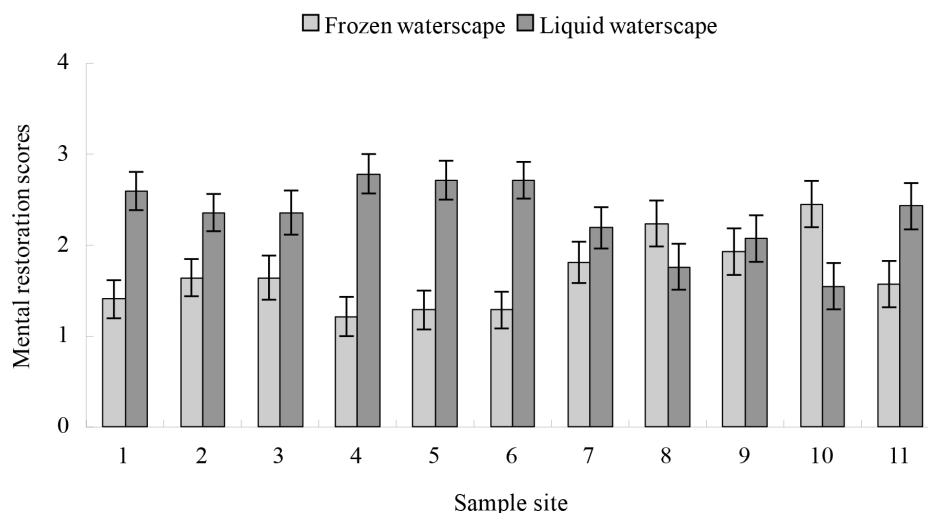


Figure 3. Mean scores (±Standard error) of mental restoration of frozen and liquid waterscapes across 11 sample sites

regression showed that landscape diversity was significantly and negatively associated with MRD (Mode 2 in Table 4), suggesting that enhancing landscape diversity, including the richness of landscape characteristics and the evenness of various characteristics within the landscape, could narrow the restorative gap between liquid and frozen waterscapes.

4. Discussion

4.1. The mental restoration capacity of frozen water

This study reveals that frozen water features are significantly less effective than liquid ones in terms of mental restoration, aligning with previous research (White et al., 2010; McDougall et al., 2021), which indicates that the dynamic properties of water, such as flow and ripples, can more deeply engage observers, offering aesthetic and sensory experiences that promote stress reduction. In contrast, frozen water features are generally perceived as being static, providing fewer opportunities for visual engagement and emotional connection. According to Attention Restoration Theory, the lack of sensory engagement potentially reduces the fascination, which is one of the four key items that promote mental restoration (Kaplan, 1995). Therefore, frozen water diminishes the ability of landscapes to evoke mental restoration.

From the perspective of evolutionary theory, the environment that symbolizes adequate resources unconsciously reduces mental stress (Kaplan, 1995). Humans can not drink frozen water directly, and compared to the liquid

water, it is more difficult for fishing from frozen water. Furthermore, frozen water provides less support to other organisms including vegetation and animals, indicating a low-productivity environment. These functional and ecological constraints likely diminish its mental restoration capacity. On the other hand, the frozen water is the unique features of winter in mid- and high-latitude regions. Its presence distinctly signals a winter season, which has been associated with lower mental restoration due to the reduced greenness (Paddle & Gilliland, 2016).

4.2. People's education level and past frequency of seeing frozen water in relation to the restorative capacity

This study found that participants with higher education levels reported a greater MRD. This can be explained by the influence of ecological knowledge on environmental perception. Prior research indicates that such knowledge can reshape how people value environments (Van der Wal et al., 2014) and that higher education is linked to more positive attitudes toward nature (Li et al., 2019). We therefore posit that well-educated individuals may possess a deeper understanding of the distinct ecological functions of frozen and liquid water, leading them to perceive a sharper contrast in restorative potential between the two.

Existing literature suggests that when a stimulus continuously acts on human sensory system, it can cause sensory adaptation, which is defined as a decrease in sensitivity to the stimulus (Mikuni et al., 2022). When a person regularly sees the frozen water, sensory adaptation to frozen water generates, inducing a low mental restoration.

Table 4. Two hierarchical linear regression results for MRD (landscape characteristics as independent variables)

Model prediction	Model 1				Model 2			
	β	Std. Error	t value	p value	β	Std. Error	t value	p value
Intercept	1.358	0.833	01.631	0.104	13.575	7.193	1.887	0.060
Gender	−0.204	0.307	−0.665	0.506	−0.204	0.302	−0.676	0.499
Age	0.045	0.120	0.373	0.709	0.042	0.118	0.355	0.722
Education level	0.558	0.222	2.514	0.012*	0.560	0.218	2.563	0.011*
The frequency of seeing frozen outdoor water in the past	0.505	0.218	2.316	0.021*	0.505	0.214	2.355	0.019*
Ratio of buildings					−9.060	8.582	−1.056	0.292
Ratio of paved areas					−8.311	12.639	−0.658	0.511
Ratio of sky					−12.546	14.343	−0.875	0.382
Ratio of woody plants					−4.125	12.128	−0.340	0.734
Ratio of grass					−8.940	9.785	−0.914	0.361
Ratio of water bodies					−4.657	12.625	−0.369	0.712
Landscape diversity					−5.000	2.248	−2.224	0.027*
R ²	0.128				0.375			
ΔR^2					0.247			
F	3.291*				6.332***			

Note: * $p < 0.05$, *** $p < 0.001$.

These evidences can explain the finding that the higher the frequency of seeing frozen water, the less mental restoration induced by the frozen water, in turn leading to more MRD.

4.3. Landscape diversity in relation to the restorative capacity of frozen water

This study identifies landscape diversity as a crucial factor in narrowing the MRD. While both waterscapes and greenness improve well-being (MacKerron & Mourato, 2013), users show greater interest and stress reduction in biodiverse waterscapes (Fairchild et al., 2018). We propose that diverse landscapes engage viewers' attention across a broader array of elements, thereby reducing the perceptual dominance of the water feature itself. This diminished focus on the water's state (frozen or liquid) subsequently lessens the perceived difference in restoration, leading to a smaller MRD.

4.4. Frozen water hypothesis

Water is universally recognized as the biological fountain-head of life, yet its significance overflows into the cultural and spiritual realms. It is central to rituals marking birth, marriage, and death (Völker & Kistemann, 2011) and holds profound religious meaning, such as in Buddhist doctrines that attribute healing powers to certain waters. However, these profound symbolic and biological associations are intrinsically linked to the properties of liquid water. Its fluidity, life-giving capacity, and dynamic nature stand in stark contrast to the static, solid form of frozen water, which lacks the same immediate functional and symbolic connections to vitality and ritual. The frozen water features may evoke feelings of stagnation or isolation, which are linked to the emotional and psychological challenges in winter (Melrose, 2015). The environments perceived as stagnation may fail to capture attention in a restorative manner, potentially exacerbating the negatively psychological impacts (Kaplan, 1995).

Given the spatiotemporal convergence between SAD and frozen water prevalence, as well as the similarity between SAD symptoms and symptoms of high mental stress (Jones et al., 2022; Iorio et al., 2024), we posit an inherent link between the two. We therefore propose the "frozen water hypothesis", positing that frozen water may serve as a previously overlooked environmental stressor contributing to SAD. Building on this, we suggest "liquid water therapy" as a potential intervention, which involves encouraging individuals with SAD to visually, tactilely, and/or auditorily engage with liquid water. Nevertheless, further empirical evidence is required to substantiate the frozen water hypothesis, calling for additional research to provide robust support.

4.5. Strengths and limitations

To the authors' knowledge, this study presents the first comparative assessment of the mental restoration capacity

of liquid versus frozen water. The findings inspire a novel frozen water hypothesis, postulating frozen water as a potential contributor to SAD, and correspondingly propose liquid water therapy as a promising mitigation pathway. Furthermore, this study demonstrates that enhancing landscape diversity in blue spaces can narrow the restorative gap between liquid and frozen waterscapes, suggesting that targeted winter landscape design offers a viable strategy for alleviating SAD.

Several limitations of this study should also be noted. First, although the use of photographic stimuli effectively controlled for confounding variables, this method does not engage non-visual senses. Jeon and Jo (2020) suggested that visual factors account for 76% of environmental satisfaction, implying that nearly a quarter of the environmental information is lost by the method of photographs as stimuli. Second, while existing research has established that the duration of environmental exposure significantly influences restorative outcomes (Bock et al., 2024; Yakinlar & Akpinar, 2022), this study focused exclusively on immediate psychological responses. It therefore remains unclear whether the observed restorative effects are sustained over time or contribute to long-term mental health. Future longitudinal studies are encouraged to examine the lasting benefits of exposure to frozen versus liquid waterscapes, as well as the cumulative effects of repeated engagement with such environments. Such research would provide critical evidence regarding the temporal dynamics of water-based restoration and strengthen the empirical foundation of the frozen water hypothesis. At last, although the comparative assessment has advantages, such as facilitating the assessments and eliminating the risk of different respondents building different reference mental images, it is fundamentally limited in its ability to detect subtle restorative differences. It may also compel participants to make a forced choice even when they perceive no clear distinction. These limitations remind policymakers to exercise caution when attempting to apply the results in practice.

5. Conclusions

Frozen outdoor water bodies are ubiquitous features in mid- and high-latitude regions during cold seasons, yet their impact on human well-being remains poorly understood. This study, conducted in a typical mid-latitude city, presents a pioneering comparison of the mental restoration capacity between frozen and liquid waterscapes. Results demonstrate that frozen waterscapes are significantly less effective at promoting mental restoration than their liquid counterparts. This finding inspired us to propose the frozen water hypothesis, which posits that frozen water is a contributor of SAD. Furthermore, we identified landscape diversity as a key factor in narrowing the restorative gap between liquid and frozen water. This insight suggests that strategically designing winter landscapes to enhance diversity can improve their restorative potential, offering a novel pathway to mitigate SAD symptoms.

Disclosure statement

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

Research ethics and consent

This study is based on the perceptual responses of human participants, and the stimuli (photos describing the liquid and frozen waterscapes) used in this study definitely do not cause harm to the participants, who give informed verbal consent to participate anonymously in our experiments.

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