Memory in Motion: How Real-Life Event Features Influence the Tempo of Episodic Recall

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Abstract

How do people mentally replay real-life events, and what shapes the time it takes to remember them? In this study, we investigated the temporal compression of memories by examining how long it takes participants to recall everyday events they recorded using wearable cameras. While remembering duration increased with the actual length of events, this relationship was nonlinear: recall duration rose steeply for events lasting up to ~10 min, then plateaued, suggesting scale-invariant retrieval beyond this threshold. Crucially, various event characteristics also influenced remembering duration, with events that were more unusual, unpredictable, emotionally positive, socially engaging, or marked by greater change showing less temporal compression. These effects were not explained by retrieval difficulty, but rather reflected the richness of memory representations, including greater detail and stronger sense of reliving. Together, these findings suggest that memory compression depends not only on the event's actual duration, but also on how it was subjectively experienced and structured in memory. By linking event features to the tempo of recall, this study offers novel insight into the dynamics of episodic memory and the mechanisms that shape how we mentally replay real-life experiences.

Keywords: autobiographical memory; temporal compression; wearable camera; time; duration judgments

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Why does it take less time to remember an event than to experience it? This question highlights a fundamental property of our memories—that they compress the unfolding of events—yet it has received surprisingly little empirical attention. Indeed, most studies on human memory have relied on discrete, static stimuli (e.g., words or pictures). While these controlled paradigms enable precise manipulation of experimental variables, they fall short of capturing the richness and temporal dynamics of real-world experiences. Consequently, findings from traditional laboratory studies may not fully generalize to the complexities of everyday memory (Pooja et al., 2024). In response, memory research has increasingly adopted naturalistic approaches. Among these, studies using wearable cameras have gained traction, offering a way to enhance ecological validity while providing objective records of events (Bainbridge & Baker, 2022; Chow & Rissman, 2017; Finley & Brewer, 2024; Fu et al., 2020; Nielson et al., 2015; Rissman et al., 2016; Sreekumar et al., 2018). Building on this approach, the present study aims to investigate how the time it takes to recall an event relates not only to its actual duration, but also to key characteristics of the event itself. In doing so, we aim to better understand the temporal structure of memories for real-life events and the features that influence how we compress our past experiences.

To investigate how the continuous stream of real-world experiences is represented in memory, previous research has examined the duration and content of event recall, comparing them to objective measures of the original experiences (for a review, see D’Argembeau et al., 2022). In one line of work, participants visited various locations across a university campus and performed specific actions at each site (e.g., purchasing a drink at the cafeteria) while wearing a camera that recorded their experience from a first-person perspective. Later, they were asked to mentally ‘relive’ each event in as much detail as possible, and the time they took to do so was compared to the actual duration of the original events. It was found that, on average, events were remembered approximately eight times faster than they were experienced (Jeunehomme & D'Argembeau, 2019). This phenomenon—where remembering an event takes less time than its actual duration—has been referred to as *temporal compression* in episodic memory (Jeunehomme & D'Argembeau, 2019). Importantly, this compression was not uniform: some events were recalled with finer temporal resolution than others (see also, Bonasia et al., 2016; Folville et al., 2020; Jeunehomme & D'Argembeau, 2020).

Although these studies provided the first empirical evidence for temporal compression in memory, they are limited by the brevity and mundane nature of the events examined. As such, the influence of event characteristics on recall duration remains largely unexplored. One key feature that likely plays an important role is the duration of the event itself. Although this variable was not directly examined in the original study, our reanalysis of data from Jeunehomme and D'Argembeau (2019) revealed a significant positive relationship between event duration and recall duration[1]. However, the events in that dataset were relatively short—ranging from 18 to 800 seconds, with a median of 177 seconds—leaving open the question of how recall duration scales for longer, more complex experiences lasting more than a dozen minutes. Intuitively, one might expect that the increase in recall time with event duration would not necessarily be linear. Supporting this view, recent results suggest that the rate of increase in recall duration becomes less pronounced for longer events (Leroy et al., 2024). However, that study used simple video stimuli with minimal temporal variation, ranging from 3 to 15 seconds. To provide a more comprehensive understanding of how events are

[1] We fitted a linear mixed-effects model predicting remembering duration (in seconds) from event duration (in minutes), including a by-participant random intercept and random slope, using the lme4 package in R (Bates et al., 2015). The model showed that event duration was a significant predictor of remembering duration, $b = 3.74$, $SE = 0.55$, $t = 6.81$, $p < .001$. The parameter estimate indicated that for each additional minute in the actual duration of the event, the remembered duration increased by 3.74 s.

temporally compressed in memory, the present study investigates how recall duration evolves for richer, more varied events of extended length—events lasting up to an hour.

Beyond the event's duration, other characteristics likely influence the degree of temporal compression in memory. A key factor is the presence of perceptual or conceptual shifts within an event, which can enhance memory by segmenting the continuous flow of experience into meaningful units (Clewett & Davachi, 2017; Zacks, 2020). Accordingly, events characterized by more changes tend to be less temporally compressed in memory (Faber & Gennari, 2015; Jeunehomme & D'Argembeau, 2020).

Although not directly concerned with temporal compression, other research indicates that various event features modulate the vividness and level of detail of memories (Morales-Calva & Leal, 2025). In particular, memories are generally stronger for events that are unusual (Finley & Brewer, 2024; Thompson et al., 1996; Thomsen et al., 2015), unpredictable (Bein et al., 2021; Loock et al., 2025), or that occur in unfamiliar places or involve new people (Bainbridge & Baker, 2022). Emotional salience is another well-established factor: autobiographical memories tend to be more detailed when events are positively charged (Brewer, 1988; D'Argembeau et al., 2003; Thompson et al., 1996). More broadly, events that are personally important or goal-relevant are more likely to be retained (Conway, 2005), and repeated rehearsal further enhances retention (Thompson et al., 1996; Thomsen et al., 2015). Overall, characteristics known to enhance memory vividness—such as novelty, emotional significance, or personal relevance—may also influence temporal compression in episodic memory, given that vivid and detailed memories are typically associated with reduced temporal compression (Folville et al., 2020). However, this possibility has not been directly tested.

Another open question concerns the extent to which memory compression influences the perceived duration of past events. Research on retrospective timing indicates that duration estimates are shaped not only by an event's actual duration but also by memory-related factors, particularly the amount of information retained per unit of time (Block et al., 2010; Ornstein, 1969; Faber & Gennari, 2015). However, most of this research has relied on simple laboratory stimuli and relatively brief time intervals (Block et al., 2010). Only a few studies have examined retrospective duration judgments in the context of more naturalistic events (Balcı et al., 2023; Tobin et al., 2010; Yarmey, 2000), and to our knowledge, no research has directly tested whether perceived duration for real-life experiences is systematically related to the degree of temporal compression in memory.

In summary, although temporal compression is a fundamental property of memory for real-life events, little is known about how specific event characteristics influence the time it takes to recall past experiences. In the present study, we used wearable camera technology to examine how features such as event duration, familiarity, importance, emotionality, change, and rehearsal shape recall duration. Participants recorded a series of events from their daily life during three consecutive days. On returning to the lab, they were asked to mentally replay each event, which was cued by pictures representing the beginning and end of the event, extracted from the video recording. The time taken to silently recall each event was measured, and participants then rated the characteristics of their memories and verbally described remembered content. Finally, they rated the characteristics of all events. Our primary goal was to investigate how recall duration varies with event duration and to identify which additional event characteristics contribute to this variation. The subjective and objective characteristics of memories were also assessed to examine to what extent they predict recall duration. In addition, we examined whether retrospective duration estimates are influenced by the time taken to recall an event, beyond its actual duration.

Method

Participants

Participants were 40 adults (32 females and 8 males) aged between 18 and 33 years (*M* = 20, *SD* = 3), who were recruited through a subject pool and word-of-mouth. This sample size was determined based on a power analysis for linear mixed-effects models using SIMR (Green & MacLeod, 2016). We used data from Jeunehomme and D'Argembeau (2019) as a starting point to provide us with parameter estimates for fixed and random effects. We fitted a model predicting remembering duration (in seconds) from event duration (in minutes), including a by-participant random intercept and random slope, using the lme4 package in R (Bates et al., 2015). The model yielded an estimated effect size of 3.74 for the fixed effect of event duration (indicating an increase in remembering duration of 3.74 s for every one-unit increase in the predictor, i.e. per minute of the actual event duration). Then, we calculated power curves for the smallest effect size of interest $b = 2$ (indicating an increase in remembering duration of 2 s for every one-unit increase in the predictor), which indicated that a sample of 40 participants (with 9 events per participants) provided over 95% statistical power to detect this effect size. Note that this was only an approximation, as data were analyzed using generalized additive mixed models to allow for nonlinear relationships between remembering duration and predictors (see below).

Eligibility criteria included not taking medications that could affect attentional capacities and the absence of psychological, psychiatric, or neurological disorders. All participants were fluent in French. One participant was excluded and replaced by another due to signs of inattention during the task. All participants provided written informed consent. The study was approved by Ethics Committee of the Faculty of Psychology of the University of Liège (ref.2324-026).

Materials and procedure

Participants first used a wearable camera to record three events per day over three consecutive days, resulting in a total of nine recorded events. Detailed instructions on camera use and event selection were provided during an initial introductory session. Five days after this session (i.e., two days after the event recording was over), participants completed an unexpected memory task in which they mentally replayed each of the nine recorded events and then verbally described the content of their memories. Following this, they rated the nine events on dimensions such as usualness, familiarity, and valence. Both the memory and rating tasks were administered using the Gorilla Experiment Builder (Anwyl-Irvine et al., 2020). The different phases of the experiment (instruction session, event recording, and memory test) were scheduled on specific days over a one-week period (see Figure 1A).

Wearable camera

The BOBLOV 007 Mini camera is a compact, wearable device designed for continuous video and audio recording. The camera records video in Full HD 1080p resolution (1920 x 1080 pixels) with a 90-degree field of view, providing clear and wide-angle images. Recorded videos are stored in AVI format on a 64 GB microSD card. The battery, which can be recharged using a standard USB cable, provides 90 minutes of continuous recording. For data security and participant anonymity, all files were transferred from the memory card to a secure hard drive and deleted from the memory card after each use to prevent any data overlap between participants. The BOBLOV 007 camera was chosen for its portability (i.e., first-person filming), ease of use, adequate video quality, and affordable cost.

Recording of events

On the Thursday of their testing week, participants attended a group introductory session (with 3 to 5 participants per group), during which a researcher explained the study procedure. Participants were instructed to wear the camera during three distinct daily-life events over three consecutive days: Friday, Saturday, and Sunday (see Figure 1A). Including the weekend in the recording period was intended to capture a broader variety of activities, including non-academic contexts. Participants were asked to select events that varied in content (to avoid recording the same type of event twice), familiarity (events that are more or less common in their daily life), valence (positive, neutral or negative), social context (alone or with others), and significance (more or less important events). It was also specified that the duration of events should be between a few minutes and up to one hour (to prevent the camera battery from running flat). Participants were instructed to turn on the camera at the beginning of the event, to let the camera record the event continuously, and to turn off the camera as soon as the event was over. To ensure an optimal perspective, participants were asked to position the camera at the center of their chest. They were asked to behave as naturally as possible during the recording. Participants were required to record three events per day (nine in total); if a recording was missed, participants were instructed to compensate by recording an additional event the following day (e.g., if only two events were recorded on Friday, four should be recorded on Saturday).

We followed the ethical guidelines proposed by Kelly et al. (2013) for the use of wearable cameras in research. Participants were free to choose which events they were comfortable recording and could switch off the camera at any time. If they wished a recorded event not to be seen by the researcher, they could flag this event (with day and time) to be deleted before the researcher could view it (in this case, participants were instructed to record an additional event for a total of 9 usable events). Additionally, participants were instructed not to activate the camera in places where people might expect privacy and to obtain permission from all people present when recording in private areas.

After receiving the event recording instructions, participants were shown how to operate the camera, and a practice session was held to ensure that they could turn the camera on and off by themselves. Participants were asked to recharge the camera each evening but not to view or download their recordings (they were informed that viewing their own recordings would result in exclusion from the study). At the end of the session, each participant received an instruction manual and the researcher's contact details in case of further questions. Importantly, participants were not informed that their memory for the recorded events would be tested. Instead, they were told that the study aimed to pre-test the effectiveness of the Boblov 007 camera for capturing everyday events in the life of university students. The detailed instructions are available in OSF at https://osf.io/gc7yh/.

Memory and event assessment tasks

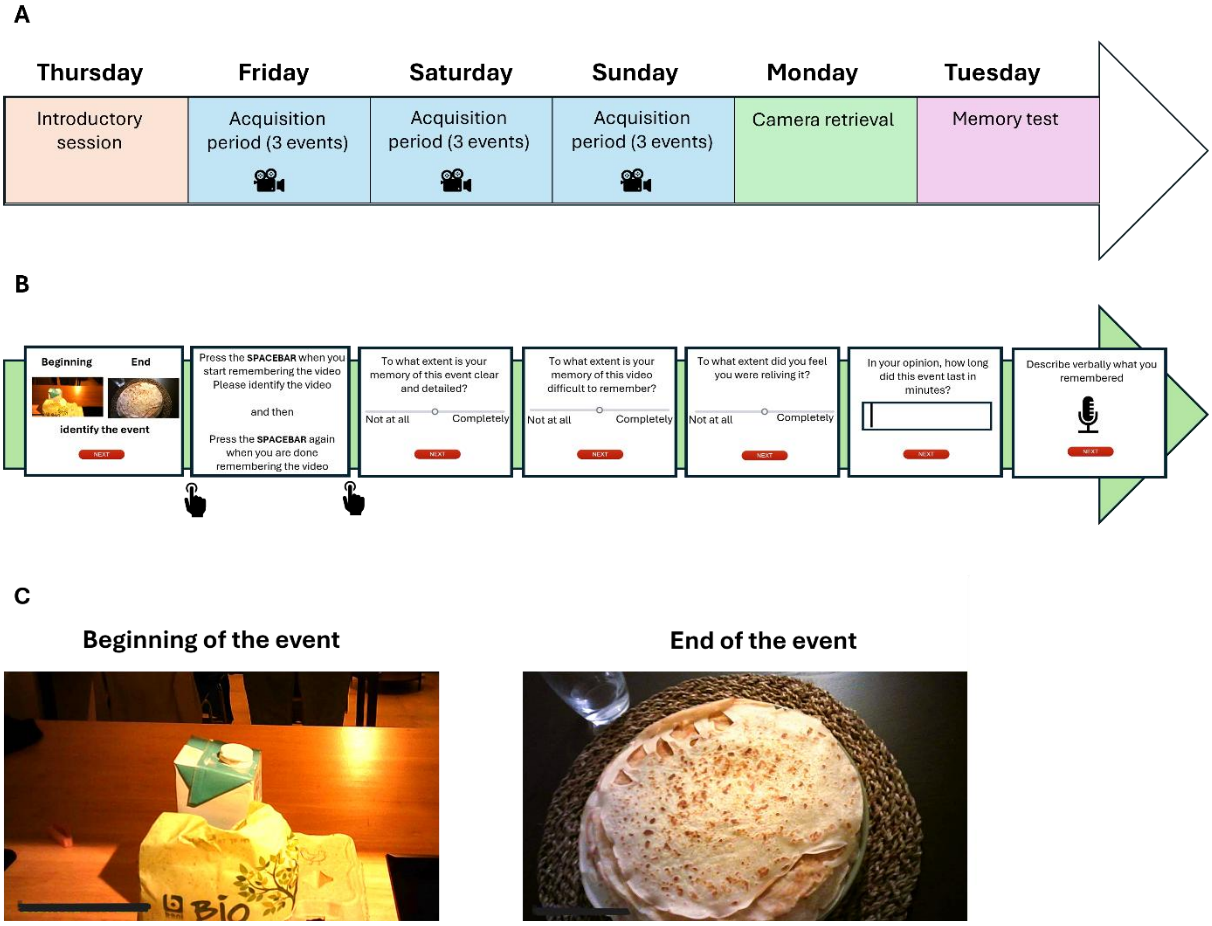
Selection of retrieval cues. On the Monday following the acquisition period, participants returned the camera to the lab. The researcher briefly examined each recorded event and, using VLC Media Player, extracted two images per video: one representing the beginning and the other the end of the event. These images served as retrieval cues for each specific event. Timestamps were removed from the images to avoid providing participants with temporal information about the events (see Figure 1C for an example of cues).

Memory task. Each trial began with the presentation of visual retrieval cues corresponding to one of the recorded events (see Figure 1B). Participants were asked to identify the event and to mentally replay it in as much detail as possible, from the moment they turned on the camera to the moment they turned it off, as if they were reliving the event again in their minds. They were instructed to press the spacebar to indicate the start and the end of their mental replay, allowing us to measure the time needed to remember the event (Jeunehomme & D'Argembeau, 2019). Following the mental replay, participants rated their memory on visual analogue scales (VAS, ranging from 0 to 100) assessing the level of detail of the memory (from not at all detailed to very detailed), the sense of reliving the event (from not at all to completely), and the difficulty of remembering the unfolding of the event (from not at all to very difficult). They were then asked to estimate the original duration of the event (in minutes). Finally, participants gave a verbal description of everything that came to mind during their mental replay. Once the verbal report was complete, the next trial began. The cues corresponding to each event were presented in random order. Exact instructions for the memory task are available in OSF at https://osf.io/gc7yh/.

Event assessment task. After completing the memory task, participants rated each event on several dimensions (see Table 1), including usualness, importance, familiarity of the environment, familiarity with people, familiarity of the activity, goal relevance, emotional valence, emotional intensity, unpredictability, and rehearsal. These dimensions were selected based on prior research showing their influence on autobiographical memory recall (Bainbridge & Baker, 2022; Thomsen et al., 2015). Participants also assessed the degree of change that occurred during the unfolding of each event. In addition, for exploratory purposes, we included a measure of situational characteristics using "the situational eight DIAMONDS" framework (Rauthmann et al., 2014), which assesses eight dimensions of experience: duty, intellect, adversity, mating, positivity, negativity, deception, and sociality. Due to time constraints, we used one of the ultra-brief validated versions, the S8-II scale (Rauthmann & Sherman, 2016), which includes one item per dimension and has been recommended for its construct and nomological validity. All ratings were collected on VAS ranging from 0 to 100.

Figure 1

Overview of the experimental procedure and memory task



Note. **A.** Illustration of the experiment timeline. **B.** Illustration of a trial of the memory task. Participants were first shown two visual cues representing the beginning and the end of a recorded event. Once the event was identified, they mentally replayed its unfolding in as much detail as possible, pressing the spacebar to mark the start and end of their mental replay. They then rated their memory using VAS assessing the level of detail, sense of reliving, and difficulty of recall, and provided an estimate of the event's original duration. Finally, they verbally described everything that came to mind during the mental replay. **C.** Example of retrieval cues for the event "cooking pancakes." The left image marks the onset of the event, showing ingredients arranged on a kitchen worktop. The right image marks the end of the event, showing the prepared pancakes ready to be eaten.

Scoring of episodic and semantic details in memory descriptions

Verbal descriptions of memories were analyzed to estimate the amount of episodic and semantic information they contained. A widely used scoring system for this purpose, proposed by Levine et al. (2002), distinguishes between internal and external details. Internal details refer to episodic elements specific to the remembered event—such as time, place, people, objects, actions, perceptual details, and thoughts—while external details include semantic or factual information, repetitions, and references to other events. In the present study, we used an automated scoring method developed by Van Genugten and Schacter (2024), which uses natural language processing to estimate the amount of internal and external content in each sentence of a narrative. This method has been shown to produce estimates that strongly correlate with human-coded assessments.

Table 1

Event characteristics and rating items

Event characteristic	Item
Usualness	To what extent is this event usual or unusual for you? (Very unusual – very usual)
Personal importance	How important is this event for you? (not important at all – extremely important)
Familiarity with the environment	How familiar are you with the environment of the event? (not familiar at all – very familiar)
Familiarity with the people/objects involved	How familiar are you with the people/objects involved in the event? (not familiar at all – very familiar)
Familiarity with the activity	How familiar are you with the activity of the event? (not familiar at all – very familiar)
Goal-related	How does this event relate to your personal goals (something you want to achieve or accomplish)? (not at all – completely)
Valence	How negative/unpleasant or positive/pleasant is this event? (very negative – very positive)
Arousal	How emotionally intense is this event? (not intense at all – very intense)
Unpredictability	Was this event planned (you knew it would unfold this way) or completely unexpected? (completely planned – completely unexpected)
Rehearsal	Have you thought about this event since you experienced it? (not at all – frequently)
Sharing	Have you talked about this event since you experienced it? (not at all – frequently)
Change	To what extent does the course of this event involve changes (e.g., changes of location, objects/people involved, actions/activities, etc.)? (not at all – a lot)

Note. The original items were in French, and the table shows their English translation.

Data cleaning and statistical analyses

Trials with remembering durations exceeding three standard deviations from the mean (mean = 46 seconds, SD = 47) were excluded, resulting in the removal of 11 trials with durations longer than 187 seconds. In addition, one participant recorded only seven events instead of nine. As a result, the final dataset included 347 trials (except for the analyses of change rating, which were not recorded for 2 participants) from the 40 participants.

Data were analyzed with mixed-effects models to account for the dependency between observations (events nested within participants). In addition, Generalized Additive Mixed Models (GAMMs) were used to capture potential non-linear relationships between remembering duration and the predictors of interest. GAMMs are highly flexible, allowing for the modeling of non-linear effects through smooth functions such as splines (Pedersen et al., 2019). These models are particularly well suited for situations where the functional form of the relationship between variables is unknown, as they do not require a priori specification of this form. To prevent overfitting and the generation of overly complex curves, a ‘wiggliness’ penalty is applied during model fitting. A key concept in interpreting GAMMs is the Effective Degrees of Freedoms (EDF), which quantifies the degree of non-linearity of a smooth term. An EDF close to 1 indicates an approximately linear relationship, whereas higher EDF values reflect increasing non-linearity in the modeled effect.

All analyses were conducted using the *mgcv* package in R (Wood, 2023). Partial effect plots were generated using the *gratia* package (Simpson, 2024) and show the component contributions, on the link scale, of each model term to the linear predictor. The y axis on these plots is centered around 0 because the smooths have a sum-to-zero identifiability constraint applied to them (Simpson, 2024). In all models, the maximal random effects structure justified by the design was specified, including a by-participant random intercept and a by-participant random slope (Barr et al., 2013). Model diagnostics were conducted using the gam.check() function, which provides residual plots to assess the adequacy of model fit. All data and analysis code are available in OSF at https://osf.io/gc7yh/.

Results

The recorded events lasted between 30 s and 70 min, with a mean duration of 17 min (SD = 13). The average remembering duration was 40 s (SD = 28 s), with recall times ranging from 3 to 158 s. On average, events were replayed approximately 25 times faster than their original duration.

Remembering duration as a function of event duration

One of our main interests was to examine the relationship between event duration and remembering duration. The distribution of remembering duration was right-skewed, so we first applied a log-transformation for use in the statistical analyses[2]. We fitted a GAMM with log-transformed remembering duration (in seconds) as the outcome variable and event duration (in minutes) as the predictor. As expected, the effect of event duration was significant, indicating that longer events were associated with longer remembering durations (EDF = 5.77, $F = 5.42$, $p < .001$). The effective degrees of freedom (EDF) of 5.77 indicated a non-linear relationship between event duration and remembering duration. As shown in Figure 2, there was a steep increase in remembering duration as a function of event duration for events lasting up to 10 min, after which the time taken to recall events remained more stable (note that the estimated effect was less precise for events lasting longer than 50 min due to the lower number of data points; see the rug plot on Figure 2).

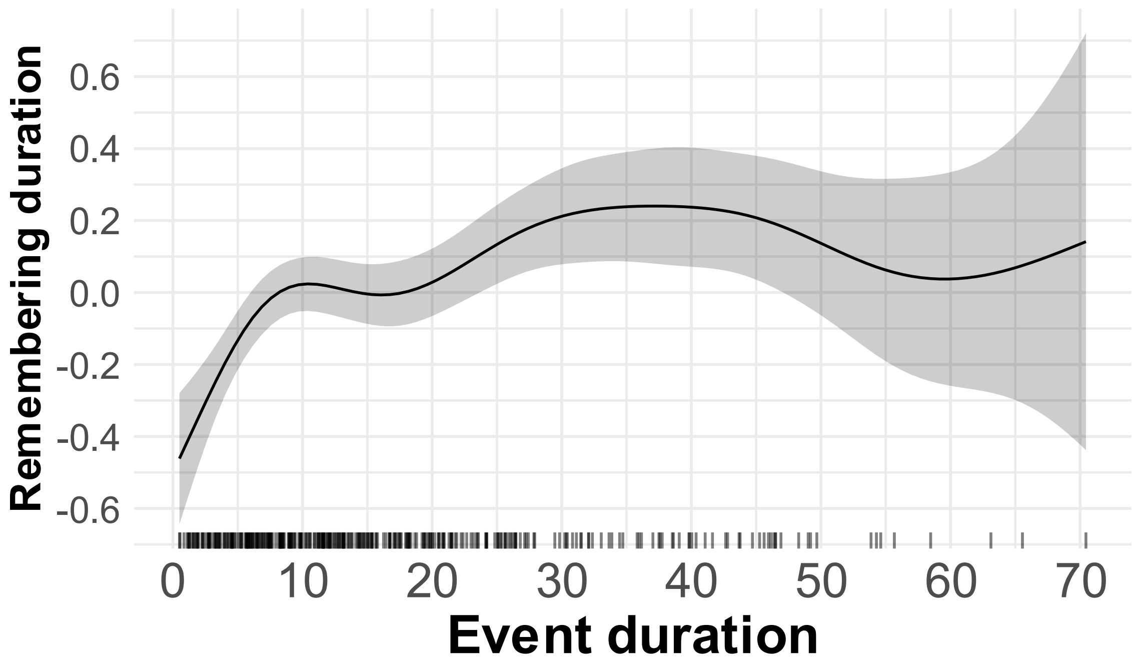
In the GAMM described above, we did not center the predictor to allow visualizing the effect of event duration on a meaningful scale (i.e., with zero as a meaningful reference point) but it should be noted that the interpretation of the effect is tricky because it conflates two sources of variance: between- and within-subject variability (Hoffman, 2019). Therefore, to disentangle these two sources of variability, we fitted another model that included both the

[2] We verified that the shape of the relationship between event duration and remembering duration was similar when using untransformed data, which confirmed the robustness of the pattern.

group-mean (person-mean) centered event duration (to isolate within-participant variability) and the centered between-participant effect of average event duration (to isolate between-participant variability). This showed that within-participant variability in event duration significantly predicted remembering duration (EDF = 2.49, $F = 4.86$, $p = 0.0021$), whereas between-participant variability did not (EDF= 1, $F = 0.18$, $p = 0.67$). Therefore, the effect of event duration on remembering duration was primarily driven by differences between the recorded events, rather than by between-participant differences in the average duration of events.

Figure 2

Relationship between remembering duration (log-transformed) and event duration



Note. Partial effect plot of event duration on remembering duration, estimated from a Generalized Additive Mixed Model (GAMM). The black line represents the estimated effect, and the error bar (shown in grey) represents the 95% confidence interval. The rug plot on the *x*-axis indicates the density of recorded events as a function of event duration.

Effects of event characteristics on remembering duration

Our next goal was to investigate which features of events predicted remembering duration, beyond the actual event duration. We fitted separate GAMMs for each dimension of interest, with remembering duration as the outcome variable, the rated feature as predictor, and event duration as covariate. This allowed us to assess the contribution of each feature to remembering duration, independently of the actual event duration. In each model, the two continuous predictors were group-mean centered to isolate within-participant variability, that is, differences across events.

The models revealed that familiarity with the environment and activity, usualness, level of change, unpredictability, valence, and rehearsal significantly predicted remembering duration (see Table 2 and Figure 3). Specifically, after taking into account the duration of the event itself, remembering duration was longer for events involving unfamiliar environments and activities, events involving more change, unusual and unpredictable events, positive events, and events that had been rehearsed. The relationship between remembering time and these dimensions was linear, except for rehearsal (EDF = 2.03). By contrast, familiarity with objects, arousal, goal-relatedness, sharing, and personal importance were not significant predictors of remembering duration. In all models, event duration remained a significant predictor of remembering duration.

Table 2

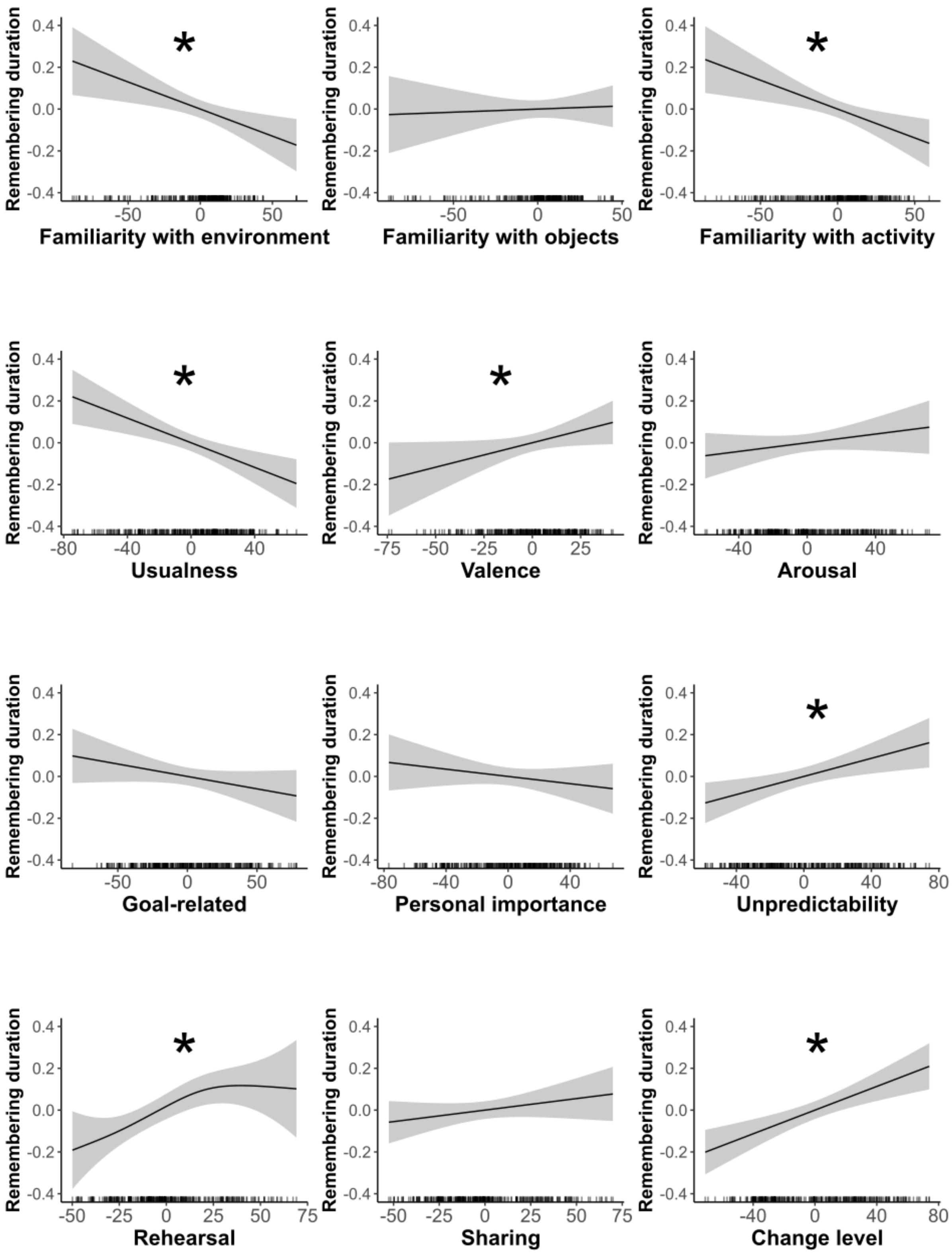
Results of Generalized Additive Models (GAMs): Relationship between event characteristics and remembering duration

Characteristic	EDF	*F*	*p*
Familiarity with environment	1	8.28	.004
Familiarity with objects	1	0.08	.774
Familiarity with activity	1	9.04	.003
Usualness	1	12.29	< .001
Change level	1	16.34	< .001
Unpredictability	1	8.17	.005
Valence	1	4.03	.045
Arousal	1	1.47	.226
Goal-related	1	2.48	.117
Rehearsal	2.03	5.51	.003
Sharing	1	1.52	.218
Personal importance	1	1.06	.305

Note. An EDF (estimate degrees of freedoms) close to 1 indicates an approximately linear relationship, while higher EDF values reflect increasing non-linearity.

Figure 3

Relationship between event features and remembering duration



Note. The plots display the partial effects of each predictor on remembering duration, after taking into account the duration of the event. The rug plots on the *x*-axis indicate the density of recorded events as a function of event duration. * Indicates a statistically significant relationship ($p < .05$).

For exploratory purposes, we also investigated whether the situational characteristics of the DIAMONDS framework (Rauthmann et al., 2014) predicted the time taken to recall events. We fitted separate models with duty, intellect, positivity, negativity and sociality as predictors, remembering duration as outcome, and event duration as covariate. Due to low response variability (over 80 % of responses at 0 on the VAS scale), the dimensions adversity, mating, and deception were excluded from the analyses. The results revealed that events involving social interactions were associated with longer remembering durations (see Table 3 and Figure 4). Conversely, events characterized by task-related duties led to shorter remembering durations. Positivity, negativity, and intellect were not significant predictors of remembering duration. In all models, event duration remained a significant predictor of remembering duration.

Table 3

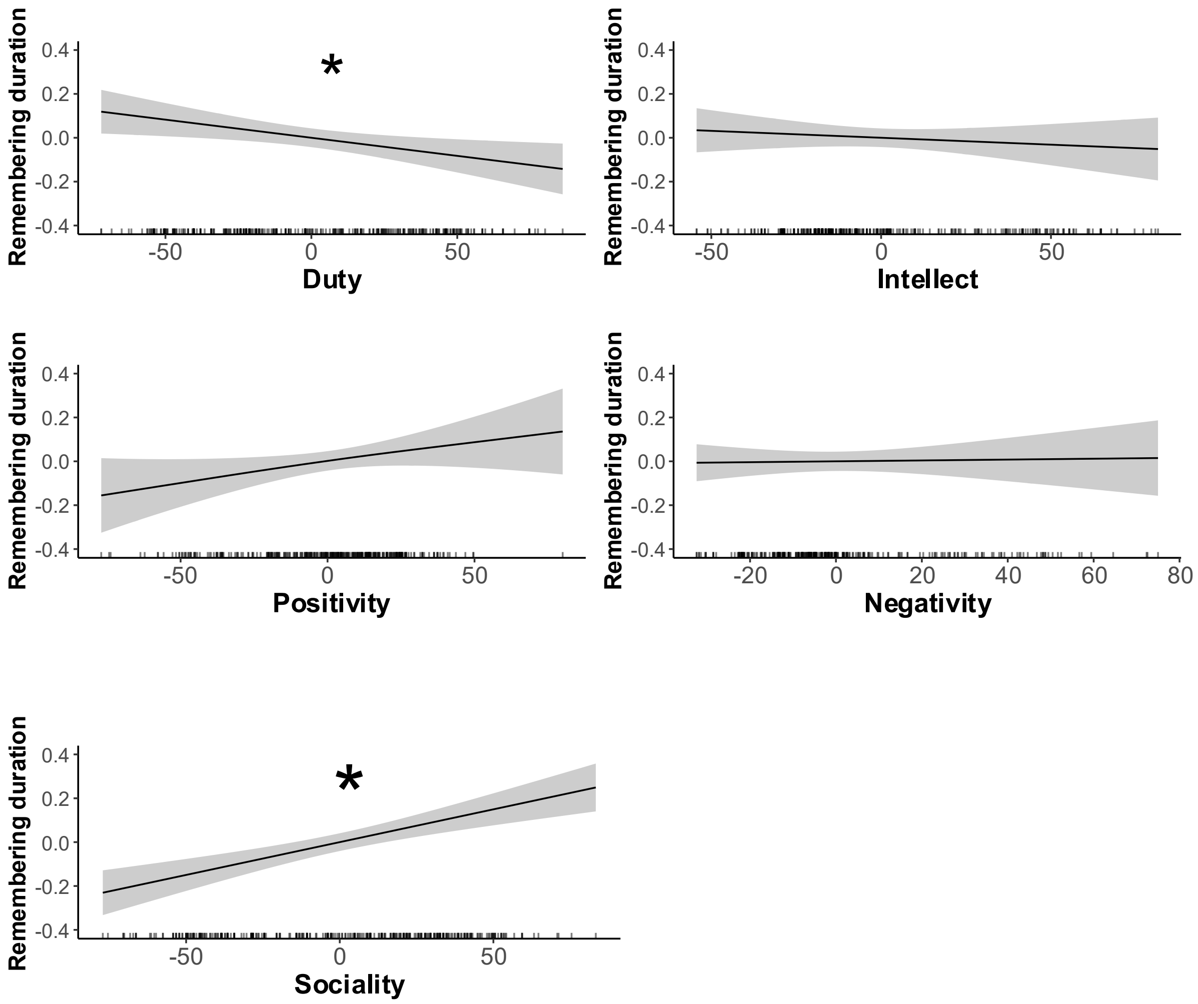
Results of Generalized Additive Models (GAMs): Relationship between event situation characteristic and remembering duration

Situation dimensions	EDF	*F*	*p*
Duty	1	6.72	.01
Intellect	1	0.54	.462
Positivity	1.11	2.69	.075
Negativity	1	0.031	.861
Sociality	1	23.27	< .001

Note. An EDF (estimate degrees of freedoms) value close to 1 indicates an approximately linear relationship, while higher EDF values reflect increasing non-linearity.

Figure 4

Relationship between event situation characteristics and remembering duration



Note. The plots display the partial effect of each predictor on remembering duration, after taking into account the duration of the event. The rug plots on the *x*-axis indicate the density of recorded events as a function of event duration. * Indicates a statistically significant relationship ($p < .05$).

Subjective and objective characteristics of memories

We next examined the extent to which remembering duration was associated with memory characteristics. We first focused on participants' subjective ratings of their memories (i.e., ratings of difficulty, level of detail, and sense of reliving). We then analyzed objective indicators of memory content derived from verbal descriptions, including number of words as well as counts of internal and external details.

For each subjective memory characteristic, we fitted a GAMM with remembering duration as the outcome variable, the memory rating as predictor of interest, and event duration as covariate. The results indicated that ratings of detail and reliving significant predicted remembering duration, whereas ratings of difficulty did not (see Table 4 and Figure 5). In all three models, event duration remained a significant predictor of remembering duration.

Table 4

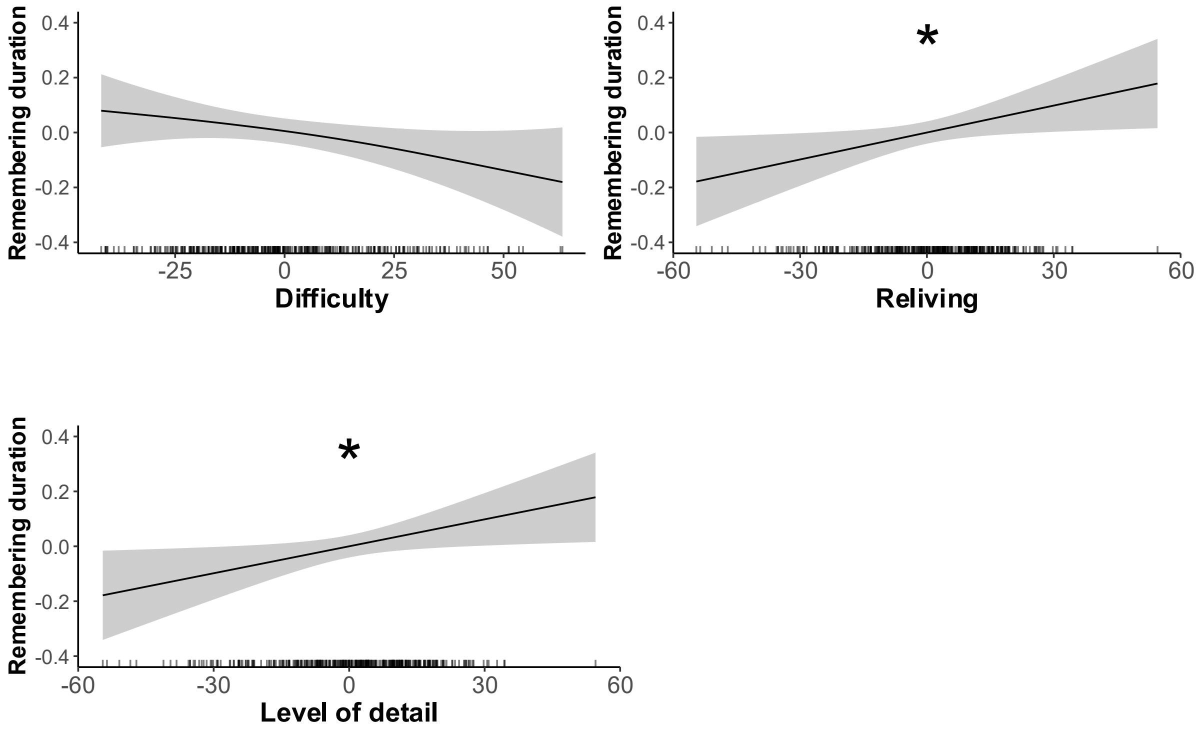
Results of Generalized Additive Models (GAMs): Relationship between memory characteristics and remembering duration

Memory characteristics	EDF	*F*	*p*
Subjective characteristics			
Difficulty	1.27	3.11	.095
Reliving	1	4.94	.027
Level of detail	1	15.23	< .001
Objective characteristics			
Number of words	3.96	25.48	< .001
Word count for internal details	3.30	14.60	< .001
Word count for external details	1.49	9.03	< .001

Note. EDF (estimate degrees of freedoms) value close to 1 indicates an approximately linear relationship, while higher EDF values reflect increasing non-linearity.

Figure 5

Relationship between subjective memory characteristics and remembering duration



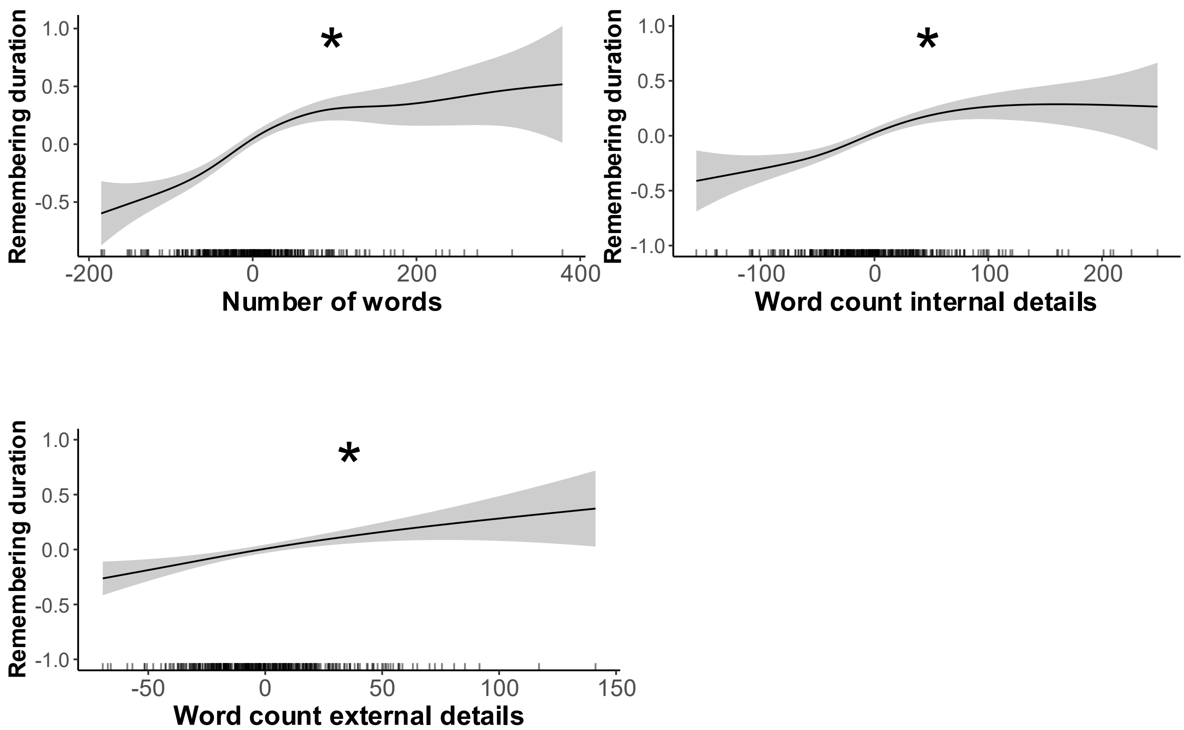
Note. The plots display the partial effect of each predictor on remembering duration, after taking into account the duration of the event. The rug plots on the *x*-axis indicate the density of recorded events as a function of event duration * Indicates a statistically significant relationship ($p < .05$).

We then used participants' verbal descriptions to derive objective estimates of the level of detail in memory representations: the length of the verbal report (total word count) and the amount of internal and external details contained in each memory (see Method). Trials with a word count exceeding three standard deviations from the mean (mean = 194 words, SD = 187) were excluded, resulting in the removal of four trials with more than 755 words. On average, memories contained 131 internal words (SD = 102) and 49 external words (SD = 41).

In a first model, total word count was used as a predictor, event duration as a covariate, and remembering duration as the dependent variable. Word count significantly predicted remembering duration (see Table 4 and Figure 6), while the effect of event duration was no longer statistically significant (EDF = 1.65, $F = 2.87$, $p = 0.055$). In a second model, the number of internal and external words were included as predictors, with event duration again entered as a covariate. The number of internal and external words were both significant predictors of remembering duration (see Table 4 and Figure 6), whereas the effect event duration was no longer significant (EDF = 1.55, $F = 2.12$, $p = 0.096$).

Figure 6

Relationship between objective memory characteristics and remembering duration



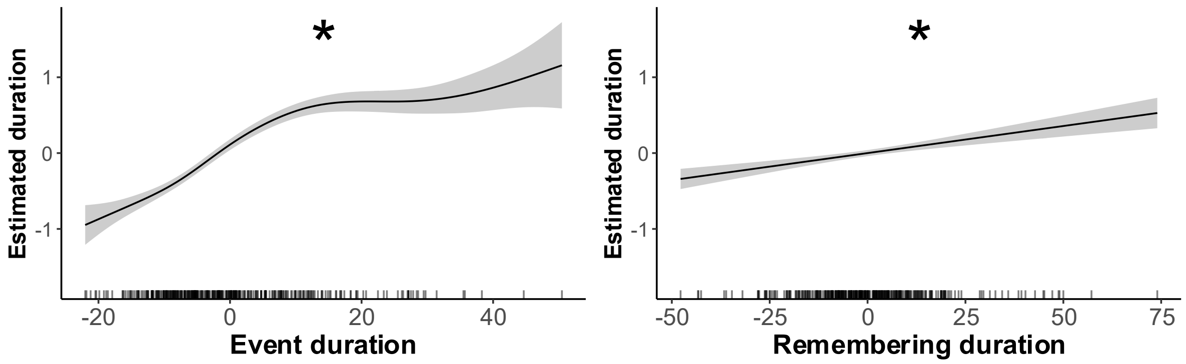
Note. The plots display the partial effect of each predictor on remembering duration, after taking into account the duration of the event. The rug plots on the *x*-axis indicate the density of recorded events as a function of event duration * Indicates a statistically significant relationship ($p < .05$).

Retrospective duration estimates

Finally, we analyzed participants' duration estimates for the recorded events. Specifically, we assessed whether remembering duration predicted duration estimates beyond the actual duration of the events. Because the distribution of estimated durations was right-skewed, a log transformation was applied. We then fitted a model with remembering duration as the predictor of interest, event duration as a covariate, and estimated duration (log-transformed) as the outcome variable. The results showed that both event duration (EDF = 4.67, $F = 85.01$, $p < .001$) and remembering duration (EDF = 1, $F = 26.01$, $p < .001$) significant predicted duration estimates (see Figure 7).

Figure 7

Retrospective duration estimates as a function of event duration and remembering duration



Note. The plots display the partial effect of each predictor on remembering duration. The rug plots on the *x*-axis indicate the density of recorded events as a function of event duration. * Indicates a statistically significant relationship ($p < .05$).

Discussion

The continuous flow of information that constitutes real-world experiences is compressed in memory representations, such that the time it takes to remember an event is typically shorter than the event's actual duration. Emerging research suggests that the rate of this temporal compression is not constant but varies across events. However, prior research has primarily examined brief, mundane events, leaving the influence of event characteristics on memory compression largely unexplored. In the present study, we addressed this gap by using wearable camera technology to investigate how specific features of everyday events shape memory representations of their temporal unfolding.

Before discussing the influence of specific event features, it is important to clarify what the remembering duration measure captures. In this study, we treated remembering duration—controlling for the actual length of the event—as an indicator of memory compression. An alternative interpretation is that it reflects memory accessibility, or the ease with which information is retrieved. However, our findings do not support this view. Remembering duration was predicted by both objective measures of memory detail (number of words, internal and external details) and subjective ratings of memory richness and sense of reliving, but not by ratings of retrieval difficulty. If remembering duration primarily reflected difficulty accessing information in memory, we would expect a positive relationship between subjective difficulty ratings and remembering duration. Instead, if anything, there was a non-significant trend in the opposite direction (see Figure 5). Taken together, these results suggest that remembering duration reflects how richly the temporal unfolding of an event is represented during mental replay, rather than retrieval effort per se.

One of the primary aims of the present study was to examine how the actual duration of an event influences the time it takes to recall it. Consistent with Jeunehomme and

D'Argembeau (2019), we found that remembering duration increased with the event's original length. Importantly, however, this relationship was non-linear: remembering duration increased steeply with event duration for events lasting up to approximately 10 min, after which it plateaued. This suggests a stabilization in the time needed to mentally replay longer events. In other words, events lasting more than 10 min tend to be increasingly compressed in memory—the discrepancy between their actual duration and the time taken to recall them grows as event length increases. This non-linear pattern may reflect the adaptive nature of memory compression mechanisms (Arnold et al., 2016): if remembering duration scaled linearly with event duration, recalling long episodes would become increasingly time—and resource—intensive, potentially reducing the efficiency of memory representations.

The observed plateau in remembering duration for longer events parallels the scale invariance reported in autobiographical memory retrieval (Maylor et al., 2001; Moreton & Ward, 2010). Maylor et al. (2001) found that the rate at which people retrieved autobiographical memories remained stable across time scales: whether recalling events from the previous day, week, or year, the number of memories produced per unit of time was similar. This invariance may reflect pragmatic constraints, with individuals adjusting the type and specificity of information retrieved depending on the temporal scope (e.g., breakfast is more likely to be recalled when considering yesterday than when reflecting on the past year). As the retrieval window widens, the nature of remembered content may shift—from specific to general, or from detailed to gist-like—to maintain efficiency.

A similar adaptative mechanism may operate during the recall of specific events, though our findings suggest that scale invariance emerges only for events longer than approximately 10 min. For shorter events, remembering duration increased substantially with actual event length, suggesting that the level of detail in memory representations scaled—though not necessarily linearly—with the duration of the original experience. In contrast, for longer events, recall time stabilized, consistent with a shift toward a scale-invariant retrieval mode. One possibility is that individuals dynamically adjust the granularity of mental replay—"zooming in" on shorter events and "zooming out" on longer ones—to keep recall duration manageable (see also D'Argembeau, 2020). Future studies could test this hypothesis by asking participants to recall the same event at different temporal granularities (e.g., a 15-min segment alone versus as part of a broader sequence) to determine whether the level of detail in recall flexibly adjusts to the duration of the target episode.

Beyond event duration, several other characteristics influenced recall duration, including the novelty or familiarity of the event. Consistent with previous research showing better autobiographical memory for novel or unusual experiences (Antony et al., 2023; Bainbridge & Baker, 2022; Brewer, 1988; Finley & Brewer, 2024; Thomsen et al., 2015), we found that—after controlling for event length—remembering duration increased linearly with event unusualness, suggesting that novel events are recalled in a less compressed, more detailed manner. This aligns with the classic "novelty effect" in episodic memory (Tulving & Kroll, 1995), where novel and unexpected stimuli are prioritized during encoding, partly via dopaminergic-hippocampal interactions (Frank & Kafkas, 2021; Kafkas & Montaldi, 2018; Quent et al., 2021). Consequently, the sampling rate of information might be higher for novel events, allowing their temporal unfolding to be replayed in greater detail.[3] This interpretation is consistent with a recent theoretical framework linking episodic memory compression to event novelty, which proposes that novel or surprising experiences are encoded in a relatively uncompressed format—preserving more episodic details—whereas familiar or expected

[3] It should be noted that familiarity can also enhance memory by facilitating encoding and reconstruction processes based on prior knowledge structures, such as schemas (Fernández & Morris, 2018; Gilboa & Marlatte, 2017; Van Kesteren et al., 2012). One might therefore have expected a U-shaped relationship between familiarity and memory compression, in which both highly novel and highly familiar events lead to longer remembering durations, albeit via distinct mechanisms (see De Chastelaine et al., 2017; Kafkas & Montaldi, 2014; Quent et al., 2021, for evidence that novelty and familiarity engage different mnemonic functions). However, in the present study, we did not observe a memory advantage for familiar events.

events are stored in a more compressed, schematic form (Nagy et al., 2025). This variable-rate encoding is thought to optimize the trade-off between conserving memory resources and retaining information useful for future learning.

In this study, we distinguished between the familiarity of different event components: people, objects, and the surrounding environment. Our findings suggest that spatial familiarity or novelty influences memory for the event's temporal unfolding more than familiarity with people or objects. Spatial context is a fundamental component of episodic memory (Bird & Burgess, 2008; Byrne et al., 2007; Hassabis & Maguire, 2007; Tulving, 2002), playing a key role in the neural representation of events and serving as a particularly effective retrieval cue (Robin et al., 2018). Exposure to spatial novelty has been shown to promote memory encoding (Horstmann & Herwig, 2016; Schomaker & Meeter, 2015) and to enhance memory consolidation (Cowan et al., 2021). The present findings align with this evidence, indicating that the temporal resolution of event representations increases when events occur in novel environments.

In addition to novelty, events marked by a high degree of change or unpredictability were associated with longer remembering durations. This finding is consistent with research demonstrating that contextual change and prediction error shape the temporal structure of memory (Clewett et al., 2019; Kurby & Zacks, 2018; Zacks, 2020). According to event segmentation theory, continuous experience is divided into meaningful units marked by event boundaries, often triggered by prediction errors (Zacks et al., 2007, 2011)—as reflected in our unpredictability ratings. Significant changes in location, actions, or people—regardless of predictability—can also signal boundaries (Clewett et al., 2019; Clewett & Davachi, 2017; Kurby & Zacks, 2008), as captured by our change ratings. Our findings suggest that both unpredictability and change enhance the temporal resolution of memories, possibly by promoting finer event segmentation during encoding.

Another factor that influenced remembering duration was rehearsal: the more an event was rehearsed, the richer and more detailed its unfolding was represented. The beneficial effect of rehearsal on memory is well established (Greene, 1987; Martin et al., 2022; Rubin et al., 2003; Thomsen et al., 2015). Repeated reactivation may strengthen the links between successive slices of experience that form the event's temporal structure, thereby enhancing memory for its unfolding. However, rehearsal can also promote memory updating through reconsolidation processes (Elsey et al., 2018), sometimes leading to distortions or the incorporation of inaccurate details (Chan & LaPaglia, 2013; St. Jacques & Schacter, 2013). As our study did not assess memory accuracy, we cannot exclude the possibility that recalled events included some false or altered elements.

Regarding the role of emotion, we found that the unfolding of events was represented in more detail for positive than neutral events. This finding aligns with previous studies showing better autobiographical memory for positive events (Bainbridge & Baker, 2022; D'Argembeau et al., 2003; Shi et al., 2024; Thompson et al., 1996). By contrast, we are unable to draw conclusions about the effects of negative emotion or emotional arousal, as very few of the recorded events were negative or highly arousing. A recent study using videos under controlled laboratory conditions showed that negative emotion reduces the temporal compression of events in episodic memory (Colson et al., 2025). Whether this effect extends to real-life events remains an open question for future research.

Social information is often well remembered—for example, images containing people are more memorable than those depicting natural scenes (Goetschalckx & Wagemans, 2019). Extending this line of research, we found that social content increased remembering duration, suggesting that the social nature of an event influences how its temporal unfolding is represented in memory. Notably, socially interactive events were associated with longer replay durations regardless of whether the individuals involved were familiar or unfamiliar.

While some previous research has reported better memory for events involving unfamiliar individuals (Bainbridge & Baker, 2022), our findings suggest that memory compression depends more on the degree of social engagement than on the familiarity of the people involved.

Surprisingly, we did not find an association between the perceived importance of an event, or its relevance to personal goals, and the richness of its memory representation. This result is not unprecedented; previous studies have also reported that importance does not always predict memorability (Brown, 2023; Shi et al., 2024; Thomsen et al., 2015). However, our findings should be interpreted in light of the relatively short delay (2–4 days) between encoding and retrieval. Given this limited interval, it is possible that the events had not yet been consolidated into long-term autobiographical memory (Conway, 2005; Cowan et al., 2024). As such, differences in event importance may only emerge over longer retention intervals, once events are more fully integrated into autobiographical knowledge (see Radvansky et al., 2022, for evidence of a shift in retention after approximately one week). Future research could test this possibility by extending the delay between encoding and retrieval.

What mechanisms underlie variations in memory compression across different types of events? Evidence suggests that events are not remembered as continuous streams, but as sequences of discrete experience units, interspersed with temporal discontinuities in which less informative segments are omitted (Jeunehomme & D'Argembeau, 2023). A recent study investigated the origin of these omissions by comparing recognition performance for recalled versus unrecalled moments, showing that both encoding and retrieval processes contribute to the discontinuities observed during event recall (Durocher et al., 2025). In light of this, the variations in temporal compression observed in the present study may reflect differences in how events are encoded, retrieved, or both.

One possibility is that events characterized by novelty, unpredictability, high levels of change, positive emotion, or social engagement are prioritized during encoding because they attract greater attentional resources. Attention fluctuates dynamically during naturalistic experiences (Hard et al., 2011; Kosie & Baldwin, 2019) and plays a key role in forming the units of experience that constitute episodic memories (Leroy et al., 2025). Enhanced attention during such events may increase the sampling rate of encoded information, leading to richer and less compressed memory representations of their unfolding.

Another, not mutually exclusive, possibility is that event characteristics modulate retrieval processes. Some portions of events may have been encoded but not accessed during recall (Tulving & Pearlstone, 1966), resulting in shorter remembering durations and greater temporal compression. Supporting this idea, a recent study showed that people often engage in a skipping process during event recall—mentally jumping from one event boundary to the next rather than reconstructing the experience in full detail (Michelmann et al., 2023). Event characteristics may influence the extent to which an event is bypassed versus mentally replayed in detail, thereby shaping the richness of temporal memory representations. Future research should identify which specific features drive this process and elucidate the mechanisms through which they influence retrieval.

The final contribution of our study was to examine the extent to which retrospective duration judgments are related to memory compression. While the importance of studying duration judgments in everyday life has been emphasized (Wearden et al., 2014), most prior research has relied on laboratory stimuli (e.g., words, sounds) and focused on short durations (Block et al., 2010). To our knowledge, no previous study has directly examined whether the perceived duration of real-life events is linked to their degree of temporal compression in memory (but see Jeunehomme & D’Argembeau, 2019). Our results show that, beyond an event’s actual duration, the richness of its unfolding in memory modulates retrospective timing: events are judged to have lasted longer when they are more extensively recalled. This result aligns with memory-based models of time perception, which propose that retrospective duration judgments are driven by the amount and complexity of retrieved content (Block & Reed, 1978; Ornstein, 1969; Poynter, 1983; Roseboom et al., 2019). In particular, our results support the contextual-change hypothesis (Block & Reed, 1978), which posits that the subjective duration of past events depends on the amount of contextual change (e.g., in environment, internal state, or activity) stored in memory.

A potential limitation of the present study is that participants were actively involved in the event recording procedure, which may have influenced encoding by introducing factors such as the intentional organization or selection of events (Nicolás et al., 2021). Although participants were unaware of the subsequent memory task, they may have paid greater attention to the events they chose to record. However, because recording conditions were consistent across all events, any attentional or selection bias would likely have affected all events similarly. Therefore, relative comparisons between events remain valid and informative, despite this potential influence of the recording procedure.

In conclusion, the present study demonstrates that the temporal compression of real-life events in memory is shaped by both event duration and specific event characteristics. Remembering duration increased steeply with event length for events lasting up to ~10 min, then plateaued—suggesting that compression becomes more pronounced beyond this threshold. For longer events, retrieval may follow a scale-invariant pattern in recall rates, similar to what has been observed for extended autobiographical periods. Beyond event duration, characteristics such as novelty, unpredictability, positive emotion, social engagement, and degree of change significantly influenced how richly events were represented. Events high in these characteristics were associated with less temporal compression, indicating more detailed recall of their unfolding. Together, these findings offer new insights into how the temporal course of real-life experiences is represented in episodic memory. An important avenue for future research will be to investigate how these effects evolve over longer retention intervals, as events become more fully integrated into autobiographical memory.

Statements

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CRediT authorship contribution statement

Charline Colson: Methodology, Resources, Data curation, Formal analysis, Visualization, Writing - original draft.

Arnaud D'Argembeau: Conceptualization, Methodology, Funding acquisition, Supervision, Writing - original draft, Writing - review & editing.

Availability of data and materials

Data, analysis script and materials are available in the following OSF repository: https://osf.io/gc7yh/.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) and DeepL Translate to assist in improving the language and readability of certain passages. All content was subsequently reviewed and edited by the authors, who take full responsibility for the final version of the manuscript.

Disclosure of interest

The authors report there are no competing interests to declare.

References

Antony, J. W., Van Dam, J., Massey, J. R., Barnett, A. J., & Bennion, K. A. (2023). Long-term, multi-event surprise correlates with enhanced autobiographical memory. *Nature Human Behaviour*, *7*(12), 2152–2168. https://doi.org/10.1038/s41562-023-01631-8

Anwyl-Irvine, A. L., Massonnié, J., Flitton, A., Kirkham, N., & Evershed, J. K. (2020). Gorilla in our midst: An online behavioral experiment builder. *Behavior Research Methods*, *52*(1), 388–407. https://doi.org/10.3758/s13428-019-01237-x

Arnold, A. E. G. F., Iaria, G., & Ekstrom, A. D. (2016). Mental simulation of routes during navigation involves adaptive temporal compression. *Cognition*, *157*, 14–23. https://doi.org/10.1016/j.cognition.2016.08.009

Bainbridge, W. A., & Baker, C. I. (2022). Multidimensional memory topography in the medial parietal cortex identified from neuroimaging of thousands of daily memory videos. *Nature Communications*, *13*(1), 6508. https://doi.org/10.1038/s41467-022-34075-1

Balcı, F., Ünübol, H., Grondin, S., Sayar, G. H., Van Wassenhove, V., & Wittmann, M. (2023). Dynamics of retrospective timing: A big data approach. *Psychonomic Bulletin & Review*, *30*(5), 1840–1847. https://doi.org/10.3758/s13423-023-02277-3

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255–278. https://doi.org/10.1016/j.jml.2012.11.001

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, *67*, 1–48. https://doi.org/10.18637/jss.v067.i01

Bein, O., Plotkin, N. A., & Davachi, L. (2021). Mnemonic prediction errors promote detailed memories. *Learning & Memory*, *28*(11), 422–434. https://doi.org/10.1101/lm.053410.121

Bird, C. M., & Burgess, N. (2008). The hippocampus and memory: Insights from spatial processing. *Nature Reviews Neuroscience*, *9*(3), 182–194. https://doi.org/10.1038/nrn2335

Block, R. A., Hancock, P. A., & Zakay, D. (2010). How cognitive load affects duration judgments: A meta-analytic review. *Acta Psychologica*, *134*(3), 330–343. https://doi.org/10.1016/j.actpsy.2010.03.006

Block, R. A., & Reed, M. A. (1978). Remembered Duration: Evidence for a Contextual-Change Hypothesis. *Journal of Experimental Psychology: Human Learning and Memory*, *4*(6), 656–665.

Bonasia, K., Blommesteyn, J., & Moscovitch, M. (2016). Memory and navigation: Compression of space varies with route length and turns. *Hippocampus*, *26*(1), 9–12. https://doi.org/10.1002/hipo.22539

Brewer, W. F. (1988). Memory for randomly sampled autobiographical events. In U. Neisser & E. Winograd (Eds.), *Remembering reconsidered: Ecological and traditional approaches to the study of memory* (pp. 21–90). Cambridge University Press. https://doi.org/10.1017/CBO9780511664014.004

Brown, N. R. (2023). Autobiographical memory and the self: A transition theory perspective. *WIREs Cognitive Science*, *14*(3), e1621. https://doi.org/10.1002/wcs.1621

Byrne, P., Becker, S., & Burgess, N. (2007). Remembering the past and imagining the future: A neural model of spatial memory and imagery. *Psychological Review*, *114*(2), 340–375. https://doi.org/10.1037/0033-295X.114.2.340

Chan, J. C. K., & LaPaglia, J. A. (2013). Impairing existing declarative memory in humans by disrupting reconsolidation. *Proceedings of the National Academy of Sciences*, *110*(23), 9309–9313. https://doi.org/10.1073/pnas.1218472110

Chow, T. E., & Rissman, J. (2017). Neurocognitive mechanisms of real-world autobiographical memory retrieval: Insights from studies using wearable camera technology. *Annals of the New York Academy of Sciences*, *1396*(1), 202–221. https://doi.org/10.1111/nyas.13353

Clewett, D., & Davachi, L. (2017). The ebb and flow of experience determines the temporal structure of memory. *Current Opinion in Behavioral Sciences*, *17*, 186–193. https://doi.org/10.1016/j.cobeha.2017.08.013

Clewett, D., DuBrow, S., & Davachi, L. (2019). Transcending time in the brain: How event memories are constructed from experience. *Hippocampus*, *29*(3), 162–183. https://doi.org/10.1002/hipo.23074

Colson, C., Panneels, G., & D'Argembeau, A. (2025). Negative emotion reduces the temporal compression of events in episodic memory. *Cognition and Emotion*, 1–16. https://doi.org/10.1080/02699931.2025.2501047

Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language*, *53*(4), 594–628. https://doi.org/10.1016/j.jml.2005.08.005

Cowan, E. T., Chanales, A. J., Davachi, L., & Clewett, D. (2024). Goal Shifts Structure Memories and Prioritize Event-defining Information in Memory. *Journal of Cognitive Neuroscience*, *36*(11), 2415–2431. https://doi.org/10.1162/jocn_a_02220

Cowan, E. T., Schapiro, A. C., Dunsmoor, J. E., & Murty, V. P. (2021). Memory consolidation as an adaptive process. *Psychonomic Bulletin & Review*, *28*(6), 1796–1810. https://doi.org/10.3758/s13423-021-01978-x

D'Argembeau, A. (2020). Zooming In and Out on One's Life: Autobiographical Representations at Multiple Time Scales. *Journal of Cognitive Neuroscience*, *32*(11), 2037–2055. https://doi.org/10.1162/jocn_a_01556

D'Argembeau, A., Comblain, C., & Van Der Linden, M. (2003). Phenomenal characteristics of autobiographical memories for positive, negative, and neutral events. *Applied Cognitive Psychology*, *17*(3), 281–294. https://doi.org/10.1002/acp.856

D'Argembeau, A., Jeunehomme, O., & Stawarczyk, D. (2022). Slices of the past: How events are temporally compressed in episodic memory. *Memory*, *30*(1), 43–48. https://doi.org/10.1080/09658211.2021.1896737

De Chastelaine, M., Mattson, J. T., Wang, T. H., Donley, B. E., & Rugg, M. D. (2017). Independent contributions of fMRI familiarity and novelty effects to recognition memory and their stability across the adult lifespan. *NeuroImage*, *156*, 340–351. https://doi.org/10.1016/j.neuroimage.2017.05.039

Durocher, B., Leroy, N., & D'Argembeau, A. (2025). *Understanding the origin of omitted moments in memories of real-world events*. OSF. https://doi.org/10.31234/osf.io/gs7cj_v3

Elsey, J. W. B., Van Ast, V. A., & Kindt, M. (2018). Human memory reconsolidation: A guiding framework and critical review of the evidence. *Psychological Bulletin*, *144*(8), 797–848. https://doi.org/10.1037/bul0000152

Faber, M., & Gennari, S. P. (2015). In search of lost time: Reconstructing the unfolding of events from memory. *Cognition*, *143*, 193–202. https://doi.org/10.1016/j.cognition.2015.06.014

Fernández, G., & Morris, R. G. M. (2018). Memory, Novelty and Prior Knowledge. *Trends in Neurosciences*, *41*(10), 654–659. https://doi.org/10.1016/j.tins.2018.08.006

Finley, J. R., & Brewer, W. F. (2024). Accuracy and completeness of autobiographical memory: Evidence from a wearable camera study. *Memory*, *32*(8), 1–31. https://doi.org/10.1080/09658211.2024.2377193

Folville, A., Jeunehomme, O., Bastin, C., & D'Argembeau, A. (2020). The impact of age on the temporal compression of daily life events in episodic memory. *Psychology and Aging*, *35*(4), 484–496. https://doi.org/10.1037/pag0000456

Frank, D., & Kafkas, A. (2021). Expectation-driven novelty effects in episodic memory. *Neurobiology of Learning and Memory*, *183*, 107466. https://doi.org/10.1016/j.nlm.2021.107466

Fu, M.-H., Yen, A.-Z., Huang, H.-H., & Chen, H.-H. (2020). Incorporating Semantic Knowledge for Visual Lifelog Activity Recognition. *Proceedings of the 2020 International Conference on Multimedia Retrieval*, 450–456. https://doi.org/10.1145/3372278.3390700

Gilboa, A., & Marlatte, H. (2017). Neurobiology of Schemas and Schema-Mediated Memory. *Trends in Cognitive Sciences*, *21*(8), 618–631. https://doi.org/10.1016/j.tics.2017.04.013

Goetschalckx, L., & Wagemans, J. (2019). MemCat: A new category-based image set quantified on memorability. *PeerJ*, *7*, e8169. https://doi.org/10.7717/peerj.8169

Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution*, *7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

Greene, R. L. (1987). Effects of Maintenance Rehearsal on Human Memory. *Psychological Bulletin*, *102*(3), 403–413.

Hard, B. M., Recchia, G., & Tversky, B. (2011). The shape of action. *Journal of Experimental Psychology: General*, *140*(4), 586–604. https://doi.org/10.1037/a0024310

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, *11*(7), 299–306. https://doi.org/10.1016/j.tics.2007.05.001

Hoffman, L. (2019). On the Interpretation of Parameters in Multivariate Multilevel Models Across Different Combinations of Model Specification and Estimation. *Advances in Methods and Practices in Psychological Science*, *2*(3), 288–311. https://doi.org/10.1177/2515245919842770

Horstmann, G., & Herwig, A. (2016). Novelty biases attention and gaze in a surprise trial. *Attention, Perception, & Psychophysics*, *78*(1), 69–77. https://doi.org/10.3758/s13414-015-0995-1

Jeunehomme, O., & D'Argembeau, A. (2019). The time to remember: Temporal compression and duration judgements in memory for real-life events. *Quarterly Journal of Experimental Psychology*, *72*(4), 930–942. https://doi.org/10.1177/1747021818773082

Jeunehomme, O., & D'Argembeau, A. (2020). Event segmentation and the temporal compression of experience in episodic memory. *Psychological Research*, *84*(2), 481–490. https://doi.org/10.1007/s00426-018-1047-y

Jeunehomme, O., & D'Argembeau, A. (2023). Memory editing: The role of temporal discontinuities in the compression of events in episodic memory editing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *49*(5), 766–775. https://doi.org/10.1037/xlm0001141

Kafkas, A., & Montaldi, D. (2014). Two separate, but interacting, neural systems for familiarity and novelty detection: A dual-route mechanism. *Hippocampus*, *24*(5), 516–527. https://doi.org/10.1002/hipo.22241

Kafkas, A., & Montaldi, D. (2018). How do memory systems detect and respond to novelty? *Neuroscience Letters*, *680*, 60–68. https://doi.org/10.1016/j.neulet.2018.01.053

Kelly, P., Marshall, S. J., Badland, H., Kerr, J., Oliver, M., Doherty, A. R., & Foster, C. (2013). An ethical framework for automated, wearable cameras in health behavior research. *American Journal of Preventive Medicine*, *44*(3), 314–319. https://doi.org/10.1016/j.amepre.2012.11.006

Kosie, J. E., & Baldwin, D. (2019). Attention rapidly reorganizes to naturally occurring structure in a novel activity sequence. *Cognition*, *182*, 31–44. https://doi.org/10.1016/j.cognition.2018.09.004

Kurby, C. A., & Zacks, J. M. (2008). Segmentation in the perception and memory of events. *Trends in Cognitive Sciences*, *12*(2), 72–79. https://doi.org/10.1016/j.tics.2007.11.004

Kurby, C. A., & Zacks, J. M. (2018). Preserved Neural Event Segmentation in Healthy Older Adults. *Psychology and Aging*, *33*(2), 232–245. https://doi.org/10.1037/pag0000226

Leroy, N., Majerus, S., & D'Argembeau, A. (2024). Working memory capacity for continuous events: The root of temporal compression in episodic memory? *Cognition*, *247*, 105789. https://doi.org/10.1016/j.cognition.2024.105789

Leroy, N., Majerus, S., & D'Argembeau, A. (2025). *The role of working memory in encoding the temporal structure of events in episodic memory: Evidence from a dual-task paradigm*. OSF. https://doi.org/10.31234/osf.io/gafjp

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging*, *17*(4), 677–689. https://doi.org/10.1037/0882-7974.17.4.677

Loock, K., Kalbe, F., & Schwabe, L. (2025). Cognitive mechanisms of aversive prediction error-induced memory enhancements. *Journal of Experimental Psychology: General*, *154*(4), 1102–1121. https://doi.org/10.1037/xge0001712

Martin, C. B., Hong, B., Newsome, R. N., Savel, K., Meade, M. E., Xia, A., Honey, C. J., & Barense, M. D. (2022). A smartphone intervention that enhances real-world memory and promotes differentiation of hippocampal activity in older adults. *Proceedings of* *the National Academy of Sciences*, *119*(51), e2214285119. https://doi.org/10.1073/pnas.2214285119

Maylor, E. A., Chater, N., & Brown, G. D. A. (2001). Scale invariance in the retrieval of retrospective and prospective memories. *Psychonomic Bulletin & Review*, *8*(1), 162–167. https://doi.org/10.3758/BF03196153

Michelmann, S., Hasson, U., & Norman, K. A. (2023). Evidence That Event Boundaries Are Access Points for Memory Retrieval. *Psychological Science*, *34*(3), 326–344. https://doi.org/10.1177/09567976221128206

Morales-Calva, F., & Leal, S. L. (2025). Tell me why: The missing w in episodic memory's what, where, and when. *Cognitive, Affective, & Behavioral Neuroscience*, *25*(1), 6–24. https://doi.org/10.3758/s13415-024-01234-4

Moreton, B. J., & Ward, G. (2010). Time scale similarity and long-term memory for autobiographical events. *Psychonomic Bulletin & Review*, *17*(4), 510–515. https://doi.org/10.3758/PBR.17.4.510

Nagy, D. G., Orbán, G., & Wu, C. M. (2025). Adaptive compression as a unifying framework for episodic and semantic memory. *Nature Reviews Psychology*. https://doi.org/10.1038/s44159-025-00458-6

Nicolás, B., Wu, X., García-Arch, J., Dimiccoli, M., Sierpowska, J., Saiz-Masvidal, C., Soriano-Mas, C., Radeva, P., & Fuentemilla, L. (2021). Behavioural and neurophysiological signatures in the retrieval of individual memories of recent and remote real-life routine episodic events. *Cortex*, *141*, 128–143. https://doi.org/10.1016/j.cortex.2021.04.006

Nielson, D. M., Smith, T. A., Sreekumar, V., Dennis, S., & Sederberg, P. B. (2015). Human hippocampus represents space and time during retrieval of real-world memories.

Proceedings of the National Academy of Sciences, *112*(35), 11078–11083. https://doi.org/10.1073/pnas.1507104112

Ornstein, R. E. (1969). *On the experience of time* (p. 126). Penguin.

Pedersen, E. J., Miller, D. L., Simpson, G. L., & Ross, N. (2019). Hierarchical generalized additive models in ecology: An introduction with mgcv. *PeerJ*, *7*, e6876. https://doi.org/10.7717/peerj.6876

Pooja, R., Ghosh, P., & Sreekumar, V. (2024). Towards an ecologically valid naturalistic cognitive neuroscience of memory and event cognition. *Neuropsychologia*, *203*, 108970. https://doi.org/10.1016/j.neuropsychologia.2024.108970

Poynter, W. D. (1983). Duration judgment and the segmentation of experience. *Memory & Cognition*, *11*(1), 77–82. https://doi.org/10.3758/BF03197664

Quent, J. A., Henson, R. N., & Greve, A. (2021). A predictive account of how novelty influences declarative memory. *Neurobiology of Learning and Memory*, *179*, 107382. https://doi.org/10.1016/j.nlm.2021.107382

Radvansky, G. A., Doolen, A. C., Pettijohn, K. A., & Ritchey, M. (2022). A new look at memory retention and forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *48*(11), 1698–1723. https://doi.org/10.1037/xlm0001110

Rauthmann, J. F., Gallardo-Pujol, D., Guillaume, E. M., Todd, E., Nave, C. S., Sherman, R. A., Ziegler, M., Jones, A. B., & Funder, D. C. (2014). The Situational Eight DIAMONDS: A taxonomy of major dimensions of situation characteristics. *Journal of Personality and Social Psychology*, *107*(4), 677–718. https://doi.org/10.1037/a0037250

Rauthmann, J. F., & Sherman, R. A. (2016). Ultra-Brief Measures for the Situational Eight DIAMONDS Domains. *European Journal of Psychological Assessment*, *32*(2), 165–174. https://doi.org/10.1027/1015-5759/a000245

Rissman, J., Chow, T. E., Reggente, N., & Wagner, A. D. (2016). Decoding fMRI Signatures of Real-world Autobiographical Memory Retrieval. *Journal of Cognitive Neuroscience*, *28*(4), 604–620. https://doi.org/10.1162/jocn_a_00920

Robin, J., Buchsbaum, B. R., & Moscovitch, M. (2018). The Primacy of Spatial Context in the Neural Representation of Events. *The Journal of Neuroscience*, *38*(11), 2755–2765. https://doi.org/10.1523/JNEUROSCI.1638-17.2018

Roseboom, W., Fountas, Z., Nikiforou, K., Bhowmik, D., Shanahan, M., & Seth, A. K. (2019). Activity in perceptual classification networks as a basis for human subjective time perception. *Nature Communications*, *10*(1), 267. https://doi.org/10.1038/s41467-018-08194-7

Rubin, D. C., Schrauf, R. W., & Greenberg, D. L. (2003). Belief and recollection of autobiographical memories. *Memory & Cognition*, *31*(6), 887–901. https://doi.org/10.3758/BF03196443

Schomaker, J., & Meeter, M. (2015). Short- and long-lasting consequences of novelty, deviance and surprise on brain and cognition. *Neuroscience & Biobehavioral Reviews*, *55*, 268–279. https://doi.org/10.1016/j.neubiorev.2015.05.002

Shi, L., Brown, N. R., & Reimer, P. J. C. (2024). Exploring the metamnemonic and phenomenal differences between transitional and mundane events. *Memory & Cognition*, *52*(5). https://doi.org/10.3758/s13421-024-01534-7

Simpson, G. L. (2024). Gratia: An R package for exploring generalized additive models. *Journal of Open Source Software*, *9*(104), 6962. https://doi.org/10.21105/joss.06962

Sreekumar, V., Nielson, D. M., Smith, T. A., Dennis, S. J., & Sederberg, P. B. (2018). The experience of vivid autobiographical reminiscence is supported by subjective content representations in the precuneus. *Scientific Reports*, *8*(1), 14899. https://doi.org/10.1038/s41598-018-32879-0

St. Jacques, P. L., & Schacter, D. L. (2013). Modifying Memory: Selectively Enhancing and Updating Personal Memories for a Museum Tour by Reactivating Them. *Psychological Science*, *24*(4), 537–543. https://doi.org/10.1177/0956797612457377

Thompson, C. P., Skowronski, J. J., Larsen, S. F., & Betz, A. (1996). *Autobiographical memory: Remembering what and remembering when* (pp. xiv, 238). Lawrence Erlbaum Associates, Inc.

Thomsen, D. K., Jensen, T., Holm, T., Olesen, M. H., Schnieber, A., & Tønnesvang, J. (2015). A 3.5year diary study: Remembering and life story importance are predicted by different event characteristics. *Consciousness and Cognition*, *36*, 180–195. https://doi.org/10.1016/j.concog.2015.06.011

Tobin, S., Bisson, N., & Grondin, S. (2010). An Ecological Approach to Prospective and Retrospective Timing of Long Durations: A Study Involving Gamers. *PLoS ONE*, *5*(2), e9271. https://doi.org/10.1371/journal.pone.0009271

Tulving, E. (2002). Episodic Memory: From Mind to Brain. *Annual Review of Psychology*, *53*(1), 1–25. https://doi.org/10.1146/annurev.psych.53.100901.135114

Tulving, E., & Kroll, N. (1995). Novelty assessment in the brain and long-term memory encoding. *Psychonomic Bulletin & Review*, *2*(3), 387–390. https://doi.org/10.3758/BF03210977

Tulving, E., & Pearlstone, Z. (1966). Availability versus accessibility of information in memory for words. *Journal of Verbal Learning and Verbal Behavior*, *5*(4), 381–391. https://doi.org/10.1016/S0022-5371(66)80048-8

Van Genugten, R. D. I., & Schacter, D. L. (2024). Automated scoring of the autobiographical interview with natural language processing. *Behavior Research Methods*, *56*(3), 2243–2259. https://doi.org/10.3758/s13428-023-02145-x

Van Kesteren, M. T. R., Ruiter, D. J., Fernández, G., & Henson, R. N. (2012). How schema and novelty augment memory formation. *Trends in Neurosciences*, *35*(4), 211–219. https://doi.org/10.1016/j.tins.2012.02.001

Wearden, J., O'Donoghue, A., Ogden, R., & Montgomery, C. (2014). Subjective Duration in the Laboratory and the World Outside. In V. Arstila & D. Lloyd (Eds.), *Subjective time: The Philosophy, Psychology, and Neuroscience of Temporality* (pp. 287–306). The MIT Press. https://doi.org/10.7551/mitpress/8516.003.0022

Wood, S. (2023). *mgcv: Mixed GAM Computation Vehicle with Automatic Smoothness Estimation* (Version 1.9-1) [Computer software]. https://cran.r-project.org/web/packages/mgcv/index.html

Yarmey, A. D. (2000). Retrospective duration estimations for variant and invariant events in field situations. *Applied Cognitive Psychology*, *14*(1), 45–57. https://doi.org/10.1002/(SICI)1099-0720(200001)14:1<45::AID-ACP623>3.0.CO;2-U

Zacks, J. M. (2020). Event Perception and Memory. *Annual Review of Psychology*, *71*, 165–191. https://doi.org/10.1146/annurev-psych-010419-051101

Zacks, J. M., Kurby, C. A., Eisenberg, M. L., & Haroutunian, N. (2011). Prediction Error Associated with the Perceptual Segmentation of Naturalistic Events. *Journal of Cognitive Neuroscience*, *23*(12), 4057–4066. https://doi.org/10.1162/jocn_a_00078

Zacks, J. M., Speer, N. K., Swallow, K. M., Braver, T. S., & Reynolds, J. R. (2007). Event perception: A mind-brain perspective. *Psychological Bulletin*, *133*(2), 273–293. https://doi.org/10.1037/0033-2909.133.2.273