cortex xxx (2012) 1–15

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Special issue: Research report

The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life

Daniela J. Palombo [a,b], *Lynne J. Williams* [a], *Hervé Abdi* [c] and *Brian Levine* [a,b,d,*]

[a] *The Rotman Research Institute, Baycrest Centre for Geriatric Care, Toronto, ON, Canada*
[b] *Department of Psychology, University of Toronto, Toronto, ON, Canada*
[c] *School of Behavioral and Brain Sciences, The University of Texas at Dallas, Richardson, TX, USA*
[d] *Department of Medicine (Neurology), University of Toronto, Toronto, ON, Canada*

ARTICLE INFO

Article history:
Received 12 October 2011
Reviewed 15 March 2012
Revised 17 April 2012
Accepted 30 August 2012
Published online xxx

Keywords:
Autobiographical memory
Declarative memory
Questionnaire
Recollection
Trait memory

ABSTRACT

Compared to the abundance of laboratory-based memory tasks, few measures exist to assess self-reported memory function. This need is particularly important for naturalistic mnemonic capacities, such as autobiographical memory (recall of events and facts from one's past), because it is difficult to reliably assess in the laboratory. Furthermore, naturalistic mnemonic capacities may show stable individual differences that evade the constraints of laboratory testing. The Survey of Autobiographical Memory (SAM) was designed to assess such trait mnemonics, or the dimensional characterization of self-reported mnemonic characteristics. The SAM comprises items assessing self-reported episodic autobiographical, semantic, and spatial memory, as well as future prospection. In a large sample of healthy young adults, the latent dimensional structure of the SAM was characterized with multiple correspondence analysis (MCA). This analysis revealed dimensions corresponding to general mnemonic abilities (i.e., good *vs* poor memory across subtypes), spatial memory, and future prospection. While episodic and semantic items did not separate in this data-driven analysis, these categories did show expected dissociations in relation to depression history and to laboratory-based measures of recollection. Remote spatial memory as assessed by the SAM showed the expected advantage for males over females. Spatial memory was also related to autobiographical memory performance. Brief versions of the SAM are provided for efficient research applications. Individual differences in memory function are likely related to other health-related factors, including personality, psychopathology, dementia risk, brain structure and function, and genotype. In conjunction with laboratory or performance based assessments, the SAM can provide a useful measure of naturalistic self-report trait mnemonics for probing these relationships.

* *Corresponding author*. Rotman Research Institute, Baycrest Centre for Geriatric Care, 3560 Bathurst Street, Toronto, ON M6A 2E1, Canada.
E-mail address: blevine@research.baycrest.org (B. Levine).
0010-9452/$ – see front matter
http://dx.doi.org/10.1016/j.cortex.2012.08.023

1. Introduction

The real-life expression of memory involves multiple capacities interacting with sensory, perceptual, attentional, and motor abilities. Cognitive scientists have decomposed these capacities using memory paradigms to identify specific mnemonic processes or systems. These theoretical contributions, however, have not been matched by advances in their applications to naturalistic everyday human memory function. While laboratory memory tests strive toward ecological validity, none directly address the multi-modal sensory nature of encoding, the importance of self-relevance, and the recall delay inherent in naturalistic memory, such as autobiographical memory (Conway, 2001). Accordingly, studies using naturalistic autobiographical memory (AM) stimuli have revealed patterns of spared and impaired mnemonic capacities that are not necessarily captured by laboratory analogs (e.g., Levine et al., 1998). Moreover, functional neuroimaging studies have demonstrated different patterns of brain activations associated with autobiographical versus laboratory memory tasks (Gilboa, 2004; McDermott et al., 2009).

In contrast to performance-based measures, there has been very little research on "trait mnemonics"—that is, the dimensional characterization (factor structure) of self-reported mnemonic characteristics—which we consider to be comparable to personality traits as assessed by self-report inventories. In this study, we report data concerning a new measure: the Survey of Autobiographical Memory (SAM) that represents the first attempt to assess trait mnemonics. The SAM is designed to assess individual differences in self-reported autobiographical mnemonic capacities. Such individual differences are regarded as analogous to individual differences in other neurocognitive processes such as reading and mathematics. Although nearly all adults possess these skills, individual differences can be detected at the behavioral (Knopik and DeFries, 1999) and neural levels (Ben-Shachar et al., 2007; van Eimeren et al., 2008) and, in some cases, are associated with genotype (Markowitz et al., 2005). Just as extremely high or low abilities on the spectrum of reading or mathematics has obvious practical significance, so do similarly extreme mnemonic capacities (Leport et al., 2012; Parker et al., 2006).

Recent research has demonstrated large individual differences in laboratory-assessed mnemonic performance (Kirchhoff, 2009; Unsworth, 2009a, 2009b). Functional neuroimaging studies show large, reliable inter-individual differences in brain activation during episodic memory tasks (Miller et al., 2002). Structural neuroimaging studies have also revealed that individual differences in brain structure, particularly white matter integrity, are related to individual differences in episodic memory (Fuentemilla et al., 2009; Rudebeck et al., 2009). In addition, there is rapidly accumulating evidence in support of a genetic basis for these individual differences as research has discovered several polymorphisms associated with episodic memory performance (e.g., Egan et al., 2003; Koppel and Goldberg, 2009; Papassotiropoulos et al., 2006).

In spite of the evidence for individual differences as assessed by laboratory memory tasks, there is little research on individual differences in naturalistic mnemonic capacities. As is the case for personality, memory can be subdivided into dimensions or factors. The SAM focuses on elements of long-term, remote memory for events, facts, and spatial information; constructs of short-term or working memory are not considered, nor are forms of naturalistic memory such as those associated with daily forgetfulness (e.g., memory errors and slips; Broadbent et al., 1982; Sunderland et al., 1984). The mnemonic dimensions or factors in this study were derived from evidence of AM capacities that are dissociated from others based on cognitive, neuroimaging, and neuropsychological evidence: episodic AM, semantic memory, spatial memory, and future thinking or prospection.

AM refers to memory for personal events and facts from one's life. It has typically been divided into episodic and semantic systems or processes. Episodic AM refers to recollection of personally experienced, temporally- and spatially-specific events, accompanied by an autonoetic sense of reliving the past (Tulving, 2002). Semantic AM refers to knowledge about oneself that is not tied to a specific time and place. Episodic and semantic AM are mediated by distinct neural systems (Levine, 2004; Maguire, 2001; St-Laurent et al., 2011; Svoboda et al., 2006) and they can be dissociated in patients with brain disease (Conway and Fthenaki, 2000; Kapur, 1999; Kopelman et al., 1999; McKinnon et al., 2008).

Semantic AM is part of semantic memory, which refers to general knowledge about the world (e.g., that the capital of France is Paris). Semantic memory is often considered as memory system because it can be dissociated from other memory systems. For example, atrophy in lateral temporal areas, as in semantic dementia, leads to specific deficit of semantic knowledge (e.g., difficulties with naming) with relative sparing of other cognitive functions, including episodic memory (Hodges et al., 1995). Also, neuroimaging studies have specifically linked semantic memory to left lateral inferior frontal and temporal areas (Demonet et al., 1992; Graham et al., 2003; Martin, 2001).

In addition to the episodic and semantic systems, AM can be characterized by its remote spatial and prospective memory characteristics. Remote spatial memory refers to awareness of previously encoded spatial coordinates that enable orientation and navigation in previously encountered settings. These spatial abilities are bound with AM because of the biological importance of the recall of spatial context (Hassabis and Maguire, 2007; O'Keefe and Nadel, 1978; Tulving, 1983). Accordingly, there is marked overlap between brain activation patterns associated with AM and remote spatial memory (Buckner and Carroll, 2007; Burgess et al., 2001b; Maguire, 1997). Yet, there also is evidence for both behavioral and neuroanatomical dissociation of some types of spatial navigation from episodic memory (Aguirre and D'Esposito, 1999; Moscovitch et al., 2005; Rosenbaum et al., 2000).

Prospection or future thinking, while not a form of memory *per se*, is closely related to AM (Atance and O'Neill, 2001; Buckner and Carroll, 2007; Schacter and Addis, 2007; Tulving, 1983; Wheeler et al., 1997). Prospection entails imagining future events in one's life. Brain regions supporting AM share considerable overlap with prospection into the future (Addis et al., 2007; Spreng et al., 2009). Moreover, patients with amnesia also have difficulties conceiving their personal future (Hassabis et al., 2007; Kwan et al., 2010; but see Cooper et al., 2011). Given the degree of overlap in the neural substrates of episodic, future and spatial abilities, some authors have proposed that all of these functions share common underlying component processes (Buckner and Carroll, 2007). Disambiguating the relationships among these cognitive capacities can provide a richer understanding of the phenotypic properties of episodic memory as well as its function.

There are various well-validated interviews designed for assessing AM (Kopelman et al., 1989; Levine et al., 2002; Piolino et al., 2002). Although these measures have been useful for characterizing patterns of spared and impaired AM in various patient populations (Kopelman et al., 1989; McKinnon et al., 2008; Piolino et al., 2003) and in normal aging (Levine et al., 2002; Piolino et al., 2002) they are lengthy and impractical for larger scale research, such as cohort or epidemiological studies. As an alternative approach, structured questionnaires have also been developed for assessing AM (Johnson et al., 1988; Rubin et al., 2003; Rubin and Siegler, 2004). These measures, however, are intended to investigate characteristics of single events as opposed to stable memory characteristics.

We created items for the SAM that addressed each of the four putative AM capacities. We elected to use the term "autobiographical" in the SAM as most of the items (excluding the strictly semantic items) related to the self, whether in past episodes, past spatial contexts, past semantic knowledge, or future thinking. We administered the SAM to a large ($N = 598$) sample of healthy adults and used a factor analytic technique, multiple correspondence analysis (MCA; Abdi and Valentin, 2007; Abdi and Williams, 2010; Benzécri and Cazes, 1978; Greenacre, 1984) to quantitatively assess the dimensions of the SAM. We predicted some degree of overlap in the representation of the four identified naturalistic cognitive capacities. Given our *a priori* interest in assessing these capacities separately, we also derived category scores for each memory capacity to examine their relationship to other measures. Hierarchical models of AM hold that more experience-near episodic details may be embedded in larger knowledge structures (Conway, 2001; Conway and Pleydell-Pearce, 2000). While such a model is compelling, there is no clear consensus on the hierarchical structure of AM. We therefore did not make any assumptions about the hierarchy of SAM factors.

The SAM's discriminant validity was assessed in two ways. First, because depression is typically associated with reduced event specificity (Williams et al., 2007), we examined how groups with and without a history of depression would perform on the dimensions and memory item categories derived from the MCA. We hypothesized that participants endorsing a history of depression would exhibit reduced episodic AM as assessed by the SAM relative to non-depressed subjects. Second, there is evidence for sex differences in memory tasks. Males outperform females on spatial tasks (Astur et al., 1998, 2004; Gron et al., 2000; Postma et al., 2004), leading to the prediction that self-reported spatial memory on the SAM may be higher in males than in females. There is also evidence for a female advantage on laboratory tests of episodic memory, especially those involving non-spatial processes (Herlitz et al., 1997, 1999; Herlitz and Rehnman, 2008) and AM (Bauer et al., 2003; Pillemer et al., 2003; Rubin and Berntsen, 2009).

Criterion-related validity was assessed by correlating SAM measures with recollection as assessed in the laboratory using both objective tests of episodic recollection (i.e., recognition memory for specific laboratory events) and of naturalistic AM (i.e., recollection for specific personal events). While we argue that naturalistic trait mnemonics can be dissociated from memory performance as assessed in the laboratory, moderate relationships between these two kinds of measures are expected, especially between episodic AM as assessed by the SAM and for measures of recollection as assessed in the laboratory. These two measures share a basis in episodic re-experiencing, but their relationship is constrained by method variance (i.e., self-report as opposed to performance-based assessment).

2. Methods

2.1. Participants

Six hundred and ninety-one volunteers participated in this study. Participants were excluded if they had a significant medical disorder affecting cognition or major psychiatric disorders with the exception of those who reported a history of depression or anxiety. These participants were not excluded, but were flagged for additional analyses (see below). Ninety-three participants were excluded due to invalid response profiles (see below). The remaining 598 volunteers (191 males and 407 females, aged 18–65; mean age $= 30.4$, $SD = 40$; mean education $= 15.2$ years, $SD = 3.8$ years) were included in this study. Participants were recruited via postings at the University of Toronto as well as through Baycrest's volunteer subject pool. A subset of the participants ($N = 89$), recruited primarily from the University of Toronto, also participated in a laboratory task of recognition memory (Rudebeck et al., 2009). A subset of these participants ($N = 52$) completed the Autobiographical Interview (AI; Levine et al., 2002), a laboratory-based measure of AM. These data were collected as part of a separate study investigating individual differences in memory.

2.2. Procedure

2.2.1. SAM

The SAM is a self-report inventory designed to assess naturalistic episodic autobiographical, semantic, and spatial memory, as well as prospection or future thinking. Items for the SAM were derived from previously developed instruments (Johnson et al., 1988; Levine et al., 2002; Rubin et al., 2003; Rubin and Siegler, 2004; Sutin and Robins, 2007) and from literature on naturalistic memory capacities (Conway, 2001; Hassabis and Maguire, 2007; Kapur, 1999; Maguire, 2001; Rosenbaum et al., 2000; Tulving, 2002, 1985). The resulting 102 questionnaire items comprised 42 episodic AM items (e.g., When I remember events, in general I can recall people, what they looked like, or what they were wearing), 24 semantic items (e.g., I can learn and repeat facts easily, even if I don't

Please cite this article in press as: Palombo DJ, et al., The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life, Cortex (2012), http://dx.doi.org/10.1016/j.cortex.2012.08.023

remember where I learned them), 20 spatial items (e.g., In general, my ability to navigate is better than most of my family/friends), and 16 future items (e.g., When I imagine an event in the future, the event generates vivid mental images that are specific in time and place). Participants were asked to rate the extent to which a particular item applied to their memory in general, using a 5-point Likert scale (1 − completely disagree, 2–4 − intermediate degrees of agreement/disagreement, 5 − completely agree). For episodic AM, participants were told that the questions should be applied to multiple events that happened at least 3–4 weeks ago: "*When answering, don't think about just one event; rather, think about your general ability to remember specific events*", and to avoid thinking of only one particular exemplar to answer the questions (Conway, 1992). Twenty-six percent of items from each memory type were negatively formulated and were reverse coded prior to analyses. Participants completed the SAM online. History of depression was assessed with a single item: "*Have you ever suffered from depression that significantly interfered with your functioning?*" This item was obviously not intended to provide a formal diagnosis of depression (which could not be attained in the context of this on-line survey). Rather, this item was intended to survey self-reported history of mood disturbance for the purposes of testing hypotheses concerning this history and elements of autobiographical memory. A similar item pertained to anxiety. As responses to this item did not add to our results over and above those for depression, these results are not reported. Participants with valid surveys were reimbursed with a $10 electronic gift card to iTunes or Amazon.ca. This study was approved by the Baycrest and University of Toronto Research Ethics Boards.

2.2.2. *Compliance with web-based test administration*

Web-based testing is a reliable medium for psychological studies (Logie and Maylor, 2009; McGraw et al., 2000; Reimers and Maylor, 2005; Spreng and Levine, 2006) and shows concordance with data collected using more traditional offline methods (McGraw et al., 2000). Nonetheless, as SAM administration was unsupervised, several measures were included to screen for invalid responding. Specifically, twice during testing, participants were asked to enter the current time. For four items, a specific response (e.g., "select 'strongly agree'") was requested. Participants who failed to follow these instructions were excluded. One item was negatively formulated but otherwise left identical to its positive counterpart; participants with discrepant responses between these two items were excluded from the analysis. The duration of survey completion was recorded, and participants with unrealistically short durations (<15 min) were excluded from the analysis. Finally, response profiles were inspected for signs of invalidity, such as entering the same response for all or most items. These screening methods resulted in the exclusion of 93 participants.

2.3. *Validity of the SAM*

2.3.1. *Construct validity of the SAM*

SAM data were analyzed using MCA (Abdi and Valentin, 2007; Abdi and Williams, 2010; Benzécri and Cazes, 1978; Greenacre, 1984). MCA is more suitable than traditional data reduction techniques (e.g., principal components analysis) for data involving ordinal scales, such as Likert scales, where the response categories have a rank order but the interval between values cannot be assumed to be equal (i.e., MCA does not assume an interval scale). MCA represents these data by computing orthogonal components called *dimensions* that are expressed as *factor scores* for both observations (i.e., participants) and variables (i.e., responses). These factor scores can be displayed as maps in which observations and variables are represented as points such that similar observations (or variables) are near each other so that relationships between observations and between the variables can be visually identified. Each dimension extracts a portion of the total variability—called *inertia*—of the data. The variability extracted by a dimension, analogous to variance, is called the eigenvalue of this dimension (note that, in MCA, this eigenvalue is always smaller than 1).

First, we submitted the data from the full list of questions to MCA. The analysis was performed on a data table that integrated four sub-tables (one sub-table for each memory category). Given the unequal number of questions in each sub-table, the questions were re-weighted so that each sub-table contributed equally to the analysis. This was done by dividing each entry of a sub-table by the square root of the number of columns of this table (see Abdi et al., 2012 for justification of this normalization scheme). Based on analysis of the distribution of the responses for each item, we also recoded most questions because participants used the scales in different ways: in most cases responses were binned into three categories (i.e., if participant's scores were skewed toward one end of the response categories), in some cases responses were binned into four response categories, and in few cases, the five response categories were retained in their original form (i.e., if participants spread their responses equally across all five response categories).

The analysis provided *factor scores* for the observations and *factor scores* (analogous to loadings) for the modalities of each variable. The statistical significance of the dimensions or factors was assessed via a permutation test in which participants' responses were permuted independently for each question. A new analysis was performed for which the total inertia was computed as well as the eigenvalue associated to each dimension. This procedure was repeated 1000 times. The proportion of observed inertia and eigenvalues larger than the observed values can be interpreted as an empirical *p* value. In all reported analyses, the observed inertia (a value akin to variance) across all dimensions was larger than all the permuted values (i.e., $p < .001$). For dimensionality reduction, we decided to keep for further analysis only the dimensions whose eigenvalues were larger than 5% of the permuted values (i.e., $p < .05$).

The stability of the factor scores of the modalities of the variables to the dimension was assessed with a bootstrapping procedure by which 1000 new data sets were created by re-sampling with replacement from the original data set. Each data set was projected as supplementary elements on the original solution (see Abdi and Williams, 2010 for details on this procedure) in order to obtain a bootstrapped factor scores for the responses. The ratios of the means of these factor scores to their SDs gives bootstrap ratios that can be interpreted as analogous to *t*-statistics. Responses with a bootstrap

Please cite this article in press as: Palombo DJ, et al., The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life, Cortex (2012), http://dx.doi.org/10.1016/j.cortex.2012.08.023

ratio of 3 or greater for a given dimension (corresponding to a p value of .05 after Bonferroni correction for the total number of questions) were retained.

The validity analyses described below assessed the relationship of SAM dimensions as determined by the MCA to individual differences in history of depression, sex differences, and recognition memory and autobiographical recollection. When these dimensions comprised more than one of our original four categories, we conducted supplemental analyses using category scores composed of reliable items (as determined by bootstrap ratio) for each category.

2.3.2. *Discriminant validity of the SAM*

The effects of depression and sex on the SAM were independently assessed with mixed-design analysis of variance (ANOVA) with self-reported history of depression or sex as a between-subjects variables and SAM dimension or category scores as a within-subjects variables. Corrections for violations in sphericity were used if necessary (we used the Greenhouse–Geisser correction, see Abdi, 2010). Follow-up paired t-tests were used for group comparisons. ANCOVA was also used when necessary. Values of $p < .05$ were considered significant. Effect sizes (i.e., Cohen's d) are reported for follow-up comparisons (Cohen, 1988).

2.3.3. *Criterion-related validity of the SAM*

To assess criterion-related validity of the SAM, dimension and category scores were correlated with recognition memory and AM performance in a subset of participants who completed ancillary laboratory testing. SAM data from this subset of participants were reanalyzed with MCA to confirm that they were representative of the larger sample.

2.3.3.1. Recognition memory test. Eighty-nine participants were randomized to one of two versions of the recognition memory test: object or scene (Rudebeck et al., 2009). For the object version, participants viewed grayscale photographs of everyday objects; for the scene version, photographs of unfamiliar indoor and outdoor scenes were used. At encoding, participants saw 120 individual photographs, each presented for 10 sec. For objects, participants were asked to decide whether each item could fit in a shoebox. For scenes, participants were asked whether the scene was indoor or outdoor. Following a 20-min delay period filled with an unrelated task, participants were then presented with the encoding items intermixed with 120 lures, each presented for 15 sec. Participants were asked to judge whether they recognized the items by using a six-point confidence scale (1 = sure an item is new, 6 = sure an item is old).

A dual process signal detection model (Yonelinas, 1994, 2001) was used to fit the recognition memory data. This model assumes that recognition memory tasks can be accomplished using two independent processes: recollection (mentally re-experiencing the context of the specific encoding episode) and familiarity [knowing one encountered the stimulus without remembering anything about the context; (Tulving, 1985; Yonelinas, 2001)]. In order to derive recollection and familiarity scores, a Microsoft solver add-in that implements a sum of squares algorithm was employed (available at http://psychology.ucdavis.edu/labs/Yonelinas). To assess whether individual differences in SAM scores are related to recognition memory, correlational analyses (Pearson product-moment) were used across the recognition memory measures (i.e., recollection, familiarity) from both the scene and object versions and SAM dimensions and category scores.

2.3.3.2. The AI. The AI assesses AM using text-based analysis of transcribed autobiographical protocols. The AI was administered according to previously described methods (Levine et al., 2002) with some modifications. Prior to coming into the laboratory, participants were asked to select two events (negative and neutral) that were specific in time and place from the last 3 years, excluding the last 3 months. During *Free Recall* of the event, participants spoke about the event extemporaneously until it was evident that they had reached a natural ending point. After an event was recalled, *General Probes* were used to clarify instructions and to encourage greater recall of event details. General probes were limited to non-specific statements or repetitions of the instructions. The *Specific Probe* phase consisted of a structured interview designed to elicit additional sensory, perceptual, and mental state details of the event.

Subjects' descriptions of the selected events were audio-recorded for later transcription and analysis. Each memory was segmented into informational bits or details. Each detail was then classified by scorers who had previously attained high reliability on a separate set of memories already scored by an expert scorer (for reliability procedures, see Levine et al., 2002) and who were blind to any information concerning the participant. Details were classified as "internal" or episodic if they were related directly to the main event described, were specific to time and place, and conveyed a sense of episodic re-experiencing. To avoid individual differences among scorers in judgment of detail categorization, the AI scoring instructions stipulate that any detail that could reasonably be interpreted to reflect episodic re-experiencing be scored as "internal." Otherwise, details were considered "external," and consisted of semantic facts (factual information or extended events that did not require recollection of a specific time and place), autobiographical events tangential or unrelated to the main event, repetitions, or other metacognitive statements ("I can't remember") or editorializing ("It was the best of times").

Internal details were separated into five categories: event (i.e., happenings or the unfolding of the story), place, time, perceptual, and emotion/thought. External details were separated into four categories: semantic (i.e., factual information or extended events), repetitions and other details, external event details, which were details pertaining to specific events other than the main defined internal event. Scorers also assigned ratings for each detail category. Detail categories were analyzed separately but also summed to form internal and external composites. For the purposes of this study, only scores obtained from specific probe (cumulatively summed across all probing levels) are reported. Pearson correlations were computed between each dimension and category scores and AI measures.

2.3.4. *Construction of the short forms of the SAM*

For the sake of efficiency, a shortened version of the SAM was constructed for use in further research. Items from each memory category were selected based on their significant bootstrap ratios (>3). Items with overlap among the first four dimensions within each memory category type were selected. If two questions were very similar to each other, only one item was selected among the two. To ensure that the items chosen were still well represented of the pattern of results yielded by the first MCA, the validity analyses reported above were rerun on this subset of items. Finally we selected a subset of the highest loading items for a brief version of the SAM (B-SAM), which can more readily be used in epidemiological or cohort studies.

3. Results

3.1. *Construct validity of the SAM*

MCA on the full set of items provided 79 dimensions, with the first 17 dimensions reaching significance by the permutation test. From these, the first four dimensions were kept based on analysis of a scree plot of the sorted eigenvalues and on their interpretability. Dimension 1 ($\lambda = .04$, $\tau = 63\%$) and 2 ($\lambda = .008$, $\tau = 12\%$), where λ is the eigenvalue and τ is the percent of inertia of a given dimension, contrasts good and bad memory responses across memory types. Fig. 1A shows SAM responses with bootstrap ratios >3 for Dimension 1 along the horizontal axis, while Fig. 1B shows SAM responses with bootstrap ratios >3 for Dimension 2 along the vertical axis. As seen in Fig. 1A, Dimension 1 is defined by high (3, 4, 5 on the Likert scale; right side of axis) and low (1, 2 on the Likert scale, left side of axis) item responses across all the domains of memory. A similar pattern is present on for Dimension 2, with high and low item responses at the top and bottom of the axis, respectively. SAM responses with bootstrap ratios >3 for Dimension 3 ($\lambda = .004$, $\tau = 8\%$) are represented on the horizontal axis of Fig. 1C, which shows higher item responses for the spatial category relative to other categories clustering on the right, with the left side of the axis dominated by low responses to spatial items. SAM responses with bootstrap ratios >3 for Dimension 4 ($\lambda = .002$, $\tau = 4\%$) are shown on the vertical axis of Fig. 1D. In this case, high responses on future questions relative to most other memory types cluster near the top, with low responses to future items toward the bottom. The percentage of contribution of each memory category to each of these dimensions is displayed in Table 1. Items in the episodic AM category contributed the most to Dimension 1, followed by semantic and spatial, then future. While Dimension 2 is similar to Dimension 1 in that it also has contributions from all memory types, the contributions of episodic AM, semantic, and spatial are nearly identical. The category contributions to Dimensions 3 and 4 are more clearly isolated to spatial and future, respectively.

3.2. *Correlations between SAM memory item categories*

Table 1B shows the percentage of shared variance between the memory categories (R^2). All memory types shared a significant percentage of variance ($p < .001$), with the greatest shared variance between episodic and semantic memory ($R^2 = .39$), followed by episodic and future ($R^2 = .21$).

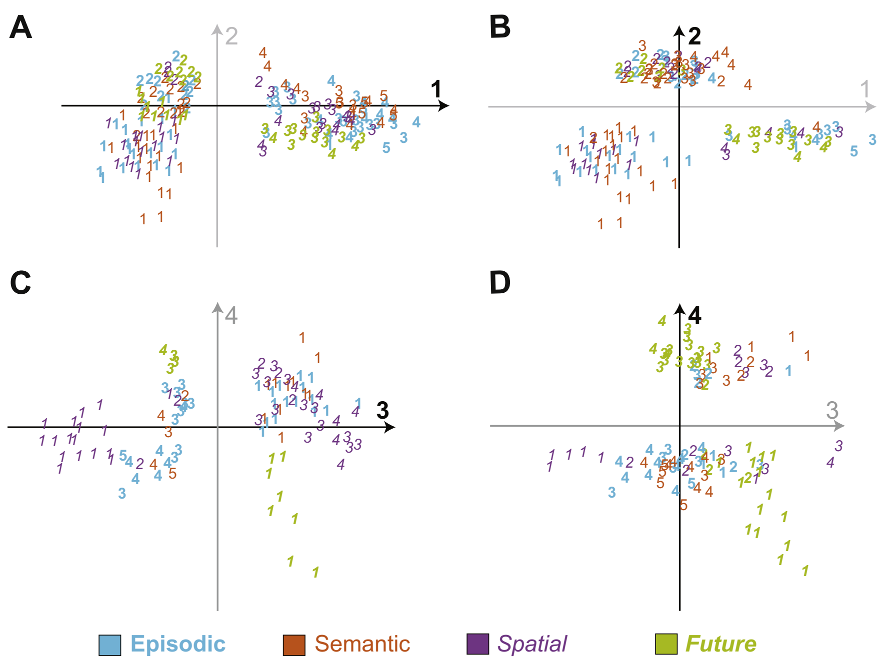

Fig. 1 – SAM responses with bootstrap ratios >3 shown on dimensions 1 through 4 (1 = poor memory, 5 = good memory). (A) Dimension 1 and (B) Dimension 2 separate good from poor memory across all memory categories. (C) Dimension 3 separates individuals with good versus poor spatial memory relative to other memory types. (D) Dimension 4 separates people with versus poor future prospection relative to other memory types. Items that cluster close to the origin do not significantly contribute to the patterns observed. Although each plot is represented in two-dimensional space, we have included four separate plots, highlighting the patterns for each dimension separately.

Table 1 – (A) Percentage of contribution of each memory type to each dimension. (B) Percentage of shared variance between memory item categories (R^2).

A	Dim. 1	Dim. 2	Dim. 3	Dim. 4
Episodic	.34	.28	.18	.18
Future	.19	.16	.09	.50
Semantic	.24	.29	.09	.16
Spatial	.23	.27	.65	.17

B	Future	Semantic	Spatial
Episodic	.21[a]	.39[a]	.14[a]
Future		.14[a]	.07[a]
Semantic			.14[a]

a $p < .001$.

Semantic memory shared less variance with the other memory types ($R^2 = .14$ for each type) and future and spatial had the smallest relationship ($R^2 = .07$).

3.3. *Discriminant validity of the SAM: self-reported history of depression*

Ninety-three of the 598 participants endorsed a history of depression (two participants did not respond to this question). As seen in Fig. 2A, individuals with a history of depression scored low on Dimension 1 relative to other dimensions, as supported by a main effect of depression ($F_{(1,594)} = 4.06$, $p = .04$) and a significant interaction between depression status and dimension type ($F_{(1.7,980.4)} = 4.01$, $p = .03$, with Greenhouse–Geiser correction), with follow-up comparison showing those endorsing depression scoring lower than others on Dimension 1 ($t_{(594)} = -2.28$, $p = .02$; Cohen's $d = .19$). Dimension 1 is multi-modal, with the highest loading from episodic AM items, and then semantic and spatial items (see Table 1A). Given the literature on reduced AM specificity and recollective qualities in depression, we conducted hypothesis-driven paired *t*-tests assessing the effects of depression history on episodic and semantic category scores. As seen in Fig. 2B, those reporting a history of depression had significantly lower scores on episodic AM items ($t_{(594)} = -2.89$, $p = .004$; Cohen's $d = .24$), with the difference for semantic falling short of significance ($t_{(594)} = -1.69$, $p = .08$; Cohen's $d = .14$). These effects could not be accounted for by group differences in age ($t_{(594)} = .16$, $p = .40$), education ($t_{(594)} = .84$, $p = .87$) or the distribution of sex ($\chi^2 = .85$, $p = .36$). There were no differences between the groups for the other dimensions.

3.4. *Discriminant validity of the SAM: sex*

As shown in Fig. 3A, there were sex differences on the SAM dimensions ($F_{(1.595)} = 4.46$, $p = .04$). Males scored significantly higher on Dimension 3 ($F_{(1,595)} = 20.68$, $p < .0001$; Cohen's $d = .37$). A significant, although smaller effect was also noted for Dimension 2 ($F_{(1,\ 595)} = 3.92$, $p = .05$; Cohen's $d = .19$). Education was included as a covariate in this analysis as the female group was significantly more educated than that of the male group ($t_{(309.7)} = -2.36$, $p = .03$). Groups did not differ in age

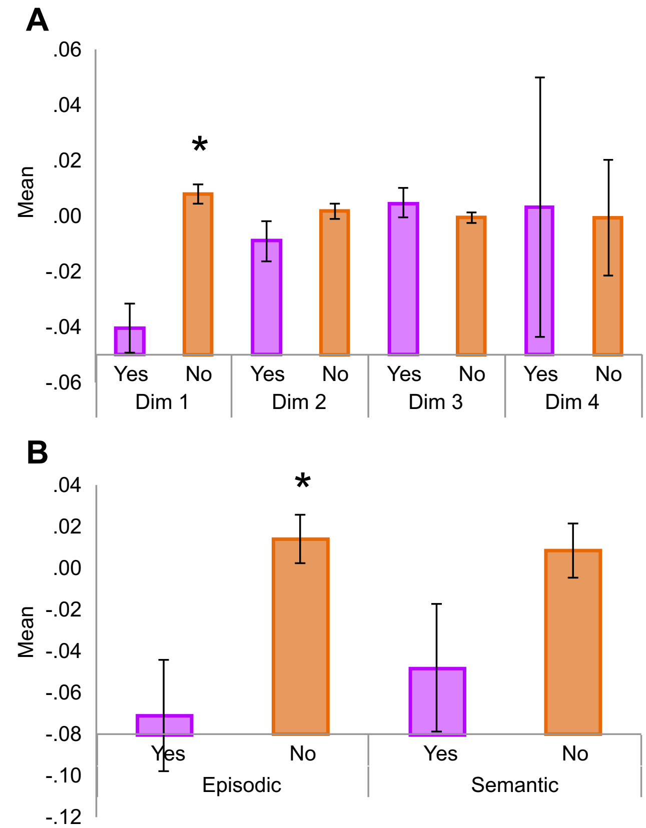

Fig. 2 – (A) Comparison of individuals with and without a history of depression on (A) dimensions and (B) episodic and semantic item categories (bars represent standard errors).

($t_{(595)} = .12$, $p = .91$) or depression status ($t_{(594)} = .92$, $p = .36$). Follow-up analyses did not reveal any significant sex differences for episodic AM or semantic memory (Fig. 3B).

3.5. *Criterion validity of the SAM: recognition memory*

Recollection on the scene version of the recognition test was positively correlated with Dimension 1 ($r = .34$, $p = .03$; Fig. 4), but there was no significant relationship with familiarity ($p > .30$). None of the other correlations between the dimension scores and the spatial recognition memory task were significant. Considering episodic AM and semantic category scores, episodic AM was marginally significantly positively associated with scene recollection ($r = .29$, $p = .06$) but not with familiarity ($p > .60$). Semantic memory was marginally correlated with scene recollection ($r = .26$, $p = .09$) but not with familiarity ($p > .90$). For the object task, there were no statistically significant correlations, although Dimension 4 was marginally significantly correlated with recollection ($r = .27$, $p = .07$) and familiarity ($r = .29$, $p = .06$). To ensure that the observed association between the recognition memory task and SAM could not be explained by sex, education, age, or depression, we conducted a hierarchical regression analysis with each of these variables and recollection or familiarity entered into the model last. Accounting for the contributions

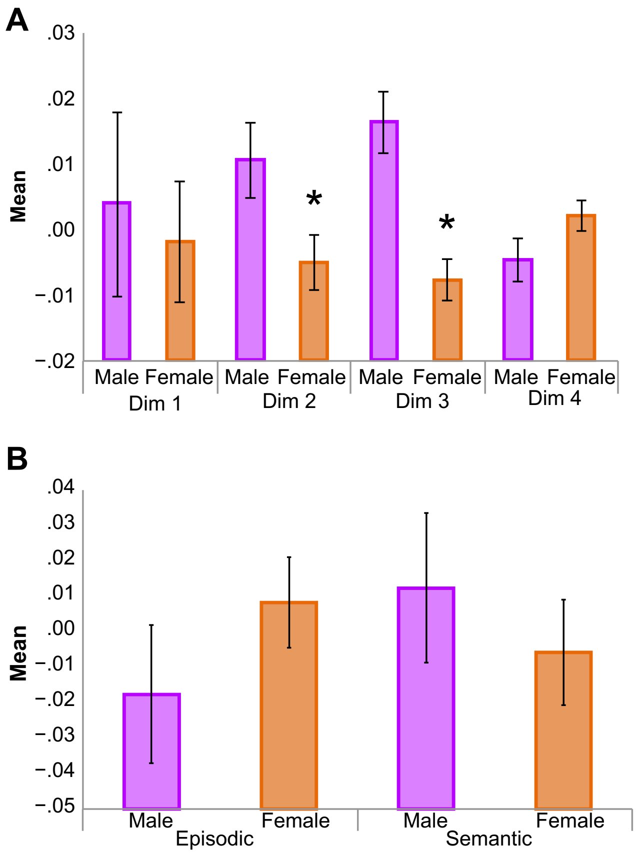

Fig. 3 – (A) Comparison of males and females on (A) dimensions and (B) episodic and semantic item categories (bars represent standard errors).

of these variables, the correlations remained significant between recollection and dimension 1 ($p = .03$) and the correlation between recollection and episodic AM was now significant ($p = .04$); the relationship between recollection and semantic memory was only marginal ($p = .07$). No relationships with Dimension 4 remained significant after controlling for these variables. The correlations between the four dimensions and recollection and familiarity are shown in Table 2.

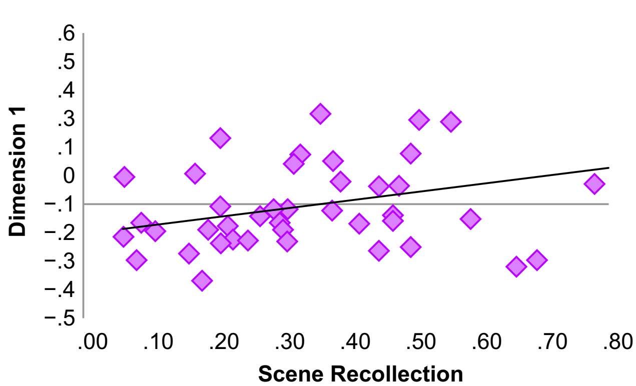

Fig. 4 – Relationship between Dimension 1 and scene recollection.

Table 2 – The correlations between the four dimensions (dim) of the SAM and recollection (R) and familiarity (F) for the object and scene recognition memory tasks.

	Objects		Scenes	
	R	F	R	F
Dim 1	.19	.15	.34[a]	.16
Dim 2	−.08	−.06	.10	−.11
Dim 3	−.05	.09	.09	.20
Dim 4	.27	.29	−.20	−.06

Marginally significant correlations are indicated in italics.
a $p < .05$.

3.6. *Criterion validity of the SAM: the AI*

Dimension 3 was significantly positively correlated with internal place details ($r = .37$, $p = .007$), place ratings ($r = .44$, $p = .001$), time ratings ($r = .33$, $p = .001$), perceptual ratings ($r = .27$, $p = .001$), episodic richness scores ($r = .41$, $p = .002$), and total ratings after probing ($r = .32$, $p = .02$; see Fig. 5). There were no other significant correlations observed between any of the dimensions and AI performance measures. Accounting for the contributions of sex, education age, and depression status, using hierarchical regression, did not alter the pattern of results (Dimension 3 with internal place details $p = .009$, with place ratings $p = .001$, with time ratings $p = .01$, with

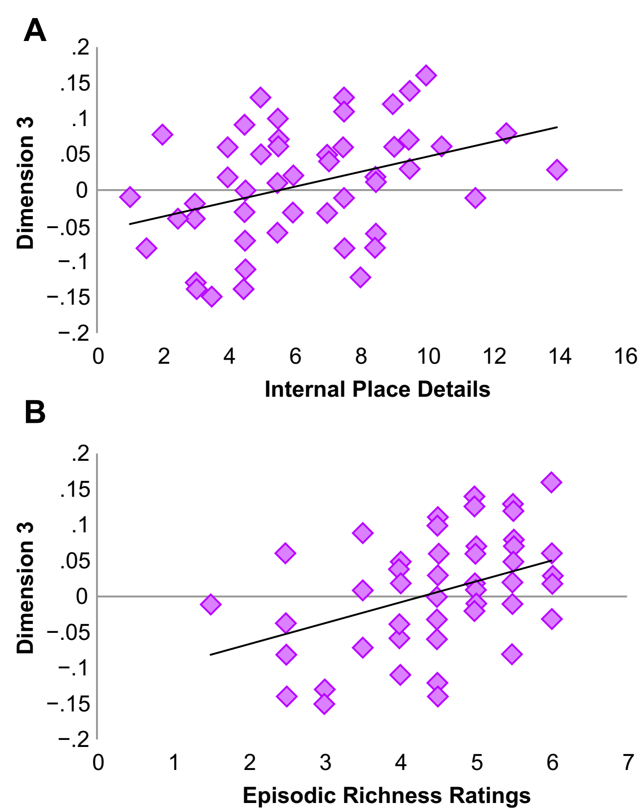

Fig. 5 – Relationship between Dimension 3 (A) internal place details and (B) episodic richness scores.

Please cite this article in press as: Palombo DJ, et al., The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life, Cortex (2012), http://dx.doi.org/10.1016/j.cortex.2012.08.023

perceptual ratings $p = .03$, with episodic richness scores $p = .004$, and with total ratings after probing $p = .03$).

3.7. Item analysis for development of reduced SAM and B-SAM

The item analysis yielded a 26-item version of the questionnaire for use in research applications (9 episodic, 6 future, 6 semantic, and 6 spatial) and a brief screening measure (B-SAM, 10 items) for use in large-scale epidemiologic studies (see Appendix). While the items are reproduced in the Appendix, derivation of SAM/B-SAM dimension scores cannot be attained simply by summing the responses to these items. Please contact the authors for information on proper administration and scoring of the SAM/B-SAM.

4. Discussion

The goal of this study was to develop a measure to assess naturalistic self-reported trait mnemonics, the SAM. We used a data reduction technique (i.e., MCA), to examine the SAM's latent dimensional structure in a large sample of healthy individuals. This analysis revealed that a four-dimensional structure best summarized the data. The first two dimensions represented general memory abilities (i.e., good *vs* poor memory across subtypes), while the third and fourth dimensions characterized individual differences in spatial and future abilities, respectively, relative to all other memory types. The validity of the SAM was further assessed in a series of analyses relating SAM to history depression, sex and other mnemonic in-lab performance measures designed to separate recollection from non-recollective processes. Based on these findings, the original version of the SAM was reduced to a 26-item final version and a 10-item brief version (B-SAM) for application in epidemiological or cohort research.

4.1. The latent structure of naturalistic AM

The latent structure of the SAM data, as revealed by MCA, indicated that the first dimension (which accounted for the largest amount of inertia or variance) characterized good versus poor episodic autobiographical, semantic, and spatial memory. In other words, when people reported having high or low abilities for one category of memory, they tended to do the same for other categories.

When considered separately, episodic AM and semantic memory shared nearly 40% of item response variance. This finding could be interpreted as supporting the notion that episodic and semantic memory are not independent, or that memory is best accounted for by a single-factor model (Squire and Zola, 1998; Squire et al., 2007).

On the other hand, research treating episodic recollection and semantic memory processes as independent (Yonelinas, 2001) does not rule out their interaction and even close correspondence in healthy adults' self-report of naturalistic mnemonic traits. For example, in healthy adults fame judgments are facilitated for names associated with an episodic event from the participant's past, but not in patients with medial temporal lobe damage (Kan et al., 2009; Westmacott and Moscovitch, 2003; Westmacott et al., 2004). Interaction between episodic recollection and semantic memory is also highlighted in neuroimaging studies, which demonstrate both common and unique areas of activation among these memory types (Burianova and Grady, 2007; Levine et al., 2004; St-Laurent et al., 2011).

Demonstrating the independence of episodic recollection and semantic processes requires specialized testing and data analysis methods. Within recognition memory, for example, both recollection and familiarity (corresponding to episodic and semantic memory, respectively) are assumed to contribute to performance; it is only through statistical manipulation of test scores (e.g., through process dissociation; Jacoby, 1991) analysis of receiver operating characteristics (Yonelinas, 2001, 1994) or self-report of conscious experience accompanying recognition (Tulving, 1985), that these processes are teased apart. Within AM, episodic events are embedded in a semantic context such that the subject recollects not only the specific happenings of that episode but also the historical personal and public facts surrounding the event (Levine et al., 2002). For the AI, it is only at the time of scoring that the distinction between episodic and semantic AM is made. Given the continuity of these memory processes in healthy participants, it is not surprising that healthy individuals do not make this distinction in judgments of their own naturalistic memory.

Interacting memory systems are of course dissociable in certain circumstances (Tulving, 1983, 1985), as classically demonstrated in medial temporal amnesia where performance on certain short-term or working memory tasks is preserved despite severe deficits in long term memory (Scoville and Milner, 1957), whereas short-term and long-term memory are normally closely related both behaviorally and at the neural level (Cabeza et al., 2002; Nyberg et al., 2002). Similarly, naturalistic episodic AM and semantic memory is expected to correlate in healthy adults.

Although Dimensions 1 and 2 were conceptually similar, only Dimension 1 demonstrated discriminant validity in subsequent analyses, possibly due to the dominance of episodic AM or recollective items. The behavioral, neuropsychological, and neuroimaging evidence in support of a dissociation between episodic AM and semantic memory motivated our supplemental analyses in which these categories were assessed separately, with results lending further support to this dissociation by discriminating depressed from non-depressed individuals and in relation to laboratory memory tests (i.e., recognition memory and AI performance).

The third dimension separated spatial memory from other memory types, which supports the validity of this memory type as a distinct process within naturalistic memory. The validity of this dimension was further highlighted as it best characterized performance on our laboratory AM task, particularly for measures of spatial AM. According to Cognitive Map Theory (O'Keefe and Nadel, 1978), hippocampally-mediated spatial memory processes enable the formation of an allocentric cognitive map of the environment that provides a scaffold for the formation of episodic memories (Burgess et al., 2001a). The correspondence of episodic and spatial memory is likely highest for experientially detailed (as opposed to schematic) representations (Moscovitch et al.,

Please cite this article in press as: Palombo DJ, et al., The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life, Cortex (2012), http://dx.doi.org/10.1016/j.cortex.2012.08.023

2005). Yet spatial memory as assessed by the SAM involves multi-component processes with variable and interacting contributions by hippocampal and neocortical elements of the brain's spatial network, including navigation from egocentric perspectives, landmark use, and use of schematic spatial representations (Aguirre and D'Esposito, 1999) in addition to the allocentric, detailed representations considered to overlap with hippocampal function and episodic memory.

Finally, the MCA revealed a fourth dimension, which distinguished future prospection from other memory types. As future prospection it is not actually a form of memory, it was expected that it should be distinct from the other memory abilities. On the other hand, episodic memory is considered to be closely related to future prospection (Atance and O'Neill, 2001; Schacter and Addis, 2007; Tulving, 1985). Prospection is thought to be constrained to a large degree by what has happened in the past; imagining what one needs to bring to a forthcoming event, such as a picnic, requires the use of past experiences of having picnics in a particular temporal-spatial context (Addis et al., 2007; Spreng and Levine, 2006). Moreover, functional neuroimaging studies show overlap in the neural substrates of episodic and future thinking (Addis et al., 2007; Spreng et al., 2009). Finally, some patients with amnesia who are impaired on the ability to recall past events are also unable to project themselves into the future (Hassabis et al., 2007; Kwan et al., 2010).

Among the other three categories, the future items shared the most common variance with episodic memory, although this was not a large association. Hence, our data suggest that when people are asked about their real world capacities, future prospection is only partially associated with episodic memory. It is likely that other cognitive abilities, such as problem solving or social reasoning contribute to future prospection. Indeed, in addition to commonalities, important differences between episodic and future thinking have also been highlighted in neuroimaging. For example, future thinking recruits the frontal polar cortex, important to representing intentions, to a greater degree than past events (Addis et al., 2007; Okuda et al., 2003). Moreover, while deficits in future thinking have been observed in amnesia (Hassabis et al., 2007; Kwan et al., 2010), intact future prospection has also been observed (Cooper et al., 2011). Taken together, these results suggest that the relationship between future prospection and episodic memory may not be as direct as originally formulated (Buckner and Carroll, 2007; Schacter and Addis, 2007; Tulving, 1985), and may be affected by method variance.

4.2. *Relation of self-reported AM capacities to other variables*

The validity of SAM was supported by relating it to variables that were external to the main constructs assessed by the SAM. In particular, we showed that episodic AM was specifically related to history of depression, sex, and performance on a recognition memory task of recollection. Further, self-reported spatial processes were positively associated with spatial AM on laboratory-assessed AM. Overall, these results indicate that trait mnemonics as assessed by the SAM are relevant to individual differences in other domains.

It is well established that depression is characterized by a lack of AM specificity, which is a tendency to produce less phenomenologically rich or overgeneralized memories during AM assessment (Lemogne et al., 2006; Williams et al., 2007). One influential hypothesis is that AM deficits in depression are a consequence of poor executive control; when tasks are poorly constrained, which is typically the case in AM assessment, impoverished retrieval strategies result in premature termination of the top-down retrieval search process at the level of general knowledge retrieval (Conway and Pleydell-Pearce, 2000; Dalgleish et al., 2007). Moreover, difficulties with inhibition may lead to distracting information such as the negative ruminations that are characteristic of depression, resulting in a negative bias (Dalgleish et al., 2007; Hertel and Hardin, 1990; Lemogne et al., 2006). Accordingly, we found that individuals with a self-reported history of depression produced lower scores for self-rated episodic AM; self-reports of semantic AM were less affected by depression. Hence, our data support research showing that depression is characterized by specific deficits in the recollective component of AM, or in one's ability to travel through time and phenomenologically re-experience spatial and temporally bound episodes; whereas the ability to generate semantic or factual information is less affected by depression (Söderlund et al., submitted for publication). Our assessment of depression history was constrained to a single item and not considered to reflect a formal diagnosis as attained through a detailed history (i.e., structured interview). It is possible that our assessment of depression added noise to our analysis owing to subjects' differential interpretation of our depression item. This noise, however, should not have selectively biased our findings in favor of an association of depression with reduced episodic re-experiencing.

There is growing evidence that sex influences learning and memory processes (Cahill, 2006). Within memory, males are consistently found to outperform females on spatial tasks (Astur et al., 1998, 2004; Gron et al., 2000; Postma et al., 2004). In line with this research, we found that males had markedly higher endorsement of items on Dimension 3, which separated those with low and high self-reported spatial abilities. The findings for other forms of memory were less clear. Males also had higher endorsement on Dimension 2, a general memory factor, although in non-spatial tasks prior research indicates a female to male advantage in episodic memory (Herlitz et al., 1997, 1999; Herlitz and Rehnman, 2008) and AM (Bauer et al., 2003; Pillemer et al., 2003; Rubin and Berntsen, 2009). However, analysis of the item categories indicated that this difference was likely accounted for by males' higher endorsement of spatial items; there were no sex differences in the episodic AM or semantic categories. A lack of difference in episodic AM between males and females was surprising given the literature supporting a female to male advantage on episodic memory tasks; however, studies of sex differences in episodic memory show complex results. For example recent work has shown that while women show an advantage on verbal episodic memory tasks, men outperform women in visuospatial episodic memory tasks (Herlitz and Rehnman, 2008).

The SAM's criterion validity was assessed with a laboratory analog of real-life AM (i.e., using laboratory generated stimuli;

Rudebeck et al., 2009), derived from a dual process model of recognition memory (Yonelinas, 2001) that models episodic (i.e., recollection) and non-episodic contributions (i.e., familiarity) as separate functions (as opposed to standard neuropsychological measures that conflate these processes). The measure of recollection derived is more fundamentally similar to self-reported episodic AM than standard recognition memory. We found a positive association between Dimension 1 and recollection as assessed by the scene recognition task. Follow-up analyses revealed a significant association between episodic AM and scene recollection; the relationship with semantic memory showed a positive trend but was not statistically reliable. Considering the major superficial differences between self-reported episodic AM and the statistically derived measure of recollection from a recognition memory test, this association provides strong support for the use of the episodic AM category as independent from the other categories. Moreover, these findings support the use of dual-process laboratory measures in the assessment of episodic memory (correlations to standard recognition memory scores from these same tests were not significant). We did not observe an association between the spatial dimension on the SAM and scene recollection. This was not surprising as scene recollection does not require processing of information concerning spatial configuration. Nonetheless, scenes are considered more perceptually complex than objects, which may be why the object task demonstrated only marginally significant associations with the SAM.

Given that real-life episodes are much more complex than what is captured with laboratory generated stimuli (i.e., objects/scenes), we also included the AI (Levine et al., 2002) in our validity analysis as an ecologically valid laboratory assessment of AM that more closely resembles the naturalistic memory capacities probed by the SAM. While the AI produced more statistically robust associations with the SAM relative to the recognition memory measure, these associations were observed for Dimension 3, which is dominated by spatial memory. This observation corresponds to the notion that episodic AM is supported by spatial memory (Burgess et al., 2001a; Hassabis et al., 2007; O'Keefe and Nadel, 1978). Notably, Dimension 3 scores related to both numbers of place details and to spatial specificity as rated by independent scorers, supporting the validity of these AI categories.

The lack of a more general association between Dimension 1 or the episodic AM category and internal details on the AI, considered to be an objective measure of episodic AM, was contrary to expectation. This may reflect the low threshold for classification of a detail as internal in the AI scoring system. That is, any detail that could reasonably reflect episodic re-experiencing is considered internal. While this practice reduces the subjectivity of scoring, it is acknowledged that specific spatial-temporal "episodic-like" details can be produced even in the absence of episodic re-experiencing (Brewer, 1988), as in instances of family folklore when details are memorized and repeated through story telling (Cermak and O'Connor, 1983). In aging or patients with brain disease, the deficit in episodic AM is large enough to manifest itself in spite of this liberal scoring (e.g., Irish et al., 2011; McKinnon et al., 2008; Milton et al., 2010), whereas in healthy adults the liberal scoring may have obscured relationships to corresponding measures of AM in the SAM. Indeed, in our case study of selectively impaired episodic AM (with preserved semantic AM) following traumatic focal right frontotemporal disconnection (Levine et al., 1998), self-reported episodic AM was severely affected, yet internal details on the AI were only marginally reduced, possibly due to compensation from non-episodic systems that allowed production of episodic-like details (Levine et al., 2009).

The fact that the SAM is based on self-report must be taken into consideration when interpreting findings from this instrument. While it is standard practice to derive estimates of traits from self-report inventories, there is always a possibility that these may be biased by inaccurate self-appraisal. The foregoing validity data indicate that, at least for the healthy adults tested in this study, trait AM as assessed by the SAM does correspond in meaningful ways to performance-based measures, supporting the use of the SAM as a measure of trait AM in future research. Moreover, it demonstrates effects of depression and sex predicted from other memory research. Overall, the effect sizes were modest, owing either to a genuine difference in the naturalistic AM constructs as assessed by the SAM as compared to other measures, or to measurement error inherent in self-report.

4.3. *Future directions*

The SAM differs from other memory questionnaires in many respects. Our questionnaire is not designed to assess everyday memory errors and slips (Broadbent et al., 1982; Sunderland et al., 1984), which may add additional clinical utility for detecting absentmindedness that the SAM does not probe. The SAM is also distinguished from questionnaires that probe specific events (Johnson et al., 1988; Rubin et al., 2003; Rubin and Siegler, 2004). The assessment of specific events provides an advantage of manipulating event characteristics, such as vividness (Rubin et al., 2003). However, the assessment of specific events does not provide information regarding more stable between-subject characteristics. Interpretation of the SAM must be qualified by potential bias owing to self-appraisal abilities, such as lack of insight in relation to brain disease. In general, comprehensive assessment of naturalistic memory capacities requires a convergence of performance-based and self-report measures.

To date, there has been very little research examining normal individual differences in AM, yet there is a growing body of research demonstrating important behavioral and neural correlates of individual differences in laboratory mnemonic processes. These studies provide a benchmark for the construct of AM as an individual differences variable, an idea that is further validated in extreme cases of autobiographical remembering (Leport et al., 2012; Parker et al., 2006). The study of individual differences in AM is not merely of theoretical interest. In addition to the importance of AM for patients with memory disorders and the dementias, altered AM processing is implicated in psychopathology, particularly trauma-related disorders (McNally et al., 1995), and depression (Lemogne et al., 2006; Williams et al., 2007). Moreover, the AM profile mnemonic traits likely correspond to individual differences in other health-related domains, such as personality, other cognitive abilities, and daily life function. The SAM will be a useful instrument in such analyses.

Acknowledgements

We wish to thank Morris Moscovitch, Louis Renoult and Patrick Davidson for input on developing the SAM and Aggie Bacopulos, Tayler Eaton and Angela C. Zhang for their assistance with laboratory testing, and management of the database, including gift-card administration. We also wish to thank Rebecca M. Todd for assistance with developing the testing battery, and Robert S.C. Amaral, for help with scoring autobiographical memories. A special thanks to Andy Lee for kindly proving us with the recognition memory paradigm. D.J.P. was supported by the Ontario Graduate Scholarship. This study is part of D.J.P's PhD dissertation. This research was supported by a grant from the Canadian Institutes of Health Research to B.L. (MOP-62963).

Appendix. SAM − 26 items[1,2]

Please indicate the strength of your agreement with each of the following statements.

1 Strongly disagree
2 Disagree somewhat
3 Neither agree nor disagree
4 Agree somewhat
5 Agree strongly

Episodic (event)
1). **Specific events are difficult for me to recall (R)**
2). When I remember events, I have a hard time determining the order of details in the event (R)
3). **When I remember events, in general I can recall objects that were in the environment**
4). When I remember events, in general I can recall what I was wearing
5). I am highly confident in my ability to remember past events
6). **When I remember events, I remember a lot of details**
7). When I remember events, in general I can recall which day of the week it was
8). When I remember events, in general I can recall people, what they looked like, or what they were wearing

Semantic
1). I can learn and repeat facts easily, even if I don't remember where I learned them
2). After I have read a novel or newspaper, I forget the facts after a few days (R)
3). After I have met someone once, I easily remember his or her name
4). **I can easily remember the names of famous people (sports figures, politicians, celebrities)**
5). I have a hard time remembering information I have learned at school or work (R)
6). **I am very good at remembering information about people that I know (e.g., the names of a co-worker's children, their personalities, places friends have visited etc.)**

Spatial
1). **In general, my ability to navigate is better than most of my family/friends**
2). **After I have visited an area, it is easy for me to find my way around the second time I visit**
3). I have a hard time judging the distance (e.g., in meters or kilometers) between familiar landmarks (R)
4). **I get lost easily, even in familiar areas (R)**
5). If my route to work or school was blocked, I could easily find the next fastest way to get there
6). I use specific landmarks for navigating

Future
1). **When I imagine an event in the future, the event generates vivid mental images that are specific in time and place**
2). When I imagine an event in the future, I can picture the spatial layout
3). When I imagine an event in the future, I can picture people and what they look like
4). When I imagine an event in the future, I can imagine how I may feel
5). **When I imagine an event in the future, I can picture images (e.g., people, objects, etc)**
6). I have a difficult time imagining specific events in the future (R)

[1] (R) − Reverse Coded Items, 10 Brief SAM (B-SAM) items indicated in bold.

[2] While the items are reproduced in the Appendix, derivation of SAM/B-SAM dimension scores cannot be attained simply by summing the responses to these items. Please contact the authors for information on proper administration and scoring of the SAM/B-SAM. The SAM/B-SAM is Copyright © 2012 to Baycrest Centre for Geriatric Care, all rights reserved.

REFERENCES

Abdi H. The Greenhouse–Geisser correction. In Salkind N (Ed), *Encyclopedia of Research Design*. Thousand Oaks: Sage, 2010.

Abdi H and Valentin D. *Multiple Correspondence Analysis. Encyclopedia of Measurement and Statistics*. Thousand Oaks, CA: Sage, 2007. 651–657.

Abdi H and Williams LJ. *Correspondence Analysis. Encyclopedia of Research Design*. Thousand Oaks, CA: Sage, 2010. 267–278.

Abdi H, Williams LJ, Valentin D, and Bennani-Dosse M. STATIS and DISTATIS: Optimum multi-table principal component analysis and three way metric multidimensional scaling. *Wiley Interdisciplinary Reviews: Computational Statistics*, 4: 124–167, 2012.

Addis DR, Wong AT, and Schacter DL. Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, 45(7): 1363–1377, 2007.

Aguirre GK and D'Esposito M. Topographical disorientation: A synthesis and taxonomy. *Brain: a Journal of Neurology*, 122(Pt 9): 1613–1628, 1999.

Astur RS, Ortiz ML, and Sutherland RJ. A characterization of performance by men and women in a virtual Morris water task: A large and reliable sex difference. *Behavioural Brain Research*, 93(1–2): 185–190, 1998.

Astur RS, Tropp J, Sava S, Constable RT, and Markus EJ. Sex differences and correlations in a virtual Morris water task, a virtual radial arm maze, and mental rotation. *Behavioural Brain Research*, 151(1–2): 103–115, 2004.
Atance CM and O'Neill DK. Episodic future thinking. *Trends in Cognitive Sciences*, 5(12): 533–539, 2001.
Bauer PJ, Stennes L, and Haight JC. Representation of the inner self in autobiography: Women's and men's use of internal states language in personal narratives. *Memory*, 11(1): 27–42, 2003.
Ben-Shachar M, Dougherty RF, and Wandell BA. White matter pathways in reading. *Current Opinion in Neurobiology*, 17(2): 258–270, 2007.
Benzécri JP and Cazes P. Problème sur la classification., 33. *Les Cahiers d' Analyse des Données*, 3(1): 95–101, 1978.
Brewer WF. Memory for randomly sampled autobiographical events. In Neisser U and Winograd E (Eds), *Remembering Reconsidered: Ecological and Traditional Approaches to the Study of Memory*. New York, NY: Cambridge University Press, 1988: 21–90.
Broadbent DE, Cooper PF, FitzGerald P, and Parkes KR. The cognitive failures questionnaire (CFQ) and its correlates. *British Journal of Clinical Psychology/British Psychological Society*, 21(Pt 1): 1–16, 1982.
Buckner RL and Carroll DC. Self-projection and the brain. *Trends in Cognitive Sciences*, 11(2): 49–57, 2007.
Burgess N, Becker S, King JA, and O'Keefe J. Memory for events and their spatial context: Models and experiments. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 356(1413): 1493–1503, 2001a.
Burgess N, Maguire EA, Spiers HJ, and O'Keefe J. A temporoparietal and prefrontal network for retrieving the spatial context of lifelike events. *NeuroImage*, 14(2): 439–453, 2001b.
Burianova H and Grady CL. Common and unique neural activations in autobiographical, episodic, and semantic retrieval. *Journal of Cognitive Neuroscience*, 19(9): 1520–1534, 2007.
Cabeza R, Dolcos F, Graham R, and Nyberg L. Similarities and differences in the neural correlates of episodic memory retrieval and working memory. *NeuroImage*, 16(2): 317–330, 2002.
Cahill L. Why sex matters for neuroscience. *Nature Reviews. Neuroscience*, 7(6): 477–484, 2006.
Cermak LS and O'Connor M. The anterograde and retrograde retrieval ability of a patient with amnesia due to encephalitis. *Neuropsychologia*, 21(3): 213–234, 1983.
Cohen J. *Statistical Power Analysis For the Behavioral Sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates, 1988.
Conway MA. A structural model of autobiographical memory. In Conway DCR MA, Spinnler H, and Wagenaar WA (Eds), *Theoretical Perspectives on Autobiographical Memory*. Dordrecht, the Netherlands: Kluwer, 1992: 167–194.
Conway MA. Sensory-perceptual episodic memory and its context: Autobiographical memory. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 356(1413): 1375–1384, 2001.
Conway MA and Fthenaki A. Disruption and loss of autobiographical memory. In Boller F and Grafman J (Eds), *Handbook of Neuropsychology*: 281–312.
Conway MA and Pleydell-Pearce CW. The construction of autobiographical memories in the self-memory system. *Psychological Review*, 107(2): 261–288, 2000.
Cooper JM, Vargha-Khadem F, Gadian DG, and Maguire EA. The effect of hippocampal damage in children on recalling the past and imagining new experiences. *Neuropsychologia*, 49(7): 1843–1850, 2011.
Dalgleish T, Williams JM, Golden AM, Perkins N, Barrett LF, Barnard PJ, et al. Reduced specificity of autobiographical memory and depression: The role of executive control. *Journal of Experimental Psychology. General*, 136(1): 23–42, 2007.
Demonet JF, Chollet F, Ramsay S, Cardebat D, Nespoulous JL, Wise R, et al. The anatomy of phonological and semantic processing in normal subjects. *Brain: A Journal of Neurology*, 115(Pt 6): 1753–1768, 1992.
Egan MF, Kojima M, Callicott JH, Goldberg TE, Kolachana BS, Bertolino A, et al. The BDNF val66met polymorphism affects activity-dependent secretion of BDNF and human memory and hippocampal function. *Cell*, 112(2): 257–269, 2003.
Fuentemilla L, Camara E, Munte TF, Kramer UM, Cunillera T, Marco-Pallares J, et al. Individual differences in true and false memory retrieval are related to white matter brain microstructure. *Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, 29(27): 8698–8703, 2009.
Gilboa A. Autobiographical and episodic memory – one and the same? Evidence from prefrontal activation in neuroimaging studies. *Neuropsychologia*, 42(10): 1336–1349, 2004.
Graham KS, Lee AC, Brett M, and Patterson K. The neural basis of autobiographical and semantic memory: New evidence from three PET studies. *Cognitive, Affective and Behavioral Neuroscience*, 3(3): 234–254, 2003.
Greenacre MJ. *Theory and applications of correspondence analysis*. London: Academic Press, 1984.
Gron G, Wunderlich AP, Spitzer M, Tomczak R, and Riepe MW. Brain activation during human navigation: gender-different neural networks as substrate of performance. *Nature Neuroscience*, 3(4): 404–408, 2000.
Hassabis D, Kumaran D, Vann SD, and Maguire EA. Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences of the United States of America*, 104(5): 1726–1731, 2007.
Hassabis D and Maguire EA. Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, 11(7): 299–306, 2007.
Herlitz A, Airaksinen E, and Nordstrom E. Sex differences in episodic memory: The impact of verbal and visuospatial ability. *Neuropsychology*, 13(4): 590–597, 1999.
Herlitz A, Nilsson LG, and Backman L. Gender differences in episodic memory. *Memory and Cognition*, 25(6): 801–811, 1997.
Herlitz A and Rehnman J. Sex differences in episodic memory. *Current Directions in Psychological Science*, 17(1): 52–56, 2008.
Hertel PT and Hardin TS. Remembering with and without awareness in a depressed mood: Evidence of deficits in initiative. *Journal of Experimental Psychology. General*, 119(1): 45–59, 1990.
Hodges JR, Graham N, and Patterson K. Charting the progression in semantic dementia: implications for the organisation of semantic memory. *Memory*, 3(3–4): 463–495, 1995.
Irish M, Hornberger M, Lah S, Miller L, Pengas G, Nestor PJ, et al. Profiles of recent autobiographical memory retrieval in semantic dementia, behavioural-variant frontotemporal dementia, and Alzheimer's disease. *Neuropsychologia*, 49(9): 2694–2702, 2011.
Jacoby LL. A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language.*, 30: 513–541, 1991.
Johnson MK, Foley MA, Suengas AG, and Raye CL. Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology. General*, 117(4): 371–376, 1988.
Kan IP, Alexander MP, and Verfaellie M. Contribution of prior semantic knowledge to new episodic learning in amnesia. *Journal of Cognitive Neuroscience*, 21(5): 938–944, 2009.
Kapur N. Syndromes of retrograde amnesia: A conceptual and empirical synthesis. *Psychological Bulletin*, 125(6): 800–825, 1999.
Kirchhoff BA. Individual differences in episodic memory: The role of self-initiated encoding strategies. *Neuroscientist: A Review*

Journal Bringing Neurobiology, Neurology and Psychiatry, 15(2): 166–179, 2009.
Knopik VS and DeFries JC. Etiology of covariation between reading and mathematics performance: A twin study. *Twin Research: The Official Journal of the International Society for Twin Studies*, 2(3): 226–234, 1999.
Kopelman MD, Stanhope N, and Kingsley D. Retrograde amnesia in patients with diencephalic, temporal lobe or frontal lesions. *Neuropsychologia*, 37(8): 939–958, 1999.
Kopelman MD, Wilson BA, and Baddeley AD. The autobiographical memory interview: A new assessment of autobiographical and personal semantic memory in amnesic patients. *Journal of Clinical and Experimental Neuropsychology*, 11(5): 724–744, 1989.
Koppel J and Goldberg T. The genetics of episodic memory. *Cognitive Neuropsychiatry*, 14(4–5): 356–376, 2009.
Kwan D, Carson N, Addis DR, and Rosenbaum RS. Deficits in past remembering extend to future imagining in a case of developmental amnesia. *Neuropsychologia*, 48(11): 3179–3186, 2010.
Lemogne C, Piolino P, Friszer S, Claret A, Girault N, Jouvent R, et al. Episodic autobiographical memory in depression: Specificity, autonoetic consciousness, and self-perspective. *Consciousness and Cognition*, 15(2): 258–268, 2006.
Leport AK, Mattfeld AT, Dickinson-Anson H, Fallon JH, Stark CE, Kruggel F, et al. Behavioral and neuroanatomical investigation of highly Superior autobiographical memory (HSAM). *Neurobiology of Learning and Memory*, 98(1): 78–92, 2012.
Levine B. Autobiographical memory and the self in time: Brain lesion effects, functional neuroanatomy, and lifespan development. *Brain and Cognition*, 55(1): 54–68, 2004.
Levine B, Black SE, Cabeza R, Sinden M, McIntosh AR, Toth JP, et al. Episodic memory and the self in a case of isolated retrograde amnesia. *Brain: A Journal of Neurology*, 121(Pt 10): 1951–1973, 1998.
Levine B, Svoboda E, Hay JF, Winocur G, and Moscovitch M. Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging*, 17(4): 677–689, 2002.
Levine B, Svoboda E, Turner GR, Mandic M, and Mackey A. Behavioral and functional neuroanatomical correlates of anterograde autobiographical memory in isolated retrograde amnesic patient M.L. *Neuropsychologia*, 47(11): 2188–2196, 2009.
Levine B, Turner GR, Tisserand D, Hevenor SJ, Graham SJ, and McIntosh AR. The functional neuroanatomy of episodic and semantic autobiographical remembering: A prospective functional MRI study. *Journal of Cognitive Neuroscience*, 16(9): 1633–1646, 2004.
Logie RH and Maylor EA. An Internet study of prospective memory across adulthood. *Psychology and Aging*, 24(3): 767–774, 2009.
Maguire EA. Hippocampal involvement in human topographical memory: Evidence from functional imaging. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 352(1360): 1475–1480, 1997.
Maguire EA. Neuroimaging studies of autobiographical event memory. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 356(1413): 1441–1451, 2001.
Markowitz EM, Willemsen G, Trumbetta SL, van Beijsterveldt TC, and Boomsma DI. The etiology of mathematical and reading (dis)ability covariation in a sample of Dutch twins. *Twin Research and Human Genetics: The Official Journal of the International Society for Twin Studies*, 8(6): 585–593, 2005.
Martin A. Functional neuroimaging of semantic memory. In Cabaza R and Kingstone A (Eds), *Functional Neuroimaging of Semantic Memory*. Cambridge, Massachusetts: MIT Press, 2001: 153–186.
McDermott KB, Szpunar KK, and Christ SE. Laboratory-based and autobiographical retrieval tasks differ substantially in their neural substrates. *Neuropsychologia*, 47(11): 2290–2298, 2009.
McGraw KO, Tew MD, and Williams JE. The integrity of web-delivered experiments: Can you trust the data? *Psychological Science*, 11(6): 502–506, 2000.
McKinnon MC, Nica EI, Sengdy P, Kovacevic N, Moscovitch M, Freedman M, et al. Autobiographical memory and patterns of brain atrophy in frontotemporal lobar degeneration. *Journal of Cognitive Neuroscience*, 20(10): 1839–1853, 2008.
McNally RJ, Lasko NB, Macklin ML, and Pitman RK. Autobiographical memory disturbance in combat-related posttraumatic stress disorder. *Behaviour Research and Therapy*, 33(6): 619–630, 1995.
Miller MB, Van Horn JD, Wolford GL, Handy TC, Valsangkar-Smyth M, Inati S, et al. Extensive individual differences in brain activations associated with episodic retrieval are reliable over time. *Journal of Cognitive Neuroscience*, 14(8): 1200–1214, 2002.
Milton F, Muhlert N, Pindus DM, Butler CR, Kapur N, Graham KS, et al. Remote memory deficits in transient epileptic amnesia. *Brain: A Journal of Neurology*, 133(Pt 5): 1368–1379, 2010.
Moscovitch M, Rosenbaum RS, Gilboa A, Addis DR, Westmacott R, Grady C, et al. Functional neuroanatomy of remote episodic, semantic and spatial memory: A unified account based on multiple trace theory. *Journal of Anatomy*, 207(1): 35–66, 2005.
Nyberg L, Forkstam C, Petersson KM, Cabeza R, and Ingvar M. Brain imaging of human memory systems: between-systems similarities and within-system differences. *Brain Research Cognitive Brain Research*, 13(2): 281–292, 2002.
O'Keefe J and Nadel L. *The Hippocampus as a Cognitive Map*. Oxford University Press, 1978.
Okuda J, Fujii T, Ohtake H, Tsukiura T, Tanji K, Suzuki K, et al. Thinking of the future and past: The roles of the frontal pole and the medial temporal lobes. *NeuroImage*, 19(4): 1369–1380, 2003.
Papassotiropoulos A, Stephan DA, Huentelman MJ, Hoerndli FJ, Craig DW, Pearson JV, et al. Common Kibra alleles are associated with human memory performance. *Science*, 314(5798): 475–478, 2006.
Parker ES, Cahill L, and McGaugh JL. A case of unusual autobiographical remembering. *Neurocase*, 12(1): 35–49, 2006.
Pillemer DB, Wink P, DiDonato TE, and Sanborn RL. Gender differences in autobiographical memory styles of older adults. *Memory*, 11(6): 525–532, 2003.
Piolino P, Desgranges B, Belliard S, Matuszewski V, Lalevee C, De la Sayette V, et al. Autobiographical memory and autonoetic consciousness: Triple dissociation in neurodegenerative diseases. *Brain: A Journal of Neurology*, 126(Pt 10): 2203–2219, 2003.
Piolino P, Desgranges B, Benali K, and Eustache F. Episodic and semantic remote autobiographical memory in ageing. *Memory*, 10(4): 239–257, 2002.
Postma A, Jager G, Kessels RP, Koppeschaar HP, and van Honk J. Sex differences for selective forms of spatial memory. *Brain and Cognition*, 54(1): 24–34, 2004.
Reimers S and Maylor EA. Task switching across the life span: Effects of age on general and specific switch costs. *Developmental Psychology*, 41(4): 661–671, 2005.
Rosenbaum RS, Priselac S, Kohler S, Black SE, Gao F, Nadel L, et al. Remote spatial memory in an amnesic person with extensive bilateral hippocampal lesions. *Nature Neuroscience*, 3(10): 1044–1048, 2000.
Rubin DC and Berntsen D. The frequency of voluntary and involuntary autobiographical memories across the life span. *Memory and Cognition*, 37(5): 679–688, 2009.
Rubin DC, Schrauf RW, and Greenberg DL. Belief and recollection of autobiographical memories. *Memory and Cognition*, 31(6): 887–901, 2003.

Please cite this article in press as: Palombo DJ, et al., The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life, Cortex (2012), http://dx.doi.org/10.1016/j.cortex.2012.08.023

Rubin DC and Siegler IC. Facets of personality and the phenomenology of autobiographical memory. *Applied Cognitive Psychology*, 18(7): 913–930, 2004.

Rudebeck SR, Scholz J, Millington R, Rohenkohl G, Johansen-Berg H, and Lee AC. Fornix microstructure correlates with recollection but not familiarity memory. *Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, 29(47): 14987–14992, 2009.

Schacter DL and Addis DR. The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 362(1481): 773–786, 2007.

Scoville WB and Milner B. Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery, and Psychiatry*, 20(1): 11–21, 1957.

Söderlund H, Moscovitch M, Kumar N, and Levine B. Memory for autobiographical and public events in major depressive disorder: Dissociating episodic and semantic memory. *Psychological Medicine*, submitted for publication.

Spreng RN and Levine B. The temporal distribution of past and future autobiographical events across the lifespan. *Memory and Cognition*, 34(8): 1644–1651, 2006.

Spreng RN, Mar RA, and Kim AS. The common neural basis of autobiographical memory, prospection, navigation, theory of mind, and the default mode: A quantitative meta-analysis. *Journal of Cognitive Neuroscience*, 21(3): 489–510, 2009.

Squire LR, Wixted JT, and Clark RE. Recognition memory and the medial temporal lobe: A new perspective. *Nature Reviews Neuroscience*, 8(11): 872–883, 2007.

Squire LR and Zola SM. Episodic memory, semantic memory, and amnesia. *Hippocampus*, 8(3): 205–211, 1998.

St-Laurent M, Abdi H, Burianova H, and Grady CL. Influence of aging on the neural correlates of autobiographical, episodic, and semantic memory retrieval. *Journal of Cognitive Neuroscience*, 23(12): 4150–4163, 2011.

Sunderland A, Harris JE, and Baddeley AD. Assessing everyday memory after severe head injury. In Harris JE and Morris PE (Eds), *Everyday Memory, Actions, and Absent-mindedness*. London: Academic Press, 1984: 193–212.

Sutin AR and Robins RW. Phenomenology of autobiographical memories: The memory experiences questionnaire. *Memory*, 15(4): 390–411, 2007.

Svoboda E, McKinnon MC, and Levine B. The functional neuroanatomy of autobiographical memory: A meta-analysis. *Neuropsychologia*, 44(12): 2189–2208, 2006.

Tulving E. *Elements of Episodic Memory*. New York: Oxford University Press, 1983.

Tulving E. Memory and consciousness. *Canadian Psychologist*, 25: 1–12, 1985.

Tulving E. Episodic memory: From mind to brain. *Annual Review of Psychology*, 53: 1–25, 2002.

Unsworth N. Individual differences in self-initiated processing at encoding and retrieval: A latent variable analysis. *Quarterly Journal of Experimental Psychology*, 62(2): 257–266, 2009a.

Unsworth N. Variation in working memory capacity, fluid intelligence, and episodic recall: A latent variable examination of differences in the dynamics of free recall. *Memory and Cognition*, 37(6): 837–849, 2009b.

van Eimeren L, Niogi SN, McCandliss BD, Holloway ID, and Ansari D. White matter microstructures underlying mathematical abilities in children. *NeuroReport*, 19(11): 1117–1121, 2008.

Westmacott R, Black SE, Freedman M, and Moscovitch M. The contribution of autobiographical significance to semantic memory: Evidence from Alzheimer's disease, semantic dementia, and amnesia. *Neuropsychologia*, 42(1): 25–48, 2004.

Westmacott R and Moscovitch M. The contribution of autobiographical significance to semantic memory. *Memory and Cognition*, 31(5): 761–774, 2003.

Wheeler MA, Stuss DT, and Tulving E. Toward a theory of episodic memory: The frontal lobes and autonoetic consciousness. *Psychological Bulletin*, 121(3): 331–354, 1997.

Williams JM, Barnhofer T, Crane C, Herman D, Raes F, Watkins E, et al. Autobiographical memory specificity and emotional disorder. *Psychological Bulletin*, 133(1): 122–148, 2007.

Yonelinas AP. Receiver-operating characteristics in recognition memory: Evidence for a dual-process model. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, 20(6): 1341–1354, 1994.

Yonelinas AP. Components of episodic memory: The contribution of recollection and familiarity. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 356(1413): 1363–1374, 2001.

Please cite this article in press as: Palombo DJ, et al., The survey of autobiographical memory (SAM): A novel measure of trait mnemonics in everyday life, Cortex (2012), http://dx.doi.org/10.1016/j.cortex.2012.08.023