Benefits of Nostalgic Landmarks for People Living with Alzheimer's Disease

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Cite this paper as:

Oliver A, Wildschut RT, Redhead ES, Parker MO, Sharif A, Wood AP, Sedikides C and Cheston R (2024) Benefits of Nostalgic Landmarks for People Living with Alzheimer's Disease, *Journal of Alzheimer's Disease*, 102(3), 683-702, DOI: 10.1177/13872877241291908.

Running title: Benefits of nostalgia for people with dementia

Abstract.

Background: Emerging literature shows that nostalgia induced by autobiographical reflection and music confers psychological benefits to people living with dementia.

Objectives: Our objective was to test the potential benefits of nostalgic landmarks for people living with Alzheimer's disease.

Methods: We displayed the landmarks as wall-mounted pictures within a virtual environment. In Experiment 1, we developed the nostalgia manipulation by using pictures associated with the decade during which participants lived most of their childhood. To examine the effectiveness, tolerability, and safety of this pictorial nostalgia induction, we conducted the experiment with 172 healthy adults. In Experiment 2, we recruited 20 participants living with Alzheimer's disease who experienced mild to moderate cognitive impairments. We further personalised the pictorial nostalgia induction by interviewing them about fond memories from their past and generating images corresponding to these events. We hypothesised that navigating a virtual environment with wall-mounted nostalgic (compared to control) pictures would confer psychological benefits.

Results: The nostalgic (vs. control) pictures evoked higher levels of momentary nostalgia; the manipulation was successful (Experiments 1-2). Compared to control pictures, nostalgic pictures significantly increased self-reported positive (but not negative) affect, self-esteem, self-continuity, social connectedness (Experiment 1-2), and meaning in life (Experiment 2). Participants in the nostalgia condition (compared to controls) evinced better picture recognition, but not improved spatial memory (Experiment 2).

Conclusion*:* Our findings demonstrate that nostalgic landmarks confer psychological benefits and enhance picture recognition among people living with Alzheimer's disease. This work has real-world applications for dementia-friendly design and therapy-related practices.

Keywords: Alzheimer's disease, dementia, memory, nostalgia, psychological benefits, dementia-friendly design

INTRODUCTION

In the earliest stages of Alzheimer's disease (AD), getting lost in everyday environments is common [1]. Brain regions key for navigation success are among the first to present AD pathophysiology [2]. People living with condition, as a result, experience difficulties with navigation [3], especially when learning new routes [4]. Becoming lost can heighten spatial anxiety [5, 6] and reduce confidence in exploring unfamiliar places [7]. Indoor residential environments are too often poorly designed, with similar looking hallways and long corridors [8, 9]. AD causes visual attention deficits [10], which affect a person's ability to attend to sensory information. To combat this behavioural challenge, environmental design guidelines recommend implementing recognisable and meaningful landmarks to support spatial navigation [11]. Clinicians, researchers, and laypeople have called for artwork or items that evoke positive emotions and are of personal relevance to a navigator [11-13]. Kris and Henkel [12] highlighted the importance of enriching environments for people with memory loss by using autobiographically-salient images to preserve the sense of self and stimulate emotions, such as nostalgia.

Nostalgia, a sentimental longing or wistful affection for the past [14], has attracted substantial scholarly attention over the past decades. It is a predominantly positive, social emotion [15], with a bittersweet affective signature [16]. Nostalgic reflections embody personally meaningful memories, typically drawn from childhood or close relationships [17, 18]. Reliving events from the past can trigger both ordinary and nostalgic memories (Coleman, 2005), but it is often the nostalgic ones that feature the self as the protagonist whilst surrounded by their loved ones. In nostalgic reverie, the person feels content, warm, and comforted, yet misses valued moments of the past [17]. The emotion is experienced frequently (e.g., several times per week) [19, 20], throughout a person's lifetime [19, 21, 22], and across cultures [23]. Crucially, empirical research has established that nostalgia confers important psychological benefits. It increases positive affect [20, 24], boosts self-esteem [17, 20], strengthens self-continuity (i.e., a sense of connection between one's past and present self) [25], enhances social connectedness [17, 26, 27], and augments meaning in life [28]. Nostalgia confers these benefits across cultures [29].

The psychological benefits of nostalgia among people living with dementia have been addressed in an investigation by Ismail and colleagues [30]. They induced nostalgia among people living with dementia who experienced mild to moderate levels of cognitive impairment. In the first two experiments, participants completed the Event Reflection Task [31], in which they wrote about a nostalgic event (e.g., their wedding day) versus an ordinary autobiographical event (e.g., a shopping trip) [20, 32]. In the third experiment, participants listened to a song they had identified as evocative of nostalgia (vs. a non-nostalgic song). Across experiments, participants in the nostalgia (relative to control) condition felt more positive affect, reported higher self-esteem, experienced stronger self-continuity, felt more socially connected, and had a greater sense of meaning in life.

Based on Ismail and colleagues' [30] findings, we hypothesised that, in the course of spatial navigation, landmarks that evoke nostalgia would convey psychological benefits to individuals living with dementia. To test this, we embedded within a virtual environment personalised nostalgic pictures. Virtual-environment technology can generate life-like and interactive design features [33], thus providing an ecologically valid platform to implement our nostalgia induction. The virtual environment simulated an indoor hallway through which participants navigated a designated route, from a starting point to an end destination. To manipulate nostalgia, we varied whether the pictures mounted along the route were nostalgic (nostalgia condition) or non-nostalgic (control condition). In Experiment 1 (N = 172), we tested our pictorial nostalgia induction on healthy adults. Having established its effectiveness, tolerability, and safety, we examined in Experiment 2 the impact of our pictorial nostalgia induction among people living with dementia who experienced mild to moderate levels of cognitive impairment (N = 20). Across both experiments, we hypothesised that nostalgia (compared to control) would confer key psychological benefits: positive affect, self-esteem, self-continuity, social connectedness, and meaning in life [17, 20, 27, 34-36]. A secondary objective of Experiment 2 was to test the influence of nostalgia on picture recognition and spatial memory. According to Caduff and Timpf [37], the overall salience of a spatial cue (e.g., a picture) is determined by (1) visual salience (e.g., size, contrast, colour), (2) structural salience (e.g., location), and (3) semantic salience (e.g., the cue's cultural, personal, or historical relevance to a person). Nostalgic pictures should be high in semantic salience owing to their connection with unique and meaningful autobiographical memories. We therefore expected that nostalgic (compared to non-nostalgic) pictures would enhance picture recognition and spatial memory.

EXPERIMENT 1

In Experiment 1, we examined the effectiveness, tolerability, and safety of our pictorial nostalgia induction in a sample of healthy adults, prior to implementing it among people living with AD in Experiment 2. We hypothesised that nostalgic (compared to non-nostalgic) pictures would increase positive (but not negative) affect, self-esteem, self-continuity, social connectedness, and meaning in life.

MATERIALS AND METHODS

Participants and design

Experiment 1 received ethics approval from the University of Southampton ethics board on 17th November, 2020 (ref: 61455). We conducted an a priori power analysis for a between-participants design, using G*Power 3.1 [38]. It yielded a minimum sample size of 128 to detect a medium-sized effect (f = .25) with power equal to .80 and an alpha level of .05 (two-tailed). To hedge against attrition, 172 adults (90 women, 82 men) took part in the experiment. We recruited participants via the online platform, Prolific, www.prolific.ac [8]. We advertised the experiment to a large pool of participants on Prolific using the following recruitment criteria: (1) individuals aged 49-78 years, (2) of U.K. nationality, and (3) with normal or corrected to normal vision. The first two criteria enabled us to tailor the pictorial nostalgia induction to a specific cohort of participants (see below). We implemented the third criterion because the virtual environment involved visual processing. We excluded one participant who reported a dementia diagnosis, because we wanted to evaluate the induction before implementing it among people living with AD. Participants completed a 25-minute online experiment in return for payment (£3.12). We randomly assigned them to one of two conditions: nostalgia (n = 87) or control (n = 85). We present sample characteristics by experimental condition in Table 1. Participant age, gender, ethnicity, and educational level did not differ significantly between conditions.

Online survey

We generated the experiment using the Qualtrics platform. Prior to consent, we instructed participants to find a quiet, distraction-free space before starting the experiment (Supplementary Material S1).

Personality measures

Participants next completed two personality measures, assessing trait-level nostalgia and resilience. We measured trait nostalgia with an adapted version of the Southampton Nostalgia Scale (Supplementary Material S2) [31]. We first presented participants with two illustrations, each detailing a personal account of nostalgia. Then, participants rated seven items (e.g., "How much do you like to feel nostalgia?" "How often do you feel nostalgia when you think about things that happened when you were younger?"; 1 = *not at all, very rarely*, 7 = *very much, very frequently*; α = .90, M = 4.83, SD = 1.21). We measured resilience with the 6-item Brief Resilience Scale [39]. Participants rated each item on a 5-point response scale (e.g., "I tend to bounce back quickly after hard times," "I have a hard time making it through stressful events"; 1 = *strongly disagree*, 5 = *strongly agree*; α = .89, M = 3.33, SD = 0.84).

Control measures

We then assessed participants' familiarity with the term "nostalgia" ("How familiar are you with the meaning of the word nostalgia?"; 1= *not at all*, 4 = *very well*, M = 3.51, SD = 0.61). We also assessed participants' previous experience with computer games (e.g., "How much experience do you have with playing computer games?") and virtual reality environments (e.g., "How much experience do you have with playing computer games which involve a virtual environment technology [e.g., flight simulation]?") via a 3-item Computer Experience Questionnaire (1 = *no experience at all*, 7 = *a lot of previous and recent experience*; α = .69, *M* = 4.14, *SD* = 1.09) [40]. We measured spatial anxiety using the 8-item Spatial Anxiety Scale [6]. Items included a series of hypothetical spatial scenarios (e.g., "Finding my way to an appointment in an unfamiliar area of a city or town," "Trying a new route that I think will be a shortcut, without a map"). Participants rated how anxious each scenario would make them feel (1 = *not at all anxious,* 5 = *very anxious*; α = .94, *M* = 2.55, *SD* = 0.99). Lastly, we recorded self-reported cognitive impairment using the 13-item Mild Cognitive Impairment Questionnaire (MCIQ; 0 = *never,* 4 = *always*) [41]]. This questionnaire yields two subscales. Scores on each subscale are transformed to a 0-100 metric, with higher scores indicating greater impairment concerns. Seven items comprise the Practical Concerns subscale (e.g., "Worry that you have forgotten what you had planned to do;" α = .88, *M* = 21.08, *SD* = 17.14) and six items comprise the Emotional Concerns subscale (e.g., "Irritation or frustration about your memory problems;" α = .93, *M* = 17.30, *SD* = 21.39). Mean scores on these subscales were low, indicating that, on average, participants never or rarely experienced the relevant concerns.

Nostalgia manipulation

Next, we manipulated nostalgia in the context of a virtual navigation task. We did so by varying the content of 14 pictures that were mounted on the walls along the route of a virtual environment. The pictures comprised the following themes: TV series, films, musicians, cars, technology, sports figures (i.e., Olympic athletes, footballers), and Royal Family events. Nostalgia is a personally meaningful emotion that often revolves around childhood memories [28]. We followed a nomothetic approach by tailoring the inductions to specific cohorts. Specifically, we selected the pictures according to the time period in which participants would have lived their childhood years (i.e., when they were 6-11 years of age). For the nostalgia condition, we created three sets of nostalgic pictures according to participants' current age. The pictures reflected the decades (i.e., 1950s, 1960s, 1970s) during which participants lived most of their childhood. For example, we conducted Experiment 1 in

2021, and so participants aged 49-58 would have lived at least three of their five childhood years (i.e., 6-11 years of age) in the 1970s (for a worked example, see Supplementary Material S3). They would therefore view nostalgic pictures dated to this specific decade (e.g., a picture of the Queen's Silver Jubilee in 1977; Fig. 1, bottom left). Participants aged 59-68 viewed nostalgic pictures from the 1960s (e.g., Princess Margaret and Antony Jones's wedding in 1960; Fig. 1, top right). Participants aged 69-78 viewed nostalgic pictures from the 1950s (e.g., the Queen's coronation in 1953; Fig 1., top left). In the control condition, participants viewed thematically-matched control pictures dated between 2008-2020 (e.g., Prince William and Catherine Middleton's wedding in 2011; Fig. 1, bottom right). In total, we sourced 56 pictures from online search engines (Supplementary Material S4). We equalised the average luminance and global contrast of coloured pictures using MATLAB.

Virtual environment

We presented the pictures to participants within a virtual indoor environment using Unity software. We developed a standard virtual 3D environment that enabled participants to explore a route from a starting point to an end destination (Fig. 2). Along the route, there were 14 wall-mounted pictures (nostalgic or control) that served as local landmarks. Participants first navigated the designated route three times with guidance from green arrows placed at decision points. After this, they navigated the route once without arrows. The virtual environment offered a first-person perspective (Fig. 3). Participants controlled their movement using the "forward," "backward," "left," and "right" arrow keys.

Outcome measures

After the nostalgia manipulation (i.e., following completion of the navigation task), participants filled out a manipulation check and the dependent measures. The manipulation check assessed the extent to which participants felt nostalgic. We administered a validated 3-item measure ("Right now, I am feeling quite nostalgic," "Right now, I am having nostalgic feelings," and "I feel nostalgic at the moment") [42]. Participants rated these items from 1 (*strongly disagree*) to 6 (*strongly agree*) ($\alpha = 0.99$, $M = 2.70$, $SD = 1.60$). Then, we assessed six psychological benefits, using an adapted version of Hepper et al.'s [17] Nostalgia Functions Scale, with the addition of a self-continuity measure [25]. This generated a 12-item instrument (two items per function): positive affect (e.g., "The pictures made me feel happy," $\alpha = 0.95$, $M = 3.56$, $SD = 1.46$), negative affect (e.g., "The pictures made me feel sad," $\alpha = 0.76$, $M = 1.58$, $SD = 0.84$), self-esteem (e.g., "The pictures made me feel good about myself," $\alpha = 0.91$, $M = 2.59$, $SD = 1.31$), self-continuity (e.g., "The pictures made me feel closer to my past," $\alpha = 0.93$, $M = 3.10$, $SD = 1.59$), social connectedness (e.g., "The pictures made me feel connected to loved ones," $\alpha = 0.91$, $M = 2.40$, $SD = 1.29$), and meaning in life (e.g., "The pictures made me feel like life is meaningful," $\alpha = 0.96$, $M = 2.47$, $SD = 1.36$), Participants rated these items from 1 (*strongly disagree*) to 6 (*strongly agree*).

Debriefing

Lastly, we asked participants an open-ended debriefing question (i.e., "*How did you find the game?*") to assess the tolerability and safety of the induction procedure.

Statistical analyses

Data were recorded and analysed using SPSS version 27. Chi-squared and independent samples t-tests were performed to detect differences (if any) on socio-demographic and personality variables between participants in the nostalgia and control condition. A series of independent samples t-tests were then used to examine the effect of nostalgic (vs. control) pictures on momentary nostalgia and its associated psychological functions. Ancillary analyses of covariance (ANCOVAs) were used to adjust for the influence of one personality measure on these comparisons.

RESULTS

Personality and control measures

We present descriptive and inferential statistics for the personality and control measures in Table 1. The conditions did not differ significantly on either trait nostalgia or resilience. There was a trend, however, for participants in the control condition to score higher on spatial anxiety than those in the nostalgia condition. We statistically controlled for this difference on spatial anxiety in ancillary analyses, reported below. None of the other control measures differed significantly between conditions.

Outcome measures

We present descriptive and inferential statistics for our outcome measures in Table 2. Participants in the nostalgia condition felt significantly more nostalgic (i.e., scored higher on the manipulation check) than those in the control condition, confirming that our pictorial nostalgia induction was effective. Crucially, participants in the nostalgia condition reported significantly higher levels of positive affect (but not negative affect), self-esteem, self-continuity, and social connectedness than those in the control condition. The effect of nostalgia on meaning in life was trending.

Ancillary analyses

In ancillary analyses, we controlled for spatial anxiety by including it as a covariate in an Analysis of Covariance (ANCOVA). This did not alter the pattern of significant and non-significant nostalgia effects, with one exception. When controlling for spatial anxiety, the effect of nostalgia on meaning in life was significant, $F(1, 169) = 4.48$, $p = 0.036$, $d = 0.33$. We did not run ANCOVAs to adjust for the other control measures or for the personality measures, because they did not differ significantly between the nostalgia and control conditions (Table 1).

Finally, we tested whether any of the two personality and five control measures qualified the effects of nostalgia on psychological benefits. We did so by first mean-centring these measures and then entering them as covariates in a series of moderated ANCOVAs. These analyses tested the main effects of nostalgia (vs. control) and the covariate, as well as the interaction between nostalgia and the covariate. Results did not reveal significant Nostalgia × Covariate interaction effects, attesting to the generality of nostalgia's psychological benefits.

Participant feedback

We examined participants' responses to the open-ended debriefing questions. We applied a simple coding scheme, which included the following categories: unrelated comments ($n = 6$), negative comments ($n = 18$), neutral comments ($n = 19$), positive comments ($n = 118$), and a mix of negative and positive comments ($n = 11$). The frequency distribution of these categories did not differ significantly between the nostalgia and control conditions, $\chi^2(4, N = 172) = 5.75$, $p = .219$. Most participants (69%) provided exclusively positive feedback (e.g., “interesting,” “easy,” “enjoyable,” “fun”). Some participants (10%), however, reported exclusively negative feedback. These comments referred to instances of getting lost, physical symptoms (e.g., “dizziness,” “nausea”), and psychological symptoms (e.g., “frustrating,” “difficult”). To mitigate this among people living with AD, in Experiment 2, we implemented additional training with a set criterion to assess suitability, and monitored any adverse effects that could occur.

DISCUSSION

In Experiment 1, we provided evidence that pictures can effectively induce nostalgia. We followed a nomothetic approach by tailoring general stimuli (e.g., popular culture) to a particular cohort [43]. Specifically, we generated pictorial content specific to the decade (i.e., 1950s, 1960s, 1970s) during which participants would have lived most of their childhood (i.e., 6-11 years of age). Although childhood memories are an important source of nostalgia [17, 18], our cohort-based induction may not have captured fully the highly personal nature of the emotion [28, 44], as well as the nostalgic memories from adolescence and early adulthood (Kirk, 2018). Idiographic nostalgia inductions allow the individual to select their own nostalgic songs [34, 45] or recall unique personal experiences [20, 31]. Based on this, and the feedback received during our Patient and Public Involvement work, we further developed our pictorial induction in Experiment 2 by tailoring it to participants’ unique autobiographical memories.

EXPERIMENT 2

In Experiment 2, we implemented the pictorial nostalgia induction among people living with AD who experienced mild to moderate cognitive impairments. To strengthen the induction, we adopted an idiographic approach and enhanced the personal relevance of the pictures by collating images that represented an individual’s unique autobiography. We hypothesised that nostalgic (vs. control) pictures would increase positive (but not negative) affect, self-esteem, self-continuity, social connectedness, and meaning in life. We further hypothesised that participants would evince better recognition for nostalgic than control pictures, and that nostalgic (compared to control) pictures would enhance spatial memory.

MATERIALS AND METHODS

The experiment received ethics approval from the University of Southampton ethics board[1] and an NHS Research Ethics Committee,[2] and gained site approval.[3] In addition, we conducted Patient and Public Involvement work to help design our nostalgia induction and virtual environment (Supplementary Material S5).

Participants and design

Twenty participants (8 women, 12 men, age range: 63-83 years, $M = 72.90$, $SD = 5.32$) completed the study (Fig. 4). Each participant had a study partner (typically their spouse), who also filled out a number of questionnaires. All participants identified themselves as White. The sample comprised a variety of education levels, that is, completion of secondary education ($n = 7$), University undergraduate degree ($n = 2$), University postgraduate degree ($n = 2$), doctoral degree ($n = 1$), and other ($n = 8$). Participants attended two 3-hour visits within an 8-week period.

We adopted a within-participants design, such that participants completed both experimental conditions (nostalgia and control) in counterbalanced order. Within-participants designs afford higher statistical power than between-participants designs, because each participant serves as their own control. An exhaustive recruitment process (Fig. 4) resulted in a final sample of 20 participants. A sensitivity power analysis using G*Power 3.1 [38] indicated that this sample size would allow us to detect a medium-to-large effect, $d = 0.66$, with 80% power (two-tailed $\alpha = 0.05$). For comparison, the average effect size across the five psychological benefits (i.e., positive affect, self-esteem, self-continuity, social connectedness, meaning in life) in Experiment 1 was $\bar{d} = 0.55$, and the average effect size across these same benefits in a series of studies among people living with AD was $\bar{d} = 1.49$ [30]. Considering these prior estimates and the strengthened pictorial nostalgia induction, it was reasonable to expect medium-to-large effects in Experiment 2.

All participants included in the study:

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[1] Ethics approval received on 6th March, 2020 (ref: 526320).
[2] South Central - Hampshire A Research Ethics Committee on the 13th July 2021 (REC ref: 20/SC/0210).
[3] From Southern Health NHS Foundation Trust, Research and Innovation Department.

- had a diagnosis of probable AD in line with the National Institute of Neurological and Communicative Disorders and Stroke Association – Alzheimer's Disease and Related Disorders Association criteria (NINCDS-ADRDA) [46] or National Institute on Aging and Alzheimer's Association criteria (NIA-AA) [47];
- had mild to moderate levels of cognitive impairment as indicated by a score of 18 or above on the Standardized Mini-Mental State Examination (SMMSE) [48] screening tool;
- had normal or corrected-to-normal vision;
- had a willing study partner or carer to attend and take part, who had >10 hours weekly contact with the participant;
- were fluent in English;
- and gave informed consent before participating in the study.

We excluded participants who:

- had a confirmed diagnosis of another dementia type;
- had a significant history or current premorbid psychiatric problems including severe anxiety or depression, as well as substance misuse;
- had any condition or disorder that could affect the patient's safety during participation;
- had a significant neurological disease other than AD which may affect cognition;
- had any previous or current medical condition that might impact cognitive performance;
- had a history or recent experiences (e.g., within the last 6 months) of motion sickness or vertigo;
- did not want to attend two separate sessions;
- or did not provide consent, because they lacked capacity or demonstrated a loss of capacity over the course of the two study visits.

Procedures

<u>Recruitment</u>

We recruited participants at the Memory Assessment & Research Centre (MARC), Moorgreen Hospital, Southampton, UK. We identified suitable participants using a database of volunteers who had given consent to be contacted regarding research opportunities and reviewed their medical notes to assess eligibility. We documented the number of individuals we approached as well as the number and reason of those who declined to take part.

Sample identification

The experimenter (AO) or a member of the MARC team (SS) made a judgement as to whether participants met the inclusion and exclusion criteria. These decisions were informed by electronic medical records and recent cognitive assessments, followed by a discussion with the potential participant. The experimenter contacted participants (and their study partners) by phone and email. After a brief introduction to the study, if interested, participants received information sheets via email or post. A week later, the experimenter contacted participants by phone to discuss participation in more detail and arrange a date for them to take part. If they were not interested, we made no further contact. We explained verbally and in writing that participation in the study was independent of the medical care that participants received, and that declining the opportunity to participate would not prejudice their ongoing care.

First visit

Informed consent

We obtained informed consent from all participants (and their study partners) prior to the start of any study-related procedures and in accordance with the Declaration of Helsinki (1975) and ICH Good Clinical Practice guidelines. We provided participants with written information about the design, purpose, and duration of the study, and gave them sufficient time (i.e., a minimum of 24 hours) to make an informed decision whether to take part. The experimenter discussed the study with participants and, in the process, assessed their understanding of the study, the potential risks involved, and their comfort with study-specific tasks, including computer technology. The experimenter then answered any questions before participants signed the consent forms.

Screening

After consent, the experimenter administered the SMMSE [48]—a well-established measure of cognitive function in older adults. We used this tool to assess cognitive ability at entry in an effort to ensure that participants met the inclusion criteria (i.e., probable AD with mild to moderate levels of cognitive impairment as indicated by an SMMSE score of 18 or above). In total, 28 participants entered the study, which took place in a clinical meeting room at MARC.

Joystick-computer training

Participants needed to complete joystick training to continue in the study (Supplementary Material S6). The purpose of this was to (1) introduce participants to virtual environment technology, and (2) offer guidance in how to manoeuvre in a virtual space. The clinical meeting room contained a single computer monitor, which connected to a Dell laptop with a standard Windows 7 operating system and a Thrustmaster USB joystick. In the training session, participants completed three tasks. All three virtual environments offered a first-person perspective. Participants could explore each environment by moving the joystick in “forward,” “backward,” “left,” and “right” motion, but could not look up or down, or interact with items.

We addressed participant feedback received in Experiment 1 (i.e., physical symptoms endured during the virtual task) by informing participants that they might experience temporary motion sickness or nausea and that, if this occurred, they should stop the task immediately and inform the experimenter. In the first training task, participants explored an outdoor virtual environment, which depicted a naturalistic model of the Psychology building and surrounding areas of the University of Southampton campus (e.g., car park, green spaces) [49, 50]. The experimenter gave verbal guidance on where participants could explore. In the second training task, participants completed the free-movement pattern Y-maze [51]. Participants learned how to turn at Y-shaped junctions within a virtual maze. Each task lasted three minutes. The third training task involved route-learning. The virtual environment presented an indoor hallway. Participants had to follow a specific route, including three turning points and one T-shaped junction. The path contained three neutral wall-mounted pictures, which we sourced from the Open Affective Standardised Image Set [52]. Participants navigated a guided route from a starting point to an end destination. Initially, they completed three training trials in which green arrows directed them along a designated route. In a final trial, participants had to navigate the same route without the arrows.

Participants entered the study if they met the following criteria:

- felt comfortable using the technology;
- successfully moved around the virtual environments using the joystick, and
- completed all three training tasks.

If participants did not meet the criteria, the experimenter thanked them for their participation and ended the study. Four participants failed the joystick training task and a further three withdrew from the study at this point. Data from one participant were excluded from analysis because this participant did not follow instructions for the navigation task on the second visit (Fig. 4).

If participants met the criteria, the experimenter concluded the session with a brief demonstration of the picture-recognition and spatial-memory tasks. The experimenter presented participants with one (out of the three) neutral pictures encountered along the virtual route in the third training task and asked a series of questions that captured picture recognition ("Did you see this picture during the game?" "Yes" or "no"), spatial memory ("In the game, which way did you have to go at this picture?" "Left," "right," "straight on," or "not sure"), and confidence ("How confident do you feel about your answer to the previous question(s)?" "1 = *not confident at all*, 5 = *very confident*").

Personality measures

Next, participants (and their study partners) completed a series of personality measures. The experimenter verbally read out the questions and recorded participants' responses. The study partner independently completed the same set of personality measures. Questionnaires completed by the study partner referred to the participant in question (e.g., "How often does your partner feel nostalgia when he or she thinks about things that happened when they were younger?"), providing an informant report. The person selected as the study partner knew the participant well (spent ≥ 10 hours per week) and could therefore draw from their personal experience. We collected both self-reports and informant-reports to obtain a richer account of the participants' personality [53]. We used the same personality measures as in Experiment 1, assessing trait nostalgia (self-report: $\alpha = 0.97$, $M = 4.47$, $SD = 1.70$; partner-report: α = 0.92, *M* = 5.09, *SD* = 1.28) and resilience (self-report: α = 0.95, *M* = 3.54, *SD* = 0.74; partner-report: α = 0.85, *M* = 3.29, *SD* = 0.92). There was considerable agreement between reports by self and partner: for trait nostalgia, $r(20) = 0.51$, $p = 0.020$; for resilience, $r(20) = 0.57$, $p = 0.008$. Self- and partner-reports did not differ significantly on either measure.

Spatial anxiety and computer experience

As in Experiment 1, we assessed spatial anxiety with the Spatial Anxiety Scale (self-report: α = 0.95, *M* = 3.06, *SD* = 0.94; partner-report: α = 0.89, *M* = 3.62, *SD* = 0.82) [6]. Reports by self and partner showed a sizeable correlation, $r(20) = 0.54$, $p = 0.014$. Participants rated themselves lower on spatial anxiety than their partners rated them, $t(19) = -2.96$, $p = 0.008$. We also administered three questions to assess participants' experience with computer games and virtual-reality technology, as in Experiment 1 (self-report only). With the benefit of hindsight, we realised that two of these questions may not be highly relevant to our older-adult participants. For example, the question "How much experience do you have with playing computer games which involve a virtual environment technology [e.g., flight simulation]?" produced extremely low ratings (*M* = 1.45, *SD* = 0.76), and this restriction of range in turn resulted in low overall scale reliability (α = 0.46). For this reason, we used only the first, face-valid question to index computer experience: "Please rate the amount of experience you have had with using a computer" (*M* = 4.40, *SD* = 2.11).

Semi-structured interview

To conclude the first study visit, participants (and their study partners) took part in a semi-structured interview on the topic, "Events from your past." The aim of the interview was to use participants' past memories to guide the selection of personalised nostalgic (vs. control) pictures. The interviews ranged from 26 minutes to 1 hour and 38 minutes (*M* = 54.09 minutes). We first asked participants to identify the era in which they felt part of and had grown up. These questions provided insight into a meaningful time-period in their lives. The remaining interview questions focused on various themes including transport (e.g., first car, bicycle, or motorbike), sports (e.g., hobbies, live events, historical moments, and favourite sports figures), technology (e.g., old-fashioned cameras, computers, or vinyl record players), TV and film (e.g., first television set, favourite movies, shows, cinema venues, or TV adverts), music (e.g., favourite musicians, live concerts, dances, or a wedding song), places (e.g., where they grew up, day trips or holidays, hang-out-spots with friends or family), fashion (e.g., clothing style, fashion trends, or work uniform), and loved ones and important events (e.g., special occasions, momentous life events). The interview comprised 43 questions (Supplementary Material S7). For each theme, the questioning style started broad (e.g., “When you were a child or young adult, how did you travel around?”), and then became more focused and specific (e.g., “What was the brand, make, and colour of your first car/bicycle/motorcycle?” “After reflecting on this, does it bring back any fond memories?”). The interviewer adapted the questions to participants’ interests. For instance, if a participant did not take much interest in a particular theme (e.g., sport), the interviewer would move onto the next theme (e.g., music), which then might elicit a fond memory (e.g., dancing at a ballroom where they met their partner). The interviewer would also ask for additional details when needed. For example, if a participant recalled a childhood memory involving a family road trip to the beach in the 1960s, the interviewer might ask follow-up questions about the specific place (e.g., St Ives, Cornwall) and the vehicle (e.g., 1966 blue Ford Popular) to help inform the picture selection.

Between visits

Picture selection

In preparation for the second study visit, we created the idiographic nostalgia induction. A member of the research team (AO) listened to the semi-structured interview recordings to identify, for each participant, personally nostalgic content that could guide picture selection. She used the interviews to select 10 personalised nostalgic pictures that mirrored each participant’s unique past experiences and sourced them from online search engines. She selected 10 control pictures to match the themes of the nostalgic pictures. For example, if one of the nostalgic pictures depicted a vintage car, the control picture would depict a modern car. After selecting the pictures, another member of the research team (ESR) inserted the personalised nostalgic and control images (nine for each condition) into separate virtual environments. As in Experiment 1, we controlled the visual salience of coloured pictures.

Randomisation

We used a within-participants design and, accordingly, participants completed the navigation task twice; once in a virtual environment with control pictures and once in a virtual environment with nostalgic pictures. We counterbalanced the order of these two tasks and randomly assigned participants to complete either the nostalgia or control condition first. We numerically labelled the two environments (i.e., Task 1, Task 2) so that the experimenter was unaware of condition order. Eleven participants completed the nostalgia condition first and nine the control condition first.

Second visit

Consent

At the start of the second study visit, we re-assessed capacity to consent. The experimenter used the Evaluation to Sign Consent Measure (e.g., “What are two potential risks?”, “What is expected from you in this study?”) to guide the capacity to consent assessment [54]. If the participant did not show sufficient understanding of the study, the experimenter asked them if they wished to continue. If they agreed, she fully explained the study and re-consent the participant. None of the participants presented a loss of capacity over the course of the study. Participants then repeated the joystick-computer training completed at the first visit.

Route-learning tasks with nostalgia induction.

Participants completed two route-learning tasks in counterbalanced order; one with nostalgic pictures tailored to their past memories and one with control pictures. Participants practiced each route a minimum of four and a maximum of eight times guided by green arrows and, then, once without arrows. We applied a 3-minute timer to the unguided route to limit the time spent in the environment, in the event that a participant became lost. Participants had to navigate at least three training trials independently (i.e., without verbal guidance) and correctly (i.e., with no errors). We allowed participants to navigate the guided route up to eight times before completing the unguided route. If a participant diverged from the guided route during the training trials, the experimenter would offer prompts (e.g., "follow the green arrows along the path"). During the unguided trial, if a participant became lost, the experimenter would offer suggestions (e.g., "retrace your steps to the beginning and try again").

In addition to condition order (nostalgia first vs. control first), we introduced a second counterbalancing variable, environment layout, to reduce carryover effects between conditions (i.e., responses in one experimental condition affecting responses in the other condition). We created two routes that were equal in length, each of which included two T-junctions and a 4-way intersection. In one environment participants encountered the 4-way intersection after the first T-junction (Fig. 5A), and in the other environment they encountered the 4-way intersection before the first T-junction (Fig. 5B). In the former environment participants saw a blue carpet and yellow walls (Fig. 6A), and in the latter they saw a wooden floor and grey walls (Fig. 6B). The two counterbalancing variables, condition order and environment layout, were crossed.

Outcome measures

Given that we implemented a within-participants design, participants completed all outcome measures twice; once in the nostalgia condition and once in the control condition (in counterbalanced order). Participants filled out a manipulation check and measures of psychological benefits, as in Experiment 1. We present Cronbach's reliability alphas in Table 3. In addition, participants completed picture-recognition and spatial-memory tasks. We presented participants with five pictures, four of which they had encountered in the given virtual environment and one they had not seen before. Participants recorded ("Yes," "No") whether they saw the picture in the virtual environment. We scored picture recognition by recording the number of correct responses (maximum score = 5). If participants correctly recognised a picture they had encountered (i.e., selected "Yes" in response to a picture they had encountered), we then asked them to recall the direction they had to turn at the picture ("Left," "Right," "Straight on," "Not sure"). We recorded the proportion of correct decisions as a measure of spatial memory (maximum score = 4). Participants also rated how confident they felt in their answers to these questions (1 = *not confident at all*, 5 = *very confident*).

Study partner reports on wayfinding effectiveness and activities of daily living

We gave participants a 45-minute to 1-hour break between the two experimental conditions to minimise carryover effects. During this interval, the experimenter administered two questionnaires to the study partner. One questionnaire assessed the study partner's view of the participant's wayfinding effectiveness and the other assessed their view of how well the participant could manage activities of daily living. We assessed everyday wayfinding ability using a modified version of the Wayfinding Effectiveness Scale [55]. This questionnaire included 17 items measuring topographical disorientation symptoms (e.g., "He/she can find his/her way around area of residence, if the route and destination were familiar," "He/she has been lost and required help to find way"). Study partners rated frequency or severity (1 = *never*, 5 = *always*; $\alpha = .82$, $M = 2.41$, $SD = 0.49$), with higher scores indicating lower wayfinding ability. We assessed daily living ability using the Alzheimer's Disease Cooperative Study – Activities of Daily Living Inventory [56]. The inventory included 23 items (e.g., "During the past 4 weeks, which best describes how participants' name usually managed to find his/her personal belongings at home"). The experimenter scored the study partners' responses depending on the degree of supervision or help the individual required (3 = *without supervision or help*, 2 = *with supervision*, 1 = *with physical help*, 0 = *participants' name did not find personal belongings*). The questionnaire yields a score ranging from 0 to 78 ($\alpha = .80$, $M = 64.15$, $SD = 8.41$), with lower scores indicating greater impairment.

Familiarity with nostalgia and debriefing

After participants completed the second experimental condition and accompanying outcome measures, we assessed familiarity with nostalgia, as in Experiment 1 (1= *not at all*, 4 = *very well*; $M = 3.35$, $SD = 0.59$). Then, we solicited participant feedback with two questions (i.e., "How did you find the two computer games, 'Pathfinder'?" and "Did you find one game easier than the other or perhaps the same?"). Following this, we debriefed and thanked participants and their study partners.

Statistical analyses

A series of non-parametric Wilcoxon signed-rank tests were used to examine the effect of nostalgic (vs. control) pictures on momentary nostalgia, psychological functions, as well as picture recognition and spatial memory. In addition, a two-part ancillary analysis was performed to examine: (1) the correlation between the personality and control measures with the difference scores on the outcome measures, and (2) whether any of the personality and control measures were associated with participants' scores on the outcome measures across both conditions.

RESULTS

Outcome measures

We present descriptive and inferential statistics in Table 3. Participants felt significantly more nostalgic in the nostalgia (than control) condition. The personalised nostalgia manipulation was effective. Moreover, participants reported significantly higher levels of positive affect (but not negative affect), self-esteem, self-continuity, social connectedness, and meaning in life in the nostalgia (than control) condition. These results replicate those of Experiment 1, with the effects being approximately twice as large.

Participants viewed five pictures after they completed each condition and recorded whether they saw the picture in the virtual environment. Participants were significantly more accurate at recognizing nostalgic (than control) pictures. Participants also recalled the direction they had to turn at each picture. Scores on this spatial-memory task were low overall, suggesting the presence of a floor effect. That is, the task may have been so challenging that there was little room for the nostalgia induction to have an impact on participants' performance. Lastly, there was no significant difference between conditions in self-reported confidence with regard to responses in the picture-recognition and spatial-memory tasks.

Ancillary analyses

In ancillary analyses, we addressed two questions. First, we asked whether any of the personality measures (trait nostalgia and resilience) and control measures (familiarity with 'nostalgia,' computer experience, spatial anxiety, wayfinding effectiveness, activities of daily living) qualified the effects of nostalgia on the outcome measures. The effect of nostalgia (vs.

control) on the outcome measures can be represented as the difference score between participants' responses in the nostalgia condition and their responses in the control condition (difference = nostalgia condition – control condition) [57]. Therefore, to address the first question, we tested the correlations of the personality and control measures with the difference scores on the outcome measures. Given the exploratory nature of these analyses and the large number of tests involved, we adopted a conservative alpha level of 0.005. One correlation was statistically significant at this level: nostalgia increased positive affect more among participants who, according to their study partner, experienced higher levels of spatial anxiety, $r(20) = 0.65$, $p = 0.002$. This solitary finding should be interpreted with caution, but nevertheless suggests that participants who are apprehensive about becoming lost may find an environment embedded with nostalgic cues particularly enjoyable.

The second question we addressed in ancillary analyses was whether any of the personality and control measures were associated with participants' scores on the outcome measures across both conditions. This is equivalent to testing the main effects of the personality and control measures, which can be represented by the correlation between these measures and the sum of participants' responses in the nostalgia condition plus their responses in the control condition (sum = nostalgia condition + control condition) [57]. Two correlations were significant at the 0.005 level. Negative affect was lower overall among participants who scored higher on resilience based on their self-report, $r(20) = -0.62$, $p = 0.003$, and based on their study partner's report, $r(20) = -0.62$, $p = 0.004$. This result conceptually replicates prior findings linking resilience to low negative affectivity [58]. Finally, there was a trend for participants who, according to their study partner, experienced more wayfinding problems to perform less well overall on the spatial-memory task, $r(20) = -0.58$, $p = 0.007$.

DISCUSSION

In Experiment 2, we used an idiographic approach to tailor the pictorial nostalgia induction to each participant's personal memories. Encountering these personalised nostalgic (compared to control) pictures in a virtual environment conferred psychological benefits for people living with AD, who also evinced better recognition of nostalgic (than control) pictures.

Ismail and colleagues [28] induced nostalgia among people living with dementia by letting them bring to mind a nostalgic (vs. ordinary autobiographical) event and briefly writing about it or by letting them listen to a song they had identified as evocative of nostalgia (vs. a non-nostalgic song). Across their three experiments, nostalgia (relative to control) increased positive affect, self-esteem, self-continuity, social connectedness, and meaning in life ($\bar{d}$ =1.49). Our idiographic pictorial nostalgia induction also markedly strengthened these same psychological benefits: $\bar{d}$ = 1.02. For comparison, the average effect size in social and personality psychology is $\bar{d}$ = 0.43 [59]. It is noteworthy, then, that these diverse nostalgia inductions all result in such exceptionally large salutary effects for people living with dementia.

GENERAL DISCUSSION

Summary of findings

Our research shows that pictures tailored to induce nostalgia convey psychological benefits when encountered in a virtual environment. In Experiment 1, we generated nostalgic images that reflected the decade during which healthy adults lived most of their childhood—a nomothetic approach focused on a specific cohort of individuals. In Experiment 2, we personalised the images further by selecting pictures that reflected specific memories of people with AD—an idiographic approach focused on each individual's unique past. In both experiments, nostalgic pictures (compared to thematically-matched control pictures) that were embedded within a virtual environment elicited nostalgia and conferred psychological benefits, including: positive affect, self-esteem, self-continuity, social connectedness, and meaning in life. These findings are consistent with previous work among non-clinical [28, 31, 60] and clinical populations [30, 61, 62].

People living with AD struggle to recognise landmarks [63]. In a residential setting, memorabilia and personal pictures helped people with dementia recognise their own rooms [64, 65]. Consistent with this finding, we observed that picture recognition was higher for nostalgic than control pictures. Spatial memory, however, was not improved by nostalgia.

Performance in the spatial memory task was generally low (*M*s), with particularly high skewness in the control condition. The task comprised recalling a directional decision (i.e., left, right, or straight on) at a specific picture, which in contrast to picture recognition, required greater spatial skill. It is worth noting that there was a delay in-between environmental navigation (containing the nostalgic versus control pictures) and the delivery of the spatial memory task. During this delay, the outcome measures capturing nostalgia were administered. Given (1) the descriptive statistical findings, (2) the increased task difficulty, and (3) the navigation difficulties evident in AD [4], it is plausible that the spatial memory task evinced a floor effect—a finding which future work would do well to address.

Limitations and future directions

The size of the nostalgia effects (as indexed by Cohen's *d*) on the manipulation check (i.e., felt nostalgia) and psychological benefits was considerably larger in Experiment 2 than Experiment 1. This suggests that idiographic approaches to inducing nostalgia are more impactful than nomothetic ones. Future research ought to rely more on idiographic than nomothetic inductions of nostalgia [43, 66].

We added to the growing literature that nostalgia conveys psychological and physical health benefits to vulnerable populations (e.g., immigrants, civil war refugees, individuals experiencing bereavement, and people with dementia; for a review, see [67]). Although we recruited people living with AD, we expect that nostalgia holds broad clinical potential independently of a medical condition or disorder. A next empirical step could be to identify whether nostalgic pictures provide similar benefits for people with other dementia types (e.g., vascular dementia, Lewy body dementia, a mixed form of dementia types, or posterior cortical atrophy) [68-70] and/or topographical disorientation disorders [71, 72]. We hope that our personalised, idiographic approach to harnessing nostalgia inspires clinical interventions.

Researchers have successfully manipulated emotions, including nostalgia, within virtual environments [73]. Although virtual interfaces provide visual input, they lack vestibular, proprioceptive, and efferent information that one would receive in real-world navigation. Researchers could therefore examine whether nostalgia's benefits generalise to other life-like virtual surroundings (e.g., indoor residences, outdoor urban landscapes [74]), real-world environments [64], or a combination of the two [75]). In the UK, healthcare organisations have turned to nostalgia to create calming spaces for people with dementia. For example, National Health Service hospitals have enriched dementia wards with vintage seaside themes, old fashioned telephone boxes, cinema booths, and 1950s-themed memory rooms [76], and dementia care facilities have installed personal memory boxes for residents to bolster their sense of identity and wayfinding abilities [77]. Using real-world environments such as these to investigate the psychological benefits of nostalgia-infused design could help translate our current findings into everyday settings. Such studies would also do well to assess the potential benefits of nostalgic design on physical health behaviours (e.g., sleep quality, falls risk, agitation).

Broader implications

Successful navigation is crucial for everyday functioning, socialisation, and overall wellbeing. Distinctive landmarks are critical for supporting navigation [37]. As AD progresses, the need for landmarks with more meaningful characteristics will likely increase. Therefore, identifying substantial emotive content to generate a salient landmark is key for creating a dementia-friendly space [74]. Nostalgic design elements could help to achieve this objective. Installing nostalgic objects within existing facilities is a cost-effective and easy-to-implement strategy. Environmental guidelines recommend introducing landmarks that are salient and memorable to aid navigation [11, 13, 37]. Audit tools then assist with creating a dementia-friendly space (e.g., Enhancing the Healing Environment Assessment Tool [78]; Environments for Ageing and Dementia Design Assessment Tool [79]). We recommend that environmental guidelines and audit tools include detailed, scientific evidence regarding nostalgic design elements (e.g., photographs, paintings, objects, furniture) that effectively provide psychological benefits.

Nostalgic pictures offer additional clinical benefits. Older adults with memory problems value meaningful cues to spark socialisation [13]. In a care home, for example, installing digital photo albums transformed care interactions from task-orientated to interpersonal [59]. For several decades, photographs have functioned as memory aids for people with dementia [80, 81], serving as non-verbal catalysts to ignite feelings and memories [82]. Person-centred care approaches, such as reminiscence therapy, emphasise the importance of a persons' stories, passions, and idiosyncrasies—all of which help to reaffirm the self and facilitate high-quality care [83, 84]. Reminiscence therapy routinely uses visual prompts to help people remember the past [85, 86]. Whereas reminiscence therapy is widely used in care settings, scientific evidence regarding its benefits for people living with dementia is inconsistent [87]. Typically, this therapy focuses on the process of recall, which can elicit a plethora of autobiographical memories, only some of which may be nostalgic [88]. Nostalgia, in contrast, pertains to specific memories that are affect-laden, personally relevant, unique, imbued with sociality, and are meaningful [62, 89]. As demonstrated here, and in other studies [30, 61, 62], nostalgia is highly beneficial to people with dementia. Interventions with a focus on cultivating nostalgia, rather than general reminiscences, could therefore be a promising avenue for therapy development.

Coda

In two experiments, we developed a pictorial nostalgia induction within a life-like virtual environment. Our findings demonstrated that nostalgic pictures confer psychological benefits and enhance the recognition of landmarks for people living with AD. Our work has real-world applications, most notably to dementia design and therapeutic practices.

ACKNOWLEDGEMENTS

We thank the Memory Assessment & Research Centre for their support and clinical expertise. We thank the National Institute for Health Research Clinical Research Network for including Experiment 2 in their portfolio. Experiment 2 was sponsored by Southern Health NHS Foundation Trust. We thank Emily Dodd and Professor Jan Wiener for peer reviewing our protocol as part of the sponsorship process. The research was funded by the Economic and Social Research Council South Coast Doctoral Training Partnership (Grant Number: ES/P000673/1) awarded to Alice Oliver.

We have no conflict of interest to declare.

Data availability statement

The data supporting the findings of these studies are openly available at:

https://osf.io/e8w52/?view_only=50744d36bb46478ca4aae4717c122091

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Table 1

Sample characteristics by experimental condition in Experiment 1

	Control *n* or *M* (*SD*)	Nostalgia *n* or *M* (*SD*)	Difference	*p*
Age	57.65 (6.72)	56.93 (5.53)	*t*(170) = -0.77	0.440
Gender				
Men	42	40	$\chi^2(1) = 0.20$	0.652
Women	43	47		
Ethnicity				
Asian/Asian British	3	2	$\chi^2(4) = 3.57$	0.468
Black/African/Caribbean/ Black British	0	2		
Mixed ethnic groups	2	1		
White	79	82		
Did not wish to state	1	0		
Highest education level				
Primary school	1	0	$\chi^2(6) = 4.93$	0.553
GCSEs or equivalent	15	14		
A levels or equivalent	26	18		
Undergraduate degree	29	36		
Postgraduate degree	11	12		
Doctoral degree	2	4		
Other	1	3		
Personality measures				
Trait nostalgia	4.89 (1.25)	4.78 (1.18)	*t*(170) = -0.56	0.575
Resilience	3.24 (0.82)	3.42 (0.85)	*t*(170) = 1.40	0.155
Control measures				
Familiarity with ‘nostalgia’	3.58 (0.59)	3.45 (0.62)	*t*(170) = -1.39	0.167
Computer experience	4.15 (1.02)	4.13 (1.16)	*t*(170) = -0.09	0.929
Spatial anxiety	2.69 (1.02)	2.39 (0.95)	t(170) = -1.95	0.052
MCIQ – Practical Concerns	21.81 (19.95)	20.36 (15.25)	*t*(170) = -0.55	0.582
MCIQ – Emotional Concerns	17.70 (23.10)	16.91 (19.70)	*t*(170) = -0.24	0.810

Note. MCIQ = Mild Cognitive Impairment Questionnaire. Distributions of the Practical Concerns and Emotional Concerns MCIQ subscales evinced high positive skew. Non-parametric Wilcoxon rank-sum tests on these two variables corroborated the *t*-test conclusions. Respective *p*-values were .900 and .717.

Table 2

Descriptive and inferential statistics in Experiment 1

	Control *M* (*SD*)	Nostalgia *M* (*SD*)	*t*(170)	*p*	Cohen's *d*
Nostalgia	2.28 (1.41)	3.11 (1.67)	3.54	< 0.001	0.54
Positive affect	3.18 (1.43)	3.93 (1.40)	3.50	< 0.001	0.54
Negative affect	1.54 (0.77)	1.63 (0.90)	0.76	0.451	0.12
Self-esteem	2.27 (1.24)	2.90 (1.31)	3.25	0.001	0.50
Self-continuity	2.44 (1.46)	3.74 (1.46)	5.82	< 0.001	0.89
Social connectedness	2.08 (1.18)	2.71 (1.33)	3.29	0.001	0.50
Meaning in life	2.26 (1.32)	2.66 (1.38)	1.93	0.055	0.30

Table 3

Scale reliabilities, descriptive statistics, and inferential statistics in Experiment 2

	Control		Nostalgia				
	α	*M* (*SD*)	α	*M* (*SD*)	*t*(df)	*p*	Cohen's *d*
Nostalgia	.90	2.85 (1.62)	.89	4.75 (1.44)	4.59	< 0.001	1.03
Positive affect	.84	3.88 (1.37)	.83	5.20 (0.97)	4.08	< 0.001	0.92
Negative affect	.78	1.68 (0.94)	.67	1.65 (0.83)	-0.09	0.928	-0.02
Self-esteem	.71	3.18 (1.42)	.86	4.48 (1.63)	4.40	< 0.001	0.98
Self-continuity	.95	2.85 (1.61)	.91	5.30 (1.25)	6.69	< 0.001	1.49
Social connectedness	.94	2.50 (1.72)	.75	4.03 (1.70)	4.59	< 0.001	1.06
Meaning in life	.91	3.18 (1.79)	.87	4.18 (1.61)	2.96	0.008	0.66
Picture recognition	-	3.40 (1.47)	-	4.20 (0.95)	3.11	0.006	0.70
Spatial memory	-	1.10 (1.41)	-	1.55 (1.28)	1.63	0.120	0.37
Confidence	.65	3.71 (0.80)	.52	3.64 (0.75)	-0.44	0.668	-0.10

Note. Degrees of freedom (df) = 19, except for social connectedness df = 18 due to a missing value in the control condition. Picture recognition and spatial memory are count variables (i.e., number correct). Non-parametric Wilcoxon signed-rank tests of the difference between the nostalgia and control conditions on these two variables corroborated the *t*-test conclusions. Respective *p*-values were .009 and .180.

Fig. 1. Examples of nostalgic and control pictures in Experiment 1

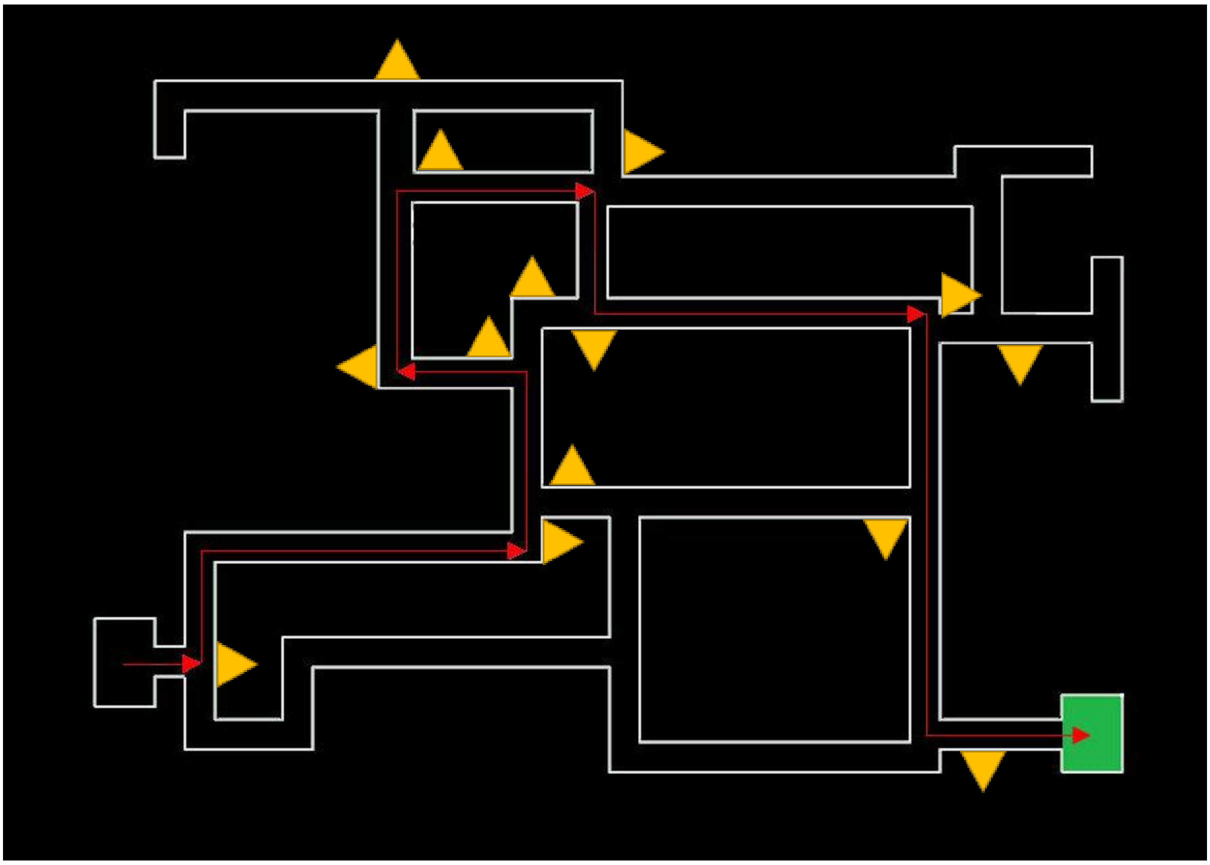

Fig. 2. Route map and layout of the virtual environment in Experiment 1. The red arrows illustrate the specified route and the green box highlights the end destination. The yellow triangles highlight the position of the 14 nostalgic or control pictures.

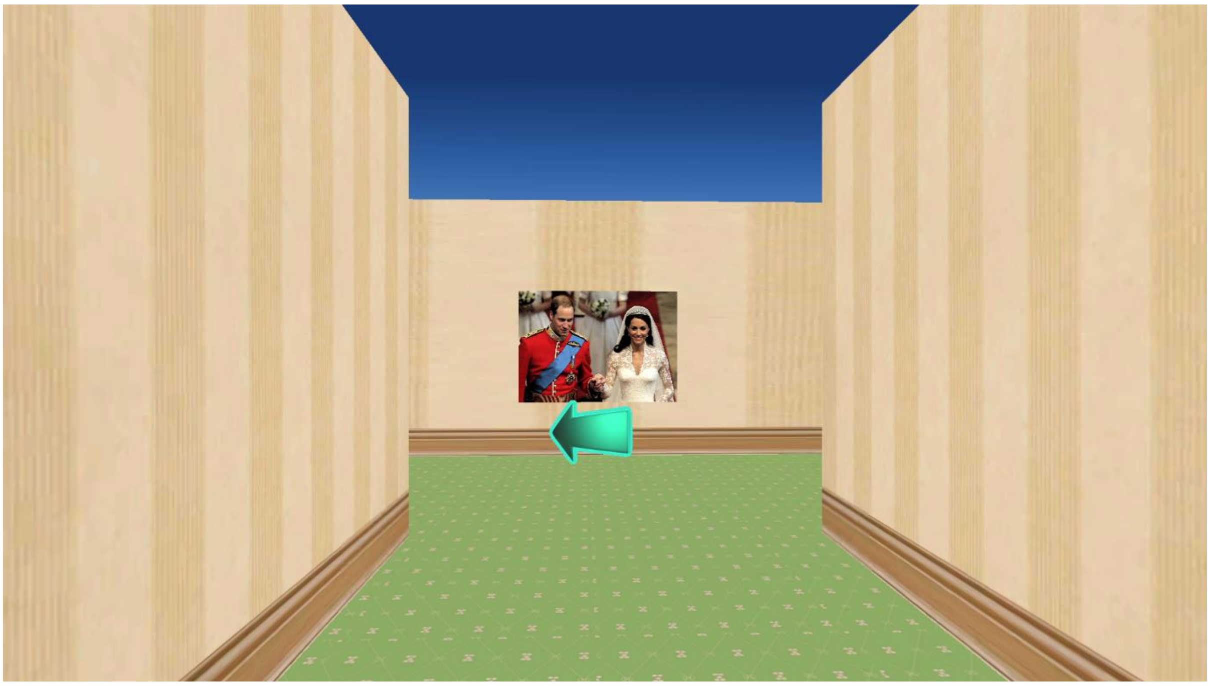

Fig. 3. Virtual environment in Experiment 1

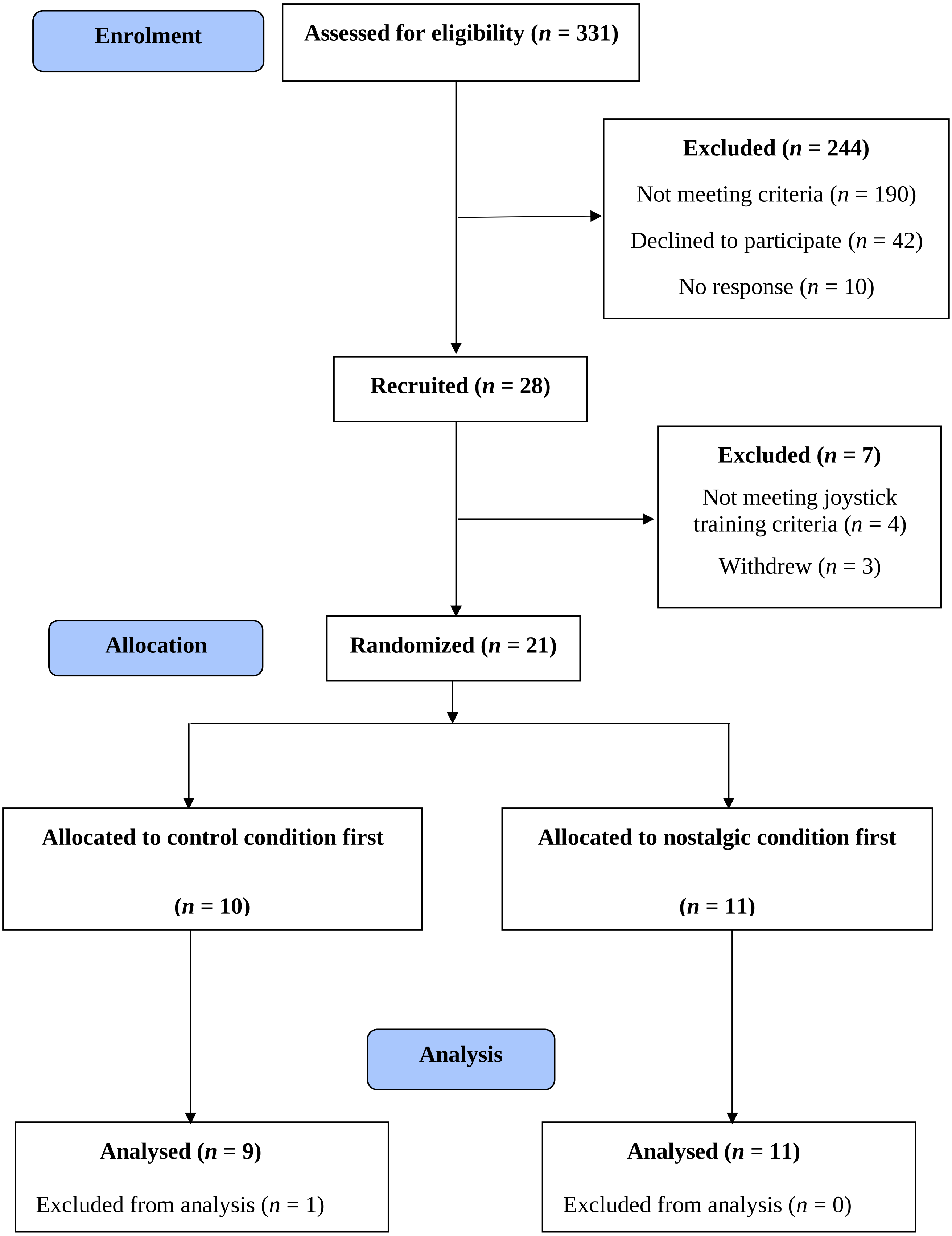

Fig. 4. CONSORT flow chart illustrating recruitment to Experiment 2.mask

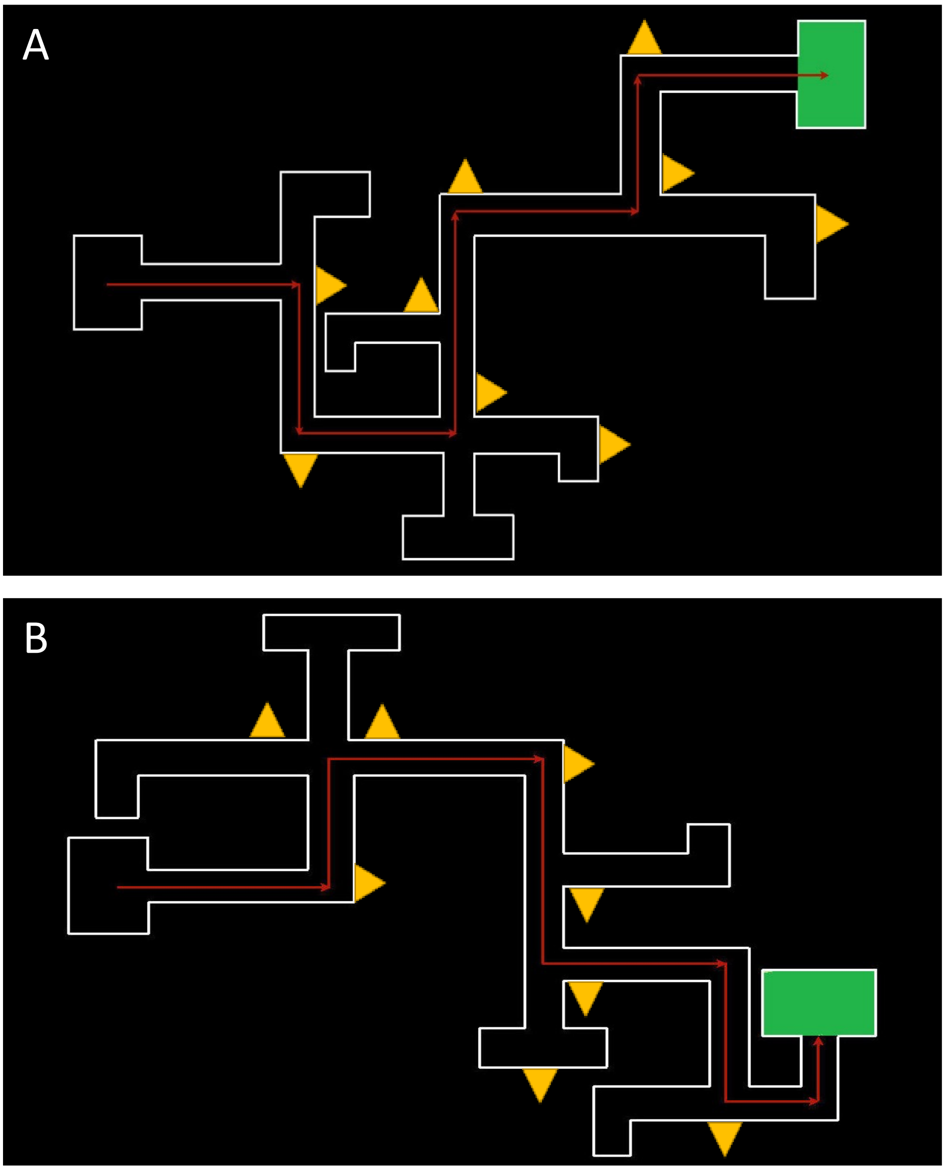

Fig. 5. Route map and layout of the virtual environment in Experiment 2. Fig. 5A presents the environment in which the 4-way intersection is encountered after the first T-junction. Fig. 5B presents the environment in which the 4-way intersection is encountered before the first T-junction.

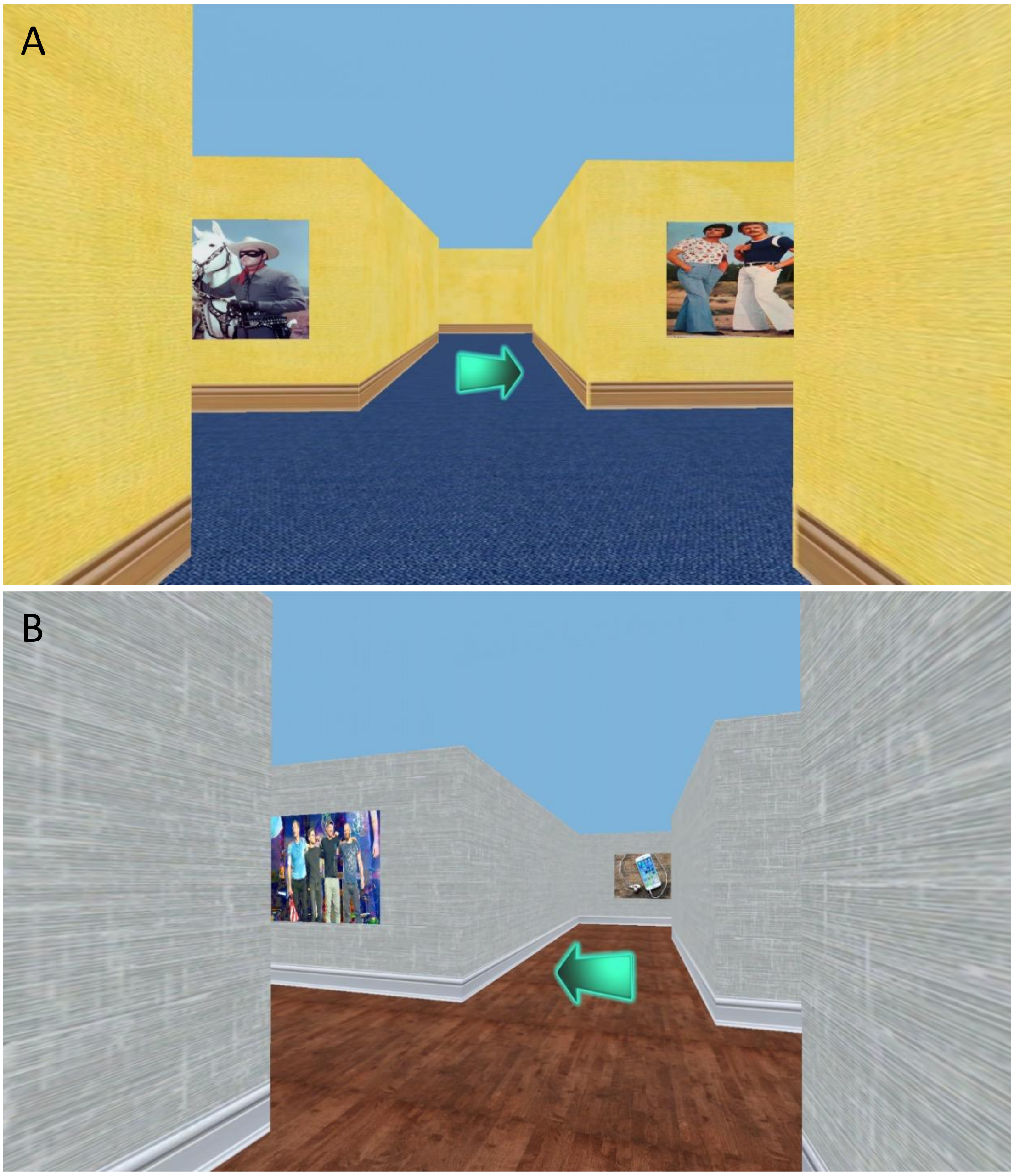

Fig. 6. Virtual environments in Experiment 2. Fig. 6A presents environment with yellow/blue décor and nostalgic pictures. Fig. 6B presents environment with grey/wood décor and control pictures.

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