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The stability of visual perspective and vividness during mental time travel

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ABSTRACT

When remembering or imagining, people can experience an event from their own eyes, or as an outside observer, with differing levels of vividness. The perspective from, and vividness with, which a person remembers or imagines has been related to numerous individual difference characteristics. These findings require that phenomenology during mental time travel be trait-like—that people consistently experience similar perspectives and levels of vividness. This assumption remains untested. Across two studies (combined $N = 295$), we examined the stability of visual perspective and vividness across multiple trials and timepoints. Perspective and vividness showed weak within-session stability when reported across just a few trials but showed strong within-session stability when sufficient trials were collected. Importantly, both visual perspective and vividness demonstrated good-to-excellent across-session stability across different delay intervals (two days to six weeks). Overall, our results suggest that people dependably experience similar visual phenomenology across occurrences of mental time travel.

1. Introduction

Humans regularly project themselves backwards in time to re-experience (remember) events, as well as forwards in time to pre-experience (imagine) events—a capacity known as “mental time travel” (Suddendorf & Corballis, 1997, 2007; Wheeler et al., 1997). When reliving (or pre-living) these events, people typically experience related visual images. For example, when a person recollects a baseball game that they attended, they might vividly visualize themselves sitting in rust-laden metal bleachers looking out over the vibrantly green, check-patterned field as the ceremonial first pitch is being thrown out by a local celebrity. These visual images are thought to be a crucial component of mental time travel (Brewer, 1986, 1996; Greenberg & Rubin, 2003; Rubin, 2005).

Two widely studied and essential aspects of visual imagery during mental time travel are the *vividness* of the constructed mental image and the *visual perspective* adopted by the mental time traveler within that image. *Visual perspective* refers to the “point of view” or “vantage point” adopted by the mental time traveler within their recollected or imagined episode (Eich, Handy, Holmes, Lerner, & McIsaac, 2013; Nigro & Neisser, 1983; Rice, 2010; Robinson & Swanson, 1993). In the above example, the person might visualize the ballpark from their own eyes, as if they were actually experiencing the event—referred to as the first-person (or field) perspective. Conversely, the person might instead visualize the baseball game from an external vantage point, viewing their remembered or imagined self as an actor in the scene—referred to as the third-person (or observer) perspective. *Vividness* refers to the perceptual clarity and intensity of the memory or future thought (Sutin & Robins, 2007). Some episodes are experienced vividly, with great

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amounts of perceptual detail, like in the above example—wherein the mental time traveler constructs a clear, intense picture of the scene, recollecting the rust on the bleachers, the color and pattern of the field, and the identity of the pitcher. Less vividly experienced episodes are perceptually vague or dim, lacking in clarity and intensity.

Visual perspective and vividness during mental time travel are strongly associated with one other, as well as with other aspects of phenomenological experience. For example, memories and future thoughts viewed from the first-person perspective are typically more vivid than their third-person counterparts (e.g., McIsaac & Eich, 2002; Sutin & Robins, 2010), although some studies using separate scales for each vantage point suggest that first-person and third-person perspectives differentially relate to vividness (e.g., Rice & Rubin, 2009). Remembered events tend to be more vivid than are imagined events (e.g., Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004; Johnson, Foley, Suengas, & Raye, 1988), and memories are typically experienced more often from the first-person perspective (e.g., McDermott et al., 2016; Nigro & Neisser, 1983), although some studies have cast doubt on the robustness of this pattern (e.g., Finnbogadóttir & Berntsen, 2014). Moreover, both vividness and visual perspective have been uniquely associated with aspects of emotional and traumatic memories. In particular, first-person memories tend to contain more emotional content than do third-person memories (Berntsen & Rubin, 2006; D'Argembeau et al., 2003; Sutin & Robins 2010), and memories with greater emotional content tend to be more vivid (e.g., Reisberg et al., 1988; Rubin & Kozin, 1984; Talarico et al., 2004). Traumatic memories, conversely, are more often experienced from the third-person perspective, relative to non-traumatic memories (Kenny & Bryant, 2007; McIsaac & Eich, 2004; Porter & Birt, 2001), despite also typically being recalled with greater vividness (Berntsen, 2001).

Visual perspective and vividness have also been related to a myriad of personal characteristics. For instance, the visual perspective one adopts during mental time travel is associated with self-reported narcissism (Marchlewska & Cichocka, 2017; Robins & John, 1997), self-consciousness (Robinson & Swanson, 1993), and trait anxiety (Finnbogadóttir & Berntsen, 2014). A greater tendency to remember and imagine from a third person perspective has been reported in various neuropsychiatric conditions, including Alzheimer's Disease (El Haj et al., 2019), autism spectrum disorder (Lind & Bowler, 2010), vulnerability to depression (e.g., Hallford, 2019; Kuyken & Moulds, 2009; Lemogne et al., 2006; though see McFadden & Siedlecki, 2020), post-traumatic stress disorder (St. Jacques, Kragel, & Rubin, 2013), obsessive–compulsive symptomology (Grisham et al., 2019; Terry & Barwick, 1995), and schizophrenia (Chen et al., 2020; Potheegadoo et al., 2013). As with visual perspective, the vividness of one's remembered or imagined events has been associated with a number of personal characteristics, including dispositional optimism (Beaty et al., 2019; Blackwell et al., 2013), time perspective (Arnold et al., 2011), agreeableness in social interactions (Quoidbach et al., 2008), the tendency to suppress emotional expressions (D'Argembeau & Van der Linden, 2006), and the tendency to perseverate on negative past experiences (Beaty et al., 2019).

Despite a burgeoning literature on personal characteristics related to visual perspective and vividness, little attention has been paid to whether these phenomenological aspects of mental time travel are stable across time. Research on the relationship between visual perspective, vividness, and individual difference measures (implicitly) assumes that people have tendencies to experience similar levels of vividness or adopt similar visual perspectives across instances of mental time travel—but empirical evidence for this assumption is presently lacking.

This critical lack of empirical investigation into the stability of visual perspective was highlighted over a decade ago by Sutin (2009), who noted that "…there are basic questions about the nature of visual perspective … which remain unanswered. For example, to what extent is visual perspective trait-like versus state-like? Is it a general retrieval style or is it memory specific? Is it stable over time?" (p. 832). Surprisingly little empirical work has addressed the questions posed by Sutin.

Visual perspective ratings appear to be reliable for individual memories (i.e., memories elicited by the same cues) within a single experimental session (e.g., Boyacioglu & Akfirat, 2015; Sutin & Robins, 2007, 2010). There is mixed evidence, however, regarding whether the visual perspective adopted for a single memory (i.e., elicited by the same cue) is reliable when that memory is retrieved across multiple experimental sessions (e.g., Butler et al., 2016; Luchetti et al., 2016; Mooren et al., 2016; Talarico & Rubin, 2003; 2007), although inconsistencies in methodology may underlie these conflicting results (Butler et al., 2016). Moreover, within a single experimental session, visual perspective ratings for different memories and future projections (i.e., elicited by unique cues) have been shown to be reliable (e.g., Siedlecki, 2015; Verhaeghen et al., 2018). For instance, Siedlecki (2015) provided participants with nine different cue words (three positive, three negative, three neutral), in response to which participants retrieved nine different memories, all within the same session. Siedlecki then assessed consistency across memories within that single session, finding that visual perspective ratings were moderately reliable and the most reliable of the measured phenomenological characteristics. Verhaeghen et al. (2018) asked participants to retrieve three memories and imagine three future events, prompted using distinct cues, all within the same session. Like Siedlecki (2015), Verhaeghen found that visual perspective ratings demonstrated acceptable reliability.

Nevertheless, the conclusions drawn from these studies are limited regarding the stability of visual perspective. First, assessing consistency using different cues within a single experimental session arguably does not provide information about long-term stability of individual tendencies to experience mental time travel. Ratings provided within a single session may instead reflect state-like factors, and state-like versus trait-like components cannot be disentangled. Second, the use of the same event cue—even across multiple experimental sessions—risks conflating the stability of an individual's memory for (or imagination of) that single event with the stability of an individual's general mental time travel tendencies. In other words, assessing the stability of a single memory (or future thought) is unlikely to provide information about whether the phenomenology of mental time travel is trait-like in nature. The visual perspective or vividness of a single memory or future thought may be idiosyncratic to that particular episode or event domain. Determining the stability of individual tendencies requires the collection of phenomenological ratings across numerous distinct episodes, necessitating the use of distinct event cues.

Notably, Luchetti et al. (2016) assessed whether individuals demonstrated stability in their reported visual perspective for different memories within certain event domains (life-changing events and early childhood events). In particular, the authors asked participants to retrieve a single memory within each event domain at two different timepoints across a four-week interval, and found little-to-no evidence for across-session stability in the reported visual perspective ratings. It is unclear, however, whether the retrieval of a single memory (at two time points) within a specific event domain is representative of an individual's mental time travel tendency. This limitation may have hindered the study's ability to detect stability in participants' visual perspective ratings—participants may not have retrieved enough memories to generate reliable estimates of their visual perspective tendencies, suppressing the resulting stability estimate. Altogether, trait-like behavior of mental time travel cannot readily be inferred from observations within a single session, within a single event domain, or across a small number of memories or future thoughts. Instead, an assessment of stability should involve the elicitation of (1) multiple memories and future thoughts (2) from different event domains (3) across several timepoints.

As with extant research on visual perspective, few studies have addressed whether vividness is a stable component of mental time travel, outside of extreme cases involving exceptional ability (highly superior autobiographical memory; LePort et al., 2012) or self-reported inability (severely deficient autobiographical memory; Palombo et al., 2015) to vividly recollect the past. The aforementioned paper by Luchetti et al. (2016) demonstrated that vividness ratings of the same memories of life-changing events and early childhood events were moderately and strongly correlated, respectively, across four weeks. Rubin et al. (2004) asked participants to recall the same 20 autobiographical memories at two time points separated by two weeks. The authors found that participants' average ratings of phenomenological characteristics related to vividness—such as a feeling of reliving the event, seeing the event in one's mind, and recalling the setting in which the event occurred—were highly stable. Do these initial results indicating that vividness is a stable aspect of mental time travel hold up over longer time periods? Further, the aforementioned studies focus on memories—is vividness a similarly stable feature of mental time travel into the future?

1.1. *Overview of the present research*

Across two studies with differing delay intervals, the present research thoroughly examines visual perspective and vividness—their stability, how they differ between memories and future thoughts, and their interrelationship. (1) First, we examine within-session stability: are reports of visual perspective and vividness consistent within a single experimental session? How stable are visual perspective and vividness ratings from a single trial, and how does stability change as the number of ratings increase? (2) Second, do visual perspective and vividness demonstrate across-sessions stability? That is, do participants exhibit stable reporting tendencies across different time intervals? (3) Third, do average visual perspective and vividness ratings change from the first trial to the last, or from the first session to the last? Given previous findings regarding their stability, as well as the robustness of their relationships with each other and with other phenomenological characteristics, we expected that ratings of visual perspective and vividness would demonstrate some degree of stability across time, for both memories and future thoughts. Such a result would offer strong evidence suggesting that visual perspective and vividness are (at least partially) trait-like features of mental time travel, reinforcing existing research on their associations with personal characteristics and neuropsychiatric conditions. (4) Fourth, do visual perspective and vividness differ between memories and future thoughts? Although past research has generally found differences across temporal directions, some studies have reported contradictory results. We hoped to provide a robust test of previously-documented patterns across a larger number of trials than in past work. (5) Fifth, and finally, what is the relationship between visual perspective and vividness? Although first-person episodes tend to be more vivid than third-person episodes, some studies using separate scales for each vantage point suggest a non-rectilinear relationship between the two phenomenological features. We sought to test this possibility explicitly using a single bipolar visual perspective measure, which—despite the bipolar measure's prominence in the extant visual perspective literature—has not yet been done nor received serious attention.

2. Study 1

2.1. *Study 1 method and materials*

2.1.1. *Participants*

A power analysis indicated that a sample size of 112 was required to detect a moderate correlation ($r = 0.30$) with 90% power ($\alpha = 0.05$). One-hundred and twenty participants were recruited via Amazon Mechanical Turk (AMT), and our final sample size (after attrition and exclusions) therefore provided adequate power to detect effects of interest in this report. Participants were compensated $6 for completion of the study. Participation was restricted to native English speakers located in the United States who had completed at least one study on AMT and had approval rates of at least 95% based on previous AMT work. Informed consent was obtained in accordance with the guidelines of Washington University's Human Research Protection Office.

2.1.2. *Materials*

Stimuli included 80 event cues, consisting of words or short phrases representing common life experiences (e.g., attending a concert, going on a road trip, running for exercise). The use of different event cues ensured that participants did not simply retrieve the same memory, or construct the same future thought, on each trial. Ten of the event cues were taken from McDermott and colleagues (2016), and the other 70 event cues were adapted from Gilmore et al. (2016) and Szpunar et al. (2007). The event cues were split into two groups of 40, which did not differ with respect to their average number of characters per cue ($M_{\text{Group 1}} = 21.6$, $M_{\text{Group 2}} = 20.4$), $t(78) = 0.66$, $p = .51$. Participants randomly received either Group 1 cues during Session 1 and Group 2 cues during Session 2, or vice-versa, such that participants responded to 40 different event cues during each session of the study. Within each session, the order of the event cues was randomized for each participant.

Each event cue was paired randomly with one of two time cues, which instructed participants either to recall a personal event from the past (PAST) or to imagine a plausible personal event occurring in the future (FUTURE). Within each session, PAST cues were paired with half (20) of the 40 event cues, and FUTURE cues were paired with the other half. Across both sessions, participants remembered 40 events and imagined 40 events. All stimuli were displayed in black Verdana font on a white background.

2.1.3. 2.1.3 Procedure

Participants completed two sessions consisting of the same instructions and experimental task, separated by approximately two and a half days ($M = 2.62$, $SD = 0.75$, $Minimum = 1.82$, $Maximum = 5.39$). The study was implemented in Adobe Flash and accessed via a hyperlink in the Amazon Mechanical Turk interface. After accessing the study, participants read through an online consent form and indicated whether they wished to participate. After consenting, participants received a series of instructions regarding the experimental task.

Instructions phase. First, participants were instructed that they would be remembering or imagining specific autobiographical events for 10 s at a time, and then answering two questions about their visualization of each event. Participants were asked to visualize each event as vividly and with as much detail as possible for the entire 10 s trial, and were told that each event should be unique and in a specific time and place. Next, participants were informed that the first of the two questions would be about the way in which they pictured the event in their mind's eye, adapted from Rice and Rubin (2009). More specifically, participants were told that:

> When remembering or imagining an event, most people visualize the scene in one or both of the following ways: (1) One way that people visualize an event is as an outside observer, or onlooker. For example, you might visualize an event from a bird's eye view. In this way of viewing memories or thoughts about the future, you can see yourself as an actor on stage. This viewpoint is often called the "third-person" perspective. (2) Another way that people remember or imagine events is through their own eyes, from roughly the same viewpoint that the event was originally experienced (or would be experienced in the future). This viewpoint is often called the "first-person" perspective.[1]

Participants were also provided with an example of the scale that they would use to rate their visual perspective.

The participants were then informed that the second of the two questions would be about the vividness of the event that they remembered or imagined. Participants were instructed that vividly visualized events were "very clear and full of detail," whereas non-vividly visualized events were "vague, dim, and lacking in detail." Along with the description of the vividness question, participants were provided with an example of the scale that they would use to rate the vividness of their memories and future thoughts.

Subsequently, participants received two examples of the types of cues that they would receive during the study, as well as examples of the ways in which they might visualize memories and future thoughts from the first- and third-person. Finally, participants were asked to describe the two types of perspectives from which one could visualize an event. This portion of the instructions phase was included to ensure that participants accurately understood the task, as well as the differences between first- and third-person perspectives. After providing descriptions of the two perspectives, participants received a final summary of the instructions and started the experimental task.

Task phase. Within each session of the study, participants received one of two groups of 40 task trials. During each trial, a time cue and an event cue were displayed at the top and bottom of the screen, respectively. Participants were instructed to remember or imagine (depending on the time cue) a specific personal event for the entire 10 s of each trial. Immediately after the trial, participants received a question about the visual perspective from which they visualized the event: "When remembering or imagining the event, did you see the event through your own eyes or as an outside observer?" Participants were provided with a seven-point scale, anchored at (1) "Own eyes" and (7) "Outside observer" (Rice & Rubin, 2009). Additionally, participated were allowed to select "I could not form a clear perspective for this event" if they were unable to visualize an event during the 10 s task trial. Following the visual perspective question, participants were probed regarding the vividness of their memory or future thought: "When remembering or imagining this event, the event was…?" Participants were provided with a seven-point scale, anchored at (1) "Not vivid at all" and (7) "Extremely vivid."

Overall, the event cues varied widely in their average visual perspective and vividness levels. Whereas "Sending a text message," "Playing a video game," and "Sending an email" typically engendered strongly first-person perspectives (*M*s = 1.90, 2.04, and 2.05, respectively), "Being in a group performance" was more often seen from the third-person perspective ($M = 4.86$). Further, whereas "Brushing your teeth" and "Cooking a meal at home" were both experienced quite vividly on average (*M*s = 6.12 and 6.04, respectively), "Being in a group performance," "Telling a lie," and "Babysitting" all featured average vividness ratings below the midpoint of the scale (*M*s = 3.61, 3.82, and 3.83, respectively). This variability in phenomenology echoes past findings regarding the importance of the cue in shaping one's experience of mental time travel (Maki et al., 2013; Rasmussen & Berntsen, 2014; Rice & Rubin, 2011). Descriptive statistics for each cue used in Study 1 are reported in the Supplemental Material.

Post-task phase. After completing all 40 task trials in Session 1, participants were informed that they would receive Session 2 via email and would have 48 h from the receipt of that email to complete the second and final session of the study. Approximately two days after they completed Session 1, an email with a hyperlink to Session 2 was sent to the participants. During Session 2, participants

[1] We included "bird's eye view" as an example of the third-person perspective for two primary reasons. First, we believed it to be a concise, easily understandable, and familiar viewing angle that would help participants understand how third-person and first-person perspectives differed. Second, perspectives similar to a "bird's eye view" have been commonly experienced by participants in past research examining the precise vantage points adopted during third-person memories and future thoughts (McDermott et al., 2016; Rice & Rubin, 2011).

received a different group of 40 task trials. Session 2 was otherwise identical to Session 1.

2.1.4. Exclusion criteria

As mentioned previously, 120 participants completed Session 1 of the study. Of those, 117 participants (97.5%) completed Session 2. All participants, regardless of their number of sessions completed, were included for analysis. Technical issues resulted in the loss of 28 visual perspective ratings and 31 vividness ratings. Moreover, we provided participants with the opportunity to forego providing a visual perspective rating on trials in which they could not form a clear perspective (see the Procedure section). On 299 trials, participants selected "I could not form a clear perspective for this event" from the visual perspective response options.[2] For all analyses involving visual perspective, these trials—as well as the 28 trials lost due to technical issues—were excluded, for a total of 327 excluded trials (3.4% of total trials). For all vividness analyses, only the 31 trials lost due to technical issues were excluded (0.03% of total trials).[3]

2.1.5. Analysis plan

First, we constructed identical linear mixed effects models for both visual perspective and vividness ratings to assess their within- and across-session stability, as well as estimate differences in phenomenology between memories and future thoughts (see Baayen et al., 2008; Judd et al., 2012; Quené & van den Bergh, 2004 regarding the advantages of mixed-effects models). The models were fit with the *lme4* package (Bates, Mächler, Bolker, & Walker, 2015, version 1.1–21) in R (R Core Team, version 3.6.2) using restricted maximum likelihood estimation. Participants' trial-level responses to the visual perspective and vividness scales served as outcome variables. We entered trial number as a fixed effect (within session, across temporal direction: past versus future), centered at Trial 20 (the midpoint of the task), which captured whether participants' reports of visual perspective and vividness changed during the experimental sessions (i.e., shifted between the first and the fortieth trial). Further, we modeled separate intercepts for each combination of session and temporal direction (for a total of four intercepts: Session 1-Past, Session 1-Future, Session 2-Past, Session 2-Future), including both their fixed and random effects, the latter of which were allowed to vary across participants.[4] Random intercepts were additionally specified for event cues. Both models were fit with unstructured variance–covariance structures, allowing the model to estimate separate variances for each combination of session and temporal direction (e.g., Session 1-Past), as well as separate covariances for each pairing of session-temporal direction combinations (e.g., Session 1-Past and Session 1-Future). To compute standard errors for each model estimate, we resampled the model using parametric bootstrapping (1,000 simulations) via the bootMer() function in *lme4* (see Davison & Hinkley, 1997; Goldstein, 2011). With these standard errors, we computed *p*-values, as well as percentile-based 95% confidence intervals, via the boot.ci() function in the *boot* package (Canty & Ripley, 2020, version 1.3–24; see also Rousselet, Pernet, & Wilcox, 2021). Descriptive statistics, both overall and within each of the two experimental sessions, and separated between memories and future thoughts, are reported in Table 1.

Second, to examine the relationship between the visual perspective that participants adopted during individual episodes and the vividness of their experiences, we conducted a separate linear mixed-effects analysis. The model was fit via the *lme4* package in R using restricted maximum likelihood estimation. Participants' trial-level responses to the vividness scale served as the outcome variable. Both the linear and quadratic fixed effects of visual perspective served as the primary predictors of interest. Temporal direction was added as an additional fixed factor, given its previously demonstrated relationship with vividness (e.g., McDermott et al., 2016), although its effect on vividness was not the aim of this analysis. The temporal direction factor was coded using sum contrasts, such that the effects of visual perspective could be interpreted averaging across memories and future thoughts. Random intercepts were specified for participants and event cues. Standard errors for each model estimate were computed using parametric bootstrap resampling (1,000 simulations) via the bootMer() function in *lme4*. These standard errors were used to calculate *p*-values, as well as percentile-based 95% confidence intervals via the boot.ci() function in the *boot* package.[5]

[2] The 299 "No Perspective" responses were reported by a total of 67 participants. Nineteen participants had more than 5 such responses, and seven participants had more than 10 such responses. One person had 32 such responses, accounting for 10.7% of the total "No Perspective" responses.

[3] Additionally, we ran a more conservative version of each analysis for both studies, in which we excluded (1) any trials in which the participant took longer than 20s to make a response to either the visual perspective or vividness question; and (2) any participants who took longer than 20s on more than 10% of trials within any session. The more conservative analyses produced nearly identical results. See the Supplemental Material for the results of the conservative analyses.

[4] The multilevel model can be described by the following equation:

$$Y_{ctsi} = b_1 T_t + \gamma_{cs} + u_{csi} + e_{ctsi}$$

According to the equation, an individual's i visual perspective or vividness rating (Y) for a given temporal direction c on a given trial t for a given session s is a function of the fixed effect of trial (T), the fixed effect of each combination of session and temporal direction (γ), and the random effect of each combination of session and temporal direction (u).

[5] As helpfully suggested by a reviewer, we have complemented our regression analyses in Study 1 and Study 2 with several related correlational analyses, all of which obtain parallel results. These correlational analyses have been described in the Supplemental Material.

Table 1
Descriptive statistics from Study 1.

		Visual Perspective		Vividness	
		M	*SD*	*M*	*SD*
Past	Session 1	2.919	2.757	5.132	2.141
	Session 2	2.832	2.562	5.075	2.129
	Overall	2.876	2.682	5.104	2.152
Future	Session 1	3.622	2.917	4.713	2.106
	Session 2	3.542	2.789	4.786	2.042
	Overall	3.583	2.899	4.749	2.010

2.2. Study 1 results

2.2.1. Within-session stability

If visual perspective and vividness ratings are trait-like phenomenological features of mental time travel that reliably relate to other aspects of autobiographical thinking, personal characteristics, and neuropsychiatric conditions, they should be expected to show stability both within a single session and across multiple sessions. We first computed two types of within-session stability (Shrout & Lane, 2012), based on the variance and covariance estimates produced by our models (see Supplemental Material). First, we computed the trial-level stability for each combination of session and temporal direction by finding the ratio of the variance of the random intercept (σ^2_p) to the total variance for that session-temporal direction combination (i.e., the sum of the intercept variance and the residual variance; $\sigma^2_p + \sigma^2_e$). This estimate describes the stability of participants' responses to single trials (i.e., the stability of a single visual perspective report or a single vividness report).

The trial-level stability estimates from Study 1, along with 95% confidence intervals around each estimate, are displayed in Table 2. Across the board, the stability of participants' responses to single trials was weak. For visual perspective, the trial-level stability estimates ranged from a low of 0.220 for memories during Session 2, $SE = 0.027$, 95% CI = [0.173, 0.275], to a high of 0.259 for future thoughts during Session 1, $SE = 0.028$, 95% CI = [0.203, 0.315]. For vividness, the trial-level stability estimates ranged from a low of 0.254 for memories during Session 2, $SE = 0.028$, 95% CI = [0.200, 0.314], to a high of 0.275 for future thoughts during Session 2, $SE = 0.030$, 95% CI = [0.216, 0.333]. Overall, reports of visual perspective or vividness from a single episode of mental time travel are unlikely to capture true individual differences between respondents.

Second, we computed a stability estimate averaging across all of the trials within a given combination of session and temporal direction, which we refer to as the "period-level" estimate. The period-level formula was identical to the trial-level formula, except that the residual variance was divided by the number of trials within each period [20 trials; $\sigma^2_p / (\sigma^2_p + \sigma^2_e / 20)$]. The period-level estimates are analogous to Cronbach's alpha (Cronbach, 1951) and can be interpreted as the degree to which participants' phenomenological reports are consistent across all trials within a given period.

The period-level stability estimates from Study 1, along with 95% confidence intervals around each estimate, are displayed in Table 2. When aggregating across all 20 trials within a period (i.e., combination of session and temporal direction), within-session stability was quite strong. For visual perspective, the period-level stability estimates ranged from a low of 0.850 for memories during Session 1, $SE = 0.020$, 95% CI = [0.805, 0.885], to a high of 0.875 for future thoughts during Session 1, $SE = 0.017$, 95% CI = [0.836, 0.902]. For vividness, the period-level stability estimates ranged from a low of 0.872 for memories during Session 2, $SE = 0.017$, 95% CI = [0.833, 0.902], to high of 0.884 for future thoughts during Session 2, $SE = 0.016$, 95% CI = [0.846, 0.909].

Lastly, we estimated how the stability of visual perspective and vividness ratings increased with greater numbers of trials, from a single trial to twenty trials. The within-session stability curves, for each combination of session and temporal direction, are plotted in Fig. 1. For visual perspective, approximately five or six trials were necessary to achieve a within-session stability of 0.60. Further, approximately seven to nine trials were required to reach a within-session stability of 0.70, and approximately twelve to fifteen trials were needed for a within-session stability estimate of 0.80. For vividness, approximately four or five trials were necessary to achieve a within-session stability of 0.60, approximately seven trials to reach a within-session stability of 0.70, and approximately eleven or twelve trials for a within-session stability estimate of 0.80.

2.2.2. Across-session stability

Stability within a single session, however, does not fully capture whether a phenomenological feature of mental time travel is trait-like. Determining the stability of individual differences instead necessitates the assessment of phenomenological ratings across different experimental sessions. To assess across-session stability, we examined the correlations between the random effects at each combination of session and temporal direction, using the estimated covariance matrix of the random effects. A strong correlation between two periods (i.e., session-temporal direction combinations) would indicate that an individual's deviation from the fixed intercept in a given period was associated with their deviation in the second period. That is, strong correlations would signify that participants' phenomenological ratings are similarly idiosyncratic across periods of mental time travel—the hallmark of a trait-like psychological process. This approach allows for the separation of stability from measurement error, which may otherwise confound the stability estimate (Shrout & Lane, 2012): variability in visual perspective or vividness ratings within a single period is used to quantify measurement error, which is then adjusted for in the mixed model.

The across-session stability estimates from Study 1 are displayed in Table 3. For memories, across-session stability with a two-day

Table 2
Within-session stability estimates from Study 1.

		Visual Perspective				Vividness			
		Trial-level		*Period-level (20 trials)*		*Trial-level*		*Period-level (20 trials)*	
		Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Past	Session 1	.221	[.171, .277]	.850	[.805, .885]	.264	[.211, .322]	.877	[.842, .905]
	Session 2	.220	[.173, .275]	.850	[.807, .884]	.254	[.200, .314]	.872	[.833, .902]
Future	Session 1	.259	[.203, .315]	.875	[.836, .902]	.268	[.211, .325]	.880	[.843, .906]
	Session 2	.258	[.200, .313]	.874	[.837, .901]	.275	[.216, .333]	.884	[.846, .909]

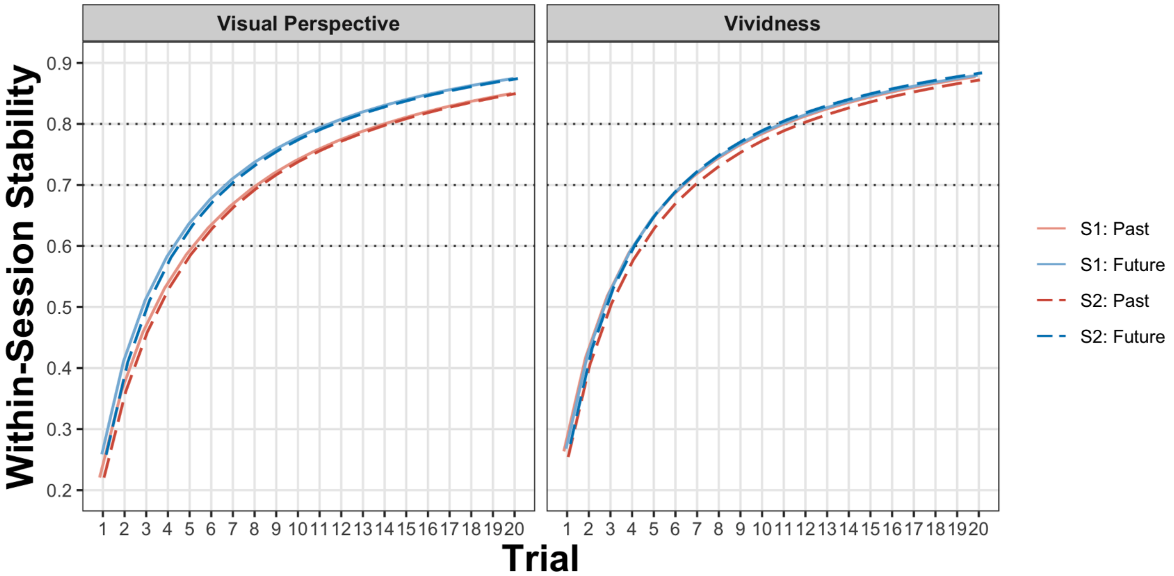

Fig. 1. Increase in within-session stability across trials in Study 1. Individual lines represent stability estimates for each combination of session (1, 2) and temporal direction (past, future).

Table 3
Across-session stability estimates from Study 1.

		Visual Perspective		Vividness	
		Estimate	*95% CI*	*Estimate*	*95% CI*
Past	Session 1, Session 2 (two days)	.950	[.880, .996]	.970	[.920, .995]
Future	Session 1, Session 2 (two days)	.820	[.715, .897]	.926	[.866, .978]

interval was extremely strong, both for visual perspective ratings, $r = 0.950$, $SE_r = 0.030$, 95% CI = [0.880, 0.996], and for vividness ratings, $r = 0.970$, $SE_r = 0.019$, 95% CI = [0.920, 0.995]. For future thoughts, across-session stability was lower but still high, both for visual perspective, $r = 0.819$, $SE_r = 0.047$, 95% CI = [0.715, 0.897], and for vividness, $r = 0.926$, $SE_r = 0.028$, 95% CI = [0.866, 0.978].

2.2.3. Effects of trial number (within-session) and session on visual perspective and vividness ratings

Did visual perspective and vividness ratings change within a session? The visual perspective model revealed a non-significant tendency for participants to adopt the first-person perspective more often as they progressed further in the experimental task, $b =$ -0.0031, $SE_b = 0.0017$, $p = .056$, 95% CI = [-0.0065, 0.0001]. This tendency was very small, amounting to a decrease of approximately 0.120 units on the seven-point visual perspective scale from the first trial to the last (fortieth) trial within a given session. Moreover, according the vividness model, participants did not experience differences in vividness across the trials of the experimental task, $b =$ 0.0003, $SE_b = 0.0013$, $p = .814$, 95% CI = [-0.002, 0.003]. Thus, in Study 1 we find limited evidence for within-session changes in participants' phenomenological ratings.

Did overall visual perspective and vividness ratings change between Session 1 and Session 2? Descriptive statistics, both overall and within each of the two experimental sessions, and separated between memories and future thoughts, are reported in Table 1. For memories, visual perspective ratings did not significantly change from Session 1 to Session 2, b = -0.074, $SE_b = 0.064$, $p = .246$, 95% CI = [-0.194, 0.053]. The same was true when restricting the analysis to future thoughts, b = -0.078, $SE_b = 0.084$, $p = .360$, 95% CI = [-0.240, 0.087]. Similarly, the vividness ratings differed little between Session 1 and Session 2, both for memories, b = -0.048, SE_b = 0.047, $p = .318$, 95% CI = [-0.143, 0.046], and for future thoughts, $b = 0.071$, $SE_b = 0.053$, $p = .176$, 95% CI = [-0.032, 0.176].

2.2.4. Effects of temporal direction on visual perspective and vividness ratings

How vividly, and from what visual perspective, did participants experience their episodes of mental time travel? Did these experiences differ between memories and future thoughts? To address these questions, we extracted estimated means from both the visual perspective and vividness models. Averaging across remembered and imagined events, participants tended to experience events more from the first-person perspective ($M = 3.24$, where 1 is "own eyes" and 7 is "outside observer") and with moderate vividness ($M = 4.93$, where 1 = "not vivid at all" and 7 is "extremely vivid"). Differences in these phenomenological characteristics were observed, however, when comparing memories to future thoughts.

We computed custom contrasts designed to test whether visual perspective and vividness ratings differed between memories and future thoughts, both across and within the two experimental sessions. Visual perspective ratings—across both sessions—were significantly lower for memories ($M = 2.89$) than for future thoughts ($M = 3.60$), indicating that remembered events were viewed more so from the first-person perspective than were imagined events, b = -0.708, $SE_b = 0.078$, $p < .001$, 95% CI = [-0.858, −0.546]. This difference in visual perspective between memories and future thoughts was evident for both Session 1, b = -0.710, $SE_b = 0.087$, $p < .001$, 95% CI = [-0.886, −0.547], and Session 2, b = -0.706, $SE_b = 0.097$, $p < .001$, 95% CI = [-0.890, −0.547].

Furthermore, vividness ratings were significantly higher for memories ($M = 5.11$) than for future thoughts ($M = 4.74$), $b = 0.368$, $SE_b = 0.043$, $p < .001$, 95% CI = [0.279, 0.455]. That is, participants experienced remembered events more vividly than imagined events. This difference in vividness held for both Session 1, $b = 0.428$, $SE_b = 0.054$, $p < .001$, 95% CI = [0.318, 0.530], and Session 2, $b = 0.308$, $SE_b = 0.052$, $p < .001$, 95% CI = [0.209, 0.409].

2.2.5. Relationship between visual perspective and vividness

Lastly, we explored the relationship between visual perspective and vividness. Are events viewed from the first-person perspective experienced more or less vividly than events viewed from the third-person perspective? Further, is the relationship between vividness and visual perspective rectilinear? Estimated mean vividness ratings for each point on the visual perspective scale (1–7) are plotted in Fig. 2. There was a strong negative linear effect of visual perspective on vividness, b = -64.38, $SE_b = 1.49$, $p < .001$, 95% CI = [-67.43, −61.48]. Indeed, a comparison of the endpoints of the visual perspective scale—"Own eyes" ($M = 5.94$) to "Outside observer" ($M = 4.86$)—indicated that instances of mental time travel viewed completely from the first-person perspective were experienced more vividly than instances viewed completely from the third-person perspective, $b = 1.08$, $SE_b = 0.031$, $p < .001$, 95% CI = [1.02, 1.14].

However, the negative linear effect was qualified by a strong quadratic effect, $b = 45.96$, $SE_b = 1.51$, $p < .001$, 95% CI = [42.85, 48.69], with the intermediate points of the scale having been experienced less vividly than the endpoints. In particular, ratings of 3, 4 (the true midpoint), 5, and 6 on the visual perspective scale were all associated with significantly lower vividness ratings than completely "Outside observer" (7), bs < -0.136, ps < 0.001. Thus, the regularly documented relationship between visual perspective and vividness—such that first-person perspectives are experienced more vividly than are third-person perspectives—did not hold for every point on the visual perspective scale.

2.3. Study 1 discussion

The stability of visual perspective ratings and vividness ratings for individual trials was quite low—in order to reliably assess individual differences in these phenomenological aspects of mental time travel, a number of reports are necessary. With a sufficient number of trials, however, both visual perspective ratings and vividness ratings demonstrated strong within-session stability, which parallels previous findings (Siedlecki, 2015; Verhaeghen et al., 2018). Notably, visual perspective and vividness also showed strong across-session stability with a two-day delay interval, both for memories and future thoughts. This study therefore provides novel evidence suggesting that these aspects of mental time travel may be (at least partially) trait-like.

Visual perspective ratings and vividness ratings showed little and no evidence, respectively, of changing as a function of trial number, and did not differ across sessions. Both visual perspective and vividness differed as a function of temporal direction, consistent with a number of previous findings in the literature—memories were viewed more from the first-person perspective than were future thoughts (e.g., D'Argembeau & Van der Linden, 2006; McDermott et al., 2016; Verhaeghen et al., 2018), and were also experienced more vividly (e.g., Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004; Johnson, Foley, Suengas, & Raye, 1988; Özbek, Bohn, & Berntsen, 2017).

Finally, we demonstrated that the relationship between visual perspective and vividness, when using the traditional seven-point continuous scale, was not rectilinear. Episodes viewed from a completely first-person perspective were indeed more vivid than episodes viewed from a completely third-person perspective, replicating past research (e.g., McDermott et al., 2016; Nigro & Neisser, 1983; Robinson & Swanson, 1993; Sutin & Robins, 2010). The middle points of the scale, however, were consistently associated with the lowest amount of vividness. This relationship between visual perspective and vividness has implications for the measurement of phenomenology, which we consider in more detail in the General Discussion.

Although the strong stability demonstrated in Study 1 is promising regarding the trait-like nature of visual perspective and vividness ratings, the two measurement periods were only separated by approximately two days. The stability estimate from Study 1 may therefore, in part, reflect memory artifacts (e.g., participants' desire for consistency in their responses) rather than systematic

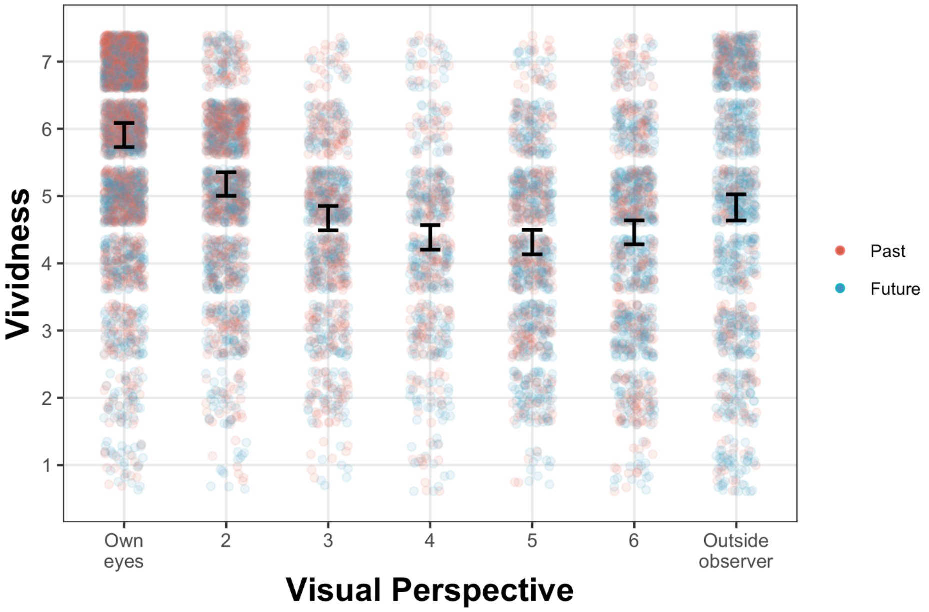

Fig. 2. Vividness ratings across levels of visual perspective in Study 1. Points represent individual trials. Error bars represent 95% confidence intervals around the average vividness rating for each visual perspective rating.

individual differences (Shrout & Lane, 2012). In Study 2, we sought to address this issue by adding a third session and increasing the length of the delay intervals between measurement periods, from two days to two weeks (Session 1 to Session 2) and six weeks (Session 2 to Session 3).

3. Study 2

3.1. Study 2 method and materials

3.1.1. Participants

One-hundred and seventy-five participants were recruited via AMT. This sample size was chosen in order to achieve equivalent power to Study 1, with the expectation of greater attrition across three sessions with longer delay intervals. Participants were compensated $2.50 for completion of the first session of the study, and received an additional $5.50 and $4.00 for completion of the second and third sessions, respectively. Participation was restricted to native English speakers located in the United States who had completed at least one study on AMT, had approval rates of at least 95% based on previous AMT work, and had not participated in Study 1. Informed consent was obtained in accordance with the guidelines of Washington University's Human Research Protection Office.

3.1.2. Materials

The stimuli used for the first and second sessions of Study 2 were identical to those used in Study 1. For the third session of Study 2, 40 new event cues were adapted from Gilmore and colleagues (2016). The new event cues did not differ statistically from the two previously used groups of event cues in terms of average number of characters per cue ($M_{\text{Session 3}} = 20.8$; *t*s < 0.49, *p*s > 0.63). All other stimuli used for the third session of Study 2 were identical to those used in Study 1.

As with Study 1, the event cues varied considerably in their average phenomenology. "Sending an email" and "Sending a text message" were again most associated with strong first-person perspectives (*M*s = 2.06 and 2.13, respectively), and "Being a group performance" was again most often seen from the third-person perspective (*M* = 4.64). Moreover, "Brushing your teeth" and "Cooking a meal at home" were again the most vividly experienced events (*M*s = 5.96 and 5.75, respectively), whereas "Being in a group performance," "Telling a lie," and "Babysitting" were again the least vividly experienced events (*M*s = 4.18, 4.20, and 4.28, respectively). Indeed, the rank ordering—in terms of phenomenology—of the 80 cues used in both Study 1 and Study 2 was quite consistent (Spearman *r*s of .856 for visual perspective and .908 for vividness), suggesting again that different cues may reliably evoke different experiences of mental time travel. Descriptive statistics for each cue used in Study 2 are reported in the Supplemental Material.

3.1.3. Procedure

Participants completed three sessions consisting of the same instructions and experimental task. Session 1 and Session 2 were separated by approximately two weeks (*M* = 15.37 days, *SD* = 2.14, *Minimum* = 14.01, *Maximum* = 25.95), whereas Session 2 and Session 3 were separated by approximately six weeks (*M* = 43.40 days, *SD* = 3.84, *Minimum* = 37.74, *Maximum* = 62.83). Session 1 and

Session 3 were therefore separated by approximately two months ($M = 58.70$ days, $SD = 4.71$, $Minimum = 53.98$, $Maximum = 82.56$). The study was implemented in Adobe Flash and accessed via a hyperlink in the Amazon Mechanical Turk interface. The instructions and task phases of Study 2 were identical to those in Study 1.

The only procedural difference between Study 1 and Study 2 was the inclusion of a brief post-task phase in the second and third sessions of Study 2. In particular, after completing both the instruction and task phases, participants were asked to explain their thought processes behind selecting specific points on the visual perspective scale. These data are beyond the scope of this paper.

3.1.4. Exclusion criteria

As mentioned previously, 175 participants completed Session 1 of the study. Of those, 167 participants (95.5%) completed Session 2, and 153 participants (87.4%) completed all three sessions. All participants were included for analysis. As with Study 1, technical issues affected a handful of trials, resulting in the loss of ten visual perspective ratings and two vividness ratings. In an additional 600 trials, participants selected "I could not form a clear perspective."[6] For all visual perspective analyses, a total of 610 trials were excluded (3.1% of total trials). For all vividness analyses, only the two trials lost due to technical issues were excluded (0.01% of total trials).[7]

3.1.5. Analysis plan

The analysis plan for Study 2 closely followed Study 1. To examine within- and across-session stability, we again constructed separate linear mixed effects models for visual perspective ratings and vividness ratings, fit with the *lme4* package (Bates, Mächler, Bolker, & Walker, 2015, version 1.1–21) in R (R Core Team, version 3.6.2) using restricted maximum likelihood estimation. The same fixed and random effects as in Study 1 were included in the models, with the addition of intercepts (both fixed and random) for Session 3-Past and Session 3-Future, and the models were again fit with unstructured variance–covariance structures. Descriptive statistics for visual perspective and vividness, both overall and within each of the three experimental sessions, and separately for memories and future thoughts, are reported in Table 4.

Moreover, the model constructed to examine the relationship between visual perspective and vividness ratings was identical to the model from Study 1. The models were again fit with the *lme4* package in R using restricted maximum likelihood estimation. For each of the abovementioned models, we again estimated standard errors using parametric bootstrapping (1000 simulations) via the bootMer() function in *lme4*, and subsequently used these standard errors to compute p-values, as well as percentile-based 95% confidence intervals via the boot.ci() function in the *boot* package.

3.2. Study 2 results

3.2.1. Within-session stability

We again computed two types of within-session stability based on the variance and covariance estimates produced by our two models (see Supplemental Material): trial-level stability, which describes the stability of participants' responses to single trials; and period-level stability, which describes the stability of participants' responses across all trials within a given combination of session and temporal direction. Both the trial-level stability estimates and the period-level stability estimates, along with 95% confidence intervals around each estimate, are displayed in Table 5.

As in Study 1, the stability of participants' responses to single trials was weak. For visual perspective, the trial-level stability estimates ranged from a low of 0.193 for memories during Session 2, $SE = 0.021$, 95% CI = [0.151, 0.232], to a high of 0.235 for future thoughts during Session 2, $SE = 0.023$, 95% CI = [0.189, 0.280]. For vividness, the trial-level stability estimates ranged from a low of 0.219 for memories during Session 1, $SE = 0.022$, 95% CI = [0.176, 0.262], to a high of 0.287 for future thoughts during Session 2, $SE = 0.024$, 95% CI = [0.236, 0.333].

When aggregating across all 20 trials within a period (i.e., combination of session and temporal direction), however, within-session stability improved dramatically. For visual perspective, period-level stability ranged from a low of 0.827 for Session 2 memories, $SE = 0.020$, 95% CI = [0.780, 0.858], to a high of 0.860 for Session 2 future thoughts, $SE = 0.016$, 95% CI = [0.823, 0.886]. For vividness, period-level stability ranged from a low of 0.849 for Session 1 memories, $SE = 0.017$, 95% CI = [0.810, 0.876], to a high of 0.889 for Session 2 future thoughts, $SE = 0.012$, 95% CI = [0.861, 0.909].

Finally, we again estimated how visual perspective and vividness ratings increased in their within-session stability with additional trials, from a single trial to twenty trials. The within-session stability curves, for each combination of session and temporal direction, are plotted in Fig. 3. For visual perspective, five to seven trials were needed to achieve a within-session stability of 0.60. Moreover, approximately eight to ten trials were necessary to achieve a within-session stability of 0.70, and approximately fourteen to seventeen trials were required to reach a within-session stability of 0.80. For vividness, approximately four to six trials were necessary to achieve

[6] The 600 "No Perspective" responses were reported by a total of 103 participants. Thirty-eight participants had more than 5 such responses, thirteen participants had more than 10 such responses, and five participants had more than 20 such responses. One person had 31 such responses, accounting for 5.2% of the total "No Perspective" responses.

[7] As in Study 1, we ran a more conservative version of each analysis, excluding (1) any trials in which the participant took longer than 20s to make a response to either the visual perspective or vividness question; and (2) any participants who took longer than 20s on more than 10% of trials within any session. The more conservative analyses again produced nearly identical results. See the Supplemental Material for the results of the conservative analyses.

Table 4
Descriptive statistics from Study 2.

		Visual Perspective		Vividness	
		M	*SD*	*M*	*SD*
Past	Session 1	2.993	2.854	5.191	2.191
	Session 2	2.941	2.838	5.222	2.151
	Session 3	2.917	2.724	4.989	2.281
	Overall	2.952	2.855	5.139	2.255
Future	Session 1	3.789	3.078	4.873	2.128
	Session 2	3.790	2.976	4.793	2.100
	Session 3	3.570	2.871	4.757	2.148
	Overall	3.721	3.055	4.810	2.189

Table 5
Within-session stability estimates from Study 2.

		Visual Perspective				Vividness			
		Trial-level		Period-level (20 trials)		Trial-level		Period-level (20 trials)	
		Estimate	95% CI	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
Past	Session 1	.222	[.178, .263]	.851	[.813, .877]	.219	[.172, .259]	.849	[.806, .875]
	Session 2	.193	[.151, .232]	.827	[.780, .858]	.225	[.181, .267]	.853	[.815, .879]
	Session 3	.195	[.151, .239]	.829	[.780, .863]	.230	[.183, .279]	.856	[.818, .886]
Future	Session 1	.217	[.174, .258]	.847	[.808, .874	.267	[.215, .306]	.880	[.845, .898]
	Session 2	.235	[.189, .280]	.860	[.823, .886]	.287	[.225, .329]	.889	[.853, .907]
	Session 3	.218	[.175, .265]	.848	[.809, .878]	.267	[.214, .313]	.879	[.845, .901]

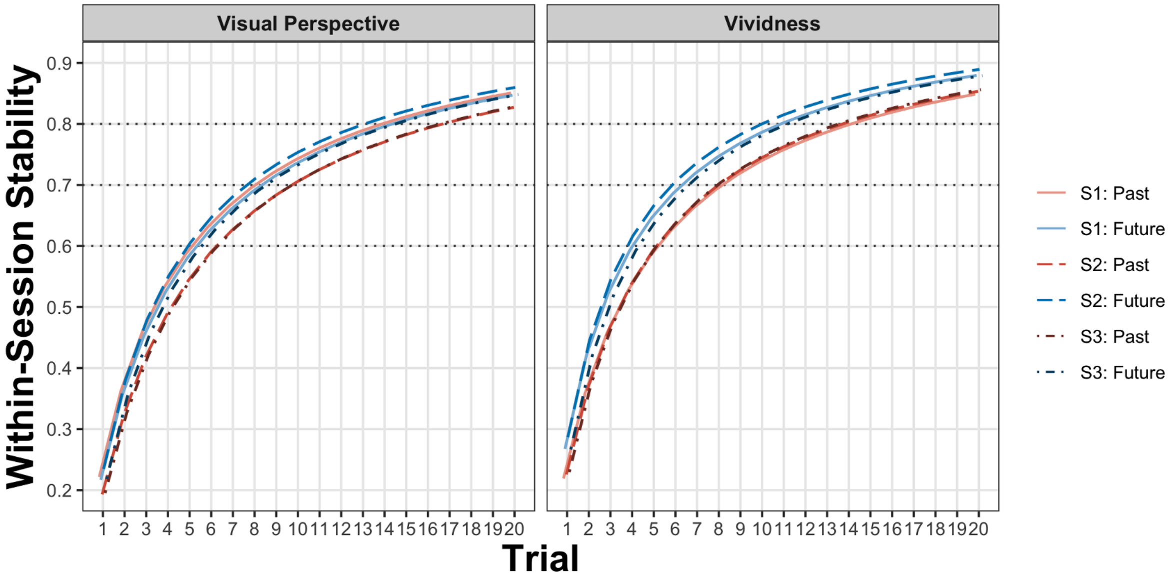

Fig. 3. Increase in within-session stability across trials in Study 2. Individual lines represent stability estimates for each combination of session (1, 2, 3) and temporal direction (past, future).

a within-session stability of 0.60, approximately six to nine trials to reach a within-session stability of 0.70, and approximately ten to fifteen trials for a within-session stability estimate of 0.80.

3.2.2. Across-session stability

To compute across-session stability, we again examined the correlations between the random effects for each combination of session and temporal direction. The across-session stability estimates for Study 2 are reported in Table 6. Generally, the across-session stability of each phenomenological characteristic was strong. Across Session 1 and Session 2 (two weeks), the stability estimates for visual perspective ratings were $r = 0.798$ for memories, $SE_r = 0.046$, 95% CI = [0.701, 0.881], and $r = 0.782$ for future thoughts, $SE_r =$

Table 6
Across-session stability estimates from Study 2.

		Visual Perspective		Vividness	
		Estimate	*95% CI*	*Estimate*	*95% CI*
Past	Session 1, Session 2 (two weeks)	.798	[.701, .881]	.829	[.731, .899]
	Session 2, Session 3 (six weeks)	.850	[.763, .926]	.834	[.759, .909]
	Session 1, Session 3 (eight weeks)	.739	[.622, .835]	.744	[.645, .840]
Future	Session 1, Session 2 (two weeks)	.782	[.690, .868]	.845	[.778, .901]
	Session 2, Session 3 (six weeks)	.700	[.578, .800]	.730	[.626, .814]
	Session 1, Session 3 (eight weeks)	.633	[.502, .751]	.784	[.704, .863]

0.046, 95% CI = [0.690, 0.686]. For vividness ratings, the stability estimates for vividness ratings were $r = 0.829$ for memories, $SE_r =$ 0.040, 95% CI = [0.740, 0.897], and $r = 0.845$ for future thoughts, $SE_r = 0.034$, 95% CI = [0.771, 0.904].

The across-session stability estimates remained high across Session 2 and Session 3 (six weeks). Specifically, the stability estimates for visual perspective ratings were $r = 0.850$ for memories, $SE_r = 0.042$, 95% CI = [0.763, 0.926], and $r = 0.700$, for future thoughts, $SE_r = 0.064$, 95% CI = [0.578, 0.800]. For vividness ratings, the stability estimates were $r = 0.834$ for memories, $SE_r = 0.041$, 95% CI = [0.746, 0.903], and $r = 0.784$ for future thoughts, $SE_r = 0.043$, 95% CI = [0.685, 0.860].

From Session 1 and Session 3, the longest delay interval in the study (eight weeks), the across-session stability estimates dropped slightly, although they remained moderately strong. In particular, the stability estimates for visual perspective ratings were $r = 0.739$ for memories, $SE_r = 0.054$, 95% CI = [0.622, 0.835], and $r = 0.633$ for future thoughts, $SE_r = 0.057$, 95% CI = [0.502, 0.751]. For vividness ratings, the stability estimates were $r = 0.744$, for memories, $SE_r = 0.052$, 95% CI = [0.630, 0.836], and $r = 0.730$ for future thoughts, $SE_r = 0.051$, 95% CI = [0.617, 0.815]. These results extend those from Study 1 to longer delay intervals, providing evidence for the stability of visual perspective and vividness ratings across many weeks.

3.2.3. Effects of trial number (within-session) and session on visual perspective and vividness ratings

Do visual perspective and vividness ratings change within a session? Descriptive statistics, both overall and within each of the experimental sessions, and separated between memories and future thoughts, are reported in Table 4. According to the visual perspective model, participants reported experiencing the first-person perspective more often on average as they completed additional experimental trials, $b =$ -0.0063, $SE_b = 0.0012$, $p < .001$, 95% CI = -0.0087, −0.0038], which parallel the results from Study 1. The effect was again quite small, however, amounting to a decrease of approximately 0.247 units on the seven-point visual perspective scale from the first trial to the last (fortieth) trial within a session.

Furthermore, according the vividness model, participants also reported experiencing an increase in vividness across the trials of the experimental task, $b = 0.0032$, $SE_b = 0.0009$, $p < .004$, 95% CI = [0.0014, 0.0050]. This result differs from Study 1, in which there was no evidence for an across-trial change in vividness ratings. However, as with the change in visual perspective ratings, the change in vividness ratings was small, amounting to an increase of approximately 0.106 units on the seven-point vividness scale from the first trial to the last (fortieth) trial within a session.

Do overall visual perspective and vividness ratings change across the three sessions? According to the visual perspective model, visual perspective ratings for memories did not significantly change from Session 1 to Session 2, $b =$ -0.051, $SE_b = 0.071$, $p = .500$, 95% CI = [−0.184, 0.103]. Visual perspective ratings for future thoughts also did not differ between Session 1 and Session 2, $b = 0.017$, $SE_b = 0.072$, $p = .742$, 95% CI = [−0.123, 0.162]. Moreover, for memories, visual perspective ratings did not differ when comparing Session 1 to Session 3, $b = -0.039$, $SE_b = 0.118$, $p = .794$, 95% CI = [−0.274, 0.194]. In contrast, for future thoughts, visual perspective ratings were marginally lower (i.e., more first-person, less third-person) for Session 3, relative to Session 1, $b = -0.214$, $SE_b = 0.124$, $p = .082$, 95% CI = [−0.467, 0.026]. This slight divergence between memories and future thoughts was reproduced when comparing Session 2 and Session 3. For memories, visual perspective ratings did not differ between Session 2 and Session 3, $b = 0.012$, $SE_b = 0.114$, $p = .918$, 95% CI = [−0.224, 0.223]. For future thoughts, however, visual perspective ratings were again marginally lower for Session 3, relative to Session 2, $b = -0.232$, $SE_b = 0.122$, $p = .058$, 95% CI = [−0.487, 0.003]. Overall, visual perspective ratings for memories differed little across the three sessions, whereas visual perspective ratings for future thoughts were marginally more first-person in Session 3, relative to the two preceding sessions.

According to the vividness model, vividness ratings for memories did not differ between Session 1 and Session 2, $b = 0.036$, $SE_b =$ 0.052, $p = .488$, 95% CI = [−0.049, 0.141]. Likewise, for future thoughts, vividness ratings did not change from Session 1 to Session 2, $b = -0.071$, $SE_b = 0.053$, $p = .198$, 95% CI = [−0.165, 0.048]. When comparing Session 1 to Session 3, vividness ratings for memories were marginally lower in Session 1, $b =$ -0.185, $SE_b = 0.101$, $p = .062$, 95% CI = [−0.400, 0.009]. Future thoughts during Session 1 versus Session 3, however, did not differ in their vividness, $b =$ -0.098, $SE_b = 0.102$, $p = .374$, 95% CI = [−0.287, 0.107]. Lastly, Session 3 memories were significantly less vivid than their Session 2 counterparts, $b = -0.220$, $SE_b = 0.100$, $p = .020$, 95% CI = [−0.420, −0.029], whereas future thoughts did not differ in vividness between the two final sessions, $b = -0.027$, $SE_b = 0.103$, $p =$ .794, 95% CI = [−0.238, 0.173]. Overall, vividness ratings for future thoughts were similar for each session, whereas memories during Session 3 were rated as more vivid than memories in the previous two sessions.

3.2.4. Effects of temporal direction on visual perspective and vividness ratings

As in Study 1, we extracted estimated means from both the visual perspective and vividness models. Participants tended to report experiencing events more from the first-person perspective ($M = 3.35$, where 1 is “own eyes” and 7 is “outside observer”) and with moderate vividness ($M = 4.98$, where 1 = “not vivid at all” and 7 is “extremely vivid”). However, remembered events and imagined events again differed in their average phenomenological characteristics.

Visual perspective ratings—averaging across all three sessions—were again significantly lower for memories ($M = 2.96$) than for future thoughts ($M = 3.73$), such that remembered events were viewed more from the first-person perspective than were imagined events, $b = -0.765$, $SE_b = 0.073$, $p < .001$, 95% CI = [−0.909, −0.617]. This divergence in visual perspective between memories and future thoughts existed in all three sessions: Session 1, $b = -0.801$, $SE_b = 0.083$, $p < .001$, 95% CI = −0.964, −0.633]; Session 2, $b = -0.869$, $SE_b = 0.091$, $p < .001$, 95% CI = [−1.048, −0.634]; and Session 3, $b = -0.625$, $SE_b = 0.099$, $p < .001$, 95% CI = [−0.829, −0.440].

Moreover, vividness ratings were again significantly higher for remembered events ($M = 5.14$) than for imagined events ($M = 4.82$), $b = 0.326$, $SE_b = 0.036$, $p < .001$, 95% CI = [0.253, 0.295]. This difference in vividness held for Session 1, $b = 0.319$, $SE_b = 0.050$, $p < .001$, 95% CI = [0.223, 0.415]; Session 2, $b = 0.426$, $SE_b = 0.049$, $p < .001$, 95% CI = [0.327, 0.515]; and Session 3, $b = 0.232$, $SE_b = 0.048$, $p < .001$, 95% CI = [0.134, 0.326].

3.2.5. Relationship between visual perspective and vividness

Finally, we again examined how vividness ratings differed as a function of visual perspective. Estimated mean vividness ratings for each point on the visual perspective scale (1–7) are plotted in Fig. 4. As in Study 1, there was a strong negative linear effect of visual perspective on vividness, $b = -48.36$, $SE_b = 1.40$, $p < .001$, 95% CI = [−51.05, −45.47]. Episodes reported as completely “Own eyes” ($M = 5.92$) were rated as more vivid than episodes reported as completely “Outside observer” ($M = 4.86$), $b = 1.06$, $SE_b = 0.040$, $p < .001$, 95% CI = [0.98, 1.14], mirroring Study 1.

Nevertheless, the relationship between visual perspective and vividness was again qualified by a strong quadratic effect, $b = 35.62$, $SE_b = 1.52$, $p < .001$, 95% CI = [32.75, 38.72], with the intermediate points of the scale being experienced less vividly than the endpoints. In particular, ratings of 3, 4 (the true midpoint), 5, and 6 on the visual perspective scale were all associated with significantly lower vividness ratings than “Outside observer” (7), *bs* < -0.178, < 0.001. Thus, the characteristic relationship between visual perspective and vividness, such that first-person perspectives are experienced more vividly than third-person perspectives, did not hold for all points on the seven-point visual perspective scale.

3.3. Study 2 discussion

As with Study 1, reports of visual perspective and vividness for single instances of mental time travel were not stable, but the within-session stability of the two phenomenological characteristics was strong across twenty trials, consistent with past findings (Siedlecki, 2015; Verhaeghen et al., 2018). Both visual perspective ratings and vividness ratings also demonstrated strong across-session stability for each delay interval (from two weeks to eight weeks), although their stability was weaker across eight weeks than across two weeks or six weeks.

Visual perspective ratings changed (minimally) as a function of trial number, similar to Study 1. In contrast to Study 1, however,

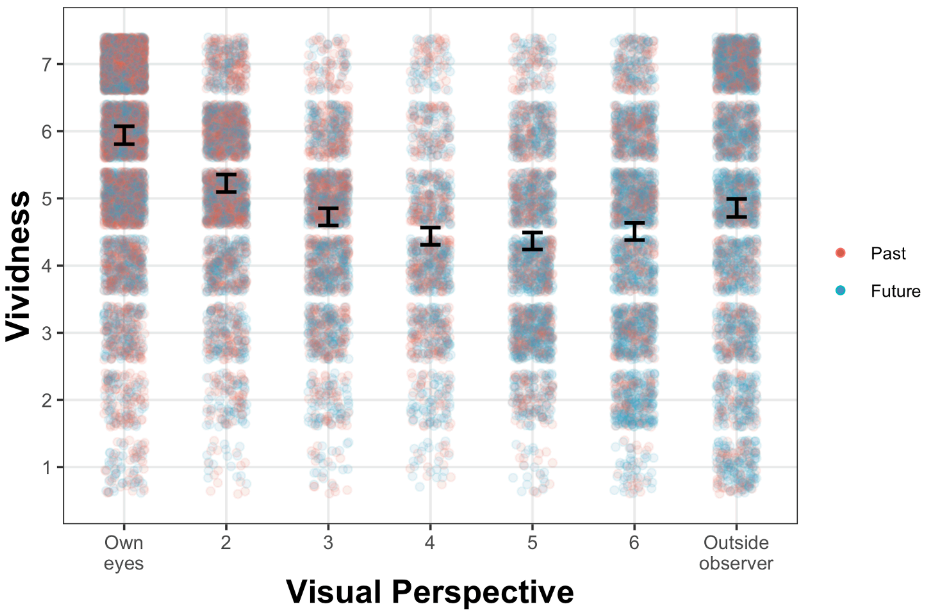

Fig. 4. Vividness ratings across levels of visual perspective in Study 2. Points represent individual trials. Error bars represent 95% confidence intervals around the average vividness rating for each visual perspective rating.

vividness ratings also changed across trials, though this effect was small. Both visual perspective and vividness ratings were largely consistent across sessions. Visual perspective and vividness again differed across memories and future thoughts, with remembered events experienced more vividly (e.g., Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004; Johnson, Foley, Suengas, & Raye, 1988; Özbek, Bohn, & Berntsen, 2017) and more from the first-person perspective (e.g., D'Argembeau & Van der Linden, 2006; McDermott et al., 2016; Verhaeghen et al., 2018) than were imagined events.

Lastly, we again show that the relationship between vividness and visual perspective is not strictly rectilinear. Although events visualized from a completely first-person perspective were more vivid than events visualized from a completely third-person perspective (e.g., McDermott et al., 2016; McIsaac & Eich, 2002; Nigro & Neisser, 1983; Robinson & Swanson, 1993; Sutin & Robins, 2010), the middle points of the seven-point visual perspective scale were associated with the lowest vividness ratings.

4. General discussion

The present studies examined the stability of visual perspective ratings and vividness ratings within and across experimental sessions, as well as the relationships between temporal direction, visual perspective, and vividness. Our primary findings are consistent across the two studies. First, we documented strong within- and across-session stability in both studies, for both visual perspective ratings and vividness ratings, and for both memories and future thoughts. Although the stability of a single visual perspective or vividness rating was low, the phenomenological ratings reached moderate stability (0.6; Shrout, 1998) with approximately five to seven trials, and showed substantial stability (>0.8; Shrout, 1998) across twenty trials within an experimental session, replicating and extending previous results (Siedlecki, 2015; Verhaeghen et al., 2018). Moreover, participants' idiosyncratic phenomenological experiences were highly consistent across sessions, even at the longest (eight week) gap between measurement periods. This finding that confirms a long-standing implicit, but integral, assumption in the literature on individual differences in, and related to, mental time travel.

Second, we found robust evidence for differences in both visual perspective and vividness between remembered and imagined events. Memories were consistently viewed more from the first-person perspective than were future thoughts, mirroring several previous findings in the literature (e.g., D'Argembeau & Van der Linden, 2006; McDermott et al., 2016; Verhaeghen et al., 2018). Moreover, memories were experienced more vividly than were future thoughts, also consistent with past research (e.g., Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004; Johnson, Foley, Suengas, & Raye, 1988; Özbek, Bohn, & Berntsen, 2017).

Lastly, we showed that visual perspective—measured using a standard seven-point scale—does not have a strictly linear (i.e., rectilinear) relationship with vividness. A comparison of the endpoints of the scale ("completely own eyes" and "completely outside observer") revealed that mental time travel from the first-person perspective was experienced more vividly than from the third-person perspective, replicating a myriad of previous studies (e.g., McDermott et al., 2016; McIsaac & Eich, 2002; Nigro & Neisser, 1983; Robinson & Swanson, 1993; Sutin & Robins, 2010). The middle points of the scale, however—including a rating of three, which is on the first-person side of the midpoint—were associated with lower levels of vividness than a completely third-person perspective.

4.1. *Visual perspective and vividness are trait-like components of mental time travel*

The present findings provide new evidence that visual perspective and vividness are (at least partially) trait-like components of mental time travel, both for memories and for future thoughts. The across-session stability estimates were strong for both phenomenological ratings, as well as for both temporal directions, even at the longest delay interval.

It should be noted that our visual perspective results diverge from those reported by Luchetti et al. (2016), who found no evidence for the across-session stability of visual perspective when examining the retrieval of life-changing events and early childhood events across a four-week interval. However, the authors asked participants to retrieve just a single memory within each event domain. Can a single retrieval attempt accurately represent an individual person's mental time travel tendencies? Our data suggest not, as the within-session stability of a single report (of either visual perspective or vividness) was quite low. Issues of measurement reliability may therefore have led to low across-session stability. Moreover, a small subsample of participants (those who reported different memories at each session; $n = 32$ for life-changing events and $n = 42$ for early childhood events) went into Luchetti et al. (2016)'s stability analysis. With larger samples and more trials per session, we find robust evidence of across-session stability for both visual perspective and vividness.

Given their strong stability and across-individual variability, future work should continue to explore how visual perspective and vividness—as well as other phenomenological features of mental time travel—relate to personal characteristics and neuropsychiatric conditions. For example, with the exception of depressive symptomatology, which has been linked to greater adoption of the third-person perspective during remembering in a myriad of studies (e.g., Bergouignan et al., 2008; Hallford, 2019; Kuyken & Howell, 2006; Kuyken & Moulds, 2009; Lemogne et al., 2006; Luchetti & Sutin, 2016), the preponderance of presently documented relationships between visual perspective, personal characteristics, and neuropsychiatric conditions are based on just a single or a few studies. More evidence is needed to establish the robustness of these relationships.

Future research should additionally explore the real-world consequences of individual differences in visual perspective during mental time travel. A host of studies have documented how visual perspective during imagination can influence academic motivation (Vasquez & Buehler, 2007), engagement in health behaviors (e.g., Christian et al., 2016; Rennie, Harris, & Webb, 2016; Stornelli et al., 2020), judgments of morally ambiguous actions (Agerström et al., 2013), likelihood of voting (Libby et al., 2007), and both neural and behavioral responses to pain (Christian et al., 2015). Moreover, visual perspective during remembering can affect the emotional intensity and impact of both everyday (Berntsen & Rubin, 2006; Robinson & Swanson, 1993) and distress-related memories (Lau et al., 2009; Williams & Moulds, 2008), and has been found to shape feelings of regret for past actions and inactions (Valenti et al., 2011). However, these studies have all manipulated visual perspective. Do natural differences in visual perspective tendencies similarly relate to these cognitive and behavioral outcomes?

More generally, our work coincides with a growing literature on individual differences in autobiographical memory (Palombo et al., 2018). Novel measures have recently been developed to assess variability in general, trait-level characteristics and capacities of autobiographical recollection (Berntsen et al., 2019; Palombo et al., 2013), as opposed to memories of a handful of individual events. These self-reported individual differences in autobiographical memory have been linked to divergent use of visual imagery to construct episodic details (Armson, Diamond, Levesque, Ryan, & Levine, 2021), discrepancies in age-related cognitive decline (Fan, Abdi, & Levine, 2021), history of depression (Palombo et al., 2013), and specific patterns of functional neural connectivity (Sheldon et al., 2016) and dynamic brain organization (Petrican, Palombo, Sheldon, & Levine, 2020). Our work bridges the gap between measuring general autobiographical memory characteristics and measuring characteristics of individual episodes, demonstrating that visual perspective and vividness—when reported across multiple individual episodes—are stable, trait-like phenomenological features of autobiographical thinking that differ between individuals.

Our stability findings complement past research documenting the stability of other aspects of mental time travel, and of visual imagery and perception more generally. For instance, a number of studies have demonstrated the stability of memory specificity (e.g., Brittlebank et al., 1993; Griffith et al., 2012; Williams et al., 1996). That is, people tend to consistently report specific versus overgeneral autobiographical memories, and this reporting tendency has been linked to a number of neuropsychiatric conditions, including bipolar disorder (e.g., Kim et al., 2014; Scott et al., 2000), vulnerability to depression (e.g., Sumner et al., 2010; van Vreeswijk & de Wilde, 2004), and schizophrenia (see Ricarte et al., 2017). Overgeneral memory has been linked to truncated searches through a hierarchical autobiographical memory system, with premature termination at the level of general knowledge representations, rather than access to deeper specific episodic representations (Williams et al., 2007; see also Conway & Pleydell-Pearce, 2000). Individual variability in the depth of—or effort required by (Haque & Conway, 2001)—this search process might also drive differences in phenomenological aspects of mental time travel, such as vividness and visual perspective, although findings regarding this possibility are presently mixed (e.g., Habermas & Diel, 2013; Kyung et al., 2016; Roberts et al., 2018; see also Harris et al., 2015).

Various aspects of general visual imagery have also been found to be stable within individuals. For example, a host of questionnaire-based scales (e.g., Andrade, May, Deeprose, Baugh, & Ganis, 2014; Blazhenkova & Kozhevnikov, 2009) and behavioral assessments (e.g., Campos, 2013; McKelvie & Gingras, 1974) have been shown to be reliable across repeated testing. Visual processing is considered essential for the phenomenological experience of autobiographic memory (Rubin, 2005), and may also contribute to individual differences in reports of visual perspective and vividness. Indeed, there is evidence that both questionnaire-assessed and behavior-assessed visuospatial imagery are predictive of the vividness with which an individual remembers and imagines events (e.g., Clark & Maguire, 2020; Fan, Abdi, & Levine, 2021; Rubin, 2020; Vannucci, Pelagatti, Chiorri, & Mazzoni, 2016), although some studies are equivocal regarding this relationship (e.g., Aydin, 2018; Greenberg & Knowlton, 2014; Vannucci et al., 2020). Moreover, there is mixed evidence that general visual imagery ability relates to reports of visual perspective (e.g., D'Argembeau & Van der Linden, 2006; Lorenz & Neisser, 1985). Neuroscientific work, however, has linked functioning in brain areas important for visual imagery (e.g., Freton et al., 2014; Hebscher, Levine, & Gilboa, 2018; Sreekumar, Nielson, Smith, Dennis, & Sederberg, 2018; St. Jacques, Szpunar, & Schacter, 2017) and visual perception (e.g., Daselaar et al., 2008; Sheldon et al., 2016; see also Dawes et al., 2020) to both visual perspective and vividness during autographical memory.

Beyond specificity and visual imagery, another key variable known to influence memory phenomenology is the memory's age—that is, how recently the remembered event occurred. A number of studies have documented that recent memories are experienced more vividly and more often from the first-person perspective (e.g., Johnson, Foley, Suengas, & Raye, 1988; Rice & Rubin, 2009; Robinson & Swanson, 1993; Sutin & Robins, 2007). As such, the stability of visual perspective and vividness ratings demonstrated in our studies may be a result of individual differences in the selection of recent versus remote events, rather than of individual differences in phenomenology *per se*. This can be clarified in future research by asking participants to retrieve memories from specific time periods, or by statistically adjusting for memory age, when assessing the stability of phenomenological ratings.

Our finding of strong within-session and across-session stability in visual perspective might seem at odds with past research documenting the capacity for people to switch perspectives (i.e., go from first-person to third-person, or vice versa), both within and across retrieval attempts. For example, Rice and Rubin (2009, Study 3) found that approximately twenty-three percent of memories were experienced from both the first-person perspective and the third-perspective (see also Berntsen & Rubin, 2006; Huebner & Fredrickson, 1999). Moreover, visual perspective can shift across retrieval attempts as memories age and visual information is lost (Butler et al., 2016), and a host of studies have been able to successfully manipulate the perspective from which participants remember autobiographical events (see St. Jacques, 2019).

The notion of memory as a (re)constructive process (Schacter et al., 1998; Schacter & Addis, 2007) helps to reconcile strong within-person stability with the ability to shift perspective. At the time the to-be-remembered event is experienced, the visuospatial content of the scene is encoded (McCarroll & Sutton, 2016; Nigro & Neisser, 1983; Rice, 2010). During retrieval, the rememberer may then visualize themself at any point in the scene (i.e., from the first-person perspective or from a third-person perspective), depending on the accessible visuospatial content, both spontaneously and in a goal-directed manner (e.g., Kenny & Bryant, 2007; Libby & Eibach, 2011; McIsaac & Eich, 2004; Williams & Moulds, 2008). Individuals therefore can have stable tendencies to visualize themselves from a particular perspective, driven by stable tendencies in reconstructing remembered events—but memory-specific processes (e.g., degradation of visuospatial information with age, strategic avoidance-related switches to a third-person perspective) or retrieval-specific processes (e.g., experimenter instruction, strategic adoption of both perspectives for epistemic purposes; McCarroll, 2017) can lead to perspective shifts, both within and across retrieval attempts. An intriguing question that follows, insightfully raised by a reviewer, is whether an individual's dominant vantage point can impact their ability to switch perspectives. Might strongly first-person individuals encounter more difficulty in switching to a third-person perspective, relative to an individual who regularly experiences both vantage points? This possibility is supported by Christian et al. (2013), who note anecdotally that participants faced difficulty in experiencing visual perspectives that were "unfamiliar to them" or different from what they "normally do" (p. 3; see also Iriye and Jacques, 2020). Moreover, do the effects of shifting visual perspective on forgetting and phenomenology differ depending on the strength of an individual's dominant perspective? These questions represent interesting avenues for future research.

An important caveat to our findings is that they are based on a particular measurement of visual perspective: the single bipolar scale. Our decision to use this measure was predicated on the single bipolar scale's widespread use within the literature on mental time travel, particularly with respect to existing studies that examine the relationship between individual differences in visual perspective, personal characteristics, and neuropsychiatric conditions. Our research was aimed at addressing a critical issue with these studies—the heretofore limited evidence that visual perspective constitutes a stable, trait-like aspect of autobiographical remembering and future thought. Moreover, past studies interrogating the stability of visual perspective have employed bipolar measures (Luchetti et al., 2016; Siedlecki, 2015; Verhaeghen et al., 2018). As such, we aimed to examine the stability of the measure most widely used by the motivating research. However, our findings of strong within- and across-session stability may have differed had we used other visual perspective measures, such as a binary first-person versus third-person choice (e.g., D'Argembeau & Van der Linden, 2004), or separate scales for the presence of first-person and third-person perspectives (e.g., Rice & Rubin, 2009). Future research should investigate differences between visual perspective measures, particularly with respect to their within- and across-session stability.

Lastly, we note that the across-session stabilities of both visual perspective and vividness ratings were lowest at the longest delay interval (eight weeks). This result coincides with the consistent finding that stability estimates systematically decline as the time between measurements increases (e.g., Cattell, 1964; Fraley & Roberts, 2005; Roberts & DelVecchio, 2000), as change is more likely to occur over longer delay intervals. Although stability estimates were still high over the course of eight weeks (ranging from .633 to .744), we cannot extrapolate from our findings to lengthier gaps between measurements. Future studies should assess phenomenological experiences during mental time travel across longer periods of time and a larger number of timepoints, as well as consider establishing the point at which the stability estimates of phenomenological ratings asymptote (Fraley & Roberts, 2005).

4.2. Observer memories may not be for everyone, but occur for most people (if they retrieve enough episodes)

Recently, Radvansky and Svob (2019) reported—across six studies—that a large proportion of people never, or rarely, experience the third-person perspective when retrieving memories. This is an important finding, suggesting that the first-person perspective is the default mode of visualizing autobiographical memories, and that an increase in third-person perspective-taking may be a predictive marker for the development of related neuropsychiatric conditions (e.g., vulnerability to depression, obsessive–compulsive symptomology). Although there are some differences in the wording of the visual perspective measure that we employed, as compared to the measure used by Radvansky and Svob,[8] we conducted conceptually similar analyses to those included Radvansky and Svob's Studies 5 and 6 in order to facilitate a comparison between our respective findings. We summarize our results below, as well as Radvansky and Svob's results. The full results have been included in the Supplemental Material.

Our findings are largely similar to those of Radvansky and Svob (2019). The overall distribution of ratings at each point in the seven-point scales are comparable across the four studies in question. As such, the proportion of first-person ratings (1–3 on the seven-point scales) and third-person ratings (5–7 on the seven-point scales) are analogous, although we find a slightly greater proportion of first-person ratings overall. The primary difference between our studies and those of Radvansky and Svob are in the proportion of participants with their highest visual perspective rating at a given scale value. In particular, Radvansky and Svob report that a substantial percentage of participants never reported a visual perspective value higher than the two most first-person values (24% in Study 5; 18% in Study 6). That is, a number of their participants only reported having clearly first-person memories. In contrast, we find that only 4% of participants never report a visual perspective higher than the two most first-person values, and nearly all participants provided at least one rating at the two most third-person values (87% in Study 1; 91% in Study 2). This is likely a consequence of the greater number of trials per participant in our studies (40 memory trials in Study 1, 60 memory trials in Study 2) relative to Radvansky and Svob (five memory trials in Studies 5 and 6)—more trials provide more opportunities to experience a third-person perspective. The upshot of both our results and those of Radvansky and Svob, however, is that visual perspective appears to be trait-like, with people consistently adopting similar perspectives across episodes of mental time travel.

4.3. Implications for the measurement of visual perspective and vividness

Our findings have several implications for the measurement of both visual perspective and vividness. First, we provide evidence for the number of visual perspective ratings and vividness ratings needed to achieve various levels of stability. In both studies, the stability of a single report was quite low, both for visual perspective and vividness. For visual perspective, approximately five trials—at a minimum—were needed before the ratings reached moderate levels of stability (i.e., greater than 0.6; Shrout, 1998), and at least twelve trials were needed before the ratings reached substantial stability (i.e., greater than 0.8; Shrout, 1998). Vividness ratings

[8] Radvansky and Svob (2019) asked participants to rate "the degree to which [an event] was experienced as an observer memory," from "not at all (1)" to "completely (7)." In contrast, we asked, "when remembering or imagining the event, did you see the event through your own eyes or as an outside observer?" from "own eyes (1)" to "outside observer (7)."

featured slightly better within-session stability, but at least four trials were needed before reaching moderate stability, and at least ten trials before reaching substantial stability.

Although we only collected vividness and visual perspective ratings, Siedlecki (2015) found that visual perspective and vividness were among the most reliable phenomenological characteristics during remembering. Thus, other phenomenological aspects of mental travel might similarly require multiple trials before satisfactory measurement is achieved. This result is problematic for the existing literature on the phenomenology of mental time travel, in which it is common for individual differences in phenomenological experience to be estimated with fewer than four trials (i.e., episodes of mental time travel) per participant. Low reliability of a given measure limits the correlations that can be observed between it and other measures (Nunally, 1970; Spearman, 1904). How can one detect a relationship between a measure and a different construct if one is unable to distinguish between individuals on the original measure (Spearman, 1910)? Relatedly, the magnitude of a measure's reliability impacts the power necessary to detect its relationship to other constructs—the lower the reliability of a measure, the larger the sample size required (Hedge, Powell, & Sumner, 2018). Previous null findings between mental time travel phenomenology and other individual differences measures (e.g., personal characteristics, neuropsychiatric conditions), in which phenomenology is assessed with just a few ratings, might reflect measurement error rather than true non-associations. Future research should consider collecting a greater number of phenomenological ratings per participant.

Second, we found that the endpoints and middle points of the visual perspective scale differentially related to the vividness of the remembered or imagined event, with the endpoints ("completely own eyes" and "complete outside observer") being associated with greater levels of vividness. Most studies measuring both phenomenological characteristics have found that first-person episodes of mental time travel are experienced more vividly than are third-person episodes (e.g., McDermott et al., 2016; McIsaac & Eich, 2002; Nigro & Neisser, 1983; Robinson & Swanson, 1993; Sutin & Robins, 2010)—a result that we replicate when comparing the endpoints of the seven-point scale (completely first-person to completely third-person). However, past research has tended to dichotomize visual perspective into first-person versus third-person vantage points, or to examine simple linear correlations between visual perspective and vividness. When looking at the full range of visual perspective ratings, a quadratic relationship with vividness emerged, which we do not believe has been demonstrated heretofore using a single bipolar visual perspective scale. In fact, vividness tended to be stronger as one moves towards the endpoints—*completely* first- or third-person perspectives are more vivid than *incompletely* first- or third-person perspectives.

This result coincides with Boyacioglu and Akfirat (2015, Study 1) finding that greater first-person and greater third-person perspectives, when measured separately, are both positively correlated with vividness. Moreover, this result converges with evidence that memories retrieved from multiple perspectives are experienced less vividly than memories experienced from a single perspective (Rice & Rubin, 2009), as preliminary results from our Study 2 suggest that participants overwhelmingly chose middle points on the visual perspective scale when they experienced multiple perspectives. Other studies, conversely, have found that first-person and third-person perspectives (when measured separately) relate differently to vividness, with greater first-person positively correlating with vividness, but greater third-person remaining uncorrelated with vividness (e.g., Boyacioglu & Akfirat, 2015, Study 2 and Study 3; Rice & Rubin, 2009, Study 2; see also Butler et al., 2016). One possibility reconciling the discrepancies between these studies and ours is that the extent of one's first-person perspective is more strongly related to vividness than is the extent of one's third-person perspective, rendering relationships between first-person ratings and vividness ratings easier to detect than between third-person ratings and vividness ratings.

More generally, these results suggest a number of related questions regarding the measurement of visual perspective (cf. Rice & Rubin, 2009). What is the experience of participants during episodes that engender visual perspective ratings at the middle points of the single bipolar scale? Do these ratings indicate that participants are experiencing multiple perspectives, either simultaneously or separately, during their mental episodes? Or are participants simply unsure of their perspective, coinciding with their reported lack of vividness? As mentioned previously, preliminary results from our research suggest that usage of the middle points of the bipolar scale reflects switching between first- and third-person perspective, as well as simultaneous experience of both perspectives, rather than participants' lack of certainty regarding their perspective. However, we note that this initial finding is complicated by our inclusion of a "no perspective" option, allowing participants to forego a visual perspective rating when they could not visualize the event, which may have discouraged participants from using the middle points when they were unsure of their perspective. Future work should continue to interrogate the prevalence of perspective switching and simultaneity during mental time travel.

Lastly, research on phenomenological experience during mental time travel should give greater consideration to the cues used to facilitate participants' remembering or imagining of events. We document a notable amount of variability in average phenomenological experience associated with different cues, a finding consistent with previous research (e.g., Maki et al., 2013; Rasmussen & Berntsen, 2014; Rice & Rubin, 2011). The type of cue used may interact with other aspects of mental time travel to affect phenomenology (e.g., temporal direction; Berntsen & Bohn, 2010), and future research should endeavor to examine the intra-individual stability of phenomenological experiences across cues differing in—for instance—imageability (e.g., Rasmussen & Berntsen, 2014; Williams et al., 1999), emotional valence (Maki et al., 2013; Robinson, 1976), and sensory modality (e.g., Belfi et al., 2016; Goddard et al., 2005; see also Sheldon & Chu, 2017). Moreover, future studies should examine the stability of phenomenology in memories and future thoughts that are generated involuntarily (e.g., Barzykowski & Staugaard, 2016; Berntsen, 1996; Cole, Staugaard, & Berntsen, 2016), as well as during mind-wandering more generally (Christian et al., 2013).

4.4. Phenomenological differences between memories and future thoughts

Our findings also contribute to the growing literature on the relationship between remembering the past and imagining the future.

In line with a wealth of past research (e.g., Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004; Johnson, Foley, Suengas, & Raye, 1988; McDermott, Wooldridge, Rice, Berg, & Szpunar, 2016), memories were experienced more vividly than were future thoughts. Moreover, our data indicate that memories were viewed more from the first-person perspective than from the third-person perspective, mirroring a number of prior studies (e.g., D'Argembeau & Van der Linden, 2006; McDermott et al., 2016; Verhaeghen et al., 2018). Other research, however, has failed to demonstrate this relationship between temporal direction and visual perspective (e.g., Aydin, 2018; De Brigard & Giovanello, 2012; Finnbogadóttir & Berntsen, 2014; Viard et al., 2011), although these studies tend to find patterns in the consistent direction. Given the robustness of our findings (across sessions and across studies), it is possible that previous research lacked the power to detect the asymmetry in visual perspective between memories and future thoughts.

5. Conclusions

During mental time travel, people can experience events with different levels of vividness and from different visual perspectives—aspects of phenomenology that have been previously linked to a host of personal characteristics and neuropsychiatric conditions. Such findings assume that the visual perspective from, and vividness with, which people project themselves into the past or future are stable, trait-like components of mental time travel. We provide novel evidence supporting this crucial, but heretofore unexamined, assumption. Across two studies, participants showed strong consistency in their phenomenological ratings, indicating that visual perspective and vividness are (at least partially) trait-like aspects of mental time travel.

CRediT authorship contribution statement

Jeffrey J. Berg: Conceptualization, Methodology, Software, Formal analysis, Investigation, Writing - original draft, Writing - review & editing, Visualization. **Adrian W. Gilmore:** Conceptualization, Methodology, Writing - review & editing. **Ruth A. Shaffer:** Investigation, Writing - review & editing. **Kathleen B. McDermott:** Conceptualization, Methodology, Writing - review & editing, Supervision, Funding acquisition.

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Appendix A. Supplementary material

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