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Properties of autobiographical memories are reliable and stable individual differences

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ABSTRACT

Autobiographical memory research typically focuses on individual memories with variability in individual participants' responses serving as error variance. Integrating individual-difference and experimental approaches demonstrated that properties of autobiographical memories are stable individual differences with stable patterns of correlations. In two sessions approximately one week apart, different cues were used to prompt seven autobiographical memories. Each memory was rated on 12 properties including visual imagery, emotional intensity, narrative coherence, reliving, and past rehearsals. In two studies with samples from different populations (*Ns* of 200 and 160), each property had a high reliability in both sessions (median $\alpha = .90$), and the mean of each property averaged over seven memories correlated highly with itself over sessions (median $r = .72$). Multiple regressions predicting three properties from Session 1 with the remaining nine properties of Session 2 and exploratory factor analyses yielded solutions consistent with expectations from studies of individual memories. Moreover, the correlation matrices of the 12 properties across studies and sessions were extremely similar. Thus, separate sessions, cues, samples, and properties provided generalizable data about individual differences in autobiographical memory. Practical, theoretical, and methodological implications include that individual differences in memory affect: life stories and narrative structure internal to events, stable clinical syndromes and symptoms, experimental results previously attributed to the properties of individual memories, and the confidence people have in the accuracy of their autobiographical and episodic memories.

1. Introduction

Stable individual differences exist for aspects of people's autobiographical memories. These include the extent to which autobiographical memories are central to one's identity and self-narrative (Berntsen & Rubin, 2006; Gehrt, Berntsen, Hoyle, & Rubin, 2018; Rubin, 2020a; Rubin, Berntsen, Deffler, & Brodar, 2019), the frequency of involuntary autobiographical memories (Berntsen, Rubin, & Salgado, 2015), the degree of their recollective experience (Berntsen, Hoyle, & Rubin, 2019), and scene recall (Rubin, 2020b online). These individual differences are consistent with a view of memory as an active, constructive process in which stable individual and cultural propensities can be observed (Bartlett, 1932; Neisser, 1967, 1976; Rubin, 1995; Rubin, 2006, 2012). Thus, individual differences can help bridge the long-standing separation of the individual-differences and experimental approaches, approaches that are both needed to understand behavior in situations where not all relevant variables can be randomly assigned (Cronbach, 1957). They are also consistent with chronic clinical disorders including posttraumatic stress disorder, anxiety disorders, and worry, which have aspects of past and potential future negative autobiographical memories as stable symptoms (e.g., Rubin, Dennis, & Beckham, 2011) and with the chronic nature of rumination (Del Palacio-Gonzalez, Berntsen, & Watson, 2017).

There is a fundamental theoretical reason to expect properties of single autobiographical memories to be strongly affected by individual differences. Psychology, philosophy, and neuroscience divide the mind and brain into basic systems including separate systems for language, emotion, and each of the senses (Rubin, 2006, 2012). Each system has its own functions, processes, structures, kinds of schemata, and types of errors that have been studied individually. Each system has a long intellectual and experimental history; most date back as far as the recorded history of speculation about the mind (e.g., the five senses, narrative, and emotion). Each can be supported by results from (a) neuroanatomy, (b) neuropsychology, (c) neuroimaging, (d) cognitive-

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experimental psychology, and (e) individual differences research. Knowledge from all five sources sharpens and constrains predictions regarding memory functions of all the basic systems. Moreover, each system is used for tasks other than memory, which provides additional information about them. The scientists who study the mind and the brain successfully even divide their journals and societies along these lines without much consideration of the other systems. Thus, it is reasonable to expect that neural structures and processes and the behavioral experience of people will vary within each of these systems somewhat independently of the other systems. Nonetheless, this expectation lacks solid empirical support.

To examine the stability of properties of autobiographical memories, 12 of the most commonly studied and theoretically important properties were selected. Seven of the 12 properties index basic systems that contribute to autobiographical memory: *emotion*,[1] three kinds of sensory imagery: *visual, auditory,* and *scene* imagery, and two kinds of narrative: *coherence* within an event and *centrality* to the life story. *Contents* is included as a second measure of scene organization. Three other properties are judgments made on the constructed memories: *reliving*, *vividness*, and *belief*. The remaining two properties are the cognitive process of *rehearsal* and the cognitive style or skill of *specific time*.

Here, in contrast to most prior research, the possibility that many commonly measured properties of individual autobiographical memories are also stable individual differences is examined. That is, the possibility that what researchers have been viewing as properties of individual memories are largely properties of the person recalling the individual memories modified in varying degrees by the event being recalled. This may be because different events support different degrees of a property (e.g., some events have more visual or emotional content), the current purpose of recalling and possibly retelling the event, the effort expended, and other factors. If more than one event is rated, the role of the specific recall and the individual difference on the rating can be assessed or experimentally manipulated. This would be similar to studying the effect of individual differences measures such as gender, working memory, or neuroticism in situations of varied stress, sleep deprivation, the traumatic nature of the event, learning strategies, or social support. To do this, seven event cues of scenarios with different content were used to cue memories in one session and approximately a week later the procedure was repeated with different cues in a second session. This design ensured that stability in the properties within each participant could not be attributed to similar content in the events rated or transient factors present within one session.

The patterns of correlations among these individual-differences measures were also examined. The properties are either aspects of the construction of autobiographical memories or its products. Thus, the task should determine how they are related to each other, and the variability in the means of the properties should provide enough variance to measure correlations among such individual differences. Studies of individual memories should provide guidance about the correlations of the properties measured as individual differences, if the properties of individual memories are effected by individual differences.

The general topic of stable individual differences in autobiographical memory has been of interest in the study of development, personality, and psychopathology (Burrow et al., 2014; Köber & Habermas, 2017; McAdams, 1995). However, in contrast to the theoretical expectations just reviewed, it has produced surprisingly little experimental research in the study of individual autobiographical memories. The only study with a design close to what is done here had undergraduates provided a brief title for 20 distinctive autobiographical memories (Rubin, Schrauf, & Greenberg, 2004). The undergraduates then recalled and rated the memories on scales measuring properties of autobiographical memory partly overlapping with the ones used here. Two weeks later they recalled and rated the events again. Although it produced encouraging results, it included only 30 undergraduates, which is a sample that would now be considered too small to detect effects reliably, early formulations of the properties of the memories that have since been modified, and memories participants selected to be memorable and distinctive enough to recall later rather than a more varied sample of memories. Moreover, it did not examine correlations among the measures, only the means of participants' ratings from the two sessions were correlated. However, in support of the design adopted here, the mean ratings of the memories of ten of the events from one session were correlated with the mean ratings of the memories of the other ten events from the other session to ensure that the correlations were not due to remembering and rating the same events. It made little difference whether the same or different events were averaged; once ten events were averaged, a stable estimate of each individual's ratings on the scales was reached with the median correlation of the individuals' average ratings on the scales of .90.

Indirect support that some properties of individual memories are stable individual differences comes from correlating the average ratings of various properties of autobiographical memories with participants' scores on standardized individual difference measures. For instance, Rubin, Schrauf, and Greenberg (2003) found that a measure of belief in the accuracy of the remembered events correlated -.33 with scores on the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) and -.30 with the Dissociative Experiences Scale (Bernstein & Putnam, 1986). A measure of belief also correlated .31 and .30 with the NEO domains (Costa Jr. & McCrae, 1992) of extraversion and openness to experience (Rubin & Siegler, 2004). And the rate at which the reported emotional intensity in memories decreases with time correlates with anxiety (Walker, Yancu, & Skowronski, 2014). In addition, averages of ratings of autobiographical memories varied in reasonable and replicable ways as a function of PTSD symptom severity and diagnosis (Rubin et al., 2011; Rubin, Boals, & Berntsen, 2008). This research is of practical interest because the most strongly recommended, evidence-based, behavioral therapies for PTSD directly address the thoughts and feelings related to the autobiographical memories of the traumatic event (Watkins, Sprang, & Rothbaum, 2018). Thus, individual-differences properties, similar to those measured here for *centrality*, *emotion*, and *rehearsal*, are at the heart of most behavioral psychotherapies.

With the exception of Rubin et al. (2004), the existing empirical support is from correlations among properties averaged over the same memories or from correlations with standardized individual-differences measures of personality, depression, dissociation, and PTSD. Theoretical support comes from noting that many of the properties are basic systems of cognition and autobiographical memory. However, direct, convincing, empirical evidence for this expectation is lacking. The first goal of the current paper is to provide such evidence by extending research to individual difference in larger, more diverse samples that meet current research standards with updated properties of autobiographical memory research. The second goal is to investigate, in an exploratory fashion, the correlations among the individual-differences properties. It is expected that they will correlate in similar ways as individual memories based on the claim that individual differences account for a substantial part of the correlations that exist among individual memories.

1.1. Justification of the choice of properties of autobiographical memories

As a set, the 12 properties in Table 1 measure key aspects of autobiographical memory, which have proven to be the among the most important conceptually and empirically in past research. As shown in Table1, each of the 12 properties are based on the average of two items. The first three properties are three classic phenomenological properties of autobiographical memories. In contrast to the component processes of

[1] The 12 properties that were rated and analyzed are placed in italics in the body of the paper to contrast them from the concepts that rely on these properties.

Table 1
The 24 rating scales and 14 cues for the autobiographical memories.

The 24 Rating Scales (Two per property)
Reliving
1. While remembering, it is as if I am reliving the event.
2. While remembering, it is as if I am mentally traveling back to the time the event occurred.
Vividness
1. My memory of the event is vivid.
2. My memory of the event has lots of details.
Belief
1. 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.
2. My memory of the event is an accurate reflection that a neutral observer would report.
Visual
1. While remembering the event, I can see it clearly in my mind.
2. My memory of the event has a clear, detailed visual image.
Scene
1. While remembering the event, I know where I am in relation to the individual things that I am remembering.
2. While remembering the event, I can describe the layout of things in my memory relative to each other.
Contents[1]
1. While remembering, I know the contents of the memory, but I cannot say where they are in relation to each other.
2. While remembering, I can imagine the individual details, but they do not all fit together as a coherent scene.
Specific time[1]
1. My memory of the event is for a specific moment in my life. It is not for a blending of several similar situations.
2. The event in my memory could be dated to one specific day in my past, even though I might not be able to date it.
Auditory
1. While remembering the event, I can hear it clearly in my mind.
2. My memory of the event has clear, detailed sounds.
Coherence[1]
1. My memory of the event is a good story or description.
2. My memory of the event comes to me a coherent and connected narrative.
Centrality[1]
1. My memory of the event has become a reference point for the way I understand myself and the world.
2. My memory of the event has become a part of my life story.
Rehearsal[1]
1. I often think about my memory of the event.
2. My memory of the event often enters my thoughts without me trying to remember it.
Emotion
1. While remembering the event, the emotions that I feel are extremely intense.
2. While remembering the event, I have a physical reaction (laugh, feel tense, sweaty, heart pounds).

The Seven Event Cues for Each Session		
	Session 1	Session 2
1.	from school or work	during travel or vacation
2.	with a close friend	with a family member
3.	that changed your life	at an important religious or national holiday
4.	that involved recreation or a hobby	that involved athletics or an outdoor activity
5.	that involved a mistake	that involved something you are proud of.
6.	that was unexpected or surprising	that was expected
7.	that involved purchasing something in a store	that involved purchasing something online

Notes. Rating are answered on a scale of 1 (not at all) to 7 (as if it were happening now) except for properties marked with a superscript 1, for which the label for 7 was changed to 'as much as any event'. The actual order of presentation was coherence 1, reliving 1, scene 1, rehearsal 1, belief 1, visual 1, centrality 1, vivid 1, specific time 1, auditory 1, contents 1, emotion 1, centrality 2, belief 2, auditory 2, contents 2, emotion 2, vivid 2, specific time 2, visual 2, coherence 2, scene 2, reliving 2, rehearsal 2.
Each cue listed above was preceded by the request 'please type a brief description of an event you remember'. The copyright for the scale is held by the author (©2019, Rubin). Permission is given to use the scale for research purposes. The full test with the items in the actual order used, each followed by their rating scale is provided in Supplemental Materials.

visual, scene, contents, auditory, and *emotion* used in the construction of autobiographical memories, the three phenomenological properties are judged on the already constructed memory. The three properties of a sense of *reliving*, *vividness*, and *belief* in the accuracy of autobiographical memories have been key in understanding autobiographical memory, both historically and in current research (e.g., Brewer, 1986; Fitzgerald & Broadbridge, 2013; Johnson, Foley, Suengas, & Raye, 1988; Rubin et al., 2003; Rubin & Siegler, 2004; Sutin & Robins, 2007). *Reliving* (e.g., autonoetic consciousness, mental time travel, recollection, remember versus know judgments) is a defining feature of autobiographical and episodic memory (Baddeley, 1992; Tulving, 1983, 2002). *Belief* in the occurrence and accuracy of an event helps to distinguish autobiographical memory from other types of memory and imagination and is a basis for reality monitoring (Brewer, 1996; De Brigard, 2017; Johnson et al., 1988). *Vividness* is a factor in determining whether memories are based on actual events and are relived or believed (Brewer, 1986, 1996).

Three properties are related to testing the concept of a scene: *scene, contents,* and *specific time* (Rubin & Umanath, 2015; Rubin, Deffler, & Umanath, 2019; Rubin, 2020b online). *Scene* has two items that are rated. The first item is whether the participant remembers the layout of things in the scene relative to each other. The second item is whether the person remembers the scene from a known location relative to the scene, which gives the participant a sense of where he or she is in relation to the scene. This is different from ratings of field (first person) versus observer (third person) perspective (Nigro & Neisser, 1983; Rice & Rubin, 2011), in which the location at recall is compared to the location at encoding.

Both the *contents* and the *specific time* properties are contrasts to the *scene* measure. The two *contents* ratings ask about knowing the contents even when their layout in the scene is not known. This separation of *scene* and *contents* occurs in many cases of amnesia (for a review see Rubin & Umanath, 2015) and is one basis for investigating the scene concept in our earlier work. Similarly, *specific time*, which is part of the original and continuously maintained definition of episodic memory (Tulving, 1972, 1983), is used to measure the specificity of events in neuropsychological and clinical tests (e.g., Kopelman, Wilson, & Baddeley, 1990; Williams et al., 2007). Although *specific time* is important for the definition of episodic memory and clinical measure, it is problematic as general measure of autobiographical memory for two reasons. First, although autobiographical memories seem like they are remembered from a single occurrence, there is strong evidence that they are constructed from many similar scenes and general semantic knowledge that endures beyond the event (e.g., Bartlett, 1932; Rubin, 2006; Rubin & Umanath, 2015). Second, the dating of events is not an inherent part of the memory but rather a distinct process (Friedman, 1993, 2004, 2005; Thompson, Skowronski, Larsen, & Betz, 1996). In empirical comparisons in two studies with different populations, we found that measures of reliving, vividness, and belief correlated highly with scene construction, whereas the correlations with measure of temporal specificity were low. Moreover, measures of scene construction added predictive power in addition to the other measures, whereas measures of temporal specificity did not (Rubin, Deffler, & Umanath, 2019). In the earlier work, we drew inferences based on measuring *contents* and *specific time* in the same memories, but here each is an individual-differences measure.

Visual measures the perceptual system most often studied in autobiographical memory research and the one with the largest effect on other properties of autobiographical memory. It is at the heart of the metaphor of the mind taking a picture of an event and doing so from a person's own eyes or another location and in the false memories than can derive from this metaphor (Brown & Kulik, 1977; Gary, Manning, Loftus, & Sherman, 1996; Hyman Jr. & Pentland, 1996; Robinson & Swanson, 1993; Rubin, 2006). However, much of what has been attributed to *visual* may be due to knowledge of *scene* and need not rely

on visual imagery (Tekcan et al., 2015).

When the *auditory* rating is based on heard language, it can measure a verbal description of the event. *Coherence* measures whether the memory itself represents an organized narrative, and *centrality* measures whether the memory is an important part of the life story and identity (Berntsen & Rubin, 2006; Rubin et al., 2016). Thus, the *auditory*, *coherence*, and *centrality* properties can all be considered as different aspects of language and narrative.

Rehearsal measures whether a memory enters one's thoughts voluntarily or involuntarily (Berntsen et al., 2015; Berntsen et al., 2019; Walker, Skowronski, Gibbons, Vogl, & Ritchie, 2009). It can, but need not, involve language (Hyman Jr. et al., 2015). Finally, *emotion* asks about the emotional intensity of the memories at the level of general feeling or through bodily reactions.

1.2. Design considerations

1.2.1. Using two sessions separated in time with different memories

In order to ensure that the 12 properties are stable individual differences measures, ratings from two sessions separated by approximately one week were used. This allowed each participant's ratings to vary with changes in mood and other factors that might artifactually increase the stability to be attributed to stable individual differences. In addition, autobiographical memories concerning different events were rated in each session to ensure that there was not overlap in the events rated (see Rubin et al., 2004 for a similar rationale). These extra precautions are not common; it is rare to have alternative forms of tests and to have them compared at a delay, except where the tests are of items that could clearly benefit from learning or practice. An added benefit of this strategy is that it provides a replication within the same participants that includes using different sessions with different materials.

1.2.2. Choice of the items and events for each property

Participants rated each property using two distinct items. This was done for three reasons. First, it allows different aspects of each property to be included, which provides more conceptual breadth to each property. For instance, as shown in Table 1, *reliving* had items, which included 'as if I am reliving the event' and 'as if I am traveling back to the time the event occurred.' *Vividness* had items, which included 'is vivid' and 'has lots of details.' *Belief* had items, which included 'really occurred in the way I remember it and that I have not imagined or fabricated anything that did not occur' and 'is an accurate reflection that a neutral observer would report.' Second, it increases reliability by increasing the number of items without increasing the time-consuming task of recalling more events. Third, having the two items widely separated in the order of items increases variety and therefore should increase the attention participants give to each item and to the task as a whole.

Based on our earlier work, seven event cues were chosen for each session to provide good stability in the average value of the measurement of rating scales (Rubin, 2014, 2020b; Rubin, Deffler, & Umanath, 2019; Rubin et al., 2004). The variability in the types of memories cued also ensured that any stability within the ratings of an individual participant would generalize across different memories and could not be attributed ratings of the same memories or even different memories with highly similar content. The event cues were chosen to be categories that were from non-identical but broadly similar classes of events as can be seen by comparing each row of Table 1. Some pairs were closely related such as 'with a close friend' and 'with a family member" whereas others are at opposite ends of a loosely defined continuum such as 'that was unexpected or surprising' and 'that was expected.' Thus, the event cues used provide a broad sample of memories without any clear underlying dimensions.

1.2.3. Choice of the sample size

As shown in Table 1, there were 2 items for each property and both were rated on 7 different events. Thus, for each participant, the individual-differences values for each of the 12 properties discussed in Section 1.1 was based on 14 ratings in each session. Based on the studies reviewed earlier in the introduction, these individual-differences values were expected to be reliable measures for each participant. This assumption was evaluated by measuring Cronbach's α (Cronbach, 1951) for each property in each session. Differences between the means across sessions are not of theoretical interest because the sessions were identical except for unknown and uncontrolled natural variation; whereas the correlations across sessions are. For a true population r of .6, which is a reasonable estimate based on the studies cited earlier, there would be a 90% confidence interval of $r \pm 0.1$ with 150 participants and a 95% confidence interval with 202 participants (Schönbrodt & Perugini, 2013, 2018). A sample size of 200 participants was chosen.

2. Study 1: The stability of properties of autobiographical memories in MTurk workers

2.1. Participants

The 200 Amazon Mechanical Turk workers included in the analysis of the study (109 female, 90 male; mean age 37.72, range 19 to 70) were paid four dollars for each session. To be included, the 200 participants had to complete both sessions, spend a minimum of 8 min on each, be native English speakers, pass three attention checks, and record that they completed the study on a computer or tablet. The attention checks, which were mixed in with the regular items, were of the form "please answer two to this item." In addition, all 14 memories were required to be descriptions of events as opposed to responses that could be computer generated as semantically related to the event cue (e.g., 'formal education takes place in schools' to the request for an event 'from school or work').

2.2. Materials and procedure

The study was administered through TurkPrime (Litman, Robinson, & Abberbock, 2017) to MTurk workers on the Qualtrics survey platform. Each participant was first asked to fill in a consent form and answer demographic questions. The second session was delayed by at least a week (range 7 to 25 days, median 8 days). Two rating scales were used for each of the 12 properties of autobiographical memories, as shown in Table 1.

For the first event in Session 1, participants were asked to "Please type a brief description of an event you remember from school or work. The description should allow us to have a sense of the specific event without revealing anything you do not wish to reveal." Immediately after providing a description, the event was rated on the 24 items in Table 1. This procedure was repeated six more times with the phrase "during travel or vacation" replaced, in sequence, by each of the remaining event cues listed in Table 1. The identical procedure was repeated for Session 2 with the set of different event cues listed in Table 1 for Session 2. Thus, for the second session the description of the first event was changed to "during travel or vacation." The single pseudo-random order of the items, which was devised to separate items from similar properties, is provided in the note for Table 1. A single order was used, as in common in individual-differences studies and tests, to avoid the extra variance randomization would introduce, as the analyses are based on variance in individual participants means on the 12 properties. To provide a clearer sense of the participants' task, a full listing of the 24 items in the order used for each event followed by the scale on which it was rated is included in the Supplemental Materials.

2.3. Results

2.3.1. Basic statistics

The top section of Table 2 presents the means, standard deviations, and reliabilities of the twelve properties of autobiographical memory for

Table 2
Means, standard deviations, reliabilities, and correlations between sessions measuring the stability of twelve properties of autobiographical memory for Studies 1 and 2.

Study 1								
	Session 1			Session 2			Correlations	
Ratings	Mean	SD	α	Mean	SD	α	r_{12}	Corrected
Reliving	5.52	0.96	.90	5.32	1.10	.92	.79	.87
Vividness	5.30	0.92	.87	5.13	1.06	.90	.75	.85
Belief	5.80	0.87	.90	5.84	0.90	.92	.75	.82
Visual	5.75	0.84	.90	5.57	0.92	.90	.77	.86
Scene	5.59	0.89	.90	5.43	0.99	.91	.81	.90
Contents	3.27	1.25	.90	3.33	1.36	.92	.67	.74
Specific time	5.58	0.97	.86	5.57	1.04	.87	.61	.71
Auditory	5.18	1.14	.91	4.95	1.27	.92	.80	.87
Coherence	5.56	0.87	.87	5.41	0.97	.89	.78	.89
Centrality	4.10	1.26	.90	3.97	1.40	.92	.81	.89
Rehearsal	4.11	1.24	.90	3.93	1.33	.91	.78	.86
Emotion	4.11	1.31	.92	3.97	1.37	.93	.78	.84

Study 2								
	Session 1			Session 2			Correlations	
Ratings	Mean	SD	α	Mean	SD	α	r_{12}	Corrected
Reliving	4.97	0.99	.88	4.64	1.11	.91	.72	.80
Vividness	4.67	0.91	.84	4.38	0.96	.86	.74	.87
Belief	5.27	0.84	.85	5.24	0.88	.87	.62	.72
Visual	5.27	0.83	.85	4.91	0.94	.88	.70	.81
Scene	5.09	0.88	.85	4.74	0.94	.86	.68	.80
Contents	3.45	0.92	.84	3.59	0.93	.86	.60	.71
Specifictime	5.54	0.96	.82	5.59	0.95	.81	.54	.66
Auditory	4.08	1.22	.90	3.73	1.22	.90	.73	.81
Coherence	5.01	0.86	.82	4.73	0.91	.85	.69	.83
Centrality	3.06	0.94	.82	2.82	1.15	.89	.63	.74
Rehearsal	3.08	0.93	.82	2.70	1.07	.90	.67	.78
Emotion	3.47	1.13	.88	3.12	1.20	.91	.70	.78

Notes: For Study 1 $n = 200$. For Study 2, $n = 160$. All ps for correlations $<.0001$, α = Cronbach's alpha. Corrected is a correction for attenuation of $r_{12} / \sqrt{(\alpha_1 \alpha_2)}$, where the subscripts refer to the sessions.

each session separately. Calculations are based on the average of the two ratings made on each property. The reliabilities for the individual sessions measured by Cronbach's α were high (Session 1: median .90, range .86 to .92; Session 2: median .92, range .87 to .93). The means ranged from 3.27 to 5.80 with a mean of 4.98 on a minimum 1 ('not at all'), a midpoint of 4, and a maximum of 7 ('as if it were happening now' or 'as much as any event'). The standard deviations ranged from 0.84 to 1.31 with a mean of 1.04, which provided enough variability for the correlational analyses. In addition, Table 2 presents the correlations of the properties between the two sessions and the correlations corrected for attenuation (i.e., the correlation divided by the geometric mean of the reliabilities in the two sessions). The correction for attenuation is included to normalize the correlations so that they are not as affected by the reliabilities of their properties and to approximate what the correlations would be if the properties approached reliabilities of 1.00. There is considerable stability across two sessions with a delay of a week or more and with values obtained using memories cued by seven different events in each session (rs: median .78, range .61 to .81; rs corrected for attenuation: median .86, range .71 to .90).

2.3.2. The relation among the 12 properties as measured by multiple regressions

In the following analyses, dependent and independent variables are based on the values of properties from different events from sessions on different days. In particular, the three phenomenological variables of *reliving, vividness*, and *belief* from Session 1, which are measures of fully formed autobiographical memories, are the dependent measures and the remaining nine properties from Session 2, which are aspects of the construction of those memories, are the independent measures. Thus, the three measures of fully formed memories were predicted by measures that contribute to the construction and maintenance of autobiographical memories from a different session which were cued by different events. The analyses were similar to multiple regressions performed in earlier studies on individual memories (e.g., Rubin et al., 2003; Rubin, Schrauf, Gulgoz, & Naka, 2007; Rubin & Siegler, 2004); whereas, here they are performed on individual-differences measures. Another change is that the variables used here are all based on two items, whereas variables in the earlier studies were based on single items. Thus, the analyses are exploratory beyond predicting that the results should be broadly consistent with results from the earlier studies that analyzed individual memories rather than individual differences.

Properties that entered and remained in the regression analyses at the $p < .05$ level are reported. However, when all variables entered into the regressions, little changed except that the standardized regression weights decreased as nonsignificant predictors accounted for variance. The standardized regressions weights are each followed by 1 to 4 asterisks indicating the weights had p-levels <0.05, $< 0.01 < 0.001$, and $<$ 0.0001, respectively. With the variables listed in the order used in the tables, the equations were: *reliving* = .27* *visual* + .35** *scene* + .22**** *centrality*, $R^2 = .52$; *vividness* = .37*** *scene* + .27** *coherence* + .23**** *centrality*, $R^2 = 0.55$; and *belief* = 0.47**** *scene* + .25**** *specific time* -.20*** *contents*, $R^2 = .48$. In general terms, *reliving* tends to be accounted for by visual properties. *Vividness* tends to be accounted for by visual properties and coherence. *Belief* tends to be accounted for by visual properties. In addition, knowing that events can be dated and are limited to only one occurrence increased *belief*; whereas, knowing the contents of events but not how they are located relative to each other decreased *belief*. Similar results have been observed for individual events and single-item measures (e.g., Rubin et al., 2003; Talarico & Rubin, 2003).

2.3.3. The relation among the 12 properties as measured by correlations

The 66 correlations among the 12 properties (i.e., 12 * 11 /2) in Session 1 and 2 are shown in the top and bottom sections of Table 3. The correlations are generally high but vary widely in magnitude. In Session 1, the median, minimum and maximum correlations were .49, −.33, and .88. In Session 2, they were .55, −.11 and .90. Thus, the substantial median values could not have been caused by individual participants having a tendency to rate all of their properties as high or low independent of the properties being rated.

On casual examination, the correlation matrices from the two sessions appear similar. If any cell in the top, Session 1, matrix and the same cell in the bottom, Session 2, matrix are compared, the values are similar. In more quantitative terms, the mean of the absolute values of the difference between each of the 66 cells is .05 (median = .04, range .00 to .19).

A correlation among the 66 cells provides a simple direct way to describe the similarity of the values between the matrices. It would not be affected if all the correlations in one matrix were smaller by an additive or multiplicative factor due to less reliability in one session. To do this, the matrices in Table 3 were each converted to a single row of 66 correlations and the rows from the two sessions were correlated. This analysis is descriptive because the 66 correlations in each matrix are not independent observations. Nonetheless, the correlation of .98 shows remarkable stability in the pattern of correlations over sessions. This result is consistent with autobiographical memories being constructed with stable relations among processes, even when there is variability in individuals' mean abilities in the processes.

2.3.4. The relation among the 12 properties as measured by factor analysis

A factor analysis investigated the relationships among the individual differences in the properties of autobiographical memories and ensured that the individual properties correlated as expected based on prior work. Unlike the multiple regressions in which nominal predictor variables 'compete' in accounting for variance in nominal dependent variables, factor analysis provides a description of the pattern of correlations among a set of properties. Because we did not have a priori predictions about the factor structure, exploratory factor analysis was selected as the analytic technique. For 12 continuous properties with the observed communality, the sample size is sufficient (MacCallum, Widaman, Zhang, & Hong, 1999; Mundform & Pearson, 2010). Principal axes extraction with squared multiple correlations on the diagonal was conducted using SAS 9.4. Moreover, given the high similarity between the correlation matrices in the two sessions of Study 1, the correlation matrix among the mean for each property from all 14 events of Sessions 1 and 2 combined was analyzed.

The first five eigenvalues were 6.81, 2.17, 0.34, 0.10, and 0.02. There was no interpretable third dimension. Therefore, the two-dimensional solution shown in the left panel of Fig. 1 was chosen for interpretation. The inter-factor correlation was .45. The items that load highest on the first factor include *reliving, vividness, belief, visual, scene,* and *auditory*; for the second factor they include *centrality, rehearsal*, and *emotion*.

2.4. Discussion

Study 1 demonstrated reliable and stable individual differences in the mean values of 12 theoretically important properties of autobiographical memory. When these properties are considered as measures of individual memories rather than of individual people, they are among the most commonly studied in research on autobiographical memory. The reliabilities of the 12 properties for the two sessions measured by Cronbach's α were high, as was the stability over session. The use of two sessions with a delay between them eliminated the possibility of short-term changes in mood or other factors adding to the stability of the mean values of the properties. Moreover, the use of different cues in the two sessions ensured different memories would be rated so that the stability in the means was not inflated by rating the same memories.

2.4.1. Multiple regressions

Specific time, which did not correlate highly with many variables,

Table 3
Correlations among the properties of autobiographical memory for each session of Study 1.

Study 1		Season 1										
		1	2	3	4	5	6	7	8	9	10	11
1	Reliving											
2	Vividness	.77										
3	Belief	.59	.64									
4	Visual	.81	.83	.75								
5	Scene	.77	.82	.76	.89							
6	Contents	.00	−.08	−.31	−.21	−.23						
7	Specific time	.38	.35	.61	.49	.45	−.24					
8	Auditory	.66	.76	.49	.73	.72	.01	.16				
9	Coherence	.73	.81	.71	.84	.87	−.20	.42	.70			
10	Centrality	.54	.56	.18	.41	.40	.33	.00	.55	.45		
11	Rehearsal	.50	.53	.16	.35	.38	.36	−.03	.60	.40	.83	
12	Emotion	.51	.51	.14	.32	.35	.35	−.03	.53	.37	.72	.83

Study 1		Season 2										
		1	2	3	4	5	6	7	8	9	10	11
1	Reliving											
2	Vividness	.83										
3	Belief	.63	.64									
4	Visual	.84	.87	.74								
5	Scene	.77	.85	.75	.90							
6	Contents	−.07	−.08	−.31	−.22	−.28						
7	Specific time	.32	.35	.62	.43	.43	−.10					
8	Auditory	.75	.79	.49	.79	.73	−.02	.15				
9	Coherence	.75	.85	.70	.83	.87	−.21	.39	.71			
10	Centrality	.56	.59	.23	.45	.40	.23	.12	.56	.42		
11	Rehearsal	.63	.68	.24	.53	.49	.22	.06	.70	.51	.84	
12	Emotion	.60	.65	.23	.48	.45	.28	.05	.63	.45	.77	.87

Notes. Study 1 had 200 participants. The minimum correlation needed for the $p < .05$, .01, .001, and .0001 are .14, .19, .24, and .28, respectively

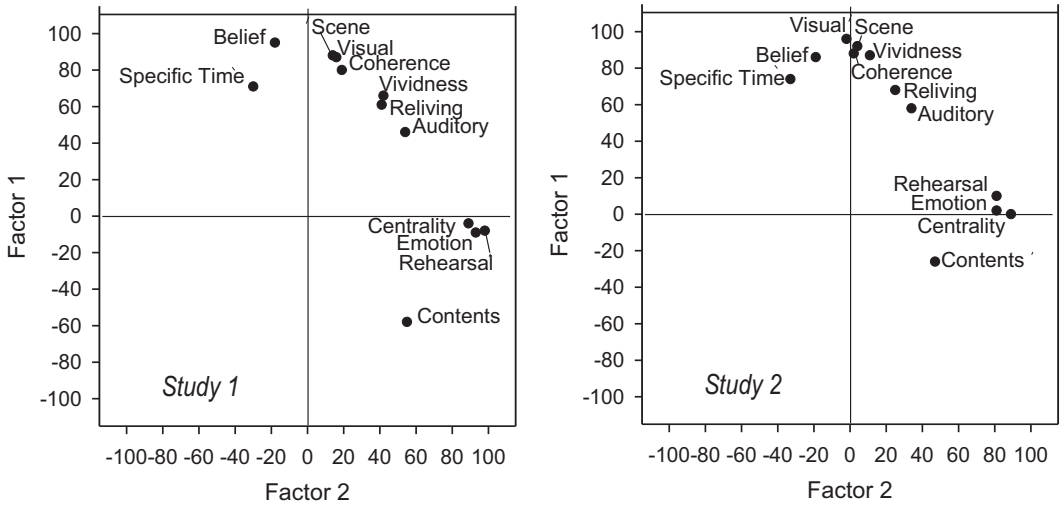

Fig. 1. Factor analyses for Studies 1 and 2. For Study 1 $n = 200$; for Study 2, $n = 160$.

entered into the equation for *belief* with a positive weight, whereas *contents* entered with a negative weight. Rating an event as having occurred on a single day that could be dated is associated with increased *belief*. Knowing its contents but not knowing how the contents fit into a coherent *scene* is associated with decreased *belief*. *Contents* and *specific times* did not enter into the regressions for *reliving* and *vividness*, whereas *scene* entered into all three regressions. These findings are consistent with earlier work where individual memories were studied (Rubin, Deffler, & Umanath, 2019).

2.4.2. The high stability of correlations among properties

The cell-by-cell correlation of 0.98 is so high that it should be considered carefully. The distributions of the 66 cells could be extreme, with a few outliers producing the high correlations. However, this is not the case here as can be seen in the 66 correlations in Table 3 and in a different form in the Supplemental Materials where cell-by-cell differences are given. Moreover, it is hard to see how any artifact could result in a correlation nearly as large as the one reported here, and that is what is needed to support the observation that the pattern of relations among the 12 properties is extremely stable over sessions. It needs to be stressed that this extremely high correlation is not a measure of the stability of the 12 properties over sessions, which has a median of .86. Rather, it measures the correlation of the 66 correlations among those 12 properties. Thus, the extremely high correlation poses the question, to be addressed in Sections 4 and 5, as why such similarity exists in the way individual-differences properties combine to produce autobiographical memories.

2.4.3. Factor analysis

In descriptive terms based on the plotted factor loadings, two groups of properties appear to cluster with *contents* and *specific time*, which had lower correlations with most other variables, being somewhat out of the clusters. The larger cluster includes *reliving, vividness, belief, visual, scene, auditory* and *coherence*. These are the three phenomenological properties of fully constructed memories that have been historically important in defining autobiographical memory, the three measures of component perceptual systems, and a measure of the internal coherence of the memories. The small cluster included *centrality, rehearsal*, and *emotion*. These are all properties related to processes that measure the importance of events and a grouping consistent with existing theory (Habermas, 2018). Unlike the correlations and the multiple regressions, there is no comparison factor analysis of these properties based on either individual differences or individual memories. Because there were no individual differences results on which to base clear hypotheses, the factor analysis was exploratory and descriptive with no statistical tests made for the descriptions of the factors obtained. Moreover, the conclusions of any factor analysis depends on the particular measures on which it is based. The primary goal of the selection of properties was not to assemble a complete set of properties central to autobiographical memory but rather the most important and commonly used ones. Thus, the results cannot be the basis of a claim about the structure of autobiographical memory in general.

3. Study 2: The stability of properties of autobiographical memories in undergraduates

3.1. Participants

The 160 Duke undergraduates (99 female, 60 male; mean age 19.20, range 18 to 21) took part in Study 2 for course credit. In order to be included in the study, the participants had to complete both sessions spending a minimum of 8 min on each, pass three attention checks, and record that they completed the study on a computer or tablet. In addition, all 14 memories required descriptions, which had to be events as opposed to responses that could be computer generated as semantically related to the event cue.

3.2. Materials and procedure

The study was administered on the Qualtrics survey platform. Each participant was first asked to fill in a consent form and answer demographic questions. The second session was delayed by at least 4 days (range 4 to 61 days, median 9 days).

3.3. Results

3.3.1. Measuring stability

The bottom section of Table 2 presents the means, standard deviations, and internal consistencies of the 12 properties of autobiographical memory for each session. The reliabilities of the 12 properties, as measured by Cronbach's α, were high (Session 1: median .85, range .82 to .90; Session 2: median .88, range .81 to .91). The means ranged from 3.06 to 5.54 with a mean of 4.41, which is 0.48 lower than Study 1. The standard deviations ranged from .83 to 1.22 with a mean of .95, which are also slightly lower than Study 1, but indicate enough variability for correlational analyses. In addition, Table 2 presents the correlations of the properties between sessions and the correlations corrected for attenuation. There is considerable stability across two

sessions with a delay of a week or more and with values obtained using memories cued by seven different events in each session (*r*s: median .68, range .54 to .74; *r*s corrected for attenuation: median .79, range .66 to .87).

Unlike the MTurk workers in Study 1, the undergraduates in Study 2 could complete the two sessions over the course of a semester, resulting in a wide range of times between the sessions. This variability allowed the stability of the ratings over time to be examined. The 160 participants were divided into four groups of roughly equal numbers based on each participant's time delays between sessions. To do this, the participants were rank ordered in terms of their delay from 4 to 64 days and sorted into the four groups. There were 42, 36, 43, and 39 participants in the four groups providing enough participants in each group for reasonably reliable correlations. The median delays of the groups were 5, 7, 10, and 25 days (ranges of 4 to 5, 6 to 8, 9 to 14, and 15 to 61 days). Fig. 2 shows the stability in these properties across time, supporting the claim of stable individual differences.

3.3.2. The relation among the 12 properties as tested by multiple regressions

The three phenomenological properties of *reliving, vividness*, and *belief* from Session 1 were predicted by the remaining nine properties from Session 2. Properties that entered and remained at the $p < .05$ level are reported. However, when all variables entered into the regressions, little changed except that the standardized regression weights decreased as nonsignificant predictors accounted for some variance. The standardized regressions weights, with variables listed in the order used in the tables, are: *reliving* = .42**** *visual* + .23** *auditory*, $R^2 = .36$; *vividness* = .41**** *visual* + .27** *coherence*, $R^2 = .43$; and *belief* = .32**** *scene* + .27** *specific time*, $R^2 = .27$. The results are generally consistent with Study 1.

3.3.3. The relation among the 12 properties as measured by correlations

The 66 correlations among the 12 properties (i.e., 12 * 11 / 2) in Session 1 and 2 are shown in the top and bottom sections of Table 4. The mean of the absolute values of the difference between each of the 66 cells is .07 (median = .06, range .00 to .21). The correlations are generally high but vary widely in magnitude. In Session 1, the median, minimum and maximum correlations were .39, -.16 and .86. In Session 2, they were .48, -.09 and 0.91. A cell-by-cell correlation of the 66 correlations from each session yielded an *r* of 0.96. This replication of Study 1 shows remarkable stability over sessions.

3.3.4. The relation among the 12 properties as measured by factor analysis

The analysis was identical to that in Study 1. The first five eigenvalues were 6.14, 1.99, 0.42, 0.14, and 0.03. There was no interpretable third dimension. The two-dimensional solution is shown in the right panel of Fig. 1. The inter-factor correlation was .39. The statistical results and the plot of the factor pattern shown in Fig. 1 were similar to those of Study 1, providing a replication.

3.4. Discussion

Study 2 replicated the findings of Study 1 using a sample of undergraduates rather than MTurk workers and providing a wider range of delay between the two sessions. The range of delays between sessions demonstrated that there was little drop in the stability from one week to one month. Reliable and stable individual differences in the mean values of 12 theoretically important properties of autobiographical memory were demonstrated. The correlations among the mean values were also stable over session, indicating that the relations among the 12 properties did not change. A more detailed discussion follows when the two studies are compared in the general discussion.

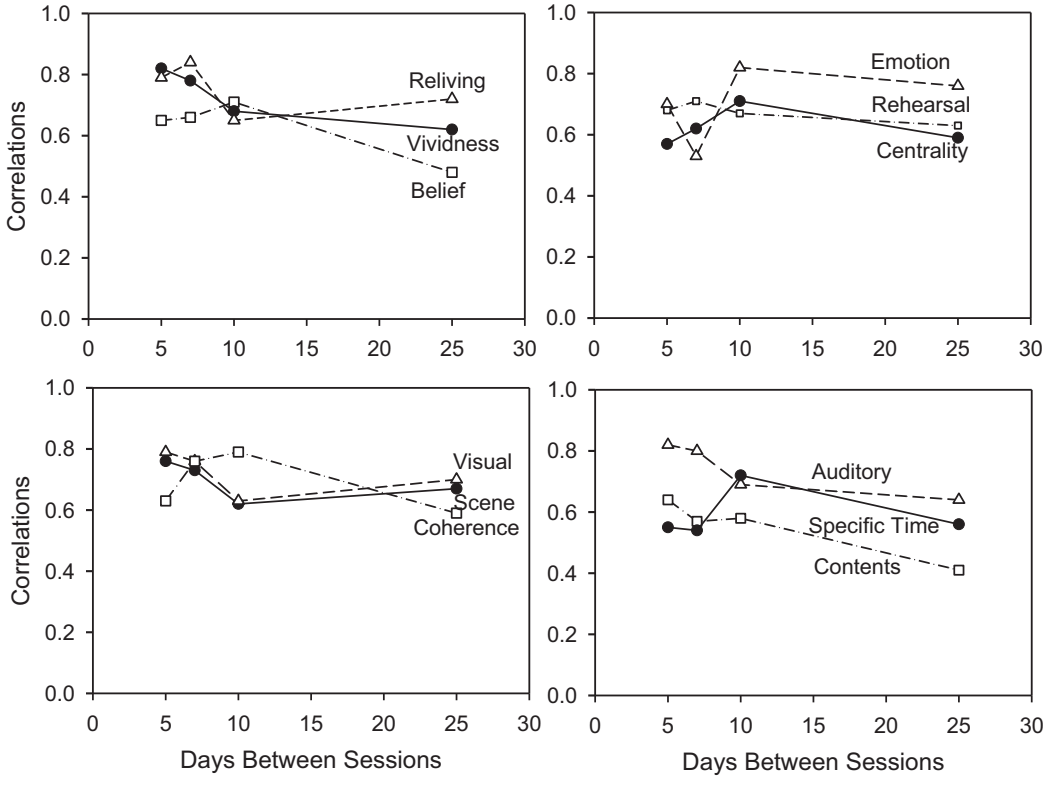

Fig. 2. Correlations between Session 1 and 2 of Study 2 as a function of the time between sessions. The 160 participants were divided into four groups with similar delays.

Table 4
Correlations among the properties of autobiographical memory for each session of Study 2.

Study 2		Season 1										
		1	2	3	4	5	6	7	8	9	10	11
1	Reliving											
2	Vividness	.73										
3	Belief	.49	.62									
4	Visual	.75	.85	.73								
5	Scene	.68	.83	.69	.86							
6	Contents	.03	−.09	−.12	−.09	−.10						
7	Specific time	.38	.49	.68	.62	.58	−.08					
8	Auditory	.59	.67	.41	.64	.65	.00	.23				
9	Coherence	.66	.80	.69	.79	.79	−.17	.54	.58			
10	Centrality	.36	.29	.11	.23	.26	.32	.09	.33	.29		
11	Rehearsal	.41	.29	.12	.22	.27	.38	.06	.39	.27	.77	
12	Emotion	.39	.35	.13	.29	.26	.29	.05	.43	.25	.59	.63

Study 2		Season 2										
		1	2	3	4	5	6	7	8	9	10	11
1	Reliving											
2	Vividness	.74										
3	Belief	.57	.64									
4	Visual	.76	.87	.67								
5	Scene	.72	.86	.66	.91							
6	Contents	.02	.04	−.10	.02	−.02						
7	Specific time	.34	.41	.65	.52	.53	−.08					
8	Auditory	.67	.71	.48	.66	.68	.03	.18				
9	Coherence	.72	.84	.68	.81	.79	−.04	.51	.62			
10	Centrality	.49	.49	.29	.38	.48	.17	.13	.51	.45		
11	Rehearsal	.42	.42	.19	.33	.42	.28	.04	.52	.36	.83	
12	Emotion	.48	.41	.15	.31	.37	.29	.01	.51	.34	.70	.75

Notes. Study 2 had 160 participants. The minimum correlation needed for the $p < .05$, .01, .001, and .0001 are .16, .21, .26, and .31, respectively.

4. Analysis of the stability of the correlation matrices across studies and sessions

The correlations between the 66 correlations in each session have the remarkably high values of .98 and .96 in the two studies. Having demonstrated in each study separately that these correlations cannot be attributed to any of artifacts considered, the analyses in this section are an attempt to probe these correlations further.

The analyses to this point have all been within participants in the same study, with comparisons across studies reported as replications. The correlations among the 12 properties are governed by the requirements of the task of recalling autobiographical memories as well as by individual differences. If the requirements of the task are the major reason for the high correlations, then there also should be considerable stability in the correlations across studies using different participants. That is, up to now the analyses were within subjects as is required for individual-differences research. Here, they switch to between-subject analyses comparing the correlation matrices across studies that have different participants. To examine this possibility, all four sessions were compared directly. There are four between-study comparisons to make using the same analyses as were performed within studies; in particular, measuring the differences in 66 means of the cells of pairs of matrices and measuring the correlations between the 66 cells. These are the four comparisons between both Study 1 sessions and both Study 2 sessions. These can be compared to the two within-subjects analyses already reported.

The between-study means of the absolute values of the difference between each of the 66 cells between Study 1 Session 1 and Study 2 Sessions 1 and 2 are .09 (median = .08, range .00 to .27) and .06 (median = 0.04, range 0.00 to 0.23). Between Study 1 Session 2 and Study 2 Sessions 1 and 2 they are .13 (median = .12, range .00 to h.39) and .09 (median = .07, range .00 to .26). For comparison, the within-study difference in means of the absolute values of the difference between each of the 66 cells of Study 1 Sessions 1 and 2 and between Study 2 Sessions 1 and 2 are .05 (median = .04, range .00 to .19) and .07 (median = .06, range .00 to .21). Thus, the between-study mean differences are numerically larger than the within study differences, but still fairly similar.

The cross-study correlations between Study 1 Session 1 and Study 2 Sessions 1 and 2 are .95 and .98. The cross-study correlations between Study 1 Session 2 and Study 2 Sessions 1 and 2 are .91 and .95. For comparison, the within-study correlations between Study 1 Sessions 1 and 2 and Study 2 Sessions 1 and 2 are .98 and .96. Again, the between-study and within-study values are not very different.

Comparisons across studies can be problematic, especially when they produce difference. Nonetheless, from these analyses, there appears to be at most minimal increases in the cross- versus the within-study differences. This implies that more than the particular participants sampled have an effect on the similar pattern of correlations observed in all four correlations matrices. The Supplemental Materials present the cell-by-cell difference for all six comparisons and Section 5 suggests reasons for the constraints introduced by the task of recalling well-formed autobiographical memories.

5. General discussion

The two studies conducted here provide clear, unambiguous, theoretically and practically important findings. Findings were replicated across the two studies, which sampled from different populations. Combined, the analyses demonstrate in one sample of participants, and replicate in another sample, highly reliable and stable individual differences in 12 theoretically important properties of autobiographical memory. The mean values of the 12 properties, which would be the values reported as individual differences, are reliable and stable over time. In addition, the pattern of correlations among the mean values are stable over time and over different samples of individuals. This pattern indicates that the relations among the 12 properties were similar. Moreover, with the exception of the recently introduced measures of *scene and contents*, when considered as measures of individual memories rather than of people, these 12 properties are among the most commonly

studied in research on autobiographical memory.

As can be seen in Tables 3 and 4 the individual properties in both sessions of both studies have correlations that vary widely. The minimum, median, and maximum correlations over the two studies combined are −.22, .52, and .89. Moreover, the correlations among both studies and sessions have similar pattern of correlations. This descriptive, qualitative observation is supported in more formal statistical ways by the similarity in the two studies of the correlations among the individual cells of these matrices, the multiple regression analyses, and the factor analyses.

5.1. Scale reliability and the stability of means over sessions

The reliabilities of the 12 properties for the four individual sessions measured by Cronbach's α were high varying from .81 to .93. There was also considerable stability in all 12 properties with seven different memories used to obtain a mean value in each session and the delays between sessions ranging from one week to one month. For both studies, the between-session correlations ranged from 0.54 to .81, which when corrected for attenuation were .66 to .90. Dividing the Study 2 participants, who had a broader distribution of delays, into four groups based on their delays indicated stability did not drop detectably from five days to a month.

5.2. Multiple regressions

Multiple regressions were examined in which the three properties of *reliving*, *vividness*, and *belief* from Session 1, which traditionally have been the three defining properties of autobiographical memories, were predicted by the remaining nine properties from Session 2, which were measured in different events. There was good agreement between the multiple regressions across the two studies. Given that predictors compete for entry into multiple regression equations and thus small differences in the correlations can determine which predictor enters, the overlap between studies is noteworthy. In addition, the regression equations were broadly consistent with those from studies of individual autobiographical memories that predicted *reliving* and *belief* (Rubin et al., 2003; Rubin & Siegler, 2004), though here they are for individual differences. These findings suggest a reinterpretation of studies that did not include individual differences in accounting for correlations among the properties of memories in order to assess the relative effects of individual differences and the specific event.

5.3. The stability of correlations among properties within studies

The correlation matrices among the 12 properties had similar patterns between both sessions in each study. The mean of the absolute values of the difference between each of the 66 cells was small with a mean of .05 and .07 and ranges of .00 to .19 and .00 to .21 in Studies 1 and 2, respectively. Cell-by-cell correlation between the 66 entries in each matrix was .98 and .95 in Studies 1 and 2, respectively. Because the correlations between sessions were calculated on mean values for each participant over seven different memories in each session, they establish that the correlations are properties of the individual participants not the properties of individual memories. A similar pattern emerged when comparing both Study 1 sessions with both Study 2 sessions.

5.4. Factor analyses

Factor analyses investigated the relationships among the 12 individual differences in the properties of autobiographical memories. For both studies, the results of the factor analyses were similar. The first five eigenvalues for Study 1 and 2 were 6.81, 2.17, 0.34, 0.10, and 0.02 and 6.14, 1.99, 0.42, 0.14, and 0.03, respectively, favoring two factor solutions. There were no interpretable third dimensions. In descriptive terms based on the plotted factor loadings, both factor analyses had two clusters of properties, with *contents* and *specific time*, which had lower correlations with most other variables, being somewhat out of these clusters. One cluster included the three phenomenological properties of fully constructed memories (*reliving, vividness,* and *belief),* three measures of component perceptual systems (*visual, scene,* and *auditory*) and a measure of the internal coherence of the memories (*coherence*). The other cluster included properties related to processes that measure the importance of events (*centrality, rehearsal*, and *emotion*) (Habermas, 2018).

The similarity in factor analyses across samples of 200 MTurk workers and 160 Duke University undergraduates provides an additional measure of the similarity of the correlations of the two samples. Thus, the results of the factor analysis are replicable for important and commonly used properties in the two different populations. One future direction is varying the populations and the properties sampled in a theoretically motivated series of studies, which might include exploratory and confirmatory factor analyses as well as other correlational analyses.

5.5. Two unexpected factor analysis findings

Two findings were unexpected. Both replicated across studies and so are worthy of post hoc consideration. The first is the division of properties into clusters based on the factor loading in the factor analyses. The first cluster includes measures related to the event itself, whereas the second cluster is focused more on the importance of the event to the individual. This suggests two clusters that may be able to be used separately in identifying individuals' strengths and offer separate targets for therapy. The practical and especially the clinical importance these two clusters are discussed in Section 5.8, practical implications. The second unexpected finding was that two properties that were both considered aspects of narrative did not have similar loadings. *Coherence*, which measures whether the memory itself is a coherent narrative that makes a good story or description, had loadings similar to visual properties, *auditory, vividness*, and *reliving*. *Centrality*, which measures how the memory fits into a coherent life narrative, had loadings similar to *rehearsal* and *emotion*. There is precedent for separating these two measures, however, not as individual differences and not to this extent (for a review see Rubin et al., 2016). *Coherence* is topic of debate in whether memories of trauma are fragmented and is in a cluster that involves measures related to the topic of overgeneral memories in clinical syndrome, whereas *centrality* is more related to the clinically important properties of the intensity of *emotion* and the frequency of occurrence of voluntary and involuntary memories as measure by *rehearsal.*

5.6. Limitations and future directions

The results reviewed supported the hypothesis that properties of autobiographical memories were likely to be individual differences, but were not specific enough for detailed a priori hypotheses. Rather they focused the analysis goals of the paper on providing clear descriptive statistics to establish the existence of individual differences. Theoretically motivated predictions can now be made base on replicated findings within the two studies.

At the empirical level, there is a lack of comparison of the individual-differences properties measured here with other measures, including individual differences measures based on standardized tests, behavioral measures other than the rating of properties, and brain imaging tasks, or with other groups including patients with neuropsychological damage or clinical disorders. At the theoretical level there is no obvious reason or good theory of the extreme degree of agreement between the correlation matrices of the two studies and thus in the agreement in their multiple regressions and factor analyses, and little data to which to probe this mystery. That is, there is the need for and opportunity to do studies that could clarify the findings.

The methods and results described here provide techniques and hypotheses to make it easier to include behaviors other than rating scales. This could be of considerable practical and theoretical value. However, for most of the properties measured here, a verbal report, or a rating scale corresponding to one, is the ultimate standard. For instance, behaviors and neural activity related to reliving and emotional intensity of autobiographical memories can be investigated (Daselaar et al., 2008). However, how much a person reports reliving or experiencing the emotions they feel is often the ultimate measure of the concept of interest, not the particular behaviors or neural process related to it.

How the individual differences measured here on autobiographical memories of general past events would correlate with practically important classes of events also needs to be studied. These include emotionally intense or negative memories and future events. Similarly, correlations with processes and disorders remain to be studied in detail. These include measures of emotion regulation, anxiety, dysphoria and the severity of stable clinical disorders. Although the literature showing such effects for individual memories was briefly reviewed, the question of using individual-differences measures remains open.

5.7. Theoretical speculations

The results demonstrate that many of the commonly measured properties of individual autobiographical memories are also stable individual differences that apply to all of an individual's autobiographical memories. Thus, some of what researchers have been viewing as properties of individual memories are actually general tendencies of the person recalling the memory rather than those of the specific memory. Exploring why this is the case is useful to understanding autobiographical memory. More generally, it suggests there could be gains by breaching the longstanding separation of individual differences and experimental approaches (Cronbach, 1957).

There is reasonable rationale for the stable individual differences of many of the properties. As reviewed earlier, autobiographical memories can be as constructed from behaviorally and neurally based systems each with its own functions, processes, and structures (Rubin, 2006, 2012). The neural structures and processes and the behavioral experience of people will vary within each of these systems somewhat independently of the other systems. Thus, the measures of these systems should vary independently providing reliable components.

A possible explanation of the stability of the pattern of correlations among the properties being similar is more speculative. Autobiographical memories are a common behavior of a highly intelligent and social species that depend on the recall of personally experienced events as well as socially and culturally shared reported events, independent of their basis in fact. It is a behavior taught to our young in culturally specific ways (Habermas, 2018; Hirst, 1994; Köber & Habermas, 2017; McAdams, 1995; McAdams, 2013; Nelson & Fivush, 2004). Thus, personal experience must be remembered and shared, which usually requires transforming personal experiences into culturally acceptable narratives. Because of the importance of this ability for each individual and for groups of individuals, a common form for autobiographical memories that is independent of the skills and dispositions of each individual is needed. That is, recalling memories so that they can be shared in coherent narrative form is a complex task that constrains the ways the component systems can be combined. At its simplest, recalling autobiographical memories is a highly practiced and practically important task with strict, socially varied expectations of how the final recall is expressed.

If this speculation, and an extrapolation beyond autobiographical memory, is correct, the degree to which individual differences will account for variance in a task will depend on several factors. These include the component processes used in the task, the amount of practice or skill of the individuals have in the task, the complexity of the task, and the constraints on what constitutes an acceptable response to the task in the intended audience. These factors should not affect a person's individual strengths and weaknesses on the component processes of the task. However, they will affect the ways the strengths and weaknesses of the component processes can be combined while still producing an acceptable response. Autobiographical memory may be at one extreme of a continuum of these constraints. At the other extreme may be a highly controlled, novel, laboratory task designed to gain maximal experimental control and minimize the participants' prior experiences. The correlations among component individual-difference processes in such tasks remains to be explored more systematically.

5.8. Practical implications

Being able to assess the abilities and dispositions of individuals can bridge the separation of the individual differences and experimental approaches, approaches that need to be combined to understand behavior in situations where not all relevant variables can be randomly assigned (Cronbach, 1957). Assessing the individual-differences properties measured here could allow clearer predictions to be made about future behavior. Many factors affect real-world behavior, but knowing how well a person reports that they have particular abilities should have significant effects on their willingness to report and defend them in public. It may also provide predictive value on performance, though the relation of confidence to performance in memory is a complex issue requiring testing in specific situations.

Scenarios in which assessing individual difference of the kind measured here might be useful follow. Assume you want to predict who might suffer most from a negative experience. For some symptoms of posttraumatic stress and depression, the individual properties of *centrality* (Del Palacio Gonzalez & Berntsen, 2018; Gehrt et al., 2018), *rehearsal* (Newby & Moulds, 2010, 2012; Watkins, 2008), and *emotion* (MacLeod & Bucks, 2011; Rubin et al., 2011), which were in the same cluster in the factor analyses, would be important. These properties involve how much people would make the negative events part of their life story and a reference point to understand themselves and the world, how often they would think about the event or have it enter their thoughts unbidden, and how intense their emotions would feel and would produce physical reactions when the negative events were thought about. The properties of *reliving, vividness, belief, visual, scene, auditory* and *coherence*, which also were in the same cluster in the factor analyses, would be important for intrusive memories including those that trigger rumination (e.g., Rubin et al., 2011). Such individual-difference properties could help in predicting and treating symptoms of these disorders individually rather than considering the disorders as unified wholes. The most commonly and strongly recommended, evidence-based, behavioral therapies directly address the thoughts and feelings related to the memories of the traumatic event. These include prolonged exposure, cognitive processing therapy and trauma-focused cognitive behavioral therapy (Watkins et al., 2018). Thus, the individual-differences properties measured here, including baseline levels in emotion, rehearsal, and imagery, are at the heart of most behavioral psychotherapies. However, their validity as individual-difference measures in autobiographical memory has not been documented before.

Assume you want to select a convincing speaker, politician, or eyewitness. That is, assume you want someone who generally appears transported back to and relives the original events, recalling vivid details of them, and is certain that their recall is always correct. You would want someone who is generally extremely high in *reliving, vividness*, and *belief* and thus probably high in the other properties with similar factor loadings.

Finally, assume that a major current global problem is that people increasingly believe that their memories are the only true version of events and are not subject to counter evidence from other people's memories or other sources. This problem is serious and causes interpersonal and political relations to suffer. To remedy this and to make the world a better place to live, you want to reduce such intellectual

arrogance and increase intellectual humility, two concepts from social psychology that include believing one's own memories independent of any evidence (Deffler, Leary, & Hoyle, 2016; Leary et al., 2017). Measuring *belief,* and the properties that correlate with it, might help you understand dispositions that might make a person prone to intellectual arrogance. Properties that correlate with *belief* include the properties in the larger factor analysis cluster, but also *specific time*, which did not correlate highly with most other properties. Judging that autobiographical memories can be dated and that they are not combinations of several different similar events correlated with *belief* .66 and .68 in the two studies.

5.9. Conclusions

Properties of autobiographical memories can be assessed and used as individual difference measures; that is, as properties of individuals rather than as just properties of particular events. The properties of commonly studied measures of individual autobiographical memories were also found to be individual dispositions that were stable for periods of a week or more. These individual differences had lawful and theoretically important relations to each other. Being able to assess the dispositions of individuals allows their effects to be combined with the effects of natural situations, experimental manipulations, and the effects of specific event. Thus, individual differences and experimental approaches can be more easily integrated and brought to bear on understanding human behavior.

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Appendix A. Supplementary data

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