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CASE REPORT



Improving autobiographical episodic memory, quality of life, and sense of self with a smartphone intervention in early dementia: A case study

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ABSTRACT

In memory disorders such as Alzheimer's disease, recent autobiographical memories are disproportionately vulnerable to loss, yet most traditional reminiscence therapies focus on remote past events. We present a case study examining whether a digital reminiscence intervention designed to support memory for recent experiences can improve episodic recall and psychosocial outcomes in neurodegenerative memory impairment. G.F., a 79-year-old man with early-stage dementia, completed an 11-week personalized intervention using HippoCamera, a neuroscience-based smartphone application that helps users generate and review multimodal memory cues from everyday events. Events that G.F. reviewed using HippoCamera were recalled with greater episodic detail than events that were recorded but not reviewed. Post-intervention, G.F. reported improvements in quality of life, life satisfaction, self-concept, and perceived episodic and spatial memory abilities, along with reduced depressive symptoms. Qualitative feedback revealed that the intervention helped G.F. regain confidence, re-engage socially, and feel more optimistic about the future. These findings suggest that digital interventions targeting memory for recent experiences – a domain often overlooked in traditional reminiscence therapy – may provide benefits to cognition and quality of life in the early stages of dementia. This work highlights the promise of HippoCamera as an accessible, neuroscience-informed tool to support memory and well-being in those experiencing memory loss.

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Dementia; Digital reminiscence; Autobiographical memory; Quality of life; Identity

The compromised ability to remember the recent past is a hallmark feature of many dementia syndromes. Autobiographical episodic memory enables us to vividly re-experience specific events from our personal past, which fosters the

construction of a meaningful narrative and coherent sense of self (Addis & Tippet, 2004; Conway, 2005; Jetten et al., 2010). Moreover, autobiographical episodic memory helps us build and maintain social relationships (Alea & Bluck, 2003; Harris et al., 2014) and guides self-relevant future thinking and adaptive behaviours (Bluck et al., 2005; Pillemer, 2003; Schacter et al., 2007; Schacter et al., 2017). In neurodegenerative diseases characterized by episodic memory dysfunction, such as mild cognitive impairment (MCI) and Alzheimer's disease (AD), autobiographical memory recollections lack sensory-perceptual details and spatiotemporal specificity, and instead become over-general and semanticized (El Haj et al., 2015; Irish, 2023; Irish et al., 2011; Murphy et al., 2008; Seidl et al., 2011). Given that memory loss contributes to reductions in personal autonomy, confidence, and mental health (Bohlmeijer et al., 2007; Hallford et al., 2013; King et al., 2019; Steeman et al., 2006), interventions that bolster episodic recollection of everyday life events may also enhance quality of life and sense of purpose in the early stages of dementia.

Reminiscence therapy is one of the most widely used non-pharmacological interventions to promote cognitive and psychosocial functioning in persons with dementia. Reminiscence therapy involves evoking meaningful events and experiences from an individual's remote past, often by using a life story book, music, photographs, objects, or other materials to promote autobiographical memory recall (Cotelli et al., 2012). Evidence suggests that recalling and re-experiencing personal life events in this way has positive effects on psychological outcomes in patients with MCI and mild-to-moderate AD, such as improvements in depressive mood, neuropsychiatric symptoms, sense of life purpose, and well-being (Cuevas et al., 2020; Duru Aşiret & Kapucu, 2016; Park et al., 2019; Pinquart & Forstmeier, 2012; Saragih et al., 2022). Furthermore, improvements in autobiographical remembering following reminiscence were evident in MCI and AD (Lopes et al., 2016; Melendez et al., 2017; Woods et al., 2016). For example, patients with AD recalled cued autobiographical memories with greater specificity and episodic detail after participating in a reminiscence therapy programme where they were immersed in museum-style environments reminiscent of their youth, relative to prior to the intervention (Kirk et al., 2019). However, a recent Cochrane Review concluded that the overall cognitive benefits of reminiscence therapy are small and its effects on well-being are inconsistent (Woods et al., 2018).

Notably, reminiscence therapy interventions have largely focused on remote autobiographical memories, which tend to remain relatively preserved in the early stages of dementia (Greene et al., 1995; Kopelman, 1989; Piolino et al., 2003). Although reviewing one's life history can yield cognitive and psychosocial benefits, this emphasis overlooks the aspects of episodic memory most vulnerable to decline in conditions such as MCI and AD. Given that remote life events – particularly self-defining events from early adulthood – are often rehearsed and consolidated over time, recent experiences are

disproportionately susceptible to forgetting as AD progresses (El Haj et al., 2015; Gilboa et al., 2005; Irish, 2023; Moscovitch et al., 2006; Nadel & Moscovitch, 1997; Serra et al., 2020). This vulnerability is compounded by neurodegeneration in medial temporal lobe regions such as the hippocampus, which are critically involved in the vivid re-experiencing of recent events and are among the earliest sites of structural and functional deterioration in AD (Dickerson & Eichenbaum, 2010; Dickerson & Sperling, 2008; Gilboa et al., 2005; Pennanen et al., 2004). As a result, the ability to retrieve the recent past in rich sensory and perceptual detail is especially compromised. The field's longstanding focus on remote memories in reminiscence therapy may therefore represent a missed opportunity: interventions that explicitly target memory for recent, day-to-day experiences may be more aligned with the specific patterns of impairment observed in AD and could provide timely support for everyday functioning and autonomy.

Moreover, engaging in reminiscence for recent life events may have a positive impact on well-being and identity. Although personal semantic knowledge and episodic memory for remote events remain accessible in the early-to-middle stages of AD, difficulties in encoding and remembering recent events (e.g., losing track of conversations, forgetting names and events) can disrupt the continuity of one's identity and self-schema, leading to confusion, frustration, and low mood (Caddell & Clare, 2011; Heersmink, 2022). Furthermore, the act of remembering recent personal events may help individuals with AD update their self-schema – rather than relying on an older, more distant version of the self that may no longer align with their current experiences and environment (Strikwerda-Brown et al., 2019) – and support the maintenance of a continuous self-identity over time (El Haj et al., 2019). Strengthening memory for everyday recent events may help individuals with early AD feel more grounded in their present lives and better able to share and connect through memory, fostering social relationships and boosting self-confidence. In these ways, targeting memory for recent events during early cognitive decline may mitigate the psychosocial burdens associated with memory loss.

One promising approach to mitigate memory loss for recent events is Digital Memory Augmentation (DMA), in which portable devices capture information about everyday events, allowing for later review and recollection. DMA is inspired by the field of “lifelogging” and “digital storytelling”, whereby a digital record of multimodal data is captured to represent and reconstruct users' life experiences and narrative (Crete-Nishihata et al., 2012; Harvey et al., 2016). One example is the SenseCam, a small wearable camera that automatically takes hundreds of photos of everyday events per day (Hodges et al., 2011). Prior work has shown that reviewing SenseCam images of recent, personally experienced events improved episodic recall of those events compared to alternative approaches such as keeping a written diary in individuals with MCI, AD, and severe memory impairment resulting from brain injury or other

neurological conditions, including limbic encephalitis, brain tumours, and Korsakoff's syndrome (Berry et al., 2007; Brindley et al., 2011; Browne et al., 2011; Loveday & Conway, 2011; Pauly-Takacs et al., 2011; Svanberg & Evans, 2014; Woodberry et al., 2015). Qualitative interviews also revealed that SenseCam usage resulted in increased confidence, reduced stress and anxiety, more positive interpersonal relationships and sense of self, and better coping with memory impairment (Berry et al., 2007; Crete-Nishihata et al., 2012; Woodberry et al., 2015). Similarly, reviewing and elaborating on pictures of events captured by NarrativeClip – a more recent version of SenseCam – enhanced the episodic richness of recent personal events in patients with schizophrenia, a population characterized by overgeneral autobiographical memory and reduced episodic specificity (Dassing et al., 2020). Together, these studies have demonstrated the utility of DMA for enhancing memory for autobiographical events in memory-impaired populations, with additional benefits for quality of life (Allé et al., 2017; Chow & Rissman, 2017). Importantly, although these DMA studies provide proof of principle and clinical applicability, they have been small-sample trials using ad-hoc cognitive outcomes and have not harnessed principles from memory science (Lustig et al., 2009). Additionally, adoption of current DMA protocols involves a lengthy indiscriminate review of many photos per day, which creates an inefficient user experience and caregiver burden.

To create a DMA platform that supports individuals with dementia in enhancing memory for recent everyday events, we developed HippoCamera – a smartphone application informed by cognitive psychology and neuroscience – to provide a personalized digital reminiscence experience. HippoCamera is an intuitive tool that was designed to maximize ease-of-use and enjoyability in older adults and individuals with cognitive impairment. First, users deeply engage with an ongoing event as they create distinctive multi-modal cues that serve as powerful memory reminders (Martin et al., 2022). These cues are later reviewed in brief, structured replay sessions that mimic hippocampal replay – an endogenous process thought to strengthen long-term memory traces in neocortical networks (Carr et al., 2011; Ólafsdóttir et al., 2018). Replay sessions also draw on principles of distributed learning and contextual associations to optimize memory benefits. In prior studies, older adults who used HippoCamera recalled replayed events with over 50% more episodic detail than events that were recorded but not replayed, and showed enhanced hippocampal activity and more positive emotional tone in recall (Martin et al., 2022). Crucially, these memory gains persisted for at least three months after participants stopped using the app, indicating durable memory strengthening rather than transient cognitive offloading. Similar benefits were observed in L.P., a young adult with dense hippocampal amnesia, who recalled replayed memories with three times more episodic detail than those recorded in a written diary (Martin et al., 2022). These findings motivated us to test

HippoCamera in individuals experiencing memory impairment due to neurodegeneration.

In October 2021, we were approached by the family of G.F., a 79-year-old man who had been recently diagnosed with early-stage dementia and was referred by his physician to explore the potential benefits of the HippoCamera intervention. The hope was that it could serve as a meaningful form of cognitive engagement and help mitigate the cognitive and psychosocial impact of his disease progression. Prior to the intervention, G.F. displayed common symptoms of early-stage AD, including forgetfulness about people and events, spatial disorientation, general confusion, and a loss of interest in previously enjoyed activities. We designed an 11-week personalized digital reminiscence programme using HippoCamera, delivered entirely online during the peak of the COVID-19 pandemic. Our aim was to examine whether reviewing memory cues through HippoCamera could strengthen episodic memory for recent, personally meaningful events and enhance G.F.'s quality of life and sense of self. Our findings contribute to the development of scalable, low-cost interventions that preserve the meaningful fabric of everyday life and offer new possibilities for supporting individuals navigating cognitive decline.

Method

Participant details

At the time of the intervention in October 2021, G.F. was a 79-year-old man with 18 years of formal education. G.F. and his family resided in Calgary, Alberta. Consistent with typical patterns of memory loss in the early stages of dementia due to AD, his psychiatrist reported that G.F. experienced memory loss for recent life events, but his memory for remote autobiographical memories was intact. G.F.'s family reported that he had trouble remembering people, family, and events, and showed a lot of confusion between the months of August and October 2021.

During our intake interview, G.F. and his family shared that he presented with difficulties in short-term memory recognition. His driving abilities were affected and his license had been returned. He also had difficulty remembering navigational directions and shared a few instances of getting lost in his own condo. G.F.'s family shared that on some days, he did not recognize family members; for example, his wife and son. G.F.'s family also mentioned that G.F. loves baseball and sports but had progressively lost interest in those areas. Additionally, he no longer found his favourite movies interesting, and he described that when he would read information, he would lose interest in it or lose track of his spot on the page. Of note, G.F. and his family reported that the COVID-19 pandemic seemed to have exacerbated his memory issues, especially following the adjustment to staying indoors with limited access to activities, events, and social

interactions. Prior to the time that G.F. contacted us about the intervention, he had been prescribed a mood stabilizer (5–10 mg) that he was taking twice a day and continued taking for the duration of the intervention.

G.F. indicated that he enjoyed working on puzzles, exercising, and playing Mahjong. He mentioned that he was very eager to participate in the memory intervention to engage in more activities. He was anxious about his memory difficulties and expressed that he was initially in denial about his condition, but at the time of the intervention, was experiencing more acceptance. He shared that he had been trying to maintain his sense of humour and was working very hard to remain coherent and in the present. G.F. also shared that he had a strong desire to keep learning and that he found it hard when his memory difficulties compromised his ability to learn. At the time of the intervention, G.F. was living with his wife and reported a close relationship with his family, who were very active in supporting G.F. throughout the onset and progression of his disease.

G.F. provided written informed consent acknowledging the intervention requirements and received monetary compensation for his time (\$18/hr for each meeting with the experimenter and \$5/day for each day that HippoCamera was used). The research protocol for HippoCamera memory intervention studies was reviewed and approved by the Research Ethics Board at the University of Toronto.

Neuropsychological characterization

To characterize G.F., we conducted the following assessments: (1) a short neuropsychological battery chosen to capture general levels of cognitive impairment, memory, naming, attention, and executive functions, and (2) a traditional version of the Autobiographical Interview (Levine et al., 2002) to assess recent and remote memory.

Standard neuropsychological tests

G.F. completed a short neuropsychological battery to assess cognitive functioning. This was administered by M.C. virtually over Zoom given that the intervention took place during the COVID-19 pandemic. The battery included: Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), Wechsler Memory Scale IV (WMS-IV) Logical Memory subtest (Wechsler, 2009), Wechsler Adult Intelligence Scale IV (WAIS-IV) Digit Span subtest (Wechsler, 2008), Boston Naming Test Short Form (Kaplan et al., 1983), National Adult Reading Test (Nelson & Willison, 1991), Trail Making Test Trail A (Reitan & Wolfson, 1985), Delis-Kaplan Executive Function System (D-KEFS) Colour-Word Interference Test (Delis, 2001), 1-minute phonemic verbal fluency (FAS; Spreen & Benton, 1977), and 1-minute categorical verbal fluency (Animal Naming; Spreen & Benton, 1977).

Traditional autobiographical interview

G.F. was asked to recall one specific event that happened at each of the following time periods: early childhood, teenage years, middle age, the last five years, and the past two weeks. He was asked to verbally describe everything he remembered about the event in as much detail as possible until his thoughts came to a natural end. Following the free recall response, G.F. was asked an open-ended general probe (i.e., “Is there anything else you want to share about that memory?”) to solicit additional detail. Recall was transcribed and scored for episodic and semantic components using the Autobiographical Interview scoring protocol (Levine et al., 2002; Renoult et al., 2020). Internal details (i.e., episodic details pertaining to the specified event) and external details (i.e., details pertaining to general semantic information, personal knowledge, and/or other non-specified events) were summed.

Case study design

This intervention aimed to improve memory for everyday life events that were captured with HippoCamera, provide a fulfilling form of cognitive engagement, and enhance quality of life in an older adult with early-stage dementia. The 11-week intervention was delivered entirely online during the peak of the COVID-19 pandemic, with G.F. using HippoCamera on his personal smartphone and completing all sessions with the experimenter (M.C.) virtually over Zoom. The HippoCamera team was based in Toronto, Ontario. We adopted a personalized approach where G.F. was encouraged to use our digital reminiscence platform to record at least one event and watch at least two replay sessions per day for 11 weeks. To maximize memory benefits and cognitive engagement, recorded events were more frequently assigned to be replayed than hidden for replay each week (see HippoCamera Intervention). To assess changes to memory and quality of life over the intervention, we conducted a series of pre- and post-assessments. The design of the intervention adheres to the Single-Case Reporting Guideline in Behavioural Interventions (SCRIBE; Tate et al., 2016). [Figure 1](#) provides a timeline of the intervention.

HippoCamera application

HippoCamera is a smartphone-based digital memory aid that allows users to record and review memory cues for personal, real-world events. Full details of HippoCamera parameters and functionality can be found in Martin et al. (2022).

Recording events. HippoCamera guides users through a 4-step process to recording cues with HippoCamera ([Figure 2](#)). First, by asking users to record at least one event per day, users are encouraged to attend to ongoing events in their everyday life that they wish to remember. Second, HippoCamera users capture an 8-second audio recording that comprises a self-generated verbal description of the event. Third, they record a 24-second high-definition

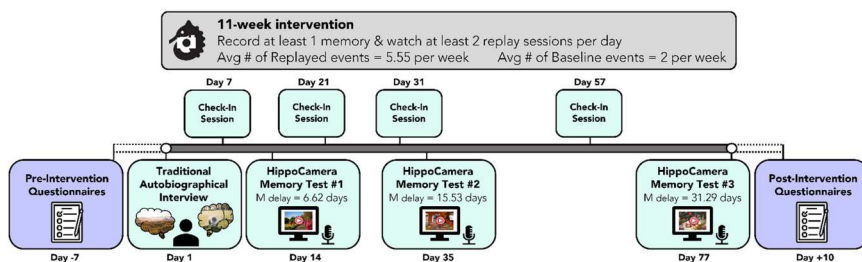


Figure 1. Intervention timeline. Across 11 weeks, G.F. was instructed to use HippoCamera to record at least one memory and watch at least two replay sessions per day. Replayed events were available for review during replay sessions, whereas Baseline events were captured but not replayed until memory testing. Day 1 and Day 77 mark the start and end of the intervention, with the pre- and post-intervention questionnaires taking place approximately one week before (Day -7) and after (Day +10) the intervention timeframe. Test sessions and check-in sessions are denoted.

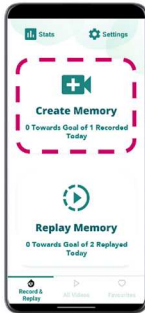
video of the event. Fourth, they rate the significance of the event on a 1–5 scale. After users capture these events, HippoCamera generates integrated cues that combine the verbal description with a speeded version of the video. Specifically, audio is stripped from the 24-second video and the resulting video file is accelerated by a factor of three, resulting in an 8-second speeded video. The speeded video is then coupled with the audio file containing the 8-second verbal description, which serves as the memory cue. A notification system in HippoCamera encouraged G.F. to record at least once per day.

Replaying events. G.F. reviewed cues for his recorded memories using HippoCamera, with instructions to replay at least twice per day. To replay cues, users view replay sessions that consist of up to five sequentially presented memory cues. Cues are separated by a lead-in screen that displays the date and approximate age of the event. Within a replay session, cues are replayed in reverse chronological order (e.g., newer cues are played before older cues). Replay sessions are curated in a way that balances distributed learning and the prioritization of recent events with high significance ratings. At the end of each replay session, users are prompted to reflect on the memories reviewed, allowing them to recreate the events in their mind and contemplate how their memories connect to one another or to their own life. We recommended that some of the replay sessions be anchored to distraction-free, routine events, such as while drinking coffee in the morning or winding down for a night's sleep, given that activities can serve as external reminders for engaging in tasks (Marsh et al., 2002), as well as the benefits of sleep on episodic memory consolidation (Szöllösi et al., 2015; Walker & Stickgold, 2004). A notification system in the app sent G.F. a daily reminder to replay.

The software used in the current work was programmed by Tactica Interactive (Winnipeg, Manitoba). A public-facing version of the HippoCamera application can be obtained for free from Apple's App Store and Google Play.

A Recording Memory Cues

1. Tap
"Create Memory"



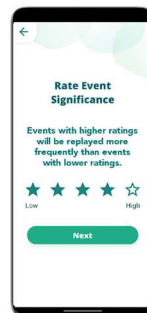
2. Audio
8s Verbal Description



3. Video
24s Recording

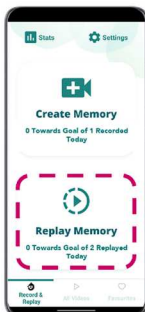


4. Rate
Event Significance



B Replaying Memory Cues

1. Tap
"Replay Memory"



2. Replay (up to 5 cues)
Verbal descriptions played with 3X speeded videos

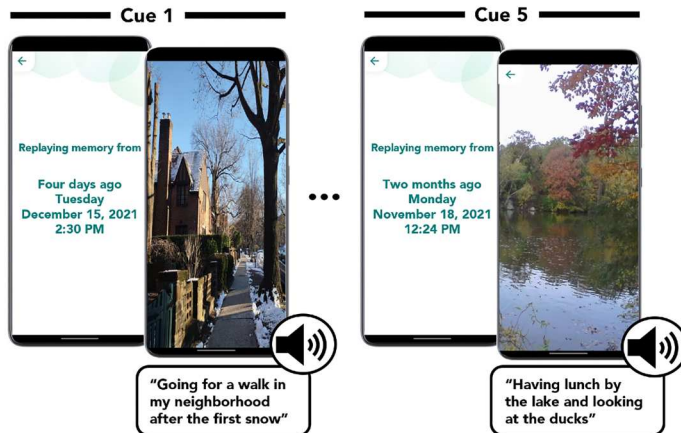


Figure 2. HippoCamera application overview. (A) Memory cues are recorded in four steps: (1) Select a real-world event and initiate recording, (2) record an 8-second verbal description, (3) record a 24-second video, and (4) rate the event's significance. (B) Replay sessions consist of up to 5 cues played sequentially. During replay, the 8-second audio is played concurrently with a speeded (3X) version of the video. Each cue is preceded by a text display that indicates approximately how much time has passed since the event as well as its exact date and time.

Access to a research backend that allows control over the user experience (e.g., implementing a baseline where some memories are held back from replay; tailoring daily goals) can be obtained from a corresponding author (M.D.B.).

Training

Prior to the start of the intervention, the experimenter trained G.F. on recording and replaying memories using the app. In this training session, G.F. also learned

about the memory science principles that are integrated within the app and ways he could implement effective techniques (e.g., produce a specific, detailed description of the event; capture a slow and steady recording of the environment of the event) into his regular app usage. The experimenter also led G.F. through a guided practice recording a cue and watching a replay session. At the beginning of the training session, G.F. required additional guidance on recording the video (e.g., how to hold the phone and look at the screen to pan around the environment from his perspective) and the verbal description (e.g., it took a few tries to ensure that the description was distinctive and not along the lines of “I am happy”, etc.), but he was able to use the app independently by the end of training. Throughout the training session, G.F. remained motivated and eager to use HippoCamera. We emphasized that G.F. take time to practice using the app and incorporate it into his lifestyle. We assured G.F. that there was no expectation regarding either the cinematographic quality or the specific content of the videos – what mattered was simply capturing events he wished to remember.

HippoCamera intervention

The memory intervention took place over 11 consecutive weeks during which G.F. was instructed to record at least one event and view at least two replay sessions per day using HippoCamera. Memory cues were assigned to either a Replayed condition and viewed multiple times ($M = 4.94$ times, $SD = 2.26$ times), or a within-subject Baseline condition and never replayed. This intervention followed an alternating-treatments single-case design, consisting of one extended intervention phase in which Replayed and Baseline events were interleaved. The sequence of conditions was determined a priori and not based on performance. There was no separate baseline-only phase preceding the intervention, nor was there a final “best treatment” phase. We opted to maximize the number of memories that were assigned to the Replayed condition ($M = 5.55$ events per week), compared to those that were hidden for replay ($M = 2$ events per week). This contrasted with our healthy older adult memory interventions which adopted a blocked ABAB design such that all cues recorded in a given week were assigned to the Replayed condition and all cues recorded in the following week to the Baseline condition (Martin et al., 2022). Given that the primary aim of our intervention was to improve memory, this design allowed us to maximize the benefits of replaying HippoCamera memories on rich episodic recollection (Martin et al., 2022). The current study also represents a systematic replication of our prior work (Martin et al., 2022; Meade et al., 2024), applying the core HippoCamera procedures to examine effects in an older adult with early-stage dementia.

A restricted randomization procedure was used to determine Baseline and Replayed days. We alternated the days of the week that would be hidden for replay and ensured that there was always a minimum of one day separating

Baseline days ($M = 3$ days). For example, in one week, the Baseline days could fall on Tuesday and Friday, and in the following week on Monday and Saturday. No procedural changes occurred during the course of the study; all intervention procedures were implemented as planned.

Check-in sessions

G.F. conducted four 30–45-minute check-in sessions with the experimenter throughout the intervention. These sessions aimed to provide reminders on app usage and ensure adherence to intervention procedures, foster an ongoing connection with G.F., and understand his experience using HippoCamera. During the second and fourth check-in sessions, short exercises were selected to build rapport. At the second check-in session, G.F. completed a Life Review exercise (adapted from Haight et al., 1998; Serrano et al., 2004), where he was encouraged to share positive memories from his life across multiple time periods, including childhood (i.e., “Tell me about a time in your childhood that you were extremely happy”), adolescence/teenage years (i.e., “During your years in school and education, what was something that you always loved to learn about?”), adulthood (e.g., “Tell me about a time that you were in love”), and life as a whole (e.g., “If you look back on your life, what kind of life do you think you had?”). At the last check-in session, G.F. completed a Future Imagination Task where he was asked to simulate himself in novel situations and describe what appears in his mind’s eye (i.e., “Imagine you are lying on a white sandy beach in a beautiful tropical bay”; “Imagine you are standing in the main hall of a museum containing many exhibits”; “Imagine you are standing in the middle of a bustling street market”) (Hassabis et al., 2007). These exercises were interesting experiences for G.F., after which he commented that “it was a good cleanse of the mind” and “[it] got me thinking of different things in my head”.

Cued recall of HippoCamera events

To assess memory for events recorded using HippoCamera, G.F. was administered an adapted version of the Autobiographical Interview (Levine et al., 2002) at three separate timepoints. These sessions provided structured opportunities for G.F. to reminisce on his recent past and took place at (1) two weeks, (2) five weeks, and (3) eleven weeks after the start of the intervention (Figure 1). At each timepoint, G.F. was tested on the HippoCamera memories that he recorded since the last testing session. With the exception of the last session having a longer delay due to scheduling, the delay between recording the memory and being tested on the memory was a mean of 18 days ($SD = 13$ days). We increased the interval between testing sessions to gradually support G.F.’s ability to retrieve recent events across slightly longer intervals. Combined across all sessions, G.F. was tested on 44 memories (32 Replayed and 12 Baseline): 13 memories at the first session (9 Replayed and 4 Baseline), 17 memories

at the second session (12 Replayed and 5 Baseline), and 14 memories at the third session (11 Replayed and 3 Baseline). The recall sessions were conducted by M.C. G.F. provided all recall responses independently but was accompanied by his son for technological assistance due to the Zoom testing format.

To probe memory for HippoCamera events, G.F. was presented with a PowerPoint slideshow over Zoom that displayed each HippoCamera memory cue. After a single cue was played, G.F. was given the following instructions: "Please tell me everything you remember about this experience. You can describe whatever you want to share with me when thinking back and remembering the event". He provided a response until his thoughts came to a natural end. Then, the experimenter asked an open-ended general probe (e.g., "Is there anything else you want to add to that experience?") to encourage recall of additional details. Following that, G.F. was asked one or two specific probes that belonged to the four categories to elicit further remembering of details: (1) space and setting, (2) people, interactions, thoughts, feelings, (3) self-related, and (4) other events. Note that the experimenter was blind to the replay condition when administering these sessions. The experimenter aimed to ask questions that were phrased with a similar level of specificity to ensure consistency in probing across events.

G.F. received guidance on details he might share, which was adapted from the standardized instructions we used in our past memory intervention studies:

You can describe details such as what you were doing, the people in the event, where you were at the time, when it took place, conversations you had, and feelings or emotions. Try to describe the event to me so I can imagine the event even though I was not actually there with you. No detail is too small, and everything is relevant.

G.F. was informed that these recall sessions were opportunities to share memories rather than tests of memory ability.

Open-ended qualitative feedback

During the scheduled check-in sessions and also at the end of the intervention, we asked G.F. open-ended questions regarding his experience using HippoCamera. These sessions were structured such that they began with an opportunity for G.F. to share how the intervention had been going, followed by prompts to describe his experience recording and replaying memories. These opportunities allowed G.F. to provide feedback on the intervention while allowing us to track progress and identify the role that the HippoCamera intervention played in G.F.'s life.

Pre- and post-assessments

To assess changes to quality of life and memory, G.F. completed a series of questionnaires during the intake interview and then again one week after the last

Autobiographical Interview session of the intervention. These are detailed below.

Quality of life: Dementia quality of life instrument (DQoL)

Quality of life was assessed by the DQoL, a 29-item questionnaire assessing the subjective experience of dementia (Brod et al., 1999). The DQoL has five measures: (1) Self-Esteem (e.g., “How often have you felt satisfied with yourself?”), (2) Positive Affect/Humour (e.g., “How often have you felt cheerful?”), (3) Negative Affect (e.g., “How often have you felt worried?”), (4) Feelings of Belonging (e.g., “How often have you felt lovable?”), and (5) Sense of Aesthetics (e.g., “How much have you enjoyed listening to the sounds of nature?”). Responses were rated on a 5-point scale. Scores were calculated by averaging responses to the questions that comprised each measure. For Self-Esteem, Positive Affect/Humour, Feelings of Belonging, and Sense of Aesthetics, higher scores indicate better QoL; for Negative Affect, lower scores indicate better QoL. The DQoL has acceptable-to-good internal consistency ($\alpha = 0.67\text{--}0.89$) and good construct validity with emotional well-being measures (Brod et al., 1999).

Life satisfaction: Satisfaction with life scale (SWLS)

The SWLS assessed global life satisfaction (Diener et al., 1985). Respondents rate their level of agreement to five statements on a 7-point scale (1 = “strongly disagree”, 7 = “strongly agree”). Total SWLS scores range from 5 (extremely dissatisfied) to 35 (extremely satisfied). The SWLS has shown strong internal consistency ($\alpha = 0.79\text{--}0.89$) across multiple studies and high convergence with measures of subjective well-being and life satisfaction (Pavot & Diener, 1993).

Depression: Beck depression inventory (BDI)

The BDI is a 21-item scale assessing the intensity of depressive symptoms (Beck et al., 1996). For each item, responses range in intensity on a 4-point scale (0–3). Total BDI score was calculated by summing the responses (1–10 = normal; 11–16 = mild; 17–20 = borderline; 21–30 = moderate; 31–40 = severe; >40 = extreme depression). The BDI has demonstrated excellent internal consistency ($\alpha = 0.73\text{--}0.93$) and moderate-to-high correlations with concurrent measures of depression (Beck et al., 1988).

Identity: Twenty statements test (TST)

Identity was assessed by the TST, a measure of self-concept and narrative identity where the respondent provides 20 statements in response to “Who am I?” (Kuhn & McPartland, 2017). The test was terminated when G.F. was unable to provide further responses. Each response was coded according to the coding scheme described in Rhee et al. (1995). Specifically, responses were classified

into six categories: traits (e.g., “I am friendly”), social identities (e.g., family information, occupation), specific attributes (e.g., preferences, aspirations, activities), emotional states (e.g., “I am afraid”), evaluative descriptions (e.g., abilities, evaluations, beliefs), and global descriptions (e.g., “I am myself”). Each category was further divided into subcategories, and each subcategory was classified as either abstract (e.g., reflective or lacking detail) or specific (e.g., includes specific details) (see Rhee et al., 1995 for full guidelines). According to the TST scoring scheme (Addis & Tippet, 2004; Rhee et al., 1995), the following scores were calculated: (1) the total number of responses provided excluding repetitions (to measure the strength of identity), (2) the percentage of abstract responses (to measure the quality of identity), and (3) the number of categories and subcategories sampled (to measure the complexity of identity).

Self-concept: Tennessee self-concept scale (TSCS)

Self-concept was assessed using a modified short form of the TSCS, which measures multiple domains of the self (i.e., physical, moral, personal, family, social, academic/work) (Fitts & Warren, 1996). A subset of 30 statements related to abilities, attitudes, and relationship with family (e.g., “I am a friendly person”; “I am satisfied with my family relationships”) were rated on a 5-point scale (1 = “always false”, 5 = “always true”). Total scores range from 30 to 150; higher scores indicate a more positive self-concept. The TSCS has demonstrated strong internal consistency ($\alpha = 0.86\text{--}0.88$ for subscales; $\alpha = 0.92$ for overall scale) and convergence with related constructs in self-esteem and mood (Fitts & Warren, 1996).

Self-reported autobiographical mnemonic capacities: Survey of autobiographical memory (SAM)

The SAM is a 26-item self-report questionnaire that measures capacities in four memory domains: autobiographical episodic memory (e.g., “When I remember events, in general I can recall people, what they looked like, or what they were wearing”), semantic memory (e.g., “I can learn and repeat facts easily, even if I don’t remember where I learned them”), spatial memory (e.g., “After I have visited an area, it is easy for me to find my way around the second time I visit”), and future thinking (e.g., “When I imagine an event in the future, the event generates vivid mental images that are specific in time and place”) (Palombo et al., 2013). Respondents rate their level of agreement on a 5-point scale (1 = “strongly disagree”, 5 = “strongly agree”). As referenced in the original validation of the SAM, scores for each domain and a total SAM score were calculated using a weighting algorithm on the raw item ratings. Individual self-reported autobiographical mnemonic capacities on the SAM have demonstrated construct validity (e.g., autobiographical episodic memory ratings correlating with recollection memory performance) (Palombo et al., 2013).

Scoring

Cued Recall of HippoCamera Events. To assess autobiographical memory recall, we transcribed G.F.'s memory recollections and scored the episodic and semantic components using the Autobiographical Interview scoring protocol (Levine et al., 2002; Renoult et al., 2020). Data from free recall, general probe, and specific probes were scored. Statements from the test sessions were segmented into internal (a measure of episodic details and vivid re-experiencing of the event) and external (a measure of semantic details, general background, and personal knowledge) detail groups.

Internal details included the following detail types: "events" referring to episodic information that pertains to the cued event (e.g., happenings, individuals present, weather, physical/emotional actions, reactions in others), "time" (e.g., year, season, month, day of week), "place" (e.g., city, street, building, room), "perceptual" information across all sensory modalities (e.g., auditory, olfactory, tactile, taste, visual, body position, duration), and "thought/emotion" information pertaining to thoughts and emotional states.

External details included the following detail types: "general semantic" (e.g., culturally shared knowledge of facts, public events, people, concepts), "autobiographical facts" (e.g., knowledge of one's past), "self-knowledge" (e.g., awareness of one's disposition and preferences), "repeated events" (e.g., descriptions of features that are common to multiple instances of an episode), "repetition" (e.g., information provided multiple times), and "other" (e.g., utterances and metacognitive statements).

Autobiographical Interview scoring was completed by M.C., who had previously received extensive training using materials from Brian Levine prior to data coding and achieved a high degree of reliability with trained raters (ICC = 0.92). Internal and external detail counts were quantified by summing the number of recalled details across corresponding detail subcategories. Note that the experimenter was blind to replay condition when scoring the memories. Recalled episodic details that were apparent in the memory cue were omitted from detail counts. This ensured that our measure of episodic details reflected true re-experiencing of the event rather than what could be recapitulated from watching the multimodal memory cue.

Results

Neuropsychological characterization

Standard neuropsychological tests

G.F.'s results on standardized neuropsychological tests and comparisons to normative sample are provided in Table 1. In summary, G.F.'s score on the MoCA (13 out of 30) was indicative of moderate cognitive impairment, with

Table 1. G.F.'s neuropsychological test performance.

Cognitive Domain	Neuropsychological Assessment	G.F.'s Scores	Compared Normative Sample
Global Cognitive Functioning	MoCA	13/30	Scores 10–17 are indicative of moderate cognitive impairment
	Visuospatial/Executive	2/5	
	Naming	2/3	
	Attention	5/6	
	Language	0/3	
	Abstraction	2/2	
	Delayed Recall	0/5	
	Orientation	2/6	
Premorbid Intellectual Functioning	National Adult Reading Test	19 errors	Predicted FSIQ = 112 79th percentile
Attention & Working Memory	WAIS-IV Digit Span	Forward: 7	SS = 7 (75–79 years)
		Longest digit span: 5	16th percentile
		Backward: 2	SS = 2 (75–79 years)
		Longest digit span: 2	<1st percentile
Verbal Memory	WMS-IV Logical Memory I	0 details recalled	SS = 1 (75–79 years) 0.13rd percentile
Language	Boston Naming Test (Short Odd-Even Form)	42 (21/30 pictures identified)	SS = 7 (78–80 years) 16th percentile
	Verbal Fluency FAS (Phonemic)	23 responses	<10th percentile (60–79 years; 13–21 years of education)
	Animal Naming (Categorical)	12 responses	<10th percentile (60–79 years; 13–21 years of education)
Processing Speed	Trail Making Test A ^a	226'' to complete	SS = 2 (78–80 years) <1st percentile
	D-KEFS Colour-Word Interference Test: Condition 1 (Colour Naming)	85'' to complete	SS = 1
		Total errors = 6	<1st percentile 1st percentile (errors)
		D-KEFS Colour-Word Interference Test: Condition 2 (Word Reading)	41'' to complete
Total errors = 0			<1st percentile 100th percentile (errors)
Executive Functioning	D-KEFS Colour-Word Interference Test: Condition 3 (Inhibition)	179'' to complete	SS = 1
		Total errors = 22	<1st percentile <1st percentile (errors)

Note: References for compared normative samples: National Adult Reading Test (Nelson & Willison, 1991), WMS-IV Logical Memory I (Wechsler, 2009), WAIS-IV Digit Span (Wechsler, 2008), Trail Making Test A (Ivnik et al., 1996), Boston Naming Test (Ivnik et al., 1996), D-KEFS Colour-Word Interference Test (Delis, 2001), Verbal Fluency (Tombaugh et al., 1999). FSIQ = Full-Scale Intelligence Quotient; SS = Standard Score.

^aFor Trail Making Test A, the raw score may be an underestimation of G.F.'s actual performance and the completion time may be higher than expected because this task was administered virtually over Zoom. Trail Making Test B was discarded because the alternating number-to-letter pattern was not recognized after many attempts and corrections.

a delayed list recall score of 0 out of 5. His level of premorbid intellectual functioning was estimated to be in the High Average range, as assessed by the National Adult Reading Test. Within his cognitive profile, he showed weak but not impaired immediate auditory attention, language (naming), and phonetic and categorical fluency. By contrast, he showed significant impairment (less than 1st percentile) on verbal memory, processing speed, and measured areas of executive functioning such as inhibition.

Traditional autobiographical interview

Results for the Autobiographical Interview are provided in Table 2. As expected for someone with early-stage dementia (Greene et al., 1995; Kopelman, 1989; Piolino et al., 2003), G.F. had the richest recall for remote memories from early childhood and diminished episodic recall for more recent memories. One exception was G.F.'s memory from his teenage years, where he showed impoverished memory (recalling only two internal details), yet he provided a considerable amount of semantic background (40 external details). G.F.'s pattern of results contrasted with those of a normative sample of healthy older adults, where recall for events from the recent past (e.g., middle adulthood, previous year) contained more episodic details relative to events from the remote past (e.g., childhood, teenage years) (Lockrow et al., 2024). Additionally, G.F. showed lower proportions of internal details across all time periods compared to healthy older adults (Lockrow et al., 2024), suggesting that his memory was over-general and semanticized, and that access to rich, event-specific detail was limited.

Furthermore, there were moments during this task when G.F. experienced confusion. For example, when prompted to recall an event that occurred in his middle age (e.g., 30–55 years old), G.F. at first recalled a memory from when he was in his sixties, then from his young adulthood, and only after further prompting, correctly described a memory from the cued time period. Moreover, when asked to provide additional details on the memory from his middle age, he forgot the memory that he had been describing and he showed signs of temporal disorientation, before getting re-oriented and providing relevant details. These observations are consistent with the memory concerns that G.F. and his family had reported.

Table 2. G.F.'s traditional autobiographical interview.

	Number of Internal (Episodic) Details		Number of External (Semantic) Details		Proportion of Internal (Episodic) Details	
	G.F.	Normative Data ^a	G.F.	Normative Data ^a	G.F.	Normative Data ^a
Childhood	21	24.70 (13.14)	16	14.80 (23.16)	0.57	0.69 (0.18)
Teenage	2	26.62 (16.88)	40	18.66 (21.81)	0.05	0.64 (0.19)
Middle Age	14	35.52 (26.33)	22	22.16 (25.67)	0.39	0.65 (0.20)
Last Five Years ^b	1	40.07 (30.09)	23	22.97 (23.66)	0.04	0.60 (0.20)
Recently (two weeks ago) ^c	10	N/A	26	N/A	0.28	N/A

^aMeans and standard deviations are obtained from Lockrow et al. (2024); $N = 151$, healthy community-dwelling older adult participants (age range = 60–92; M age = 68.8; $SD = 6.67$).

^bThe closest available norms to the tested time period of the last five years were for memories from the previous year.

^cNo normative data are available for recent memories from the past two weeks, which were tested to measure memory for events with a similar delay to those in the current study.

Memory intervention

HippoCamera usage

Over the 11-week intervention, G.F. showed reasonable compliance with our instructions to record at least once a day and to replay twice a day. He recorded 83 events (1.10 per day) and viewed 91 replay sessions (1.20 per day). Beside an unexpected pause of nine days in early January 2022 due to contracting COVID and needing to isolate, G.F. recorded at least one event for 75% of the days in the intervention and viewed a replay session for 63% of the days in the intervention, which indicates that app usage was consistent and frequent.

G.F.'s family assisted the first few recording sessions (e.g., providing guidance to G.F. around the timing of the verbal description) and at the beginning of the intervention, reminded him to record and replay daily. Within approximately a week, G.F. became independent using HippoCamera. Anecdotally, G.F. expressed his eagerness to use the app, particularly sharing his excitement of panning around the environment to record HippoCamera memory cues, which he mentioned was like "being a director". As the intervention progressed, G.F. shared that many of his family members were open and interested in using the app with him. He also shared excitedly with us that other residents in his building were curious to learn about the app, and during those encounters, G.F. would describe and show them the app. No adverse events or harms were reported for G.F. during the intervention.

Cued recall of HippoCamera events

To assess the effect of replay on autobiographical memory test detail counts, we conducted generalized linear models using a Poisson distribution with the *lme4* package (Bates et al., 2015) in R 4.2.2. Poisson models were used to best account for the count-based nature of the number of details recollected (Bolker et al., 2009). Individual models were specified for internal details and external details. To compare internal and external recall directly, we also conducted a linear model to examine the effect of replay on the proportion of internal details recalled with the *lme4* package in R (Bates et al., 2015). The proportion of internal details was defined as the ratio of internal to total details (i.e., internal and external). Poisson generalized linear models were also used to assess the effect of replay on the number of words recalled. Replay condition was effect-coded, with replayed events coded as "1" and baseline events coded as "−1". Post-hoc comparisons were conducted using the *emmeans* package (Lenth, 2021).

Combined across test sessions, G.F. was tested on 32 events assigned to the Replayed HippoCamera condition (M memory age = 15.58 days) and 12 events assigned to the Baseline HippoCamera condition (M memory age = 18.78 days). Replayed and Baseline events did not differ according to the age of the memory ($\beta = 1.60$, $SE = 2.19$, $t(42) = 0.73$, $p = .470$) and event significance rating by G.F. at

the time of recording ($\beta = -0.01$, $SE = 0.09$, $t(42) = -0.12$, $p = .904$). Critically, G.F. recalled significantly more Internal details for Replayed events ($M = 7.28$, $SD = 4.01$) than Baseline events ($M = 5.42$, $SD = 3.60$) ($\beta = 0.15$, $SE = 0.07$, $z = 2.11$, $p = .035$) (Figure 3(A)). Furthermore, the Proportion of Internal details was significantly greater for Replayed events ($M = 0.53$, $SD = 0.25$) relative to Baseline events ($M = 0.36$, $SD = 0.18$) ($\beta = 0.09$, $SE = 0.04$, $z = 2.15$, $p = .037$) (Figure 3(C)).

There was no difference in the number of External details that G.F. recalled for Replayed ($M = 7.44$, $SD = 6.19$) and Baseline events ($M = 8.67$, $SD = 5.02$)

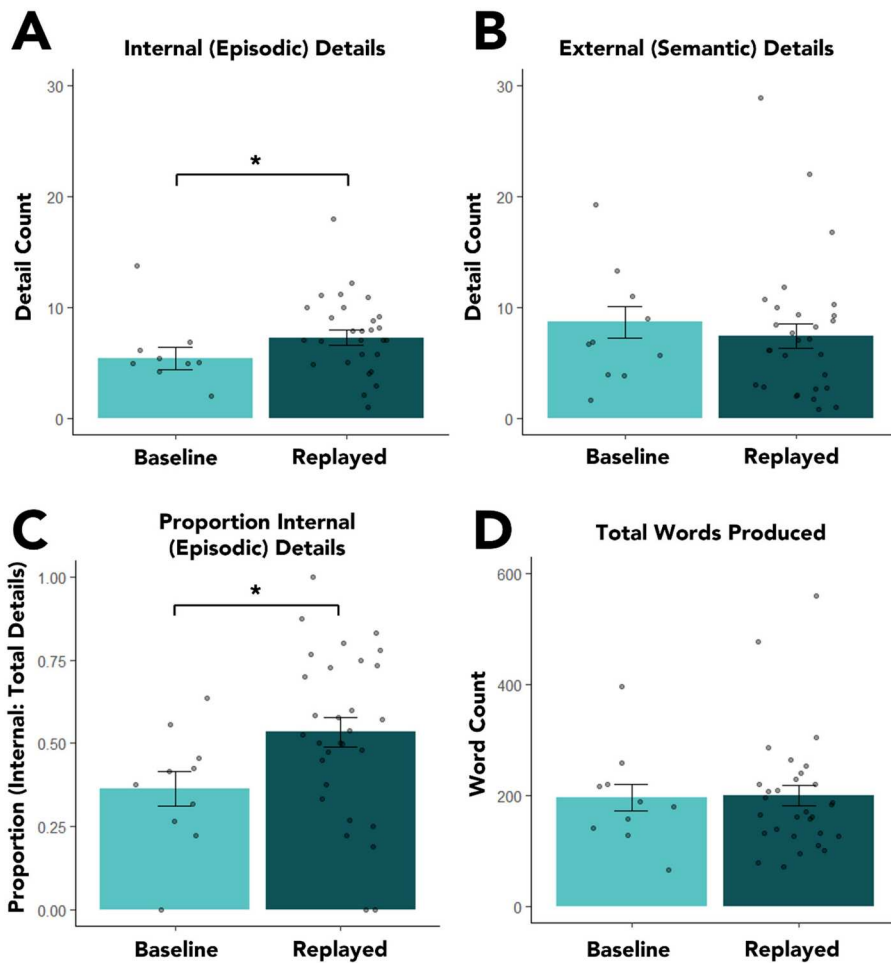


Figure 3. Results from G.F.'s HippoCamera autobiographical interviews. (A) G.F. recalled a higher number of internal (episodic) details for events that were replayed with HippoCamera relative to baseline events that were not replayed. (B) There was no difference in the number of external (semantic) details recalled for replayed versus baseline memories. (C) G.F.'s memory for events that were replayed with HippoCamera contained a greater proportion of internal (episodic) details (i.e., ratio of internal to total details recalled) relative to baseline events that were not replayed. (D) Replayed and baseline events were recalled with a similar number of words. Error bars depict confidence intervals. $*p < .05$.

($\beta = -0.08$, $SE = 0.06$, $z = -1.30$, $p = .193$) (Figure 3(B)). Additionally, there was no difference in word count for Replayed ($M = 200.13$, $SD = 18.27$) and Baseline HippoCamera events ($M = 196.58$, $SD = 24.21$) ($\beta = 0.01$, $SE = 0.01$, $z = 0.74$, $p = .458$) (Figure 3(D)).

Pre-and-post assessments

Quality of Life. G.F. showed improved quality of life, as indicated by a higher global DQoL score after the intervention (Table 3). Specifically, G.F.'s scores on level of self-esteem, sense of belonging, positive affect/humour, and sense of aesthetics improved and/or were higher than the normative data in a sample of older adults with mild-to-moderate dementia after the intervention. G.F.'s level of negative affect also decreased after the intervention.

Table 3. Results from G.F.'s pre- and post-assessments.

Construct	Questionnaire	Pre Score	Post Score	Normative Score M (SD)
Quality of Life	Dementia Quality of Life Instrument			
	Self-Esteem (1–5)	3.00	4.00	3.66 (.73) ^a
	Feelings of Belonging (1–5)	3.33	4.00	3.66 (.74) ^a
	Positive Affect/Humour (1–5)	3.33	4.33	3.55 (.73) ^a
	Negative Affect (1–5)	3.55	2.40	3.86 (.69) ^a
	Sense of Aesthetics (1–5)	3.20	3.80	3.99 (.74) ^a
Life Satisfaction	Satisfaction With Life Scale (5–35)	27 (satisfied)	32 (extremely satisfied)	24.25 (7.41) ^b
Depression	Beck Depression Inventory	8 (normal)	2 (normal)	7.74 (6.43) ^c
Identity	Twenty Statements Test			
	Total # of responses	14	17	18.33 (2.21) ^d
	% of abstract responses	35.71	58.82	25.70 (10.82) ^d
	Total # of categories	5	6	N/A
	Total # of subcategories	8	9	N/A
Self-Concept	Tennessee Self-Concept Scale (30–150)	124	144	125.75 (11.13) ^e
Self-Reported Autobiographical Mnemonic Capacities	Survey of Autobiographical Memory			
	Episodic	99.98	105.67	100.34 (14.24) ^f
	Semantic	107.76	96.50	96.60 (11.90) ^f
	Spatial	84.70	94.91	103.80 (14.21) ^f
	Future	88.52	87.35	93.75 (15.18) ^f
	Total	95.12	94.17	93.21 (13.67) ^f

^aBrod et al. (1999); $N = 95$, older adult population with mild and moderate dementia (age range = 55 to over 85; M age = 78.7; $SD = 7.43$).

^bPavot et al. (1991); $N = 39$, community-dwelling older adult population (age range = 53–92; M age = 74, $SD = 8.97$).

^cSegal et al. (2008); $N = 147$, community-dwelling older adult population (age range = 55–90; M age = 70.3, $SD = 7.50$).

^dAddis and Tippet (2004); $N = 20$, community-dwelling older adult population (age range = 65–88; M age = 75.20, $SD = 6.81$).

^eNormative data were obtained from data collection on Prolific; $N = 60$, community-dwelling older adult population (age range = 60–90; M age = 70.38, $SD = 6.46$).

^fSetton et al. (2022); $N = 184$, community-dwelling older adult population (age range = 58–92; M age = 69.41, $SD = 6.90$).

Life Satisfaction. G.F. reported an increase in life satisfaction on the SWLS from “satisfied” to “extremely satisfied”, with his score falling closer to the upper end of the normative mean after the intervention (Table 3).

Depression. G.F.’s performance on the BDI decreased, indicating fewer depressive symptoms over time, with his score falling closer to the lower end of the normative mean after the intervention (Table 3).

Identity. On the TST (Table 3), G.F. showed greater strength of identity, as measured by the total number of statements he provided. He provided more total statements after the intervention (pre = 14, post = 17), approaching the mean of the normative range of a healthy older adult sample, and required less prompting from the experimenter to generate responses. For quality of identity, measured by the percentage of abstract responses generated, G.F. provided a higher percentage of abstract responses after the intervention (pre = 35.71%, post = 58.82%), relative to specific responses. This is consistent with normative data showing that patients with AD exhibited a more abstract self-representation relative to healthy controls. For complexity of identity, measured by the number of categories and subcategories represented in his responses, G.F. provided statements from five categories and eight subcategories before the intervention, which increased to six categories and nine subcategories after the intervention. Interestingly, G.F. provided a greater number of traits (pre = 2, post = 9) and evaluative descriptions (pre = 2, post = 3) after the intervention, and he provided a lower number of statements related to emotional states (pre = 4, post = 1) and specific attributes (pre = 4, post = 3) following the intervention. Before the intervention, G.F.’s self-descriptive statements included more worries (e.g., related to family and money) and general statements about happiness, love, and helping others. After the intervention, he was able to provide more diverse statements, spanning personality traits, hobbies, and pleasures of life.

Self-Concept. G.F. showed a stronger sense of self-concept, which was reflected by a higher score on the TSCS after the intervention (Table 3). Interestingly, certain statements that G.F. agreed with before the intervention that may have led to a more negative self-concept (e.g., “I am a sick person”, “I am hard to be friendly with”, “I am losing my mind”) were rated differently after the intervention. Additionally, positive statements that G.F. denied identifying with before the intervention (e.g., “I have a healthy body”, “I have a lot of self-control”, “I am an attractive person”) were endorsed and perceived as true after the intervention.

Self-Reported Autobiographical Mnemonic Capacities. On the SAM, G.F. showed improvement in self-perceived episodic and spatial memory abilities after the intervention (Table 3). Specifically, in the episodic domain, he endorsed greater ease of retrieval for specific events, better ability to recall the order of event details, objects in the environment, and the day of the week that events took place, as well as higher confidence in the ability to remember

past events. After the intervention, G.F.'s episodic score on the SAM became closer to within the range of the normative sample. In the spatial domain, prior to the intervention he reported considerable difficulty navigating and finding his way around an area, judging the distance between familiar landmarks, getting lost in familiar areas, and finding a route if the original way was blocked, all of which he endorsed less difficulty with after the intervention. Although G.F.'s spatial scores on the SAM were lower than that of the normative sample, he showed improvement in self-perceived spatial memory abilities.

Open-ended qualitative feedback

In addition to our reported quantitative measures, we conducted qualitative interviews with G.F. both during regular check-in sessions and after study completion to gather a deeper and more holistic insight into his experience taking part in the HippoCamera intervention, which is particularly valuable in a single-case study design (Onhenga et al., 2019; Rochat & Manolov, 2024). Interview responses were transcribed verbatim, and an inductive thematic analysis was conducted on G.F.'s responses (Braun & Clarke, 2006). After becoming familiarized with the data, M.C. generated initial codes and organized these into overarching themes. These themes were reviewed, iterated upon, and refined with the other authors through discussion during regular meetings.

HippoCamera application feedback. G.F. described that HippoCamera was beneficial in allowing him to preserve his memory. For example, he noted the effectiveness of using HippoCamera to capture clips of events that he could later use to remember his recent past. He shared that watching the replay sessions “brought [his] memories back”, and that he appreciated that the videos were easily accessible a few moments after they were recorded, such that “[he didn’t] need to wait for a big event or years and years to see these pictures, it’s just a whole new life”. Overall, G.F. shared that he felt very positive about recording and having access to the memories he captured through HippoCamera.

Taking initiative to improve memory. G.F. expressed continued enthusiasm in using HippoCamera and participating in the intervention. After four weeks in the intervention, G.F. mentioned that he was “getting more keen and interested in [the programme] than before”. After five weeks, G.F. shared that the intervention had been an “eye-opener” and that he had been taking time to introduce the app and describe the programme enthusiastically with other seniors who were also dealing with memory loss. The intervention also allowed G.F. to play an active role in improving his memory; during the check-in sessions, G.F. asked for feedback on his memory performance and asked questions about app features and its relation to memory.

Connection with others. G.F. shared that engaging in the intervention allowed him to build social connections. He shared that prior to the

intervention, he was “avoiding people, not wanting to talk to them”. Because of memory loss, he felt that he was unable to remember people and was not able to continue conversations. As the intervention progressed, G.F. indicated that he began to feel more confident in his ability to carry out conversations and that he shared “many good moments with people”. Moreover, he shared that he previously thought “[he] was the only person who was losing their memory and that kind of thing”, but he was able to connect with other seniors who were experiencing similar memory concerns. Importantly, he was inspired to share with them how the intervention he participated in could instil hope.

Renewed sense of purpose and outlook on life. G.F. reflected on how the intervention helped him feel more confident and connected to who he is as a person. He noted that before the intervention, he was nervous, scared, and lacked confidence given the changes in his memory, and he stated that by engaging in the HippoCamera intervention, he was “a recipient of an improvement of life”. After G.F.’s last week of the intervention, he acknowledged the positive influence of the intervention, stating that “from the time that we started, to where I am now, [I am] feeling a lot more confident about getting out, meeting people, and getting back to my old self as well.” G.F. shared a sense of accomplishment upon completing the intervention, noting “I’m proud of myself [for that]. Every day I am growing and getting back to a piece of myself.” He also mentioned that “[his memory] is getting better”, and that

I’ll remember for all my life, how much I’ll grow from this. The point is I still want to grow. I still want to learn, I want to know what’s going on. My whole ability to want to learn more and grow has changed immensely ... I felt more confident than I ever have. The beginning of good things to come.

Meaningful form of cognitive and social engagement. The HippoCamera intervention provided G.F. with daily cognitive enrichment and the opportunity to work on memory and remember life events, while strengthening his social connections. G.F.’s family mentioned that the intervention provided him with something to actively remember, such as planning an activity or event to record. He also successfully learned how to navigate a new portable technological device, all of which helped him cognitively while enhancing his quality of life during a time when he needed it the most. Two months after the intervention, the family shared with us that “the additional homework with HippoCamera definitely helped [G.F.’s] recovery ... your HippoCamera programme should be offered as a viable option for seniors to stay connected with their family and friends and more so their memories”. Notably, after the intervention concluded, G.F. independently continued using the HippoCamera app to record and replay new memories for at least nine months.

Discussion

Here, we present a case study of G.F., a 79-year-old man recently diagnosed with early-stage dementia, who was experiencing hallmark symptoms of AD, including memory loss for recent events, spatial disorientation, confusion, and withdrawal from previously enjoyed activities. To address these challenges, we offered G.F. a personalized 11-week digital reminiscence intervention using HippoCamera, a neuroscience-informed smartphone application that supports memory for recent, personally meaningful experiences. The goal was to examine whether this intervention could enhance episodic recollection, psychosocial well-being, and self-concept in the context of neurodegenerative memory impairment. We found that G.F. recalled events that were reviewed using HippoCamera with significantly greater episodic detail than events that were recorded but not replayed. Post-intervention assessments revealed improvements in quality of life, life satisfaction, mood, self-concept, and perceived episodic and spatial memory abilities. Qualitative feedback further indicated that engaging with HippoCamera helped G.F. regain confidence, reconnect socially, and feel more optimistic about his future. Together, these findings demonstrate the potential of digital reminiscence tools to meaningfully support both memory and well-being in individuals navigating early-stage dementia.

Our findings build on prior reminiscence therapy work, which has traditionally focused on evoking *remote* memories to promote wellbeing. This traditional approach leverages the relative preservation of memory for meaningful autobiographical events from the distant past, which often remains accessible well into the later stages of disease progression (Berg-Weger & Stewart, 2017; Cotelli et al., 2012; Saragih et al., 2022). This work has shown that by encouraging the recollection of these older events – typically using photos, familiar objects, or evocative environments – traditional reminiscence therapy can improve mood and cognition (Cuevas et al., 2020; Gonzalez et al., 2015). However, a recent Cochrane Review concluded that reminiscence therapy is not consistently associated with improvements in well-being or quality of life, and that observed cognitive benefits are generally small (Woods et al., 2018).

The modest effects of traditional reminiscence therapy may stem from the fact that current approaches overlook a critical opportunity: focusing on recent autobiographical events, which – though more vulnerable to forgetting – are essential for everyday functioning and self-continuity in early-stage AD. Indeed, G.F.'s performance on a traditional autobiographical interview revealed precisely this profile – preserved memory for childhood events but impoverished episodic recall for recent experiences (e.g., the past five years, the prior two weeks). By helping G.F. repeatedly revisit specific events from the recent past (e.g., “Baking chocolate chip cookies in the afternoon”; “Working on puzzles with the grandchildren”), the HippoCamera intervention likely bolstered his connection to the present and supported a more coherent, moment-to-

moment sense of identity. Specifically, because G.F. was able to recall events that he replayed multiple times in greater episodic detail and with a larger proportion of episodic details compared to non-replayed events, our findings suggest that context-dependent cues and additional scaffolding through salient reminders with HippoCamera can strengthen and rehabilitate recent memory. In this way, our case study illustrates how targeting recent memory may be a powerful, underutilized strategy in reminiscence-based care for individuals with early-stage AD.

An important aspect of digital reminiscence work is this potential for memory improvements to extend to other domains, such as psychosocial well-being and identity. After the intervention, G.F. showed numerical improvements in all our measures of quality of life, mood, and self-concept. This aligns with the reciprocal relationship between the self and autobiographical memory: by improving access to recent events, HippoCamera may have facilitated a more coherent and continuous sense of self, which in turn supported greater social and emotional functioning (Clare, 2003; Conway & Pleydell-Pearce, 2000; Svanberg & Evans, 2014; Wilson et al., 2013). These findings build on our past work showing that memories replayed with HippoCamera were recalled with more episodic detail and greater positive sentiment in older adults (Martin et al., 2022). It could also be that the act of capturing and reviewing events with HippoCamera created natural opportunities for G.F. to share his experiences with loved ones and foster social connection and engagement with others navigating similar memory challenges (e.g., G.F. told us that “One of the biggest things I’ve been sharing with a lot of people is the enthusiasm with what this [whole programme] is about. I was very pleased that they were pleased. And he has a problem with memory loss as well.”). Moreover, during a time when G.F. was likely coming to terms with cognitive changes and reduced independence (e.g., forgetting names and events, getting lost), the intervention empowered him to take an active role in improving his memory – learning new skills and independently using a smartphone app (e.g., “Trying to use new technology ... I’m pretty happy with how things are going so far ... it’s given me a good boost”). Together, these elements could have helped promote a sense of agency and preserve self-identity (Wilson et al., 2024). As described by G.F., capturing and replaying powerful memory cues allowed him to vividly re-experience his recent past, helping his present self feel more integrated with his unfolding experiences (e.g., “I took some scenes of lake full of geese, it’s really special, my wife was right next to me ... Once I got pictures looking back, that was beautiful to have”). This, in turn, may have promoted his sense of continuity and self-confidence, which then rekindled his eagerness to grow, learn, and be engaged.

More broadly, these findings highlight the promise of our digital reminiscence intervention as a non-pharmacological intervention in memory impaired populations, especially during early stages of neurodegeneration when

maintaining memory abilities and quality of life can be transformative. Research has shown that interventions aimed at preserving or enhancing cognitive function (e.g., cognitive stimulation, reminiscence therapy) are most effective in early AD, because semantic and procedural memory remain relatively intact and can be used to support learning and skill acquisition (Clare & Woods, 2004). In addition, patients with early dementia prioritize quality of life and reduction of sadness and frustration around memory loss, as well as involvement in meaningful activities that provide them a sense of satisfaction and purpose in life (Villarejo-Galende et al., 2022; Wehrmann et al., 2021). Therefore, the psychosocial benefits from our intervention – including greater confidence, social connectedness, and self-concept – may support individuals in coping with changes in memory and help mitigate adverse social and emotional consequences. Furthermore, given that smartphones have become ubiquitous, there is growing interest in leveraging digital technologies such as HippoCamera to facilitate meaningful activities that improve memory and socioemotional well-being (Goodall et al., 2021) and promote functional independence in daily life (Astell et al., 2019; Lorenz et al., 2019). Moreover, integrating HippoCamera with traditional reminiscence therapy approaches may represent a promising clinical intervention to support both recent and remote autobiographical memories, while targeting psychosocial outcomes such as quality of life, emotional well-being, and sense of self.

In our case, G.F. showed a considerable level of awareness of his memory impairment, which is associated with successful outcomes of cognitive rehabilitation (Clare et al., 2004). We acknowledge additional factors that may have contributed to the intervention's success in G.F. For example, G.F. appeared to be a self-motivated person with a desire to learn and grow, which may have led to greater enjoyment of and engagement with the intervention. Moreover, G.F. embodied a sense of positivity and had a strong family support system, which encouraged and eagerly supported him throughout the intervention. Indeed, qualitative studies with persons with dementia report that feeling valued, having friends and family for emotional and practical support, and having a sense of humour and determination to make the most of everyday life (e.g., activities, relationships, routines) can help enhance one's ability to cope and navigate life with dementia (Górska et al., 2018; Preston et al., 2007). It is also possible that rapport with the experimenter may have positively influenced changes in mood and well-being. Furthermore, although the HippoCamera event test sessions followed standardized protocol (Levine et al., 2002), the process of sharing autobiographical memories with an actively engaged listener may itself be inherently social, fostering connectedness, self-understanding, and positive emotions (Henkel et al., 2017; O'Rourke et al., 2017). Lastly, G.F. was trained to use the app and, although he quickly gained comfort and was able to use the app independently throughout the intervention, he had

family members available to provide support if needed, which may have increased adherence and engagement.

To support the accessibility and real-world implementation of HippoCamera, future work should determine whether in-app guided tutorials are sufficient for individuals experiencing cognitive impairment. These tutorials could reflect the same instructions typically provided during participant training, include opportunities for review, and should be designed to align with users' needs and preferences (Yardley et al., 2015). It will be particularly important to evaluate tutorial effectiveness in contexts where caregiver support may not be available, and to assess whether independent use yields outcomes comparable to those observed in the current study. More broadly, integrating AI-powered smart glasses in similar interventions may enable more seamless capture of everyday experiences that could be processed and reviewed with HippoCamera, particularly in contexts where smartphone recording may be intrusive. AI-driven features could also support the extraction of contextual cues and provide personalized reminders to support engagement with HippoCamera replay functions (Wang et al., 2025). Importantly, HippoCamera's benefits likely stem in part from the intentional encoding and deep engagement required during event capture, suggesting that automated approaches should be designed to retain this active, user-driven component of memory formation.

Looking ahead, future research should build on this case study to explore the broader potential of HippoCamera as a scalable intervention for individuals with AD or other forms of memory impairment. First, it will be important to replicate these results in a larger sample of individuals with AD. Second, developing and testing a group-based version of the intervention may extend its reach while fostering social connection among individuals navigating memory loss. Consistent with this possibility, focus group discussions in patients with transient epileptic amnesia – who experience disruptions in episodic memory, including accelerated long-term forgetting of recent events – suggest that engagement in memory interventions is enhanced when participants can learn effective strategies and receive guidance from facilitators within a supportive environment that encourages sharing of lived experiences (Savage et al., 2025). At the same time, it will be important to consider individual differences in preferences, mental health, and coping styles, as well as practical constraints such as time and accessibility. Tailoring interventions to account for variability in the severity of memory impairments and associated challenges may be critical for optimizing engagement and effectiveness (Savage et al., 2025).

Future work should also examine whether using HippoCamera encourages individuals with early AD to engage in more enjoyable and purposeful activities that they might otherwise be disengaged from due to changes in memory and identity (Harding et al., 2019). We have previously shown that engaging in unique activities while using HippoCamera provides healthy community-dwelling older adults with increased positive affect, decreased boredom, and a faster

perception of time during the COVID-19 pandemic lockdowns, a period that lacked experiential diversity and was characterized by social isolation (Meade et al., 2024). Together, these findings suggest that HippoCamera may promote cognitive enrichment, with downstream benefits for social integration and a sense of purpose. Moreover, future work could investigate whether enhancing engagement and social connection through HippoCamera leads to measurable reductions in depressive symptoms in individuals with AD, particularly those experiencing loneliness and emotional changes (Steeman et al., 2006). It is important to note that the current intervention was not designed to assess changes in everyday short-term memory, which plays a critical role in supporting well-being and activities of daily living in individuals with dementia (Giebel et al., 2015; Raimo et al., 2024). Future work could examine whether memory benefits from HippoCamera extend to improvements in other cognitive functions, including attention, short-term memory, and executive functioning, which are commonly targeted in cognitive rehabilitation for dementia. To better understand the specific contribution of HippoCamera beyond existing compensatory strategies, it will be important for future interventions to include additional control conditions. Potential examples include viewing photographs of recent events, receiving verbal summaries from a caregiver, or using written or calendar-based records, allowing for more direct comparison of how different approaches support memory. Finally, longitudinal studies following individuals with early-to-moderate dementia using HippoCamera can help clarify how improvements in memory and well-being shape the course of disease progression.

In conclusion, we developed an online personalized 11-week online intervention using HippoCamera, a freely available and portable smartphone app designed to optimize memory outcomes through the capture and structured replay of everyday events. G.F., an older adult experiencing cognitive impairment due to early-stage dementia, used the app to create and revisit powerful memory cues from moments he wished to remember. Following the intervention, G.F. showed improved episodic memory for replayed events and positive changes in psychosocial well-being. Future work can extend these findings to inspire person-centered digital reminiscence interventions that incorporate opportunities for social connection, memory sharing, and the promotion of autonomy and initiative in improving memory. Our findings suggest that HippoCamera can be effectively delivered to older adults in the early stages of neurodegeneration – when intervention may be most impactful. By offering a way to retain and reconnect with cherished life moments, such interventions may help instill a sense of hope and renewed purpose during a time when it is needed the most.

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Author contributions

M.C. and M.D.B. were involved in project conceptualization and methodology. M.C. was involved in investigation, data curation, scoring, and statistical analyses. B.H. contributed to conceptualization, methodology, software development, and writing. M.D.B. provided resources and software. M.C. wrote the initial draft of the manuscript, with input from M.D.B., and both M.C. and M.D.B. revised and wrote the final manuscript. All authors provided feedback on the manuscript and approved the final version of the manuscript for submission.

Disclosure statement

B.H. and M.D.B. own shares in Dynamic Memory Solutions Inc., a company focused on developing digital tools to improve memory. The University of Toronto holds the ownership rights to the HippoCamera technology used to conduct the research described herein but has given Dynamic Memory Solutions the rights to commercialise. No person, nor organisation received any financial remuneration for the use of the HippoCamera application in these studies. At the time of publication, this is a research-dedicated application that we will make available to other memory scientists at no charge.

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