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Scenes enable a sense of reliving: Implications for autobiographical memory

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ABSTRACT

Autobiographical memory has been defined by the phenomenological properties of reliving, vividness, and belief that an event occurred. Neuropsychological damage that results in the inability to recall the layout of a scene also results in amnesia suggesting a possible milder effect in people without such neurological damage. Based on this and other observations, we hypothesized that the degree to which the layout of a scene is recalled will correlate positively with ratings of reliving, vividness, and belief, and will explain more variance in multiple regressions than recalling the scene's contents. We also hypothesized that a lack of layout underlies nonspecific autobiographical memories which are common in aging, future events, and clinical disorders, whereas currently such memories are most commonly measured by reports of extended duration. We tested these theory-driven novel hypotheses in three studies to replicate our results. In each study, approximately 200 participants rated the layout, content, and other properties of personal events. Correlational analyses in each study and a structural equation model for the combined studies provide strong support for the role of mental scene construction in an integrative neurocognitive approach to clarify cognitive theory and clinical phenomena.

1. Introduction

1.1. Mentally constructed scenes

A scene is, as in colloquial speech, a place where a real or fictitious event occurs. A scene must have contents organized in space relative to the viewer. As an example, consider just the contents of your memory for a lecture you attended, such as the name or face of the lecturer, the people who attended, the main points, or what was discussed during questions, which would let you say you know what happened. Next, consider the layout as measured by a scene that placed this and other information in its spatial context. The scene might include where the lecturer was in the room and where various people were sitting, which would let you say that you remember experiencing the lecture. This information also places you in a location from which you recall the scene. Note that simply knowing the name of the lecture hall or how lecture halls are generally organized spatially is different from having a scene of the event. Thus, in the studies reported here, we make two contrasts. First, to contrast the spatial organization of the scene to its contents, we ask participants to rate how well they can describe *where* the actions, objects, and/or people are located in the memory versus how well they can *identify* the actions, objects, and/or people that are involved in the memory, though they may not be able to clearly say where they are in relation to each other. Second, to contrast the spatial setting of the scene to just knowing its name, we ask participants to rate the degree to which they mentally experience a scene in which the elements of the setting are located relative to each other in space versus how well they can identify or name the setting where the memory occurred, even if they might not be able to describe it clearly.

As would be the case with drawing a scene, a mentally constructed scene must be remembered from a single location. The act of mental scene construction thereby locates the person recalling it in relation to the rest of the event (Berntsen & Rubin, 2006; Butler, Rice, Wooldridge, & Rubin, 2016; McIsaac & Eich, 2002; Nigro & Neisser, 1983; Rice & Rubin, 2011). Thus, the act of constructing a scene forces a person to imagine him or herself in one particular location. Rubin and Umanath's (2015) theory of event memory holds that this sense of being located relative to the event during recall is needed to report experiencing an autobiographical memory with vividness and a sense of reliving of the event and provides evidence that the event was witnessed and therefore should be believed. These observations led us to include knowing one's location in relation to the contents of the scene as a key part of our empirical measure of scene construction. Visual imagery is central to autobiographical memory (Brewer, 1986; Rubin, 2006; Rubin, Schrauf,

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& Greenberg, 2003); the crucial novel claim we make here is that this is due to the spatial layout and not just the contents of the visual image of the autobiographical memory.

1.2. Autobiographical memory

Autobiographical memory can be defined in many ways (for overviews see Rubin, 1986, 1996). However, in this paper we limit our examination of autobiographical memory to the memories individuals believe they have for specific events from their lives. Such specific autobiographical memories are viewed as occurring at a particular time, even though their contents and layout may have been constructed from schemas developed over many exposures. This definition of autobiographical memory has value for many philosophical distinctions and general discourse; it is part of our scientific and cultural heritage. Unlike autobiographical memories that are not thought to be for specific events, such autobiographical memories can be relived, can be experienced with great vividness, and can be believed to have happened in the way in which they were remembered. They help to define our identities and are central to the etiology of many clinical disorders.

This definition is useful because the conception of autobiographical memories relies heavily on the phenomenological reports of reliving, vividness, and belief that occur in specific autobiographical memories (e.g., Brewer, 1986; Conway & Pleydell-Pearce, 2000; Rubin, 2006; Rubin et al., 2003; Tulving, 1983, 2002). However, for several reasons, these phenomenological reports do not provide the best account of empirical observations about the processes that operate in human memory and cognition. First, there is no coherent theoretical motivation for this set of phenomenological properties besides historical precedent. Rather, they provide a list of properties to be investigated within each's own theoretical framework. Second, these phenomenological reports vary widely across individuals and within individuals for different autobiographical memories. Third, these phenomenological reports cannot be obtained from young children, some individuals with cognitive or language deficits, and non-human animals. In many cases in the literature, this is taken to exclude the possibility that these groups can have autobiographical memories. We propose a fundamental break from this historical approach and instead consider autobiographical memories, and thus these properties, as dependent on mental scene construction (Rubin & Umanath, 2015).

The change from phenomenological properties to scene construction isolates autobiographical memory from its history and begs the question of whether the new definition has any relation to the existing literature. This paper is an attempt to fill this gap by proposing, as hypotheses, that the degree to which an autobiographical memory contains a scene will correlate positively with the phenomenological reports of a sense of reliving, vividness, and belief that an event really occurred.

We need to stress the following two points of caution: First, the terms *event* and *event memory* are widely used in the study of autobiographical memory and in the study of cognition more broadly. Here we restrict its use to the theory developed in Rubin and Umanath (2015) as applied to autobiographical memory. There are other theories that contribute in different, but often overlapping, ways to the study of autobiographical memory, which share the words *event* and *event memory* (e.g., Barsalou, 1988; event horizon model, Radvansky & Zacks, 2014; event indexing model, Zwaan & Radvansky, 1998). These theories do not specify the same theoretical construct that we do here but contribute to our understanding of autobiographical memory and events in general in their own complementary ways that are not subject to critiques and limitations that apply to our views. Second, not all event memories are autobiographical memories. Event memories can include actual lived or witnessed autobiographical events but also events about others and imagined events in the past and future. Such events all use similar processes, including scene construction, but vary on their degree of self-reference, effort needed for construction, and other factors (Rubin & Umanath, 2015). In addition, event memories need not be for a single occurrence; event memories can be intended as a summary or prototype (e.g., Posner & Keele, 1970) of a series of repeated events that can be constructed as the same basic scene (e.g., a generic, or future, lecture you might attend). When asked for repeated events, participants recall less detail than when they are asked for specific events (e.g., Holland, Addis, & Kensinger, 2011). However, in the studies that follow, participants are asked for specific autobiographical memories rather than for repeated or other kinds of events. Nonetheless, we expect a range of the degree to which events similar to the one recalled were repeated.

1.3. Neural evidence for the central role of scene construction in autobiographical memory

Many processes contribute to constructing an autobiographical memory, especially, narrative (e.g., Adler, Lodi-Smith, Phillipe & Houle, 2016; Fivush, 2012; Habermas & Bluck, 2000; Hirst & Echterhoff, 2012; McAdams & McLean, 2013) and emotion (e.g., Talarico, LaBar, & Rubin, 2004). However, we privilege mental scene construction based on evidence from human neuropsychological damage.

Two types of amnesia support the observation that neuropsychological damage results in the simultaneous loss of scene construction and the loss of autobiographical memory. In the more common etiology, people with bilateral hippocampal damage that causes amnesia cannot imagine scenes, such as a generic beach on a sunny day, although they can describe the component contents that would be in the scene (Hassabis, Kumaran, Vann, & Maguire, 2007; Maguire & Mullally, 2013; Tulving, 2002). In the less common etiology, people with damage earlier in the visual ventral stream in areas which are needed to construct scenes have visual-memory-deficit amnesia (Greenberg, Eacott, Brechin, & Rubin, 2005; Greenberg & Rubin 2003; Rubin & Greenberg, 1998). Visual-memory-deficit amnesia provides strong independent support for the role of scene construction in autobiographical memory because the damage often spares the hippocampi, structures important to many processes and thus much less specific to scene construction. Behaviorally, visual memory deficit occurs when the patient can draw or copy something that is present but cannot identify it from visual input, nor imagine or draw it from memory (Farah, 1984); this last criterion means the patient cannot imagine or recall scenes. In visual-memory-deficit amnesia, the loss of autobiographical memory for all pre-damage events produces an amnesia that can be as severe as amnesias caused by extensive medial temporal lobe damage. After a relatively short period, post-damage events can usually be encoded and recalled with their scenes constructed from other senses. The evidence for these claims come from a review of existing cases (Rubin & Greenberg, 1998) and later testing of one of those cases (Greenberg et al., 2005). All of the eleven patients who met the criteria for the visual memory deficit also had reports of amnesia. Five of the seven cases that reported on amnesia both pre- and post-damage, reported more pre-damage amnesia. Of these five cases, four reported no temporal gradient in the amnesia. Both of the last two observations are a contrast to what would be expected from amnesia caused by hippocampal damage, in which post-damage amnesia is more severe and memories for older events tend to be spared.

The claim of autobiographical memory loss from a loss of scene construction cannot be made for the loss of any other process or system involved in constructing autobiographical memories. In particular, a loss of narrative reasoning, as is associated with frontal lobe damage, often results in confabulated autobiographical memories. A loss of normal emotional functioning results in autobiographical memories with impaired emotions. Cortical damage to language and auditory areas produce impairments to language and to auditory imagery in autobiographical memory, respectively. However, these losses do not cause amnesia. In contrast, a loss of scene construction leaves no autobiographical memory (For reviews of the behavioral and neuropsychological evidence supporting these claims, see the sections on visual object imagery, multi-modal spatial imagery, narrative, emotion, language, and auditory imagery in Greenberg & Rubin, 2003).

In addition, fMRI studies of vision and memory support the neuropsychological findings that the visual ventral stream from the visual cortex continually to the hippocampus is centrally involved in both scene construction and autobiographical memory (e.g., Baldassano, Esteva, Fei-Fei, & Beck, 2016; Cabeza et al., 2004; Daselaar et al., 2008; Kanwisher & Dilks, 2014; see Rubin & Umanath, 2015 for a review). Research has shown various effects supporting this conclusion. For instance, the parahippocampal place area is activated more by scenes than objects, and for indoor scenes its activation remains even if objects are removed, leaving just the walls and floor (Epstein & Kanwisher, 1998). The hippocampus and retrosplenial cortex are most active seconds before the precuneus and visual cortex, showing temporal course of access and elaboration autobiographical memories in the ventral stream (Daselaar et al., 2008). The parahippocampal cortex is active for objects that evoke a strong sense of the surrounding space compared to ones that do not (Mullally & Maguire, 2011, 2013). Moreover, most of these areas are more active for the recognition of autobiographical memories of the pictures taken by a participant than pictures of the same general scene taken by a different participant and viewed only in the laboratory, showing the effect of the ventral stream on a richer autobiographical memory (Cabeza et al., 2004). Thus, the importance of scene construction to autobiographical memory and its neural basis has strong converging evidence both from neuropsychological damage cases and from studies that measure activation in intact individuals when they are performing tasks."

1.4. The role of scene construction in reliving, vividness, and belief in autobiographical memory

The phenomenological reports of a sense of reliving, vividness, and belief in the accuracy of autobiographical memories have been key to understanding autobiographical memory, both historically and in current research (Brewer, 1986; Fitzgerald & Broadbridge, 2013; Johnson, Foley, Suengas, & Raye, 1988; Rubin et al., 2003; Sutin & Robins, 2007). Reliving (e.g., autonoetic consciousness, mental time travel, recollection, remember versus know judgments) is a defining feature of episodic memory (Baddeley, 1992; Tulving, 1983, 2002). Belief in the occurrence and accuracy of an event and vividness have long been important features in distinguishing autobiographical memory from other types of memory and imagination and in determining reality monitoring (Brewer, 1996; De Brigard, 2017; Johnson et al., 1988). In addition, belief in the occurrence and accuracy of events is of great practical importance. In clinical psychology, an extremely high degree of reliving is a property of flashbacks, and believing events occurred that could not have occurred (or extremes of not believing events that did occur) can be symptoms of schizophrenia spectrum, other psychotic disorders, and dissociative disorders such as depersonalization / derealization disorder (American Psychiatric Association, 2013).

There is also a growing acceptance that scenes contribute to autobiographical memory in ways that increase reliving, vividness, and belief, but to date there is little direct empirical support for this idea. Hassabis and Maguire (2007, p. 304) note that memories of events need a "stage on which the remembered event is played or the 'where' for the 'what' to occur in"; that is, they must have spatial organization (e.g., Burgess, Becker, King, & O'Keefe, 2001). Without spatial organization, an autobiographical memory lacks its most basic context and will therefore be judged as knowledge (i.e., semantic memory) and have reduced reliving and vividness of the event as a whole, and belief that the event actually occurred. The layout allows the contents to be organized. In other words, "space provides a critical contextual background for encoding and retrieving episodic memories" (Eichenbaum, Dudchenko, Wood, Shapiro, & Tanila, 1999, p. 223). This neural evidence is consistent with earlier behavioral research on situation models (e.g., Zwaan, & Radvansky, 1998).

Based on the general role of visual imagery in behavioral studies and role of scene construction in neural studies of autobiographical memory, Rubin and Umanath (2015) replaced the phenomenological properties of a sense of reliving, vividness, and belief in the accuracy of an event that are often used to define autobiographical memory and its subdivisions, such as flashbulb memories, with scene construction. Thus, a crucial test of the theory is whether scene construction actually plays a major role in producing these phenomenological reports that are critical to many cognitive, clinical, and practical real-world issues. The most convincing argument would be to separate the layout component, which is needed for a scene, from the content component, which is common to both scenes and most other aspects of visual imagery.

For the theory of event memory to be supported for autobiographical memories, scene construction should be an important contributor to the three key phenomenological reports of reliving, vividness, and belief. In addition, memory for the layout of the scene should be more important than memory for the contents of the scene that is independent of spatial organization. A failure to find either would be a strong challenge to the theory. Two untested hypotheses follow from this argument. The first is that the degree to which a memory has a scene will correlate with ratings of the phenomenological properties of reliving, vividness, and belief. The second is that the degree to which a memory has a scene will correlate with these phenomenological ratings more highly than the degree to which the memory has contents that are not organized into a scene.

1.5. The role of scene construction in nonspecific autobiographical memories

Nonspecific autobiographical memories, defined loosely as autobiographical memories that have minimal content that refers to a specific event situated in time and space, have been studied in a number of research areas, though the findings have not been used to provide an integrated theoretical understanding of the phenomenon (Berntsen, 2015), nor have nonspecific memories been related to scene construction.

1.5.1. Existing measures of nonspecific autobiographical memories

Several methods have been used to measure the specificity of autobiographical memories. All these measures score whether an autobiographical memory is related to a specific event situated in time and space and thus index temporal specificity and naming the location of the event; none require a constructed scene. The most common methods in the cognitive and neuropsychological literature are the Autobiographical Interview (AI, Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002), the Autobiographical Memory Interview (AMI, Kopelman, Wilson, & Baddeley, 1989) and a method developed by Piolino, Desgranges, Benali, and Eustache (2002). These measures include a broad range of properties, but they all require a specific event situated in time to get a relatively higher specificity score for an autobiographical memory. Thus, scores on these structured interviews should correlate highly with temporal specificity, though not necessarily with scene specificity as defined here, because a constructed scene is not needed even when mention of a specific place increases a memory's score. The most common method in the clinical psychology literature is the Autobiographical Memory Test (AMT, Griffith et al., 2012; Kuyken & Dalgleish, 1995). Ten emotional words, five negative and five positive, are used to cue memories that have occurred on a particular day at a specific place. Raters categorize the responses, reporting the proportion of responses that are autobiographical memories occurring within a day. The distinction between nonspecific memories that are merged over many experiences separated in time (e.g., 'we always went to parades') or extended in time (e.g. 'during summer vacation' or 'when I was in school'; Williams, 1996) plays less of a role empirically (Dalgleish et al., 2007).

1.5.2. Nonspecific autobiographical memories in the cognitive, neuropsychological, and clinical literatures

Using the methods described in Section 1.5.1 and variants of them, the specificity of autobiographical memories has been examined in a wide range of theoretical domains in cognition with robust conclusions. The following are examples. The specificity of autobiographical memories decreases with age in adults (Addis, Wong, & Schacter, 2008; Levine et al., 2002; Schacter, Gaesser, & Addis, 2003; Schlagman, Kliegel, Schulz, & Kvavilashvili, 2009). Imagined future autobiographical events are less specific than past autobiographical memories and decrease in specificity at a greater rate as time into the future and past increases (Addis et al., 2008; Berntsen & Jacobsen, 2008; Rasmussen, & Berntsen, 2014a). Involuntary memories are more specific than voluntary memories (e.g., Berntsen, 1998; Berntsen & Hall, 2004; Schlagman, & Kvavilashvili, 2008). Some cues produce more specific memories than others (Rasmussen, & Berntsen, 2014b; Miles & Berntsen, 2011). Neuropsychological damage in various neural structures produces decreases in specificity (e.g., Rasmussen, & Berntsen, 2018). In addition, specificity is affected in numerous clinical disorders especially depression and PTSD, but also borderline personality disorder (e.g., Jørgensen, et al., 2012 and schizophrenia (e.g., D'Argembeau, Raffard, & van der Linden, 2008). However, in all domains, the effects of scene specificity, as measured by scene construction, remain to be examined. If scene specificity were to have clear effects separate from temporal specificity and the general collection of memory properties currently measured, there would be theoretical implications that would vary with each theoretical domain.

1.5.3. Hypotheses based on nonspecific autobiographical memories

The recently introduced concept of scene specificity based on a mentally constructed scene (Rubin & Umanath, 2015) has not yet been used as an alternative measure of nonspecific autobiographical memory. Because all of the measures of specificity in the literature include properties that would be higher if a scene were present, we expect that scene construction, as measured by scene specificity, would be correlated with them. However, the relative importance of scene specificity versus temporal specificity and the relative importance of scene specificity to measures of imagery that do not require an organized scene have not been explored.

We use the term nonspecific memory to refer to the general phenomenon. We use the terms temporal and scene specificity to describe two possible mechanisms underlying nonspecific memory. Following the most widely used operational definition in the clinical literature (Williams et al., 2007), we use temporal specificity to refer to measures of the degree to which the events described in memories take place within a single day and are not extended longer in time and are not the merging of distinct temporally-distributed events. We use scene specificity to refer to measures of the degree to which memories have scenes that include a spatial layout (Rubin & Umanath, 2015).

Our third hypothesis is that the degree to which a memory has a scene will correlate with ratings of the phenomenological properties of reliving, vividness, and belief more highly than the degree to which it has temporal specificity.

1.6. Three hypotheses

Thus, we test three theoretically derived, but previously untested, hypotheses about autobiographical memory that have relevance to cognition in general and to clinical disorders: (1) The degree to which a memory has a spatial layout will correlate with ratings of the phenomenological properties of reliving, vividness, and belief. (2) The degree of spatial organization of a memory will correlate with ratings of the phenomenological properties of reliving, vividness, and belief more highly than the degree to which it has visual or language contents not in a spatial organization. (3) The degree to which the memory has a spatial layout will correlate with ratings of the phenomenological properties of reliving, vividness, and belief more highly than the degree to which it has temporal specificity. The second hypothesis also challenges the theory underlying nonspecific memories, which assumes that the contents and not the layout is what is lost in nonspecific memories.

2. A note on methods: causality, replication, item reliability, sample size, cues, and rating scales

2.1. Causality

In developing the theory of event memory (Rubin & Umanath, 2015), we made claims about behavior in people without neuropsychological damage that could not be addressed with existing studies. Our aim here is to evaluate such claims using hypotheses that depend on the natural variation among the properties of intact individuals' autobiographical memories and thus are based on correlational data. Claims of causality cannot follow from such research, except in the statistical sense assumed by using regression and structural equation models. The causality we claim comes from the totality of existing behavioral and neural data, including neuropsychological damage cases where there is strong evidence for inferring causal mechanisms (Epstein & Kanwisher, 1998; Greenberg et al., 2005; Greenberg & Rubin, 2003; Hassabis et al., 2007; Mullally & Maguire, 2011, 2013; Rubin & Greenberg, 1998; Tulving, 2002).

2.2. Replication

Because there is no empirical literature to support the three hypotheses that we test, we do replications by repeating measures related to the hypotheses across studies while varying factors that should not affect the hypothesis being tested.

2.3. Item reliability

We used single item rating scales to measure concepts, often combining them into composites of several rating scales. However, each rating scale is repeated for seven memories. Thus, unlike rating scales that are administered only once, we can and do report reliabilities for each rating scale as well as for the composites based on them.

2.4. Sample size

The sample size for each study is approximately 200 participants to ensure adequate power for the regression equations and structural equation model and to have more precision in our measures. This sample size might be considered large for some of our tests, but because our arguments depend on some, but not all, variables having predictive value, more precision is a strength. We report amount-of-variance-accounted-for measures for all tests, which also serves to indicate when statistically significant results account for little variance in our dependent measures.

2.5. Cues

To cue a fairly neutral sample of memories that could cover a range of topics, we asked participants to provide memories related to word cues (Galton, 1879), a method also used in tests of nonspecific memories. We used two different sets of seven cues so that we could generalize over both subjects and stimuli (Clark, 1973).

2.6. Rating scales

To obtain ratings of the properties of the memories, we used the Autobiographical Memory Questionnaire (AMQ Rubin et al., 2003).

Table 1
Autobiographical memory questionnaire.

Items
Reliving
Living Again: While remembering, it is as if I am living the occurrence again. [All reliving items rated from 1 (not at all) to 7 (as if it were happening now)]
Time Travel: While remembering, it is as if I am mentally traveling back to the time and place of the occurrence.
Same Feelings: While remembering, it is as if I am experiencing the same feelings, emotions, and/or atmosphere again.
Vividness
See: While remembering, I can see everything in my mind. [Both vividness items rated from 1 (not at all) to 7 (as vivid as if it were happening now)]
Vivid: While remembering, the actions, objects, and/or people that are involved in the memory are as clear now as they were when the event occurred.
Belief
Real: I believe the event in my memory really occurred in the way I remember it and that I have not imagined or fabricated anything that did not occur. [Rated from 1 (100% imaginary) to 7 (100% real)]
Accuracy: My memory of the event is an accurate reflection of the event as a neutral observer would report it and is not distorted by my beliefs, motives, and expectations. [Rated from 1 (100% distorted) to 7 (100% accurate)]
Testify: Would you be confident enough in your memory of the event to testify in a court of law? [Rated from 1 (not at all) to 7 (as much as any memory)]
Layout
Setting Layout: While remembering, I experience a scene in which the elements of the setting are located relative to each other in space. [Rated from 1 (not at all spatially organized) to 7 (a clear spatial layout)]
Event Layout: As I remember, I can describe *where* the actions, objects, and/or people are located in the memory. [Rated from 1 (not at all) to 7 (as if it were happening now)]
Content
Setting Name: While remembering, I can identify or name the setting where the memory occurred, although I might not be able to describe it clearly. [Setting name and event contents rated from 1 (not at all) to 7 (definitely)]
Event Content: As I remember, I can identify the actions, objects, and/or people that are involved in the memory, though I may not be able to clearly say where they are in relation to each other.
Perspective
Where I am: While remembering, I can identify where I am in relation to the things that I am remembering. [All perspective items rated from 1 (not at all) to 7 (I know exactly where I am seeing the event from)]
Field: While remembering, I see the memory from where I was during the event, that is, as if I was seeing it again from my own eyes at my original location.
Observer: While remembering, I see the memory from a different location than the one I was at in the event, that is, as if I was remembering a new view of the same event as an outside observer.
Emotion
Valence: How positive or negative is this memory? [Rated from 1 (extremely negative) to 4 (neutral) to 7 (extremely positive)]
Intense: While remembering, the emotions I feel are intense. [Rated from 1 (not at all) to 7 (extremely)
Time ago
When did this memory originally occur? [Choices: 1 (within the past day), 2 (within the past week), 3 (within the past month), 4 (within the past three months), 5 (within the past year), 6 (within the past five years), 7 (within the past ten years), 8 (more than ten years ago)]
Specific memory
Not Merged: Is the memory of a merging of many versions of a general repetitive event, or is it a unique event that occurred only once? [Rated from 1 (definitely a general class of events) to 7 (definitely a unique event)]
Once: Did the event appear to happen once at one particular time and place, or was it a summary or merging of related events, or did it occur over a fairly continuous extended period of time lasting more than a day? [Choices: once, merging, extended period. This led to the specific memory measure of once and the non-specific memory measures of merged and extended.]
Single Event: The memory is of a general situation that happened many times in my life, rather than of a specific occurrence with its own details that let me know the memory was of a single event. [Rated from 1 (definitely a general class of events) to 7 (definitely a specific event)]

Notes. For Study 1, specific memory questions were not included. The once question was also the basis of the non-specific merged and extended measures.

Variants of the AMQ have been used in a wide range of research and so both the statistical properties of the items and their correlations with each other and with numerous individual differences measures are known in both control and clinical populations, as is the neural basis of some ratings (e.g., Daselaar et al., 2008; Rubin, Dennis, & Beckham, 2011).

3. Study 1: The role of spatial layout and perspective in autobiographical memory

3.1. Methods

3.1.1. Participants

Two hundred participants (74% female), recruited through Amazon Mechanical Turk (MTurk), completed an online survey. All participants were from the United States; they ranged in age from 18 to 73 ($M = 33.26$, $SD = 11.56$).

3.1.2. Measures

We created a modified version of the Autobiographical Memory Questionnaire (AMQ; Rubin et al., 2003) (see Table 1). To reduce the number of ratings so that we could cue multiple events, we omitted ratings of measures that have not been among the best predictors of the dependent variables of reliving, vividness, and belief in our earlier work (Rubin et al., 2011; Rubin, 2014; Rubin, Boals, & Berntsen, 2008). We added two rating scales for layout and two for content measures; the pairs were written to be as similar in form as possible to each other. This provides a critical theoretical comparison between knowing the layout of a scene and just knowing what was in the scene but not the spatial location of the scene components. In particular, to compare the layout to the contents of the event, the items contrast, “I can describe where the actions, objects, and/or people are located in the memory” to “I can identify the actions, objects, and/or people that are involved in the memory, though I may not be able to clearly say where they are in relation to each other.” To compare the layout to the content of the setting, the items contrast “I experience a scene in which the elements of the setting are located relative to each other in space” to “I can identify or name the setting where the memory occurred, although I might not be able to describe it clearly”.

3.1.3. Procedure

The Duke University Institutional Review Board for Non-Medical Research approved all studies. Participants accessed a Qualtrics survey via MTurk. The instructions began, “As we go through life, we acquire memories for events that have happened to us. In the following section, you will be asked to recall memories of personal events that have happened to you. Autobiographical memories, or personal memories, are detailed accounts of specific events that have happened to you. A description of an autobiographical memory very often is a paragraph or more and reads like a story.” Next, participants provided brief descriptive phrases for seven autobiographical memories cued by the words that were successful in eliciting memories in pilot studies: *earth*, *friend*, *dream*, *power*, *love*, *trouble*, and *opinion*. We randomized the order of cues across participants. The exact phrasing of this request was “Think about the first memory of an event from your life that pops into your mind when you think of the word < one of the seven cue words > . The memory does not have to be related to the word - Just tell us about the first memory from your life that pops into your head. Now, write a brief phrase that describes the event. If you were later given just this phrase, you should be able to recall this memory.

Following these description, but before any ratings were done, three concepts that were central to our study were described: the meaning of a sense of reliving, the difference between being able to name or otherwise identify a scene and being able to locate elements within that scene, and the different types of perspectives from which a memory can be viewed in the mind’s eye. These instructions are included in the Supplemental Materials. For each memory, participants then wrote a longer description to ensure they had a fully formed memory; they then rated the memory. Thus, the participants were asked for specific

Table 2
Descriptive statistics for the autobiographical memory questionnaire.

	Study 1			Study 2			Study 3		
Properties	*M*	(*SD*)	*α*	*M*	(*SD*)	*α*	*M*	(*SD*)	*α*
Reliving	5.25	(0.97)	0.80	4.57	(1.20)	0.85	4.33	(1.00)	0.80
Living again	5.29	(1.02)	0.76	4.39	(1.28)	0.83	4.17	(1.03)	0.74
Time travel	5.37	(1.02)	0.77	4.83	(1.22)	0.83	4.56	(1.08)	0.78
Same feelings	5.10	(1.06)	0.74	4.48	(1.28)	0.82	4.28	(1.09)	0.78
Vividness	5.03	(1.10)	0.80	3.92	(1.45)	0.78	4.76	(0.91)	0.70
See	5.21	(1.07)	0.77	5.15	(1.13)	0.76	4.93	(0.94)	0.70
Vivid	4.85	(1.21)	0.79	4.88	(1.08)	0.76	4.60	(0.96)	0.65
Belief	5.68	(0.93)	0.80	5.58	(1.00)	0.84	5.13	(0.88)	0.75
Real	5.87	(0.88)	0.77	5.83	(0.94)	0.80	5.36	(0.87)	0.73
Accuracy	5.63	(0.97)	0.78	5.51	(1.08)	0.84	5.06	(0.90)	0.72
Testify	5.54	(1.13)	0.78	5.40	(1.26)	0.83	4.96	(1.08)	0.74
Content	5.27	(1.04)	0.79	5.27	(0.89)	0.66	5.38	(0.88)	0.71
Setting name	5.42	(1.10)	0.75	5.45	(0.93)	0.60	5.58	(0.97)	0.69
Event content	5.12	(1.09)	0.73	5.09	(0.97)	0.62	5.17	(0.93)	0.67
Layout	5.17	(0.99)	0.73	4.98	(0.97)	0.65	5.05	(0.91)	0.63
Setting layout	5.22	(1.01)	0.68	5.03	(1.02)	0.62	5.21	(0.92)	0.60
Event layout	5.13	(1.05)	0.72	4.94	(1.00)	0.63	4.89	(0.96)	0.62
Perspective	5.59	(0.84)	0.73	5.48	(0.86)	0.69	5.47	(0.84)	0.74
Where I am	5.36	(0.95)	0.66	5.24	(0.99)	0.66	5.25	(0.92)	0.64
Field	5.10	(1.24)	0.74	5.15	(1.13)	0.70	5.06	(1.13)	0.73
Observer	3.68	(1.62)	0.84	3.92	(1.45)	0.78	3.71	(1.40)	0.80
Max field/Obs	5.83	(0.86)	0.74	5.72	(0.83)	0.68	5.70	(0.85)	0.76
Spatial	5.38	(0.87)	0.74	5.23	(0.87)	0.68	5.26	(0.83)	0.69
Valence	4.63	(0.82)	0.33	4.66	(0.83)	0.37	4.13	(0.45)	0.12
Intensity	4.49	(1.05)	0.67	4.28	(1.19)	0.76	4.10	(0.91)	0.62
Time ago	6.71	(1.33)	0.85	5.07	(1.07)	0.85	5.17	(1.13)	0.78
Temp. specific	–	–	–	4.49	1.25	0.51	4.27	1.06	0.37
Not merged	–	–	–	4.89	(1.21)	0.50	4.69	(1.02)	0.38
Single event	–	–	–	4.91	(1.20)	0.52	4.71	(0.99)	0.34
Once	–	–	–	3.67	(1.58)	0.36	3.39	(1.58)	0.43
Temp. nonspecific	–	–	–						
Merged	–	–	–	1.63	(1.30)	0.31	2.16	(1.55)	0.46
Extended	–	–	–	1.70	(1.48)	0.48	1.46	(1.27)	0.37

Note. Spatial is the average of the layout and perspective questions. Max Field/Obs is the maximum score of the field and observer ratings.

autobiographical memories of events and chose and described all seven autobiographical memories before they knew what they would be rating.

3.1.4. Analytical method

We measured reliving, vividness, belief, layout, and content using several items and averaged the items corresponding to each measure to create composite measures (e.g., the same feelings, living again, and time travel items were averaged to create a reliving measure). The first column of Table 2 indicates the items that contributed to each composite measure. Additionally, the presence of a perspective, regardless of the type of perspective, was of interest, so we used the maximum response to the field and observer perspective questions. We averaged this maximum perspective measure with the where-I-am perspective question to create a perspective measure. The spatial measure averaged the items of the layout and the perspective measure. The relations among the items that were averaged here are addressed more fully later using structural equation modeling. Supplemental Tables 1, 2, and 3 contain means, standard deviations, and correlations among the measures.

3.2. Results and discussion

Table 2 presents means, standard deviations, and reliabilities for all measures. In general, the means fell towards the middle of the rating scales. The variability in all measures, as indexed by their standard deviations, indicates that none of the scales had a restricted range that would limit its correlations with other variables. Supplemental Table 1 contains the correlations among all variables.

Table 3 includes correlations between our predictors (layout, content, spatial, emotional intensity, valence, time ago, age, and gender) and our dependent variables of reliving, vividness, and belief in the accuracy of the memory for each participant's average ratings of his or her seven reported memories. As expected, reliving, vividness, and belief in the accuracy were highly correlated with layout and spatial, as well as with emotional intensity and content. Multiple regressions examined the variance in reliving, vividness, and belief explained by each predictor in the context of the other predictors.

We devised the layout and content measures to be as similar in form as we could. Both measures were the average of two items and had similar reliabilities. Thus, comparisons between them are as fair a contrast as we could devise to test our second hypothesis. We first examined which of the two measures better predicted reliving, vividness, and belief in autobiographical remembering when no other variables were entered in the regression equation, as shown by the first two rows containing the beta weights and semi-squared partial correlations, which are under the "Layout versus Content" heading in Table 3. The semi-squared partial correlations indicate the amount of variance that would be accounted for when all other variables are controlled for. For reliving, they reveal that layout uniquely explained 46% of the variance, and content explained 0% of the variance. An additional 12% of the variance in reliving was shared between layout and content, as estimated by subtracting their semi-squared partial correlations from the total variance accounted for (i.e., $R^2 - \Sigma sr^2$). These findings indicate that knowing the contents of a scene does not explain unique variance in the sense of reliving once the spatial layout is included. A similar pattern of results occurred when predicting vividness and belief, though for belief, content had a significant beta weight.

The second set of multiple regressions in Table 3 is under the heading "Event: Layout vs. Content." In the first set of multiple

Table 3
Multiple regression analyses predicting reliving, vividness, and belief.

	Predicting reliving			Predicting vividness			Predicting belief		
Predictors	*r*	*ß*	*sr²*	*r*	*ß*	*sr²*	*r*	*ß*	*sr²*
				Study 1 (*N* = 200)					
Layout vs. Content	R^2 =	0.58			0.71			0.32	
Layout	0.76***	0.78***	0.46	0.85***	0.85***	0.55	0.55***	0.48***	0.17
Content	0.35***	−0.04	0.00	0.41***	−0.01	0.00	0.39***	0.16*	0.02
Event: Layout vs Content	R^2 =	0.54			0.67			0.31	
Event Layout	0.74***	0.73***	0.41	0.82***	0.78***	0.46	0.53***	0.43***	0.14
Event Content	0.36***	0.01	0.00	0.45***	0.08	0.00	0.41***	0.21**	0.03
All Predictors	R^2 =	0.71			0.78			0.40	
Spatial	0.77***	0.67***	0.29	0.86***	0.81***	0.43	0.60***	0.52***	0.17
Content	0.35***	−0.08	0.01	0.41***	−0.06	0.00	0.39***	0.10	0.01
Intensity	0.60***	0.36***	0.10	0.51***	0.21***	0.03	0.32***	0.10	0.01
Valence	0.24***	0.06	0.00	0.18**	0.01	0.00	0.11	0.00	0.00
Time Ago	−0.10	0.01	0.00	−0.09	0.01	0.00	0.01	0.07	0.00
Age	0.07	−0.02	0.00	0.09	0.02	0.00	0.14*	0.08	0.01
Gender	−0.03	0.04	0.00	−0.04	0.02	0.00	0.01	0.04	0.00
				Study 2 (*N* = 203)					
Layout vs. Content	R^2 =	0.36			0.68			0.32	
Layout	0.59***	0.57***	0.16	0.82***	0.83***	0.35	0.55***	0.43***	0.09
Content	0.43***	0.06	0.00	0.57***	0.02	0.00	0.47***	0.17*	0.01
Temp. Specific	0.09	−0.08	0.01	0.15*	−0.08	0.01	0.16*	−0.01	0.00
Event: Layout vs Content	R^2 =	0.34			0.67			0.33	
Event Layout	0.56***	0.43***	0.11	0.81***	0.71***	0.29	0.55***	0.41***	0.10
Event Content	0.49***	0.22**	0.03	0.62***	0.17**	0.02	0.48***	0.20**	0.02
Temp. Specific	0.09	−0.06	0.00	0.15*	−0.05	0.00	0.16*	0.02	0.00
All Predictors	R^2 =	0.76			0.76			0.38	
Spatial	0.62***	0.36***	0.06	0.83***	0.78***	0.26	0.59***	0.53***	0.12
Content	0.43***	−0.02	0.00	0.57***	−0.03	0.00	0.47***	0.09	0.00
Intensity	0.80***	0.65***	0.35	0.55***	0.23***	0.04	0.22***	−0.01	0.00
Valence	0.19**	0.04	0.00	0.15*	−0.03	0.00	0.09	−0.02	0.00
Time Ago	−0.10	−0.05	0.00	−0.08	−0.10**	0.01	0.10	0.02	0.00
Age	−0.03	−0.01	0.00	0.05	0.05	0.00	0.18**	0.15*	0.02
Gender	0.03	0.04	0.00	0.03	0.03	0.00	0.08	0.05	0.00
Temp. Specific	0.09	0.01	0.00	0.15*	−0.04	0.00	0.16*	−0.01	0.00
				Study 3 (*N* = 186)					
Layout vs. Content	R^2 =	0.14			0.66			0.36	
Layout	0.36***	0.34***	0.06	0.81***	0.73***	0.26	0.57***	0.40***	0.08
Content	0.28***	0.02	0.00	0.63***	0.11	0.01	0.53***	0.22*	0.02
Temp. Specific	0.15*	0.05	0.00	0.24**	0.00	0.00	0.25**	0.05	0.00
Event: Layout vs Content	R^2 =	0.16			0.69			0.37	
Event Layout	0.38***	0.30**	0.04	0.82***	0.68***	0.23	0.59***	0.45***	0.10
Event Content	0.33***	0.11	0.01	0.68***	0.19**	0.01	0.51***	0.17*	0.01
Temp. Specific	0.15*	0.05	0.00	0.24**	0.03	0.00	0.25**	0.09	0.00
All Predictors	R^2 =	0.52			0.71			0.43	
Spatial	0.40***	0.22**	0.02	0.83***	0.74***	0.23	0.64***	0.53***	0.12
Content	0.28***	0.05	0.00	0.63***	0.08	0.00	0.53***	0.10	0.00
Intensity	0.67***	0.62***	0.34	0.31***	0.14**	0.02	0.20**	0.08	0.01
Valence	0.08	0.02	0.00	0.13*	0.03	0.00	0.13*	0.06	0.00
Time Ago	−0.14*	−0.07	0.01	−0.20**	−0.05	0.00	−0.15*	−0.02	0.00
Age	−0.05	−0.01	0.00	−0.05	0.00	0.00	−0.03	−0.01	0.00
Gender	−0.11	−0.01	0.00	0.01	−0.05	0.00	0.12	0.06	0.00
Temp. Specific	0.15*	−0.06	0.00	0.24**	−0.04	0.00	0.25**	0.02	0.00

Note. Gender is dummy coded, with a score of 1 indicating female. Across the three dependent variables in Study 1, Model 1: $F(2, 197) \geq 47.32$; Model 2: $F(2, 197) \geq 45.07$; Model 3: $F(7, 192) \geq 18.05$; in Study 2, Model 1: $F(3, 199) \geq 30.82$; Model 2: $F(3, 199) \geq 32.76$; Model 3: $F(8, 194) \geq 14.78$; In Study 3, Model 1: $F(3, 182) \leq 9.49$; Model 2: $F(3, 182) \geq 11.28$; Model 3: $F(8, 177) \leq 16.68$. All F values were significant, p's < 0.001.

* $p < .05$.
** $p < .01$.
*** $p < .001$.

regressions, we had two measures of layout and two of contents to ensure that our results were not limited by the particular wording of a single measure of our underlying theoretical concepts. The two measures of layout (setting layout and event layout) and the two measures of content (setting name and event content) each correlated between 0.70 and 0.87 in the three studies as shown in Supplemental Tables 1, 2, and 3. The estimates between these items and their latent variable constructs were between 0.81 and 0.96 in the SEM analysis in Fig. 1. Thus, the results confirm that these underlying concepts are not particular to one of the two items used to measure them. Nonetheless, the setting layout and setting name are less clearly related to their underling concepts than are event layout and event content because they focus on the surroundings of the event, which need not always be important. To test that the theoretically clearer measures would produce similar results on their own, we include an analysis based using just them in Table 3, which parallels the existing one based on the sum of two items. The results of the analyses based on just event layout and event content parallels the analyses based on two measures. Thus, the initial results hold with just one for each concept.

The third set of multiple regressions in Table 3 is under the heading

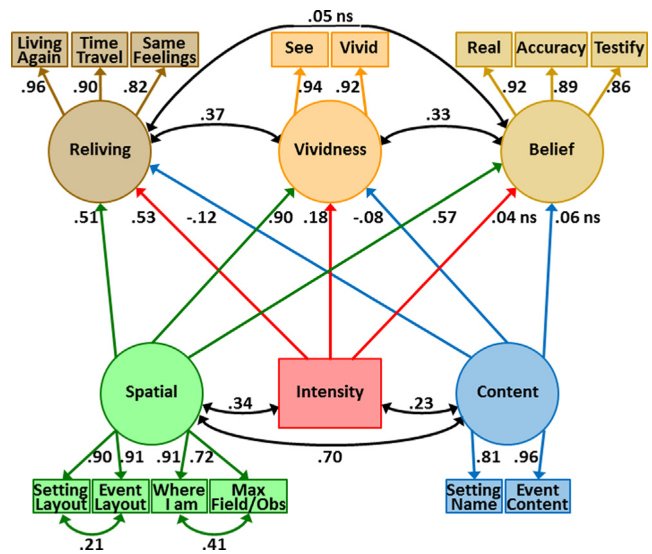

Fig. 1. Structural equation model predicting reliving, vividness, and belief. Maximum likelihood estimation used; parameter estimates shown are standardized based on background and outcome variables (STDYX). Non-significant pathways are noted. All other pathways significant at $p < 0.001$ except: reliving on content, $p = 0.007$; vividness on content, $p = 0.042$; setting layout with event layout, $p = 0.001$. Some pathways freely estimated but not shown; see Supplemental Table 4 for list of all estimated parameters.

"All Predictors."

Here, we examined the contribution of the spatial measure, which included perspective and layout questions, instead of just layout, while controlling for all other measured memory characteristics. The basic results did not change, though content no longer had a unique contribution in predicting belief. Adding more items to the layout measure to produce a more complete spatial measure had only minor effects on the correlations and multiple regressions and did not increase the reliability of the scale. However, it did increase the breadth of concepts integrated into it, which provides a measure of scene construction closer to the theory of event memory. Only spatial and emotional intensity predicted unique variance in reliving and vividness, and only spatial predicted unique variance in belief. Regardless of the other characteristics of a memory we included in the analyses, including scene content, scene construction accounted for a large proportion of the variance in a sense of reliving, vivid recollection, and belief in the accuracy of what one is remembering, supporting our first two hypotheses.

3.3. Summary

Study 1 tested and offered support for the first two of our three hypotheses. The first was that the degree to which a memory has a spatial layout will correlate with ratings of the phenomenological properties of reliving, vividness, and belief. The two-item layout spatial scale correlated.77 with reliving, 0.86 with vividness, and 0.60 with belief. The second hypothesis was that the degree of spatial organization of a memory will correlate with ratings of the phenomenological properties of reliving, vividness, and belief more highly than the degree to which it has visual or language contents not in a spatial organization. The clearest comparison here is between the two-item layout and the two-item content measures. For reliving, vividness, and belief, the beta weights for layout and content with just these two measures as predictors were 0.78 and −0.04, 0.85 and −0.01, and 0.48 and 0.16, respectively.

Study 1 provides the first support for the idea that mentally constructed scenes play a major role in the three key phenomenological reports that have been used to define autobiographical memory and do so more than the contents of memories independent of spatial organization. In doing so, it also supports our attempt to build a theory in which scenes are as central to autobiographical memory in a randomly selected population as we expected they would be based on their loss in neurological damage patients with autobiographical memory loss (Greenberg et al., 2005; Hassabis et al., 2007).

4. Study 2: Contrasting temporal versus scene specificity accounts of nonspecific memories

4.1. Rationale

Having supported our first two hypotheses, we added measures to examine nonspecific memories while otherwise keeping Study 2 a close replication of Study 1. Empirically, temporal and scene specificity are simple to tease apart because the temporal specificity classification does not ask about a scene. Thus, temporal and scene specificity provide two different categorizations of the data. Temporal specificity is based on clinical observations that have been tested. Scene specificity is based on neural and behavioral mechanisms but has not been tested with nonspecific memories.

In the consensus theory for many of the main clinical theorists researching nonspecific memories (Williams et al., 2007), functional avoidance reduces the negative affect associated with specific memories leading to the capture of retrieval at an abstract, conceptual level. Based on theories of autobiographical memory influenced by Conway and Pleydell-Pearce (2000), this functional avoidance leads to memories lacking in sensory and perceptual details. In contrast, this functional avoidance, which manifests itself as vague verbal descriptions replacing specific scenes with detailed perceptual images, can be seen as verbal capture preventing scene construction. Language and narrative processes impede visual processes (see Holmes, Blackwell, Burnett Heyes, Renner, & Raes, 2016). Thus, for the present theory, it is not the lack of sensory and perceptual content details of the memory that are important, but the lack of a scene that would locate the person recalling relative to the event and thereby increases reliving, vividness, and processes involved in increasing belief. We test this prediction by contrasting our layout and content measures. In addition, scene construction allows the integration of behavior with the neural processes supporting the theory, thereby allowing for potential future falsification of the theory from the neural level of analysis.

4.2. Methods

4.2.1. Participants

All 203 participants (72.9% female) recruited through Amazon Mechanical Turk (MTurk) were from the United States; they ranged in age from 18 to 74 ($M = 35.80$, $SD = 12.35$).

4.2.2. Measures

For each memory, three additional questions were added to the beginning of those used in Study 1 (see Table 1 for the questions and the first columns of Table 2 for the items that contributed to each composite measure). Two questions asked participants to rate how temporally specific their memories were on seven-point scales. A third question based on work by Williams (1996) asked participants to classify their memories as temporally specific in that they occurred within a single day or were merged or extended from a longer period. We used this question to create three measures: the number of the seven memories that occurred once, that were merged, or that were extended (e.g., Rubin et al., 2003).

4.2.3. Procedure

The procedure followed Study 1.

4.3. Results and discussion

Table 2 contains the descriptive statistics for each measure. Table 3 presents the correlations and regression equations. Five observations should be noted. First, the results for the measures that were common to both Studies 1 and 2 were similar, offering our first replication. Second, temporal specificity correlated with layout, perspective, spatial, and content 0.26, 0.24, 0.27, and 0.36, indicating that the spatial and content measures of event memory were correlated with the temporal-specificity measure, though not strongly enough to be the same concept. Third, in terms of our third hypothesis, the correlations among temporal specificity and the dependent variables of reliving, vividness, and belief were 0.09, 0.15 and 0.16; none of the 9 regression equations shown in Table 3 had significant beta-weights for the temporally specific measure. Thus, temporal specificity did not add predictive power in addition to the other measures of Study 2. Fourth, layout was a better predictor of reliving, vividness, and belief than content, which in the context of nonspecific memories implies that avoidance of scenes, rather than avoidance of sensory and perceptual details, is the mechanism implicated in reduced ratings of reliving, vividness, and belief. Fifth, the results of the Layout versus Content measure were similar whether both or only one of the measures of Layout versus Content was included.

We relied on participant ratings for the duration of the event because we used participant ratings for all our other measures and because the participants knew more about the duration than they would have included in a brief description. However, the standard measures of nonspecific memory in the clinical literature rely on an outside rater's judgments based on the participants' descriptions of their memories. To ensure that this difference did not affect our results, we had a trained rater, who was otherwise not involved in the study, rate whether memories were of events that occurred within a single day. The rater's scores correlated 0.69 with the participants' scores. Individual correlations among the rater's scores with reliving, vividness, and belief as well as with content, layout, and spatial did not differ significantly from the participants' (minimum $p = 0.10$, Steiger's Z, Steiger, 1980). A second rater's scoring of 20 (10%) of the participants memories correlated with the first rater 0.87.

The MTurk workers in the first two studies had a fairly wide range of ages, however as shown in Supplemental Tables 1 and 2, correlations with age were generally small, between -0.03 and 0.10 with all the other items we measured and their composite variables, with two exceptions. First, age correlated with how long ago their memories occurred between 0.13 and 0.32. Second, age correlates with belief and its three component scales of real, accuracy and testify between 0.10 and 0.24. Thus, older participants have memories that happened longer ago and that are believed more, with age being a significant predictor of belief in the multiple regression that included all predictors in Study 2.

4.4. Summary

Study 2 offers our first replication of the findings of Study 1, and our hypotheses were all supported. In particular, measures of scene construction correlated highly with reliving, vividness, and belief and correlated higher than measures of the contents. Measures of temporal specificity correlated moderately with layout, perspective, spatial, and content, but the correlations among temporal specificity measures and reliving, vividness, and belief were low and temporal specificity did not add predictive power in addition to the other measures in the study.

5. Study 3: Contrasting temporal versus scene specificity accounts of nonspecific memories in a university sample

Study 3 is a close replication of Study 2, with a university sample.

5.1. Methods

5.1.1. Participants

One-hundred and eighty undergraduates (65.60% female; ages 18 to 24, $M = 18.92$, $SD = 1.09$), recruited through the Duke University psychology participant pool, completed the online survey for course credit.

5.1.2. Procedure

The same survey was used as in Study 2. The only change was that we changed the cues used to elicit memories to those Heron et al. (2012) selected to encourage recall of nonspecific memories and to increase the generalizability of our results. The new cue words were *happy*, *bored*, *hopeless*, *excited*, *failure*, *lonely*, and *relaxed*.

5.2. Results and discussion

Table 2 contains the descriptive statistics for each measure. Table 3 includes the correlations and regression equations. As in Studies 1 and 2, higher layout while remembering predicted higher reliving, vividness, and belief in memory accuracy than did content, and spatial was the best overall predictor when all independent variables were entered. The results for temporal specificity also replicated findings from Study 2. Temporal specificity correlated with reliving, vividness, and belief 0.15, 0.25, and 0.25. However, none of the 9 regression equations in Table 3 had significant beta-weights for temporal specificity. Thus, as in Study 2, temporal specificity did not add to the other measures in the prediction of reliving, vividness, and belief in the accuracy of the memory. As in Study 2, temporal specificity correlated with layout, perspective, spatial, and content 0.28, 0.33, 0.32, and 0.37, indicating that temporally-specific memories had properties of constructed scenes, including their content. In addition, the results of the Layout versus Content measure were similar whether both or only one of the measures of Layout versus Content was included.

A rater's scoring of whether the memories were of events that occurred within a single day correlated 0.56 with the participants' scores. Individual correlations among the rater's scoring and the participants' scoring for reliving, vividness, and belief as well as with content, layout, and spatial did not differ significantly (for belief $p = 0.07$; minimum for others $p = 0.24$, Steiger's Z; Steiger, 1980). A second rater's scoring of 20 (10%) of the participants memories correlated with the first rater at 0.91.

5.3. Summary

Study 3 provided a replication of our earlier findings with a different subject population and cue words, which provides at least one replication for the test of each of our hypotheses.

6. Structural equation models

6.1. Studies 1, 2, and 3 combined

6.1.1. Analytical method

Unlike our regression analyses, structural equation modeling (SEM) analyses of our three predicted measures of reliving, vividness, and belief occur in tandem. Moreover, compared to simply averaging rating scales to produce measures as we have done so far, SEM also allows for the creation of latent variables, which more fully represent the constructs of interest (e.g., spatial, content, reliving).

We combined the data from all three studies by eliminating the temporal-specificity memory items that did not appear in Study 1 and, analyzing it in Section 6.1.2, before, we examined the nonspecific memory hypotheses using data from Studies 2 and 3 in Section 6.1.3. We used maximum likelihood estimation in MPlus 6.1. Fit was judged using the Comparative Fit Index (CFI), with values of 0.95 or higher indicating acceptable fit, and the root mean square error of approximation (RMSEA), with an upper limit of the 90% CI equal to or less than 0.08 indicating close fit and an upper limit equal to or less than 0.10 indicating moderate fit (see Hoyle, 2011). We report standardized estimates based on background and outcome variables (STDYX in MPlus). While we report chi-square measurement of model fit according to convention, we did not use it to determine fit.

We specified the tested model according to the 'all-predictors' regression equations shown in Table 3 for Study 1. Substantively motivated modifications were made to the model based upon the MPlus-generated modification indices.

6.1.2. Results

An initial model, with 84 free parameters, tested the predictive power of the spatial construct, content, and intensity on reliving, vividness, and belief, while controlling for the effects of valence, time ago, age, and gender. The model fit the data moderately well, χ^2 (120, $N = 586$) = 630.70; CFI: 0.944; RMSEA = 0.085, 90% CI: 0.079 – 0.092. Examination of the modification indices revealed two substantively motivated avenues for respecification: estimating the covariance between intensity and same feelings (MI = 83.18) and the covariance between age and time since the event (MI = 51.84). Same feelings queries the emotions that come with reliving; it is intuitive to correlate its residual with that of emotional intensity. The residuals for age and time ago were correlated because the older one is, the larger the range of potential times one can remember. The second iteration of the model freed the parameters between intensity and same feelings, and age and time ago. Fit improved, with both fit indices now indicating acceptable fit, χ^2 (119, $N = 586$) = 491.43; CFI: 0.959; RMSEA = 0.073, 90% CI: 0.066 – 0.080. We list the values of the 88 parameters estimated in this final model in Supplemental Table 5 and the model specification of variables of substantive interest, along with their parameters, in Fig. 1.

For vividness and belief, spatial information was the best predictor overall. For reliving, spatial information and emotional intensity had similar path coefficients. We conducted three separate Wald tests imposing equality constraints to test whether there were significant differences in predictive power between the spatial and content measures for the three latent constructs of interest (e.g., the paths from spatial to reliving and from content to reliving were constrained to be equal). Results indicated that the parameter estimate predicting reliving, vividness, and belief from spatial was larger than the parameter estimate from content; $\chi^2(1) = 53.37$, $\chi^2(1) = 160.04$, $\chi^2(1) = 21.59$, respectively, all $ps < 0.0001$. Thus, a high degree of spatial information is associated with reliving, vividness, and belief in the accuracy of memories over and above knowing the contents of an event, even though the covariance between these two latent predictors was quite high (0.70).

6.2. Temporal specificity measures from Studies 2 and 3 combined

We did not expect the temporal specificity measure to contribute to the SEM results because the temporal specificity construct did not add significant independent variance in the 12 regression analyses of Studies 2 and 3 (see Table 3) and had semi-squared partial correlations of 0.01 or smaller. Nonetheless, we conducted an SEM analysis not only to ensure that this was the case, but also to evaluate the relationships between the three measures of temporal specificity (not merged, single, and once) and the latent-variable constructs they are assumed to indicate. As with the SEM for all three studies, there was a good fit, χ^2 (167, $N = 389$) = 515.00; CFI: 0.951; RMSEA = 0.073, 90% CI: 0.066 – 0.080. As expected, the parameter estimates of the temporal specificity latent variable were all small and nonsignificant (p's > 0.18): −0.03 for reliving, −0.04 for vividness, and −0.01 for belief. All three estimates between the indicators and the temporal specificity latent variable were large (once 0.75, SE = 0.02; not merged 0.97, SE = 0.01; and single event 0.92; SE = 0.01; all $ps < 0.001$). Thus, the SEM model not only confirms the results from the regression analyses of Studies 2 and 3, but also shows the latent specific construct is supported by all three measures contributing to it.

7. General discussion

7.1. Summary

Event memory (Rubin & Umanath, 2015) is defined by the construction of a scene at recall. In this paper we restrict the use of the term to autobiographical memories. We confirmed three hypotheses about autobiographical memory from the theory of event memory in three studies, each with approximately 200 participants rating seven of their own autobiographical memories. We replicated the test of each hypothesis at least once. The hypotheses were that: (1) The degree to which a memory has a spatial layout will correlate with ratings of the phenomenological properties of reliving, vividness, and belief. (2) The degree to which the memory has a spatial layout will correlate with ratings of the phenomenological properties of reliving, vividness, and belief more highly than the degree to which it has visual or language contents not in a spatial organization. (3) The degree to which the memory has a spatial layout will correlate with ratings of the phenomenological properties of reliving, vividness, and belief more highly than the degree to which it has temporal specificity. In terms of nonspecific memory, the second hypothesis has the added implication that nonspecific memories reduce reliving, vividness, and belief because they limit scene information, not because they limit sensory and perceptual details as suggested in Williams et al. (2007). These three hypotheses and the implications of the second hypothesis for nonspecific memories had not been tested previously.

7.2. Theoretical implications

The phenomenological properties of a sense of reliving, vividness, and belief in the accuracy of autobiographical memories have long been studied as key to understanding the nature of autobiographical memory (e.g., Brewer, 1986, 1996; Tulving, 1983, 2002). Our results are a demonstration that measures of scene construction in populations without neural damage correlate with these phenomenological properties of autobiographical memory in a way that is consistent with extreme cases of scene construction and autobiographical memory being lost together in both hippocampal and visual ventral stream amnesias that are reported in the literature (for a review see, Rubin & Umanath, 2015). The theory of event memory predicts that the quality of scene construction should correlate with the phenomenological properties of reliving, belief, and vividness and do so more strongly than measures of the contents of the memory (Rubin & Umanath, 2015), but until the present work, there were no tests of the hypothesis. A failure to find the results we report would have been a serious challenge to the theory. Instead, the present findings support the neurocognitive theory of event memory.

A key assumption of the theory that led to this research was that the act of remembering the spatial layout of an autobiographical memory located the person recalling the scene in a particular place at recall, even if that was different from his or her place at encoding. Adding the two items that measured this location (i.e., the 'where I am' and 'maximum rating of field and observer' ratings) to the layout measure to produce the more general perspective measure had only minor effects on our results. However, it did produce a more complete spatial measure of scene construction that better represented the concepts in our theory.

Switching the description of nonspecific memories from a lack of temporal specificity to a lack of scene construction suggests that nonspecific memories can be understood with the general mechanism of scene construction rather than with the ability to name the location of the event or a temporal specificity conceptualization based on a within a day or similar period that is not used outside of the study of non-specific memories. The observation of systematic differences in autobiographical memory specificity in aging, future versus past memories, voluntary versus involuntary memories and clinical disorders suggests that scene construction may be an important factor in understanding these effects, In addition, if the observations made here replicate with diagnosed clinical populations, such a theoretical switch would suggest treatments of non-specific memories based on increasing scene construction and the sense of reliving, vividness, and belief in the memory that goes with it (e.g., Slofstra, Nauta, Holmes, & Bockting, 2016); current therapies that focus on increasing memory specificity may already inadvertently target this mechanism.

In the clinical literature, a habitual tendency to produce nonspecific memories is a behavior and a symptom called overgeneral memory. Under the current clinical definition, only a lack of temporal specificity would indicate overgeneral memory (Williams et al., 2007). However, the current theories used to understand and treat overgeneral memories have a broader conception into which scene specificity fits (Dalgleish & Werner-Seidler, 2014; Holmes et al., 2016; Williams et al., 2007). The current findings suggest that avoiding scenes, rather than avoiding sensory and perceptual details, as the consensus theory of overgeneral memory assumes (Williams et al., 2007), is the mechanism by which overgeneral memories function. Thus, the degree to which the spatial layout of a scene correlated with ratings of the phenomenological properties of reliving, vividness, and belief more highly than the degree to which the memory had contents, has an added interpretation for nonspecific memories. A lack of scene construction also could provide one mechanism for avoiding the detailed recall of events, which is consistent with current clinical theory. In terms of current practice, many therapies that attempt to stop the abstract ruminative pattern of thought that accompanies overgeneral memories use techniques that produce detailed, richer, embodied, or situated memories of events through techniques that involve scene construction (Holmes, et al., 2016; Raes, Williams, & Hermans, 2009; Watkins, 2015; Williams, 1996; Williams et al., 2007). Because such detailed, situated memories include scenes, these techniques have the effect of encouraging scene construction. Demonstrations of the usefulness of these therapies predate the 2015 Rubin and Umanath theory of event memory, but the role of scene construction as a mechanism, as well as its implications for therapy, have not been considered. Thus, although we know of no data on whether clinical overgeneral memories include scenes, the findings we produced here are relevant for the way overgeneral memories might be measured in the future.

At a more speculative level, the success of scene construction in accounting for the three phenomenological reports we used here in autobiographical memories suggests that it might also do the same for other classes of events, such as future events, fictional events, and events representations of other people's lives. The results also support the idea that measures of mental scene construction could be used instead of phenomenological reports to decide whether animals, children, and cognitively impaired adults whose phenomenological reports either cannot be obtained or cannot be trusted are exhibiting a similar form of autobiographical memory.

Perhaps the most important contribution of the paper is the integration and reinterpretation of a collection of findings that have accumulated over decades of careful study of autobiographical memory and its changes in neuropsychological and clinical disorders into a unified neurocognitive perspective. This occurs naturally because the theory of event memory accounts for disparate findings in a parsimonious fashion by using general behavioral and neural processes thought to account for a broad range of tasks that extend well beyond autobiographical memory (Rubin, 2006). For example, instead of leaving the phenomenological reports of a sense of reliving, vividness, and belief in the accuracy of autobiographical memories as isolated observations that have been central to understanding autobiographical memory, we hypothesized that scene construction would contribute to them above and beyond the contents of remembered events. For these phenomenological measures and for the dominant theories of non-specific memories, we provide clear results that sensory and perceptual details do not play as central a role as does the construction of scenes.

7.3. Limitations

The results are limited in several ways. We limited the many properties of autobiographical memories that have been studied to reduce the number of items per memory so that we could obtain multiple memories from each participant. This means that we have not examined other properties that could interact with the newly introduced measures of the spatial properties of the scene, such as narrative and senses other than vision. However, from the correlations in past studies of these measures with reliving, vividness, and belief, we expect that these properties will not affect the tests of our hypotheses or our basic conclusions. We tested undergraduates in one study and varied this only to the extent of using slightly older populations in two studies. In addition, we did not test nonspecific memory in a diagnosed clinical sample, though using a general population is common practice in studies of nonspecific and overgeneral memories (for reviews and examples see, Dalgleish et al., 2007; Heron et al., 2012). We hope future work will address these limitations. The main strength of these studies is in the clarity of the results in supporting three novel hypotheses, hypotheses that follow directly from the theory of event memory (Rubin & Umanath, 2015), but no other theories.

7.4. Conclusion

Phenomenological reports of reliving, vividness, and belief have long been defining features of autobiographical memory. Here, we replaced them with a neurocognitive theory of autobiographical memory based on mental scene construction (Rubin & Umanath, 2015). The theory provided an integration of existing behavioral, neuropsychological, and neuroimaging results, but lacked a direct test of its behavioral predictions about reliving, vividness, and belief. The three studies reported here showed that the layout of the remembered event, which is the hallmark of scene construction, correlated with reliving, vividness, and belief, and correlated with them more highly than the clarity of memory contents isolated from their spatial layout. The results also showed that spatial organization provided a mechanism for the nonspecific memories, which is consistent with many current therapies.

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Author contributions

D.C.R. conceived of the study. All authors contributed to the study design. S.U. and S.A.D. piloted and modified the procedures and study questionnaires. S.A.D. collected the data and conducted all statistical analyses. D.C.R. wrote the paper. All authors reviewed drafts, provided critical feedback, and approved the final manuscript.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cognition.2018.10.024.

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