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# The analgesic effect of nostalgia elicited by idiographic and nomothetic approaches on thermal stimulus

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## Abstract

Nostalgia is shown to relieve an individual's perception of pain evoked by cold water, pressure, and thermal stimuli. However, there is no direct evidence to show the analgesic effects of different nostalgia-inducing methods on various stimulus intensities. We conducted two studies to examine the analgesic effect, at different pain intensities, after inducing nostalgia either idiographically or nomothetically. Study 1 ($N$ = 118) induced nostalgia through an idiographic approach (i.e., event reflection task) and found that nostalgia relieved both high and low thermal pain. Study 2 ($N$ = 66) induced nostalgia through a nomothetic approach (i.e., viewing nostalgic pictures) and found that nostalgia relieved low but not high thermal pain. The findings verify the analgesic effect of nostalgia on thermal pain and suggest the potential moderating role of the nostalgia induction approach and pain intensity. Practically, these findings have implications for using nostalgia as a nonpharmacological treatment for pain.

KEYWORDS
analgesia, idiographic nostalgia, nomothetic nostalgia, pain

## INTRODUCTION

Nostalgia is a predominantly positive albeit bittersweet emotion that arises from personally relevant and longing memories of one's past.[1–3] Nostalgia is experienced frequently in daily life across cultures.[4] Nostalgia can be induced through two means: (1) idiographic approaches focus on characteristics of unique individuals and their autobiographies,[5] for example, when recalling personally nostalgic memories, and (2) nomothetic approaches focus on characteristics shared by classes or cohorts,[5] such as priming using nostalgic cues (e.g., advertisements,[2] music,[6,7] pictures,[8] or movies[9]). Compared to the nomothetic approach, the idiographic approach may require participants to immerse more deeply into self-relevant events and, therefore, often leads to a stronger nostalgic effect on behavior (e.g., product purchase).[5]

Research has established that nostalgia serves numerous adaptive functions.[3,10] Nostalgia can boost both intrapersonal and interpersonal positivity, as well as enhance self-esteem or self-positivity,[11,12] meaning in life,[13–15] psychological well-being,[16–19] and social connectedness and support.[20] Nostalgia can also relieve psychological distress, such as loneliness, boredom, stress, death anxiety, and depression.[13,21–23]

The current research focused on whether nostalgia could relieve a special kind of psychological distress, that is, pain caused by a noxious stimulus. To our knowledge, there are only two existing studies on this topic. In the earlier one, Zhou et al. found that nostalgia induced by recalling a nostalgic event can reduce thermal distress and pain.[24]

  

More recently, Kersten et al. found that nostalgic reflection-evoked nostalgia could help individuals relieve chronic pain (study 1) and make them more tolerant of mechanically induced pain (study 2).[25]

These studies provide preliminary evidence for the analgesic effect of nostalgia, yet many specifics remain unknown. First, the existing two studies did not distinguish the analgesic effect on pain perception between low and high intensities. It is unknown whether the analgesic effect of nostalgia manifests differently on pain caused by different stimulus intensities. Second, as mentioned above, nostalgia can be induced by both idiographic and nomothetic approaches.[5] However, it is not clear what the analgesic effects of the different induction methods are.

Using psychological strategies for treating pain is important and timely,[26] yet the effect of nonpharmacological analgesics may be somewhat limited.[27] For instance, this can be reflected in the varying analgesic effects achieved using different methods or intensities of noxious stimuli (low intensity vs. high intensity).[28,29] Exploring the analgesic effects of different nostalgia-inducing methods on various stimulus intensities is nonetheless helpful for clinically targeted adjuvant treatment.

The current research aimed to examine the analgesic effect of nostalgia on thermal pain using different induction methods at both low and high intensities. Study 1 induced nostalgia using the idiographic approach, that is, asking participants to recall a nostalgic memory. Study 2 induced nostalgia using the nomothetic approach, that is, presenting participants with nostalgic pictures to trigger nostalgia.

## METHODS

### Study 1

We first examined whether there was an analgesic effect on the reported pain from thermal stimuli using the idiographic approach based on a temporally extended manipulation with material specific to each participant.[21] According to the adaptive function of nostalgic emotion mentioned above, we hypothesized that after individuals recalled a nostalgic event, they would give lower reported pain for thermal stimuli than those who recalled an ordinary event.

### Participants

Considering that power was determined based on the moderate ($d$ = 0.38) to large ($d$ = 0.81) effect sizes found in the nostalgia literature,[30] we elected to detect an effect ($d$ = 0.5, power = 0.80), according to the criterion proposed by Cohen to test the medium effect.[31] The power analyses, conducted in G*Power Version 3.1, indicated that a sample size of 102 was necessary to detect the medium effect. A total of 118 participants (35 males [M ± SD] age = 21.49 ± 2.37 years, range = 18–28 years) took part in the study. To ensure participants were homogeneous before they signed up for the study, we asked them to respond to the Pain Sensitivity Scale (e.g., "*Imagine you burn your tongue on a very hot drink*," responses rated from 1 = *no pain* to 10 = *pain as bad as it could be*)[32] and the Southampton Nostalgia Scale (e.g., "*How valuable is nostalgia for you?*," responses rated from 1 = *not at all* to 7 = *very much*, to measure nostalgic proneness).[33,34] We instructed participants not to ingest any alcohol or pain medicine for at least 4 h prior to participating in the experiment.[35,36] The experiment procedures were approved by the Institutional Review Board of the Institute of Psychology at the Chinese Academy of Sciences and were performed in accordance with the Helsinki Declaration.

We conducted an independent samples $t$-test on the average scores of pain sensitivity and nostalgic proneness separately. The condition (i.e., nostalgia vs. control) acted as the between-subject variable to check whether participants were homogeneous across two groups. The results showed no significant differences in pain sensitivity across nostalgia (M ± SD, 4.38 ± 1.15) and control (4.21 ± 1.01) groups, as well as in nostalgic proneness across nostalgia (4.63 ± 0.61) and control (4.82 ± 0.77) groups ($t(116) = 0.86$, $p = 0.392$; $t(116) = -1.44$, $p = 0.152$, respectively), suggesting that participants were homogeneous in terms of pain sensitivity and nostalgic proneness. All statistical analyses were done using IBM SPSS version 23.0 (Armonk, NY, USA).

### Thermal pain stimuli

All the thermal stimuli were produced by Medoc 9-cm$^2$ Contact Heat-Evoked Potential Stimulator (CHEPS; Medoc, Compass Medical Technologies, Inc., Durham, NC, USA). Heat pain threshold (43.93 ± 2.28°C) was first assessed to help define the low and high intensities, which has been commonly done to elicit low pain and high pain as used in previous studies.[37] We followed the principles of threshold plus 1 or 3°C to formulate the stimulation intensities for low/high pain, making tiny adjustments according to participants' bearing status but keeping a 2°C difference to distinguish between low and high intensities. Pain threshold was assessed five times on the right forearm 10 cm above the wrist with a 0.5°C/s rate of temperature rise. Participants indicated when they first felt pain by pressing a button that turned the device off. In the main experiment, the CHEPS thermode was applied to the right forearm 10 cm above the wrist. A 3-s heat stimulus with a 40°C/s rate of temperature rising/falling was used. Pain perception was measured by participants' response to 15 heat pulses at the low intensity and 15 heat pulses at the high intensity.

### Procedure

Upon arriving at the lab, participants completed a consent form. Then, their pain threshold was assessed both before the nostalgia manipulation (pre-test) and after the nostalgia manipulation (post-test).

#### Pre-test

Participants responded to the thermal stimuli and rated their perception of the pain experienced. The presentation of stimuli and manual

response measurements was controlled using E-Prime 2.0 (Psychological Software Tools, Inc., Pittsburgh, PA, USA). In each trial, a white fixation cross was first presented for 0.5 s, and then, the reminder "Stimulus on" was presented for 3 s, at the same time, a thermal pulse (low pain [45.08 ± 1.95°C] vs. high pain [47.08 ± 1.95°C]) was delivered to the participants' right forearm. Then, using their left hand on a response box, participants reported the pain they experienced from the brief thermal stimuli using a numerical pain rating scale that ranged from 0 to 10 (0 = *no feeling*, 1 = *a feeling of warmth*, 2 = *a feeling of heat*, 3 = *a feeling of hotness*, 4 = *the start of a feeling of pain*, with gradual increases until 10 = *a feeling of pain as bad as it could be*). Values from 4 to 10 indicated gradually increasing degrees of pain. Finally, a black background screen appeared for 10 s, before beginning the subsequent trial.

### Nostalgia manipulation

We followed the standard nostalgia manipulation procedure using the Event Reflection Task.[3] Participants were randomly assigned to either nostalgia or control conditions. In the nostalgia group, participants first read a definition of nostalgia ("a sentimental longing for a personally experienced past").[38] Participants were then asked to bring to mind a nostalgic event in their lives and to reflect upon it for 2 minutes. In the control group, participants brought to mind an ordinary event (e.g., cooking dinner, washing dishes, etc.) from their own lives and reflected upon it for 2 minutes. Then, participants in both conditions were asked to write down four keywords that summarized and described the event. Subsequently, as a manipulation check, all participants rated their level of state nostalgia using three items (e.g., "*Right now, I am feeling quite nostalgic*") with responses rating from 1 (*strongly disagree*) to 6 (*strongly agree*).

### Post-test

Immediately following the manipulations of nostalgia, an additional reported pain task was performed using the same procedure in the pre-test session. Finally, participants were fully debriefed and compensated for participating in the study.

## RESULTS

## Study 1

### Manipulation check

The independent samples *t*-test revealed that participants in the nostalgia group (M ± SD; 4.94 ± 0.87) reported greater state nostalgia (i.e., felt nostalgic to a greater extent) than those in the control group (4.53 ± 0.98; $t(116) = 2.45$, $p = 0.016$, $d = 0.45$) (Figure 1A), indicating that the manipulation worked as intended.

**TABLE 1** Reported pain in different conditions in pre-test and post-test

| Variables | Nostalgia-low M ± SD | Control-low M ± SD | Nostalgia-high M ± SD | Control-high M ± SD |
|---|---|---|---|---|
| Pre-test | 3.91 ± 1.37 | 4.27 ± 1.77 | 7.20 ± 1.55 | 7.11 ± 1.81 |
| Post-test | 3.25 ± 1.30 | 3.93 ± 1.89 | 6.57 ± 1.61 | 6.95 ± 1.75 |

Abbreviations: M, mean; SD, standard deviation.

### Analgesic effect of nostalgia

We first compared the reported pain across the two groups for pre-test and post-test, respectively. The independent samples *t*-test revealed no significant difference between the two groups on the pre-test (control: 5.69 ± 1.65 vs. nostalgia: 5.56 ± 1.27; $t(116) = 0.50$, $p = 0.616$), but a significant difference on the post-test (control: 5.44 ± 1.60 vs. nostalgia: 4.91 ± 1.15; $t(116) = 2.08$, $p = 0.04$, $d = 0.38$). Then, following procedures used in a previous study,[39] the reported pain was averaged separately for the pre-test and post-test sessions for the following analysis. Analgesic effects (i.e., the changed reported pain for pre-test minus post-test) in these measures (Table 1) were calculated to examine the effect of nostalgia on reported pain. A two-way mixed analysis of variance (ANOVA) on the analgesic effect was conducted with the condition as the between-subject variable, and the intensity as the within-subject variable. Results showed that the main effect of condition was significant, ($F(1,116) = 5.92$, $p = 0.017$, $\eta_p^2 = 0.049$) and that the analgesic effect in the nostalgia condition (0.65 ± 0.91) was significantly larger than that in control condition (0.25 ± 0.85, $t(116) = 2.43$, $p = 0.017$, $d = 0.45$, Figure 1B), indicating that participants reported greater pain decreasing after a nostalgic experience. The main effect of intensity was not significant ($F(1,116) = 1.53$, $p = 0.218$) (suggesting a similar analgesic effect at both low and high intensities), neither was the interaction between condition and intensity ($F(1,116) = 0.97$, $p = 0.328$).

To examine how the analgesic effect was related to nostalgia, for participants who experienced an analgesic effect (i.e., the changed reported pain for pre-test minus post-test > 0) in the two groups, we also calculated the correlation between nostalgic proneness (measured using the Southampton Nostalgia Scale) and the analgesic effect, as well as the correlation between state nostalgia (measured using manipulation check questions) and the analgesic effect. Nostalgic proneness showed a nonsignificant correlation just above the alpha-level of 5% ($r = 0.195$, $p = 0.08$). It revealed that individuals' nostalgic proneness was significantly and positively correlated with the analgesic effect in the nostalgia group ($r_{nostalgia} = 0.362$, $p = 0.016$, Figure 1C), but not in the control group ($r_{control} = 0.004$, $p = 0.981$). It suggested people with higher nostalgic proneness are more likely to have analgesic effects elicited by state nostalgia. No significant correlation between state nostalgia and analgesic effects was found ($r_{nostalgia} = 0.116$, $p = 0.453$; $r_{control} = 0.154$, $p = 0.350$). The regression analysis with nostalgic proneness, state nostalgia, and experimental conditions as predictors of analgesic effects did not reveal expected

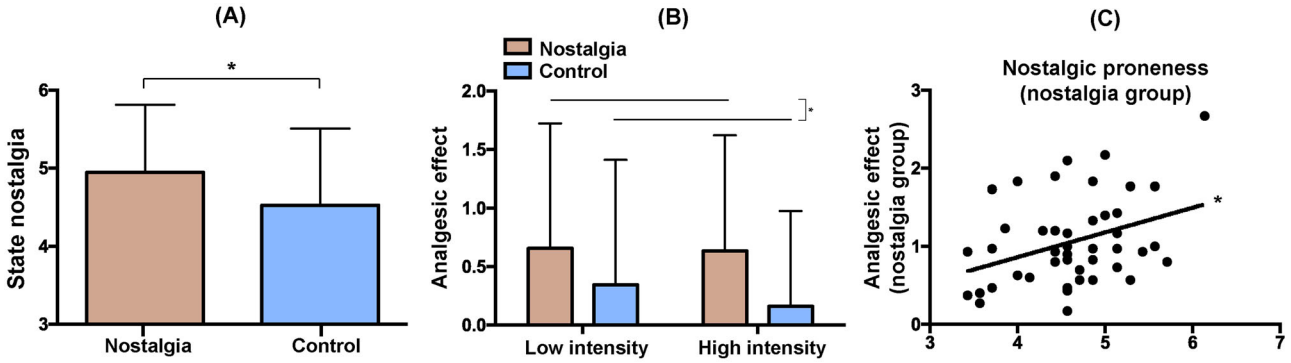


**FIGURE 1** (A) Manipulation check. (B) The effect of condition on analgesic effect. (C) Correlation between the nostalgic proneness and analgesic effect in the nostalgia group (error bars represent standard deviation, * $p < 0.05$).

results ($R^2 = 0.135$; $\beta_{nostalgic\ proneness} = 0.127$, $p = 0.161$; $\beta_{state\ nostalgic} = 0.06$, $p = 0.373$; $\beta_{condition} = 0.341$, $p = 0.009$).

Study 1 provides evidence supporting the hypothesis that there is nostalgic analgesia on reported pain evoked by thermal stimuli, which is to say that individuals reported a lower pain level after recalling a nostalgic event than after recalling an ordinary event. We did not find an interaction between condition and pain intensity, indicating that analgesic effects of event-induced nostalgia did not vary with pain intensity.

## METHODS

### Study 2

Study 2 employed a within-subject design with a different manipulation of nostalgia to examine whether the nomothetic approach—a very short manipulation using generic materials (i.e., examples of childhood memories that participants would have shared)—could replicate the analgesic effect of nostalgia and whether the analgesic effect varied according to different pain intensities.

### Participants

*A priori* power analysis indicated that a sample size of 34 would allow for the detection of medium effect size ($d = 0.25$) with 80% power at an alpha of 0.05 for the repeated measures with two within-subject factors, according to the previous study.[40] A total of 66 participants took part in study 2 (29 males, age = 21.82 ± 1.98 years, range = 18–26 years). These participants comprised samples from two separate studies to expand our total sample size ($n = 32$ and $n = 34$) to achieve more stable results; one was an fMRI study conducted in the same experimental setup but focused on different research purposes (i.e., brain mechanisms of analgesia).[40] There was no significant difference in pain sensitivity ($t(64) = 1.19$, $p = 0.237$), nostalgic proneness ($t(64) = 0.55$, $p = 0.583$), reported pain ($t(64) = 0.11$, $p = 0.915$), and nostalgic strength ($t(64) = 1.09$, $p = 0.278$) /pleasantness ($t(64) = -0.24$, $p = 0.813$) toward figure stimuli between the two studies, suggesting that participants were homogeneous and could be combined. Data analysis on behavioral performance in the current study was similar to the previous fMRI one; however, varied correlation results were found based on the different sample sizes. We instructed participants not to ingest any alcohol or pain medicine for at least 4 h prior to participating in the experiment.[35,36] Participants completed a thorough written informed consent process and were compensated and debriefed after completing all the tasks.

### Visual materials

The materials, including 26 nostalgic images and 26 control images (see Figure 2 for material samples), were adopted from a previous study in which these materials were successfully used to induce nostalgic feelings.[41] The nostalgic pictures depicted objects or scenes from childhood, while the control pictures depicted corresponding objects or scenes from modern life.

### Thermal pain stimuli

The thermal pain stimuli were the same as those used in study 1. Before data collection, the threshold of pain (42.85 ± 1.95°C) was measured to define the low intensity (43.99 ± 1.69°C) and the high intensity (46.00 ± 1.67°C). In the main experiment, pain perception was measured through participants' responses to 52 heat pulses at low or high intensity.

### Procedure

First, the heat pain threshold was determined before beginning the main experiment (same as the method used in study 1). Then, participants were asked to respond to the thermal stimuli and rate their perception of pain. This was composed of 52 trials that combined cue and thermal stimuli. The presentation of stimuli and manual response measurements was controlled using E-Prime 2.0 (Psychological Software Tools, Inc.). In each trial (Figure 2), a white fixation cross was

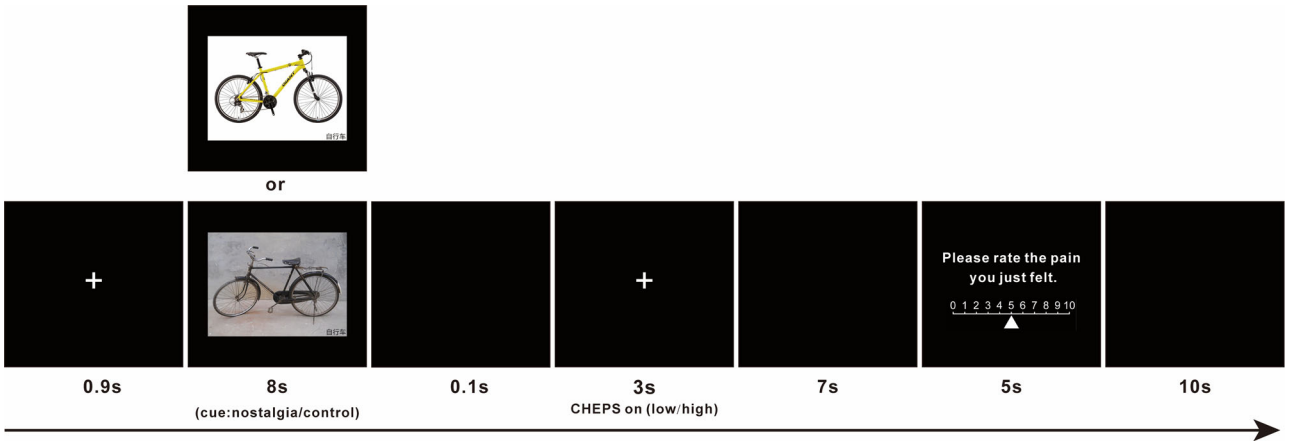


**FIGURE 2** The setup for each trial in study 2.

first presented for 0.9 s, and then one of the two cues (nostalgia or control) was presented for 8 s. After that, a white fixation cross was presented at the same time as a thermal pulse (threshold temperature plus 1°C/3°C) was delivered to the right forearm (lasted for 3 s). Then, a black background screen appeared for 7 s. Participants were then asked to consider the pain they had just experienced and use a response box with their left hand to rate the level of pain they felt from the brief thermal stimuli using a numerical pain rating scale (lasted for 5 s) ranging from 0 (*no feeling*) to 10 (*pain as bad as it could be*), with 4 denoting the threshold of pain. After this, a black background screen appeared for 10 s before the next trial began. Finally, as a manipulation check, participants were asked to rate the nostalgic strength of each picture (i.e., "*To what extent does this picture make you feel nostalgic*") by providing a response rating ranging from 1 (*not at all*) to 5 (*very much*). To examine the pleasantness of the nostalgia they experienced, we also asked participants to rate each picture (i.e., "*To what extent does this picture make you feel pleasant*") with responses rated from 1 (*very unpleasant*) to 5 (*very pleasant*).[42]

## RESULTS

## Study 2

### Post-experiment manipulation check

As expected, *t*-tests revealed that participants felt more nostalgic (i.e., nostalgic strength) toward the nostalgic figures (4.37 ± 0.37) than toward the control figures (2.23 ± 0.59; $t(130) = 24.87$, $p < 0.001$, $d = 4.33$), indicating that the manipulation worked as intended. Participants also reported feeling more pleasant toward the nostalgic figures (3.95 ± 0.40) than toward the control figures (3.60 ± 0.49; $t(130) = 8.59$, $p < 0.001$, $d = 1.50$) (Figure 3A). The reported nostalgic strength was positively correlated to the reported pleasantness ($r = 0.368$, $p < 0.001$).

### Effect of nostalgia on reported pain

Reported pain data were analyzed using two-way repeated ANOVAs with condition and intensity as the within-subject variables. Results revealed that the main effects of condition and intensity, as well as the interaction between them, were significant ($F(1,65) = 11.03$, $p = 0.001$, $\eta_p^2 = 0.145$; $F(1,65) = 462.43$, $p < 0.001$, $\eta_p^2 = 0.877$; and $F(1,65) = 21.04$, $p < 0.001$, $\eta_p^2 = 0.245$, respectively). Further analysis showed that the reported pain in the nostalgia condition (3.95 ± 1.30) was significantly lower than that in the control condition (4.20 ± 1.23) at the low-intensity level ($t(130) = -5.26$, $p < 0.001$, $d = 0.20$) (Figure 3B), but not at the high-intensity level ($t(130) = 0.60$, $p = 0.558$).

To examine how the analgesic effect was related to nostalgia, we looked specifically at participants who had experienced an analgesic effect (i.e., reported pain for control condition minus nostalgia condition > 0). We also calculated the correlation between the assessment in the different dimensions (nostalgic strength/pleasantness) of nostalgic (vs. control) figures and the analgesic effect (i.e., the differences in reported pain in the control condition compared to in the nostalgia condition), as well as the correlation between nostalgic proneness (measured using the Southampton Nostalgia Scale) and the analgesic effect. The results revealed that the differences in rated pleasantness for the figures (nostalgia > control) were significantly and positively correlated with the analgesic effect on reported pain ($r = 0.49$, $p = 0.001$, Figure 3C), indicating that the more pleasant the participants felt when they observed the nostalgic cues (vs. control), the greater the analgesic effect was. No significant correlations were found between the rated nostalgic strength/proneness differences and analgesic effects ($r_{nostalgic\ strength} = 0.14$, $p = 0.384$; $r_{nostalgic\ proneness} = 0.15$, $p = 0.352$). The regression analysis with the rated nostalgic strength difference, the rated pleasantness difference, and nostalgic proneness as predictors of analgesic effects did not reveal expected results ($R^2 = 0.31$; $\beta_{nostalgic\ strength} = 0.04$, $p = 0.424$; $\beta_{pleasantness} = 0.25$, $p < 0.001$; $\beta_{nostalgic\ proneness} = 0.09$, $p = 0.086$).

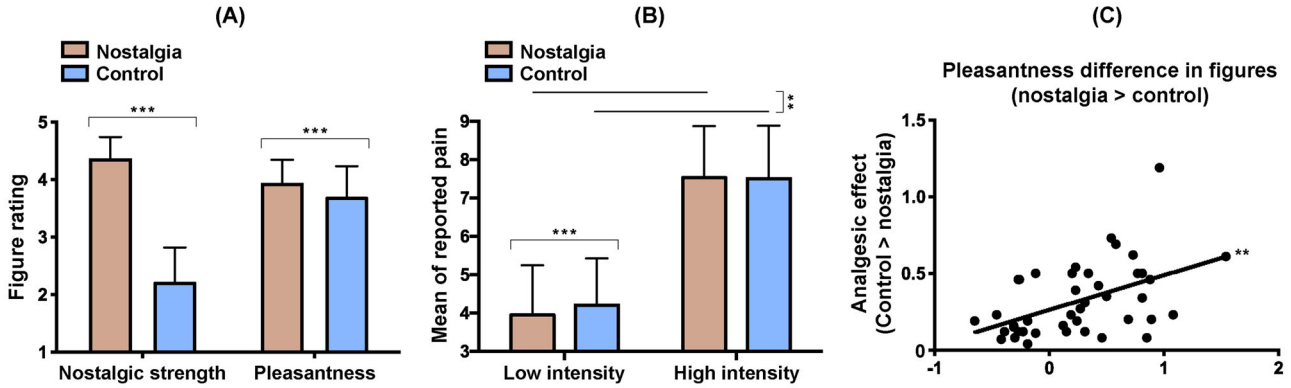


**FIGURE 3** (A) Manipulation check using a 5-point Likert scale. (B) The effect of the condition on reported pain. (C) Correlation between the analgesic effect and the rated pleasantness difference in figures (** $p < 0.01$; *** $p < 0.001$).

## Analgesic effects based on idiographic versus nomothetic approaches

Both nostalgias elicited by the idiographic approach (study 1) and the nomothetic approach (study 2) showed analgesic effects. To explore which paradigm has a better effect on pain relief, we compared the analgesic effect in study 1 and study 2. The analgesic effects in study 1 (i.e., the changed reported pain of pre-test minus post-test in the nostalgia condition) and study 2 (i.e., the difference in the reported pain between the control and nostalgia conditions) were calculated for the following analysis. Then, these data were standardized using a z-score transformed formula into a 0–1 scale for the follow-up independent *t*-test.[43] The unique max and min were obtained from combined data from two studies and used for the equation. It revealed that the

$$Z = \frac{(X - \mathrm{Min}(X))}{(\mathrm{Max}(X) - \mathrm{Min}(X))}$$

analgesic effect in study 1 (0.59 ± 0.18) was better than that in study 2 (0.49 ± 0.06; $t_{Welch\text{-}corrected}(68.42) = 3.87$, $p = 0.0002$, $d = 0.71$, Figure 4A), at both the low (0.61 ± 0.21 vs. 0.53 ± 0.07; $t_{Welch\text{-}corrected}(71.07) = 2.77$, $p = 0.0071$, $d = 0.51$, Figure 4B) and high pain conditions (0.49 ± 0.18 vs. 0.37 ± 0.06; $t_{Welch\text{-}corrected}(70.59) = 4.85$, $p < 0.0001$, $d = 0.89$, Figure 4C), indicating that the idiographic approach worked better than that the nomothetic approach on pain relief.

Using a nomothetic approach to elicit nostalgia, study 2 replicated the analgesic effect of nostalgia as observed in study 1, particularly in the low pain condition: individuals felt less pain in response to these thermal stimuli in the nostalgia condition for the low-intensity thermal stimuli.

## DISCUSSION

Using these two studies, we examined nostalgia's analgesic effect on elicited thermal pain using different induction methods at both low and high intensities. Our research results indicate a general analgesic effect of nostalgia elicited by the idiographic approach on both low and high pain (study 1). Meanwhile, the analgesic effect of nostalgia produced by the nomothetic approach had more of a relieving effect on low pain (study 2). Compared to nostalgia evoked using the nomothetic approach, there was a better analgesic effect from nostalgia elicited using the idiographic approach. These findings provide new evidence for nostalgic analgesia on reported pain evoked by thermal stimuli.

Nostalgic reflection increases optimism and perceived social support, playing a motivational component in achieving goals accompanied by positive self-regard,[12,23,44] which subsequently leads directly to positive outcomes.[19] Pain caused by physical injury can evoke unpleasant negative emotions, whereas nostalgia affords individuals comfort and counteracts adverse conditions.[24] Indeed, pleasantness was correlated to the analgesic effect (in study 2), suggesting nostalgia might provide positive status to help cope with the subsequent painful experience, instead of eliminating or reducing the objective noxious stimuli.[25] In study 2, during the passively observing cues, these childhood-related materials might elicit high instant pleasure (nostalgic strength was positively correlated to pleasantness), which is reasonable to expect that it is different from general pleasantness. It might be that nostalgia-induced pleasure induces analgesic effects. Thus, in both studies, we observed an analgesic effect on thermal stimuli after experiencing nostalgia.

## Nostalgic analgesia elicited by idiographic versus nomothetic approaches

The current research conducted two approaches—an idiographic one (the event reflection task) and a nomothetic one (viewing nostalgic pictures)—to arouse nostalgic emotions. The idiographic approach consists of active recollection stimulated by writing memory details, intending to aid participants in eliciting more in-depth, comprehensive memories of past experiences. In contrast, the nomothetic approach is a passively evoked nostalgia method using snippets of triggers within a limited time duration, intending to help participants briefly recall

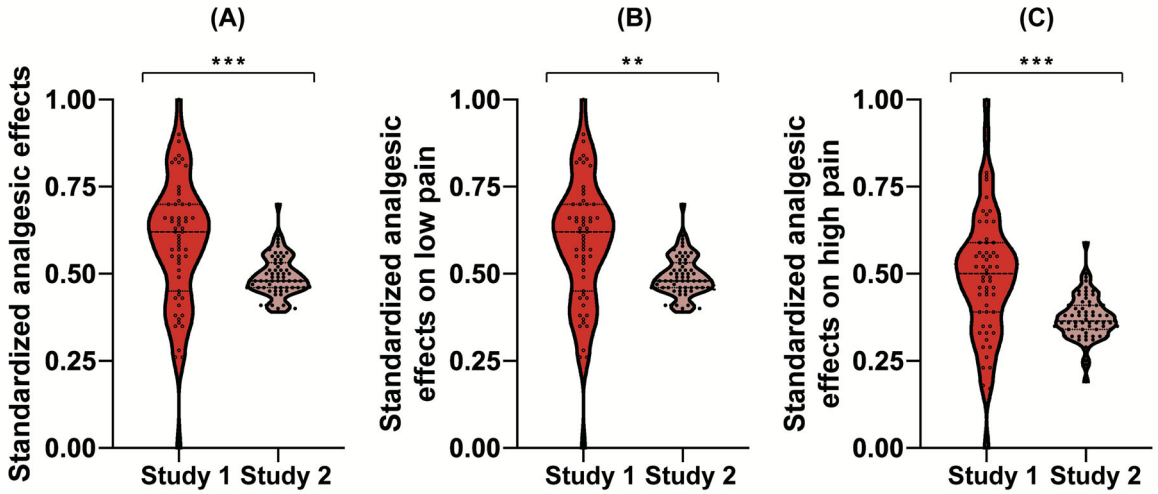


**FIGURE 4** (A) Comparison of analgesic effects of the two paradigms. (B) Comparison of analgesic effects on low pain in the two paradigms. (C) Comparison of analgesic effects on high pain in the two paradigms (** $p < 0.01$; *** $p < 0.001$).

an event rather than having them focus on the full details of the entire event. Thus, compared to passively observing nostalgic cues (study 2), actively recalling a nostalgic event (study 1) engaged higher self-involvement and aroused stronger nostalgic emotion.[2] This appeared to help individuals amplify their positive affective states in order to reduce their perception of an external noxious stimulus,[45] as we observed in their performance in the study as shown in Figure 4.

More importantly, our findings show that nostalgic emotion induced by different methods varied in analgesic effects on thermal pain. Previous studies have shown that nostalgia can alleviate physical discomfort in individuals experiencing chronic and acute pain (e.g., tenderness).[24,25] Still, whether this analgesic effect is strong enough to address tolerable pain or severe pain has not been determined. The idiographic approach, with a high degree of self-involvement by the participants, induced a general analgesic effect on both low and high intensities of pain. In contrast, the nomothetic approach only had an analgesic effect on low pain intensity. Due to the fact that nostalgia stems from one's actual lived experiences, event reflection could arouse stronger emotion and, therefore, work better on both low and high levels of pain. In contrast, observation-based nostalgia might lead to relatively weaker feelings, and, therefore, only have the ability to affect low pain levels.

## Nostalgic analgesia on low pain versus high pain

In study 2, the cues served as a primer that could affect the processing of the subsequent stimuli. As mentioned above, nostalgic cues provided a positive effect before the introduction of the noxious stimuli.[24] It is possible that the effect of nostalgia can then be easier retained and last longer when faced with the weaker-intensity noxious stimulation, reflecting a better analgesic effect on low pain. However, when faced with high-intensity stimulation, tolerating the high level of pain occupies more resources, detracting from the nostalgic effects, resulting in the pain being perceived much more strongly. Or, given that experiencing pain is shown to demand more attention,[27] it seems that the intensity of noxious stimuli dominates cognitive resources and interferes with the duration of the analgesic effect from nostalgic cues. Our findings suggest the importance of considering pain intensity when attempting to invoke the analgesic effect of nostalgia.

## Limitations and conclusion

There are several limitations to acknowledge in the current studies. First, although our manipulation in study 1 was successful, participants in the nostalgia condition did report higher levels of nostalgia than those in the control condition, even though the mean nostalgia level in the control condition was relatively high. The results should be replicated with a stronger manipulation of nostalgia. Second, nostalgia is a very complicated emotion. It is hard to determine which part of nostalgia contributes more to analgesia. Given that pleasantness is an essential component of nostalgia,[10,46] and positive emotion may also relieve pain, future studies should include another pleasant condition as a comparison to further clarify the effects of nostalgia in order to make up for the limitation of this research. Third, the experimental designs in study 1 and study 2 were different. We made a rough comparison through z-transformation for analgesic effects in the two studies. In understanding the comparison results across two studies, we should keep the differences in mind and be cautious. Fourth, the cues in study 2 were common nostalgic materials specific to the participants' age demographic, rather than self-related specific ones. Personal involvement might be lower when participants passively observed the generalized nostalgic materials in comparison to self-related nostalgic ones. It is, however, noteworthy that we nonetheless observed an analgesic effect on low pain, which could reasonably predict that nostalgia may elicit a stronger sense of pain relief when participants observe self-related cues to arouse stronger nostalgic emotion.

In conclusion, our two studies provide novel evidence for the analgesic effect of nostalgia while highlighting the potential moderating roles of both the nostalgia induction approach and pain intensity. Based on the findings of our studies, nostalgia could be considered a kind of psychological strategy for pain relief for patients experiencing mild pain. Particularly nostalgia induced using the idiographic approach could be used in psychosocial interventions to help reduce the burden of pain. In fact, nonpharmacological methods have been proven effective for a number of situations, including postoperative pain, disease recovery, chronic pain (e.g., low back pain and tension headaches), or in some cases, prolonged pain symptoms.[47]

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## AUTHOR CONTRIBUTIONS

M.Z., Z.Y., H.C., and Y.K. designed the research methods. J.Z, M.Z., and Y.Z. performed the research. M.Z. and Y.K. analyzed the data. M.Z. wrote the first draft of the paper. All authors edited the paper.

## COMPETING INTERESTS

The authors declare no competing interests.

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