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The Autobiographical Recollection Test (ART). A Measure of Individual Differences in Autobiographical Memory

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Abstract

We introduce the Autobiographical Recollection Test (ART) to examine individual differences in how well people think they remember personal events. The ART comprises seven theoretically motivated and empirically supported interrelated aspects of recollecting autobiographical memories: *reliving, vividness, visual imagery, scene, narrative coherence, life-story relevance,* and *rehearsal*. Desirable psychometric properties of the ART are established by confirmatory factor analyses demonstrating that items probing each of the seven components form well-defined, yet highly correlated, factors that are indicators of a single underlying second-order factor. The ART shows high test-retest reliability over delays averaging three weeks and correlates meaningfully with a test of different categories of memory. Overall, the findings document that autobiographical recollection is a dimension that varies among individuals. The ART forms a reliable and easily administered autobiographical memory test that will help to integrate autobiographical memory research with fields generally concerned with individual differences, such as health and personality psychology.

Keywords:
Autobiographical memory, individual differences test, recollective experience, narrative, imagery, reliving

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General Audience Summary

Autobiographical memory is the kind of memory that allows us to remember and consciously relive memories of our past. It is a complex form of memory that consists of several cognitive and emotional components that must be combined in the construction of individual memories and which can be influenced by other factors such as clinical disorders and personality. Autobiographical memory supports our sense of identity. It contributes to the development and maintenance of social relations, to problem solving and to forming ideas about the future. Despite its central importance, researchers know little about individual differences in the experience of autobiographical memories. People often claim that their memory for past events is better or worse than the that of other people, but the field is lacking a standardized test of such individual differences in the experience of autobiographic memory. The purpose of the present series of studies is to develop and test a new psychometric scale, called the Autobiographical Recollection Test (ART), which measures how well people think they remember events in their past. Across four studies, the ART showed desirable psychometric properties, high test-retest reliabilities and meaningful correlations with other measures of memory. By providing a robust and easily administered test of autobiographical memory, the ART will help to integrate research on autobiographical memory with areas that generally deal with individual differences, such as health-, industrial- and personality psychology.

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The Autobiographical Recollection Test (ART): A Measure of Individual Differences in Autobiographical Memory

Each individual has a unique past, but some individuals seem to remember their past better than others. Some claim to have very clear autobiographical memories and frequently engage in autobiographical remembering, others claim that their memories are vague and that they rarely think of their past.

Such commonsensical suggestions of stable individual differences in autobiographical memory find scientific support. For example, studies have demonstrated gender differences in autobiographical memory, with women generally showing better recall of personal events than men, especially of emotional events or emotional aspects of events (e.g., Andreano & Cahill, 2009; Bauer, Stennes and Haight, 2003; Davis, 1999; Pillemer, Wink, DiDonato & Sanborn, 2003; Rubin & Berntsen, 2009; Siedlecki & Falzarano, 2016, Seidlitz and Diener, 1998). Other studies have demonstrated age differences, with subjective ratings of autobiographical memory qualities increasing with increasing age (Rubin & Berntsen, 2009; Rubin & Schulkind, 1997). More extremely, a small group of individuals demonstrate 'highly superior autobiographical memory' (HSAM) by showing seemingly effortless access to detailed memories of almost any event in their lives (LePort et al., 2012), whereas others show 'severely deficient autobiographical memory' (SDAM), by claiming an inability to have vivid recollections of their past (Palombo, Alain, Söderlund, Khuu, & Levine, 2015). Importantly, these individual differences appear specific to autobiographical memory in the sense that they are not paralleled in any direct manner by similar differences in more standard laboratory memory tasks (see Palombo, Sheldon & Levine, 2018, for a review). This underscores the relevance of developing tests that specifically target individual differences in autobiographical memory

Presently, there is a lack of tests probing individual differences related to general autobiographical memory characteristics. Most studies of autobiographical memory examine memories for individual events, or theoretically motivated selections of events, and ignore individual differences and more stable tendencies in memory for past events. Some studies have used rating scores averaged across different memories to examine individual tendencies in the subjective qualities of memories (Rubin, Schrauf & Greenberg, 2004) as well as their stability over time (Rubin, Schrauf & Greenberg, 2003). However, the field lacks a psychometric test of individual differences in the experience of autobiographical memories.

The aim of the present work is to begin to fill this gap, by introducing an individual differences test, the Autobiographical Recollection Test (ART), which measures how well people think they remember events in their past. Individuals with higher scores on the ART are more inclined to think they remember their past well. The focus of the ART is on the recollective experience, not the accuracy, of autobiographical memories. Measuring people's intuition about their own personal memories is important because there is evidence that people act on this intuition, for example, when distinguishing between personally experienced versus imagined events (e.g., Johnson, 2006; Johnson, Foley, Suengas, & Raye, 1988) and/or identifying the source of their memory (Johnson, Hashtroudi, and Lindsay, 1993). More broadly, self-reports of recollective experience are used in many studies of autobiographical memory (for a review see

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Congleton & Berntsen, 2018) and also in diagnostic tests of mental disorders as well as in forensic settings, underscoring both their theoretical and applied relevance.

A few individual differences test of specific aspects of autobiographical memory exist, but their scope does not overlap with that of the ART. First, a handful of tests have been developed to measure deficits in autobiographical memory in clinical populations, such as the Autobiographical Memory Interview (Kopelman, Wilson, & Baddeley, 1990), the Autobiographical Interview (Levine, Svoboda, Hay, Winocur & Moscovitch, 2002), the Autobiographical Memory Test (Williams et al., 2007). These tests are time consuming because they typically require face-to-face interviewing, followed by extensive coding of the respondents' verbal reports, which requires high interrater reliability to be a robust measure. In addition, tests developed to examine deficits in clinical populations may show ceiling effects in non-clinical groups (e.g., Kirk & Berntsen, 2018). Second, a few self-report questionnaires measure how individuals generally make use of their autobiographical memories, such as using memories for social versus instrumental purposes (Bluck, Alea, Habermas & Rubin, 2005; Harris, Rasmussen & Berntsen, 2013; Webster, 1993).

Recently, Hallford and Mellor (2017) introduced the Awareness of Narrative Identity Questionnaire to measure individuals' self-reported awareness of narrative identity as well as global coherence of autobiographical memories. Palombo, Williams, Abdi and Levine (2013) introduced the Survey of Autobiographical Memory, which broadly targets episodic, semantic, spatial, and prospective (future-directed) aspects of memory as four different and relatively independent dimensions of self-reported mnemonic characteristics, which show weak to moderate correlations with one another (see Study 4).

In contrast to these existing questionnaires, the ART examines features typically associated with the recollective qualities of autobiographical memories, such as the subjective vividness and subjective reliving accompanying the memories, under the assumption that these characteristics generalize across memories within individuals (e.g., some individuals generally experience their autobiographical memories more vividly than other individuals).

The ART measures the following seven properties: *reliving, vividness, visual imagery, scene, narrative coherence, life story relevance*, and *rehearsal,* conceived as different aspects of the way individuals experience their autobiographical memories. In our first studies, we also included *emotional intensity*, but because ratings of this component did not correlate sufficiently highly with the other seven components, it was not included in the final version (see Study 1, Results). Each of the seven components are well-motivated by the autobiographical memory literature. *Reliving* and *vividness* are part of most philosophical accounts of what distinguishes autobiographical memory from other types of memory (e.g., Brewer, 1996; Rubin, Deffler, & Umanath, 2019) and are central to autonoetic consciousness and the sense of mentally travelling in time – a defining criterion for episodic memory (Wheeler, Stuss, & Tulving, 1997). Of the different sensory components, *visual imagery* is shown to be most robustly associated with other features of autobiographical remembering, such as reliving (see Rubin, 2006, for an overview). To remember the spatial layout in terms of a *Scene* is also a key component of having an event memory (Rubin & Umanath, 2015). Narrative is central to autobiographical remembering from developmental, clinical, social, and personality points of view (e.g., Adler, Lodi-Smith, Philippe & Houle, 2016; Alle et al., 2016; Habermas & Bluck, 2000; McAdams, 2001; McLean,

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Pasupathi, Greenhoot, & Fivush, 2017; Nelson & Fivush, 2006). The ART includes ratings of both the *narrative coherence* of individual memories and the *life story relevance* of the memories in the context of the overall lived and narrated life. Finally, rehearsing autobiographical memories in social communication or in silence is a common feature of autobiographical remembering that varies systematically with other characteristics of the memories (Walker, Skowronski, Gibbons, Vogl & Ritchie, 2009). We therefore also include *rehearsal* as a component of the ART.

In contrast to studies on characteristics of individual memories aggregated across subjects, the ART measures these components aggregated across memories for a person's autobiographical memories in general. We expect these different components of the recollective experience to be highly positively correlated with one another, supporting the theoretical claim of a unique underlying dimension of recollective experience that varies among individuals.

We make this prediction in spite of contradicting observations. First, the components included in the ART are often treated separately in research on autobiographical memory. For example, life story relevance and visual imagery have been conceptualized as orthogonal, or even contrasting, dimensions of autobiographical remembering (e.g., Boucher & Scoboria, 2014; Conway, Singer, & Tagini, 2004; Libby & Eibach, 2011). Second, different theories hold different views as to what are the most important or defining properties of autobiographical remembering, with some views emphasizing narrative organization (e.g., Nelson & Fivush, 2006), some a sense of reliving (Wheeler et al., 1997), and some the representation of a scene (Rubin & Umanath, 2015). Thus, the prediction that the components constituting the ART will converge on one underlying dimension when used as a test for individual differences requires empirical testing.

In addition to correlations among the seven components, we also expect that items probing each of the seven components will be more strongly correlated within rather than between components, indicating that the ART consists of seven (highly correlated) subcomponents. We test alternative predictions to these hypotheses in Study 1. To foreshadow, our analyses support the idea of seven separate subordinate dimensions (equivalent to our components) all highly correlated and reflecting a single underlying factor, suggesting that they all probe an individual differences dimension of autobiographical recollection.

Study 1

Method

Participants. We recruited 400 participants from Amazon Mechanical Turk using TurkPrime (Litman, Robinson, & Abberbock, 2016); 202 males and 198 females, with an average age of 33.8 years (range 21 to 50). In order to be included in the study, the participants had to be native English speakers, pass three attention checks, accept the informed consent, spend more than five minutes on answering the survey, and not be younger than 18 or older than 50. Each Mturk worker was paid 2 USD.

Scale development. The initial version of the scale administered to the participants in the present study consisted of 24 items; the 21 items shown in Table 1 and three additional items addressing emotional aspects of autobiographical remembering (i.e., mood impact, intensity and physical reactions associated with remembering past events).

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We started by identifying the key properties of autobiographical memory by reviewing the literature and categorizing the characteristics typically measured for individual memories. This review included theoretical models of autobiographical memory (Conway et al., 2004; Rubin, 2006), reality monitoring (e.g., Johnson, 2006), research on flashbulb memory (e.g., Luminet & Curci, 2018), autobiographical memory development (e.g., Habermas & Bluck, 2000; Nelson & Fivush, 2006; Reese et al., 2011), neuropsychological and clinical perspectives on autobiographical memory specificity and centrality (e.g., Gehrt, Berntsen, Hoyle & Rubin, 2018; Levine, 2002; Williams et al.,2007), and research on autobiographical memory rehearsal (e.g., Walker et al., 2009). We identified eight components that are frequently studied and have robust effects in research on individual autobiographical memories: *reliving*, *vividness*, *visual imagery*, *emotion*, *scene*, *narrative coherence*, *life story relevance*, and *rehearsal*. We then developed three items of each of the eight components. The 24 items were adapted from, or inspired by, concrete questions used in studies addressing characteristics of individual memories, such as the Autobiographical Memory Questionnaire (Rubin, Schrauf, & Greenberg, 2003), the Memory Characteristics Questionnaire (Johnson et al., 1988), research on involuntary memory (e.g., Berntsen & Hall, 2004), flashbulb memory (e.g., Luminet & Curci, 2018), studies on narrative identity (Adler et al., 2016; Hallford & Mellor, 2017; McLean et al., 2017) and narrative coherence (e.g., Habermas & Bluck, 2000; Reese et al., 2011), research on autobiographical memory in clinical disorders, such as PTSD (Berntsen & Rubin, 2006; Rubin et al., 2016; Brewin, 2014) and neuropsychological research on imagery and scene construction (e.g., Hassabis, Kumaran, Vann, & Maguire, 2007; Rubin & Umanath, 2015).

Our goal was to generate three items reflecting the conceptual breadth of each of the eight components. Thus, we left it as an empirical question whether these items would also be highly correlated. For example, for the component *Rehearsal*, the three items addressed three different forms of rehearsal, that is, voluntary rehearsal, involuntary rehearsal and rehearsal in conversations. In a few cases with competing items, we chose the ones that were most concise and most clearly addressed the underlying component. The final version of the ART is presented in Table 1.

Procedure. The 24 item ART was administered through the survey platform Qualtrics. Each participant was first asked to fill in a consent form and answer demographic questions before preceding to answering the ART. The ART was the first of a series of questionnaires to be answered by the participants. The remaining questionnaires were always presented after the ART, and are irrelevant for the present study.

Plan of analysis. Responses to the items were modeled using confirmatory factor analysis with maximum likelihood estimation as implemented in EQS 6.3 for Windows (Build 116; Bentler, 2006). In light of excessive kurtosis in some items, resulting in a departure from multivariate normality, we used the scaling correction developed by Satorra and Bentler (1994) to adjust fit indices for non-normality.

We first examined a set of a priori models, described below. As recommended, we evaluated fit using a set of fit indices, each based on the correspondence between the observed data and the data implied by the model. The comparative fit index (CFI; Bentler, 1990) indexes the proportionate improvement in fit of a specified model over a baseline model in which the observed variables are independent; values from .90 to .95 and greater are expected for models

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that fit the data well (Hu & Bentler, 1999). The root mean square error of approximation (RMSEA; Steiger & Lind, 1980) indexes the degree of misspecification in a model per degree of freedom, with a value of zero indicating perfect fit to the data and values from zero to .08 indicating acceptable fit (values from .08 to .10 typically are interpreted as marginal fit; Browne & Cudeck, 1993). For models of the full set of items, we report point estimates and 90% confidence limits of RMSEA, expected point estimates less than or equal to .08 and an upper confidence limit less than or equal to .10 for acceptable models. The RMSEA, which performs poorly with small-degrees-of-freedom models (Kenny, Kaniskan, & McCoach, 2015), is not reported for models of the small set of items considered as a brief version of the measure. The standardized root mean square residual (SRMR) is an absolute measure of fit and is defined as the standardized difference between the observed and predicted co-variances. Values of .08 or smaller are considered indicative of good fit between observed and model-implied data (Hu & Bentler, 1999). The standard, and generally problematic, χ^2 is reported for completeness, but not used to evaluate fit. The value referred to as χ^2 is an approximation and takes on the properties of χ^2 only under rare and untestable conditions. Under typical conditions, when the value is referenced to the χ^2 distribution it over-rejects models that provide an acceptable account of the data (Bentler & Yuan, 1999).

A set of a priori models, preregistered at the Open Science Framework (https://osf.io/zvr7j/), are first considered. The most parsimonious model is a single-factor, first-order model on which all 24 items load. The second model, which most closely represents the construction of the scale, has eight correlated first-order factors, with three items loading on each. The third model is a three-factor model that would reflect major distinctions in the literature. This model includes one factor, Imagery, that comprises items from the vividness, reliving, scene, and visual sets; a second factor, Narrative, that includes items from the coherence, rehearsal, and life story sets excluding the involuntary item from the rehearsal set; and a third factor, Emotion, that includes the emotion items plus the involuntary item from the rehearsal set.

The distinction between Imagery vs. Narrative is based on conceptual distinctions in the literature between higher versus lower levels of construal research (Trope & Lieberman, 2003, Watkins, 2007), a conceptual distinction between an experiential versus coherence focus when constructing individual autobiographical events (e.g., Berntsen & Bohn, 2010; Boucher & Scoboria, 2014; Libby & Eibach, 2011), as well as a distinction between imagery and verbal processes (Pavio, 1971; Rubin, 2005). The separation of a third factor labelled Emotion is motivated by classic distinctions between cognition versus emotion (e.g., Ledoux, 1996) and a tendency for involuntary memories to have more emotional impact (Berntsen & Hall, 2004).

The one- and eight-factor models are nested and can be compared using the χ^2 difference test. Because one of the items in the three-factor model is posited to load on a different factor than in the one- and eight-factor models, that model is not nested in the other two. Should its fit prove adequate, it would be compared to the other models using Akaike's and Bayesian Information Criteria (Chakrabarti, & Ghosh, 2011).

Exploratory analyses considered a second-order model in which a single factor accounts for the covariance between the eight first-order factors. Minor model modifications were

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examined based on specification searching using multivariate Lagrange Multiplier Tests (Buse, 1982) as implemented in EQS.

Results

Preliminary analyses. We first examined univariate and multivariate distributions of responses to the 24 candidate items. The normalized estimate of Mardia's coefficient was high, 51.51, $p < .001$, indicating significant departure from multivariate normality. An examination of univariate distributions revealed that about two thirds of the items were mildly negatively skewed. About a third of the response distributions showed nonnormal kurtosis (primarily platykurtic, or negative, kurtosis). Although maximum likelihood is reasonably robust to violations of multivariate normality, we used the Satorra-Bentler method described earlier to correct all fit statistics for nonnormality. Because there is no scaling correction for the SRMR, we report the normal theory value for that index. In the following, we first evaluate the three a priori models. We next present findings from exploratory analyses.

Evaluation of a priori models. We first estimated and tested a single-factor model on which all 24 items loaded. Although the value of SRMR, .078, fell just below our cutoff, none of the other fit indices supported interpretation of this model, $\chi^2(252, N = 400) = 1565.63$, $p < .001$, CFI = .782, RMSEA = .114 (CLs = .109, .120). Thus, there is no support for a model in which responses to all items are attributable to the direct influence of a single overarching factor.

We next considered the model that most closely corresponds to the basis for generating candidate items—a model with eight-correlated factors, with each influencing only three of the 24 candidate items. The fit of that model met our criteria on all indices of fit, $\chi^2(224, N = 400) = 478.73$, $p < .001$, CFI = .941, SRMR = .048, RMSEA = .053 (CLs = .047, .060). The standardized parameter estimates were uniformly high, with factor loadings ranging from .574 to .890, and correlations between factors ranging from .445 to .969.

The a priori three-factor model, though descriptively better in fit than the single-factor model, did not provide an acceptable account of the data, $\chi^2(249, N = 400) = 1015.45$, $p < .001$, CFI = .823, SRMR = .072, RMSEA = .088 (CLs = .082, .093). We do not consider this model further as a potential characterization of autobiographical memory as assessed by the candidate items.

Exploratory analyses. We pursued three lines of exploratory analyses. First, we consulted Lagrange Multiplier tests in search of potential modifications that would account for the minor misspecification in the eight-factor model that might be of concern moving forward. That analysis revealed only one modification that would significantly improve the fit of the model, a correlation between the uniquenesses for two items. Specifically, the uniquenesses for two of the visual items—"While remembering past events, I can see them in my mind's eye" and "While remembering past events, I can see with my mind's eye what took place"—were correlated $r = .30$ even after commonality between them was accounted for by the visual factor, on which both loaded higher than .70. We concluded that, although adding this path improved model fit, it did not change our evaluation of the latent structure of the item set.

We next examine a model in which the correlations between the eight factors could be accounted for by a single second-order factor. Such a model assumes that most of the variance in the first-order factors is common to the eight factors. That model, by structuring the covariances between factors, is nested in the eight-factor model and, therefore, can be formally compared to it. The second-order model provided a promising account of the data, $\chi^2(244, N = 400) = 688.96$, $p < .001$, CFI = .897, SRMR = .068, RMSEA = .068 (CLs = .062, .073), but constraining the covariances between the first-order factors in this way led to a significant decline in fit, $\Delta\chi^2(20) = 194.23$, $p < .001$ (see Satorra & Bentler, 2010, for information about comparing scaled statistics for nested models). Nevertheless, the fit indices for the second-order model meet our criteria, with the exception of CFI, for which the value differs trivially from the cut-off. Moreover, the loadings for the second-order factor are high, ranging from .62 to .99.

Two features of the results led us to consider whether to retain the three emotion items. First, in the eight-factor solution, the correlations between emotion and the remaining factors were noticeably lower than the correlations among the remaining factors, with two of the *r*s falling below .50. Second, and reflective of this pattern, the loading of emotion on the second-order factor was noticeably lower than the loadings of the other factors (.62 vs .71 to .99). These findings coupled with evidence that a tendency to respond with stronger emotional intensity to autobiographical memory retrieval is associated with emotional distress, such as symptoms of PTSD (e.g., Rubin, Dennis, & Beckham, 2011) and depression (e.g., Del Palacio-Gonzalez, Berntsen & Watson, 2017; Watson, Berntsen, Kuyken & Watkins, 2012), led us to evaluate a model omitting the emotion items. A model with seven first-order factors accounting for commonality among the remaining 21 items fit the data well, $\chi^2(168, N = 400) = 345.40$, $p < .001$, CFI = .953, SRMR = .045, RMSEA = .051 (CLs = .044, .059). The factor loadings were uniformly high, ranging from .55 to .89, with all but three exceeding .70. The correlations between factors were high, ranging from .61 to .97 (see Table S1). A second-order model suggested that much of the covariance between the first-order factors could be accounted for by a single second-order factor, $\chi^2(182, N = 400) = 441.20$, $p < .001$, CFI = .931, SRMR = .054, RMSEA = .060 (CLs = .053, .067), though, as with the eight-item model, a nested model comparison favored the first-order model, $\Delta\chi^2(14) = 85.49$, $p < .001$. These findings resulting from exploratory analyses serve as a basis for a priori models evaluated using new data in Study 2.

Reduced item set for assessing a single factor: The Brief ART. The fit of the second-order model provides some rationale for generating a single score from the 21 items. Moreover, we anticipated that some researchers will simply want a single score. To that end, we selected one item from each factor to form a seven-item brief version of the measure. Because the loadings were high for all items on all factors, we elected not to select the item from each factor with the highest loading. Rather, we selected the briefest and most straightforward item from each set, that is, the three items that were most clearly different from each other, and were short and clear. This was done by consensus of the three authors. Responses to the seven-item set were then fit to a one-factor model. That model fit the data exceptionally well, $\chi^2(14, N = 400) = 22.82$, $p = .063$, CFI = .989, SRMR = .027 (recall that RMSEA does not perform well with small degrees of freedom models and therefore was not consulted here).

Internal consistency and descriptive statistics. Coefficient alphas for the full 21-item set, the seven-item set, and the three-item subscales are provided in the first column of Table 2. For the full ART, $M = 4.71$, $SD = 1.00$. For the Brief ART, $M = 4.77$, $SD = 1.06$.

Summary and Discussion

Of the three a priori models, only the model with eight separate factors (corresponding to the eight conceptual components) worked satisfactorily. However, consistent with our theory, the exploratory analyses lend support to a model with one overarching factor nesting eight subscales, corresponding to the eight conceptual components of the ART. Still, there was a problem with this model as the emotion component did not correlate highly with the other seven components, which were all highly correlated with one another. This led to the exclusion of the three items representing the emotion component, consistent with evidence that emotional reactions to autobiographical memories may index emotional distress and clinical symptoms in addition to autobiographical recollective experience (e.g., Del Palacio-Gonzalez et al., 2017; Rubin et al., 2011). On the basis of this final model, we developed a brief version with just seven items, one for each component. A one-factor model provides a good account of responses to the seven items.

Study 2

Method

Participants. Three hundred and three Duke undergraduates, 186 females, with an average age of 21.8 years (range 18 to 23) completed a two-session study.

Material and procedure. The purpose of Study 2 was to replicate the Study 1 findings in a different population, and to examine the stability of the individual responses across time. The materials and procedure were identical to Study 1 except that participants were required to complete two web-based studies with a delay of at least one week but before the end of the semester.

Plan of analysis. The analysis focused on a set of a priori models preregistered at the Open Science Framework (https://osf.io/zvr7j). These models were evaluated using criteria outlined earlier and specified in the preregistration. The focal models were a first-order model with seven correlated factors, a second-order model with a single factor accounting for the covariances between the first-order factors, and a single-factor model of the seven-item set identified in Study 1. We also examined the relations between corresponding measures at the two time points using zero-order correlations

Results

Preliminary Analyses. We examined the univariate and multivariate distributions of the 21 items carried forward from Study 1. The normalized estimate of Mardia's coefficient, 22.10, though significant, was substantially smaller than for the Study 1 data. An examination of the univariate distributions indicated relatively little skew and excessive kurtosis for three items. Nonetheless, given the significant test of departure from multivariate normality, we again used Satorra and Bentler's scaling correction to all fit indices except SRMR, which is reported without correction.

In the following, we first evaluate the a priori models. We next present findings for the internal consistencies and test-retest reliabilities.

Evaluation of a priori models. Estimation of the first-order, seven-factor model yielded generally favorable fit statistics, $\chi^2(168, N = 303) = 403.84$, $p < .001$, CFI = .887, SRMR = .063, RMSEA = .068 (CLs = .060, .077), though the value for CFI was slightly below the cutoff.

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Following on the exploratory finding from Study 1, we freed the covariance between the two similarly worded visual items. That adjustment to the model resulted in fit statistics that meet all of our criteria, $\chi^2(167, N = 303) = 368.68$, $p < .001$, CFI = .903, SRMR = .061, RMSEA = .063 (CLs = .054, .072). The correlation between the two uniquenesses was .38. The factor loadings were generally high, ranging from .38 to .81, with all but three exceeding .50. The correlations between factors ranged from .29 to .95, with all but two above .40. The factor loadings and inter-factor correlations are presented in Table S2.

We retained the correlated uniqueness in a second-order model in which the seven first-order factors are influenced by a single second-order factor. The fit of this model was promising, $\chi^2(181, N = 303) = 473.59$, $p < .001$, CFI = .859, SRMR = .076, RMSEA = .073 (CLs = .065, .081), but did not meet our cutoff for CFI. It also provided a poorer account of the data than the first-order model, $\Delta\chi^2(14) = 98.30$, $p < .001$, thereby confirming the finding from Study 1.

The one-factor model provided a good account of responses to the seven-item set, $\chi^2(14, N = 400) = 41.81$, $p < .001$, CFI = .923, SRMR = .053. Loadings ranged from .42 to .74, attesting to the breadth of content captured by these items.

Internal consistency and test-retest reliability. The items were administered on two sessions (Time 1 and Time 2), permitting an evaluation of reliability beyond the estimate provided by coefficient alpha. Reliabilities (Cronbach's α) for the various scales and their correlations over the mean delay of 21.80 days (SD = 9.48, range of 7 to 54 days) are shown in Table 2. To provide an indication of the variation in stability over time, the data were divided into quintiles, which each containing approximately 60 participants (range of 57 to 62) and the correlations for the full 21-item and the brief 7-item ART were plotted in Figure 1. As shown in Table 2 and Figure 1, the ART and Brief ART had overall correlations of .78 and .70 over the two sessions, which did not decrease over the range of delays tested. Thus, the coefficient values were not associated with the length of the interval. For Time 1, the descriptive statistics for the full ART were $M = 4.87$, $SD = 0.75$, and for the Brief ART $M = 5.06$, $SD = 0.79$. For Time 2, for the full ART it was $M = 4.94$, $SD = 0.69$, and for the Brief ART, $M = 5.11$, $SD = 0.74$.

Summary and Discussion

The psychometric properties of the ART and Brief ART as well as the component subscales of the ART did not differ from Study 1, offering a replication of the properties of the test. In particular, the 21-items ART was adequately fit by a first-order, seven-factor model, corresponding to the seven theoretically derived test components. A second-order model in which the seven first-order factors were influenced by a single second-order factor was promising, although the CFI was below the cutoff. The 7-item Brief ART was fit by a one-factor model. A second administration of the ART at a delay between one and eight week produced a test-retest reliability of .78 for the ART and .70 for the brief ART that did not decrease over the interval.

Study 3

The principal aim of Study 3 was to replicate findings from Studies 1 and 2, using a different, and finalized, order of the items in the ART (see Table 1). We administered the 21 item full scale (without the three emotion questions) and we reordered the items so that the seven items of the Brief ART came first and therefore before any of the remaining 14 items of the ART

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(Table 1). Thereby, it was possible to use the same participants for evaluating the consistencies of both scales.

Method

Participants. We recruited 400 participants from Amazon Mechanical Turk; 192 males and 208 females, with an average age of 35.3 years (range 19 to 69). In order to be included in the study, the participants had to be native English speakers, pass two attention checks, accept the informed consent, answer the survey on a computer or laptop, spend more than five minutes on answering the survey, and not be younger than 19 or older than 69. Each Mturk worker was paid 2 USD.

Plan of analysis. The analysis focused on a set of a priori models preregistered at the Open Science Framework (https://osf.io/zvr7j). These models were evaluated using criteria outlined earlier. The focal models were a first-order model with seven correlated factors, a second-order model with a single factor accounting for the covariances between the first-order factors, and a single-factor model of the seven-item set identified in Study 1 and evaluated in Study 2. We also examined the internal consistency of the full scale and seven subscales comprising the full ART and the seven-item Brief ART.

Results

The normalized estimate of Mardia's coefficient was 56.26. Thus, we again used Satorra and Bentler's scaling correction to all fit indices except SRMR, which is reported without correction for models of the full scale.

Evaluation of a priori models. Estimation of the first-order, seven-factor model with the pair of correlated errors identified in Study 2 yielded fit statistics that met all of our criteria, $\chi^2(167, N = 400) = 366.22$, $p < .001$, CFI = .950, SRMR = .040, RMSEA = .055 (CLs = .047, .062). The correlation between the two uniquenesses was .26. The factor loadings and inter-factor correlations are presented in Table 3.

We next evaluated a model in which the seven first-order factors are influenced by a single second-order factor. The fit of this model was acceptable on all criteria, $\chi^2(181, N = 400) = 431.65$, $p < .001$, CFI = .937, SRMR = .052, RMSEA = .059 (CLs = .052, .066). Nonetheless, a model comparison indicated superior fit of the first-order model, $\Delta\chi^2(14) = 78.88$ $p < .001$, thereby confirming the finding from Studies 1 and 2.

Turning to the Brief ART, the hypothesized one-factor model provided a good account of the data, $\chi^2(14, N = 400) = 39.49$, $p < .001$, CFI = .970, SRMR = .035. Loadings were .80, .76, .74, .74, .71, .71, and .66 for the vividness, coherence, reliving, rehearsal, scene, visual, and life story items, respectively.

Internal consistency. Values of coefficient alpha are presented in Table 2. The high values for the two full sets of items indicate a high level of internal consistency across items. For the three-item subscales, values of alpha exceeded .80 except for the rehearsal subscale. Still, the value of .72 is high for a brief scale, reflected strong corrected item-total correlations for all items (.64, .51, and .48 for items 4, 11, and 18, respectively).

Summary and Discussion

The present study used a different and finalized order of the test items of the ART (Table 1), which allowed us to administer the Brief ART in isolation from the remaining 14 items. In contrast to Studies 1 and 2, we only presented the 21 items to the participants. In spite of these changes, we replicated the psychometric properties of the ART and Brief ART as well as the component subscales of the ART found in Studies 1 and 2. As in these previous studies, the 21-item ART was adequately fit by a first-order, seven-factor model. A second-order model in which the seven first-order factors were influenced by a single second-order factor also provided a satisfactory fit. The 7-item Brief ART was fit by a one-factor model.

Study 4

The purpose of Study 4 was to examine the correlations between the ART and the four scales (Episodic, Semantic, Spatial, and Future) of the Survey of Autobiographical Memory (SAM; Palombo et al., 2013). The SAM is not regarded as a unified measure of autobiographical memory, but as a broader measure of mnemonic characteristics in different domains.

We expect the ART will show moderate to high positive correlations with the SAM Episodic, given the shared focus on remembering past events. We also expect positive correlations between the ART and SAM Future, because the latter theoretically and empirically involves a sense of pre-experiencing the event, analogous to the recollective experience associated with remembering past events (D'Argembeau & Van der Linden, 2004; Tulving, 2002; Schacter, Benoit & Szpunar, 2017; Wheeler et al., 1997). However, because imagining future events is associated with fewer details and less vividness than remembering past events (e.g., Berntsen & Bohn, 2010), the magnitude of such correlations are not clear enough for a quantitative prediction. We expect only weak correlations between the ART and SAM Spatial and SAM Semantic scales, which are only vaguely related to autobiographical memory.

Method

Participants. We recruited 200 participants from Amazon Mechanical Turk; 101 males and 99 females, with an average age of 35.1 years (range 20 to 65). In order to be included in the study, the participants had to be native English speakers, pass four attention checks in the entire survey, accept the informed consent, answer the survey on a computer or laptop, spend more than five minutes on answering the survey, and not be younger than 19 or older than 69. Each Mturk worker was paid 2 USD.

Material. The present study was part of a larger survey, in which the ART and the SAM were separated by pilot questions for a study on the use of smart phones. This separation worked against artificially boosting the strength of the correlations between the two tests. We administered the full and brief versions of the ART (see Table 2 for internal consistencies). In addition, we administered the four scales of the SAM (Palombo et al., 2013), assessing self-reported Episodic (8 items), Semantic (6 items), and Spatial (6 items) memory as well as Future projection (6 items). The SAM measures episodic and semantic memory, consistent with the original distinction between these two forms of memory (Tulving, 1983). The episodic scale measures the ability to remember specific events, comprising a range of different kinds of event details, akin to the notion of internal details in Levine et al.'s (2002) coding scheme (e.g., "When I remember events, in general I can remember what I was wearing" p. 1537). In contrast, the semantic scale of the SAM measures the ability to remember facts, in isolation from specific

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events (e.g., "I can learn and repeat facts easily, even if I don't remember where I learned them" p. 1537). The spatial scale of the SAM generally includes items related to navigation (e.g., "I use specific landmarks for navigating" p. 1537). The future scale of the SAM addresses imagining events in the personal future (e.g., "When I imagine an event in the future, I can imagine how I may feel" p. 1537). All items of the SAM are rated on a five-point scale (1 = strongly disagree; 5 = strongly agree).

We generated a unit weighted composite score for each SAM scale. The internal consistencies of the four SAM scales as measured by Cronbach's alpha were .87 (episodic), .75 (semantic), .82 (spatial), and .88 (future). The correlations between the four scales of the SAM ranged from .27 to .53, with a median of .39, consistent with the SAM scales measuring rather independent dimensions.

Results

We excluded one item of the SAM episodic ("When I remember events, I remember lots of details"), because it was worded very similarly to an item of the ART ("My memories of past events have lots of details") and therefore could artificially boost the correlations with the episodic scale. The correlations between the full and the brief ART and the four SAM scales are shown in Table 4, and scatterplots for the correlations between the full ART and the four SAM scales are shown in Figure 2. Both the full and the brief ART had higher correlations with the SAM episodic than with the other three subscales of the SAM. Our sample size provided statistical power of .80 to detect differences of .17 or greater between the correlation coefficients. Direct tests indicated that the correlation of the full ART with SAM episodic was higher than for SAM semantic and SAM spatial, and SAM future ($Z_H = 4.43$, $p < .0001$, $Z_H = 5.71$; $p < .0001$; and $Z_H = 2.20$ $p = .028$, Hoerger, 2013), although the effect was stronger for SAM semantic and SAM spatial than for SAM future, as also indicated by the scatterplots in Figure 2. The results were similar for the Brief ART ($Z_H = 4.51$, $p < .0001$, $Z_H = 6.36$; $p < .0001$; and $Z_H = 3.09$ $p = .002$). The seven subscales of the ART showed similar correlational patterns with the four SAM scales.

Discussion

Consistent with our expectation, the ART correlated more strongly with SAM episodic than with SAM semantic and SAM spatial. This agrees with the ART measuring qualities of recollection – a key feature of episodic memory, but not of semantic or spatial memory as measured by the SAM. The overall finding that the ART correlated differentially with the different scales of the SAM supports its sensitivity as a measure targeting autobiographical recollection.

General Discussion

We have introduced the Autobiographical Recollection Test (ART) to examine individual differences in the experience of autobiographical memories. The study of autobiographical memory generally has followed the leads of cognitive psychology more broadly and studied memory characteristics and mechanisms that apply across people rather than individual differences (e.g., Logie, 2018). The typical autobiographical memory study examines memories for individual events, or theoretically motivated categories of memories, compared across conditions (e.g., in response to different kinds of memory cues). Such research is useful for many purposes, but by its very nature treats individual variability as error variance. This is radically different from an approach that examines stable individual tendencies across different types of memories of past events (Cronbach, 1957). The ART was introduced to measure such individual trends in the experience of autobiographical memory.

The ART is composed of seven components that are theoretically motivated and empirically associated with the experience of individual autobiographical memories: *reliving*, *vividness*, *visual imagery*, *scene*, *narrative coherence*, *life story relevance*, and *rehearsal*. Confirmatory factor analyses employed in Studies 1 through 3 consistently demonstrated that items probing each of the seven components could be conceived as separate, but highly correlated, factors that were primarily attributable to one underlying second-order factor. The analyses also supported the development of a brief version of the ART, consisting of a single item from each of the seven components. In our initial conception of the ART, three items addressing an emotional component of remembering were included. However, this component correlated less strongly with the other seven components and had lower loading on the second-order factor. For this reason, it was excluded from the final test. While emotional reactions to memories take part in having a recollective experience, they are also associated with other individual dispositions, such as dysphoria and anxiety (Del Palacio-Gonzalez et al., 2017; Watson et al., 2012), which may explain why this component correlated less strongly with the other seven components.

The confirmatory factor analyses showed desirable psychometric properties for both the full and the brief ART. In addition, Study 2 showed a high degree of test-retest reliability for both scales over three weeks, and Study 4 showed that both the full and the brief versions of the ART correlated meaningfully with the scales of the SAM, measuring episodic, semantic, and spatial memory as well as future projections (Palombo et al., 2013). The ART correlated most strongly with the episodic scale of the SAM, and less strongly with the spatial and semantic scales, consistent with the ART indexing recollective experience. Although the ART showed moderate correlations with the future scale of the SAM, correlations with the episodic scale of the SAM were stronger, consistent with a shared focus on memory for past events. In contrast to the SAM measuring four weakly to moderately correlated dimensions of self-reported mnemonic characteristics, the ART provides a unified test of how well people think they remember autobiographical events.

In addition to supporting the reliability of the ART as a psychometric test, the present findings have important theoretical and applied implications. First, the identification of autobiographical remembering as a phenomenon that shows reliable variability among individuals and thus can be conceived as an individual differences dimension is an important insight, which can help to integrate the field of autobiographical memory into fields generally concerned with individual differences, such as health-, industrial-, social- and personality psychology.

Second, the finding that all seven components of autobiographical remembering were highly correlated and were associated with one underlying second-order factor adds new knowledge that could not have been inferred from findings on the construction of individual memories. On the contrary, in experimental studies of individual memories, some of these components of recollection have been found to separate. For example, in such studies, a distinction is often made between an *experience focus* entailing "thinking about what it is like to experience an event as if actually there, noting specific sensorial and contextual elements" versus a *coherence focus* concerned with "the implications of the event within the context of one's life as a whole and considering how it relates to personal characteristics and other events" (Boucher & Scoboria, 2015, p. 336). These two different mental foci in the construction of events have been found to relate differently to other variables, such as visual perspective (Boucher & Scoboria, 2015; Libby & Eibach, 2011), and to respond differently to experimental manipulations, such as retention time variations (Berntsen & Bohn, 2010). In contrast, as we have shown here, when conceived as an individual disposition, these two components are highly correlated; individuals who generally recollect their past with many details and vivid imagery also tend to assume greater life story relevance and narrative coherence to their memories. Such a single trait-like dimension underlying autobiographical remembering has not been demonstrated before.

Future research should identify how this dimension relates to other individual differences dimensions, both within and external to research on memory. For example, the ability to retrieve, integrate and create continuity and meaning out of autobiographical memories is known as narrative identity, a key component of personality (McAdams & Pals, 2006; Hallford & Mellor, 2017), which has been shown to be robustly related to well-being (Adler et al., 2016). We should expect the ART to correlate positively with measures of narrative identity and thus with well-being. Relatedly, autobiographical memory disturbances are found across a range of clinical disorders, with a reduced ability to retrieve memories of specific events being the most widely studied deficit (Watson & Berntsen, 2014, Williams et al., 2007, for reviews). An important question for future research therefore is how the ART correlates with symptoms of different clinical disorders. The study of individual differences has a long history of applied relevance (e.g., Lubinski, 1996). The ART contributes to the toolbox of individual differences tests and has the potential of being used in a variety of applied context.

In summary, both experimental and correlational approaches are needed for a complete and unified understanding of a psychological phenomenon, but the correlational approach has been poorly represented in current autobiographical memory research. The ART helps to remedy this shortcoming by providing a reliable and easily administered test of individual differences in autobiographical memory. The findings we have reported here support the lay intuition that people differ as to how well they feel they remember their past and how much they engage in autobiographical remembering. Future research should determine how this variation relates to other dimensions of individual differences in order to attain a deeper understanding of its causes and consequences.

Author Contributions

DB and DCR conceived and designed the studies. RHH was responsible for conducting and reporting the confirmatory factor analyses in Studies 1- 3. DB wrote the first draft for the manuscript, with contributions from RHH and DCR. All authors commented on the manuscript and approved the final version.

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Table 1.

The Autobiographical Recollection Test: Instructions, Items and Component Categories

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Instructions:

People vary a lot as to how they remember events from their life. The following questions are about how you remember your own memories for events you have experienced in the past.

Please consider each item and indicate on a scale from 1 to 7 how much the description applies to the way you remember events from your past. Please consider how you remember past events and answer the questions in an honest and sincere way, by choosing a number between 1 (strongly disagree) and 7 (strongly agree).

Scale items	**Components**
1. *My memories of past events have lots of details.	Vivid
2. *My memories of past events come to me as good stories or descriptions.	Coherence
3. *While remembering past events, it is as if I am reliving them.	Reliving
4. *I often think back to past events in my mind and think or talk about them.	Rehearsal
5. *In my memories of past events, I remember where the actions, objects, and people are located in the events.	Scene
6. *While remembering past events, I can see them in my mind.	Visual
7. *My memories of past events are a central part of my life story.	Life story
8. My memories of past events are vivid.	Vivid
9. My memories of past events are coherent and connected, not a collection of isolated, disconnected fragments.	Coherence
10. While remembering past events, it is as if I am mentally traveling back to the time they occurred.	Reliving
11. My memories of past events often pop into my mind by themselves—without me consciously trying to remember them.	Rehearsal
12. In my memories of past events, I remember where I am in relation to the individual things in the events.	Scene
13. While remembering past events, I can see with my mind's eye what took place.	Visual
14. My memories of past events are part of my identity.	Life story
15. My memories of past events are clear, not fuzzy or clouded.	Vivid
16. My memories of past events come to me complete, not in pieces with missing bits.	Coherence
17. While remembering past events, it is as if I am experiencing the same general atmosphere again.	Reliving
18. After an event has happened, I often willfully and deliberately think back to it in my mind and try to remember it.	Rehearsal
19. In my memories of past events, I remember the layout of the broader setting in which the events are located.	Scene
20. My memories of past events have clear visual details.	Visual
21. My memories of past events are a reference point for the way I understand myself and the world.	Life story

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Note: Each item is rated on a 7 point scale: Strongly Disagree 1 2 3 4 5 6 7 Strongly Agree. Brief ART is marked by * (items 1-7). Mean score is reported.

Table 2
Internal Consistency and Retest Reliability Estimates for Autobiographical Recollection Test Full, Brief, and Subscale Scores

	Study 1	Study 2			Study 3	Study 4
		Time 1	Time 2	Retest		
	α	α	α	*r*	α	α
Full ART	.95	.90	.89	.78	.95	.96
Brief ART	.87	.76	.74	.70	.89	.89
Vividness	.79	.82	.83	.77	.86	.86
Coherence	.80	.67	.64	.69	.84	.83
Reliving	.86	.74	.72	.70	.88	.85
Rehearsal	.65	.47	.57	.57	.72	.68
Scene	.79	.72	.74	.59	.83	.81
Visual	.84	.69	.73	.71	.86	.85
Life Story	.83	.79	.84	.57	.83	.89

Note. *N*s were 400 for Study 1, 303 Study 2, 400 for Study 3, and 200 for Study 4. All test-retest correlations $p < .0001$. α is Cronbach's alpha.

Table 3

Means, Standard Deviations, and Factor Loadings for Items Included in the Seven-Factor Model of the Autobiographical Recollection Test (Study 3)

Item	*M*	*SD*	Vividness	Coherence	Reliving	Rehearsal	Scene	Visual	Life Story
1	4.68	1.39	.82						
8	4.71	1.45	.90						
15	4.54	1.50	.74						
2	4.73	1.41		.73					
9	4.38	1.64		.82					
16	4.33	1.64		.85					
3	4.43	1.53			.86				
10	4.58	1.57			.84				
17	4.64	1.48			.85				
4	5.01	1.44				.84			
11	4.86	1.43				.57			
18	4.63	1.48				.64			
5	4.96	1.32					.81		
12	5.03	1.27					.82		
19	4.85	1.31					.75		
6	5.31	1.29						.76	
13	5.06	1.32						.73	
20	4.77	1.44						.89	
7	4.94	1.44							.87
14	5.18	1.36							.77
21	4.91	1.30							.73
				Inter-factor Correlations					
Viv	4.64	1.28							
Coh	4.48	1.36	.91						
Rel	4.54	1.37	.83	.76					
Reh	4.83	1.16	.76	.70	.75				
Sce	4.95	1.13	.84	.83	.75	.67			
Vis	5.04	1.19	.93	.84	.84	.76	.89		
Lif	5.01	1.19	.66	.62	.60	.80	.67	.62	

Note. *N* = 400. Means could range from 1 to 7. For the full ART, *M* = 4.79, *SD* = 1.03. For the Brief ART, *M* = 4.86, *SD* = 1.09.

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Table 4
Correlations Between the ART (Full and Brief versions) and SAM subscales

	SAM subscales			
	Episodic	Future	Semantic	Spatial
Full ART	.60**	.47*	.34**	.18*
Brief ART	.60**	.42*	.34**	.13

Note. *N*=200, * p < .01, ***p* < .001
ART: Autobiographical Recollection Test; SAM: Survey of Autobiographical Memory. One item worded close to an item in the ART was excluded from SAM episodic.
For the full ART, M = 4.84, SD = 1.04. For the Brief ART, M = 4.92, SD = 1.12.

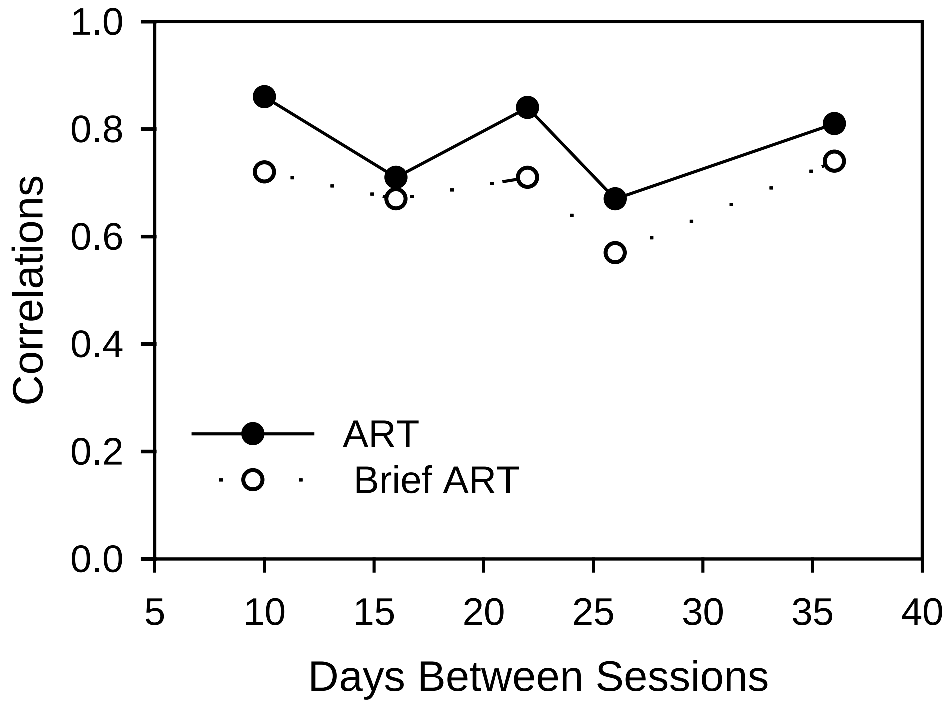

Figure 1. The correlations between the first and second administration of the ART as a function of days between sessions

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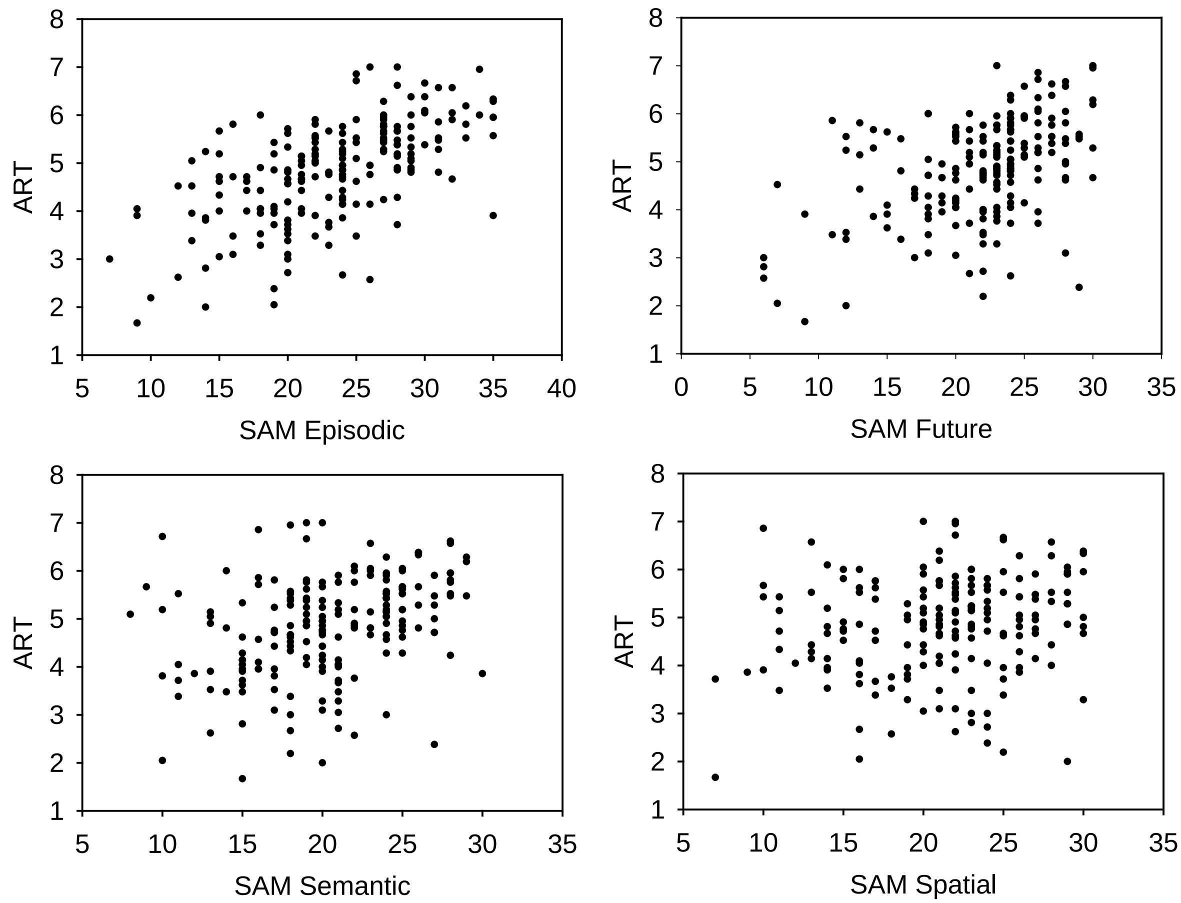

Figure 2. Scatterplots of 21 item ART as a function of four SAM scales corresponding to the correlations from Study 4, which are shown in Table 4. *N* = 200.