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# The relation between verbal and visuospatial memory and autobiographical memory

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## ABSTRACT

The basic-systems approach (Rubin, 2005, 2006) states that autobiographical memory is supported by other cognitive systems and argues that autobiographical memories are constructed from interactions between cognitive systems, such as language, vision and emotion. Although deficiencies in one or more of the basic systems influence the properties of autobiographical memories, little is known about how these cognitive abilities and autobiographical memory are related. To assert whether participants with stronger cognitive abilities also perform better on autobiographical memory tests, participants who completed verbal and visuospatial memory tests also recorded one personal event, which they recalled after a certain interval. Participants who performed well on the verbal memory tests also had better retention for the personal event, providing support for the basic-systems approach to autobiographical memory and preliminary support for the view that people have more memories from adolescence and early adulthood because the memory system works optimally in these lifetime periods.

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## 1. Introduction

### 1.1. Individual differences in memory

Autobiographical memory contains the memories people have of their own life experiences (Robinson, 1986). It not only consists of vivid memories of important and emotional events, such as what one's high school graduation was like, but it also contains memories of mundane events, such as what one ate for breakfast this morning, generic personal memories (or repeated memories), such as what it generally was like to take the train from Maastricht to Amsterdam, and autobiographical facts, such as the name of one's sixth grade teacher (Brewer, 1986; Conway, 1987).

Although autobiographical memory is taxonomically speaking a part of episodic memory (Squire, Knowlton, & Musen, 1993), autobiographical memories are far more complex than episodic memories (Brewer, 1986; Conway, 1987), suggesting that autobiographical memory is supported by different forms of memory. For example, if one cannot remember the face of a person, then that person's face will not be a part of the memory about an event that involved that person. The main goal of the present study is to examine whether autobiographical memory is related to other forms of memory. We will examine

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this relationship by looking at individual differences in autobiographical memory and other forms of memory (i.e., verbal and visuospatial memory).

Many studies on individual differences in different forms of memory have revealed large variations among individuals (e.g., Cowan, 2000; Engle, Kane, & Tuholski, 1999; Jevons, 1871; Miller, 1956; Vogel, Woodman, & Luck, 2001). Such individual differences have also been identified in autobiographical memory (Grysmen & Hudson, 2013; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; Piolino, Desgranges, Benali, & Eustache, 2002). One important factor influencing individual differences in different forms of memory and other cognitive abilities is age (e.g., Cerella & Hale, 1994; Fiore, Borella, Mammarella, & De Beni, 2012; Li et al., 2004; Park et al., 2002; Salthouse, 2004). Several studies have shown the rise and fall of memory capabilities across the lifespan. A recent study by Murre, Janssen, Rouw, and Meeter (2013), for example, examined the results of more than 28,000 participants who took at least one of possibly ten verbal and visuospatial memory tests on the Internet. The results on the tests were affected by gender, education and age. Women outperformed men on the verbal memory tests, whereas men outperformed women on the visuospatial memory tests. Participants with high educational attainment performed better than participants with low educational attainment. Adolescents and young adults performed better on the verbal and visuospatial memory tests than middle-aged adults, who in turn performed better than older adults. The performance on the visuospatial memory tests showed a higher peak in adolescence and early adulthood and a stronger decrease in middle and late adulthood than the performance on the verbal memory tests.

Despite memory being defined as a collection of separate capabilities to retain information (Squire et al., 1993), different memory systems are often functionally related. For information to be stored in long-term memory, for example, it first has to be held in short-term memory. As information is kept in short-term memory longer, the probability that it will be transferred to long-term memory increases. People who are able to hold more information in short-term memory are therefore also able to transfer more information to long-term memory. Such interactions can cause individual differences in one type of cognitive abilities to be predictive of those in other types of cognitive abilities. For example, working memory capacity has been found to predict IQ (Deary, Penke, & Johnson, 2010) and mathematical skills (Raghubar, Barnes, & Hecht, 2010).

In the present study, we will examine whether there is a relation between verbal and visuospatial memory and the formation and retrieval of autobiographical memories. People who are generally less able to store or retrieve verbal and visuospatial information are assumed to have difficulties to store and retrieve such information about personal events. There were two reasons for choosing to examine autobiographical memory's relation to verbal and visuospatial memory. The first reason is that many studies have shown strong individual differences in verbal and visuospatial memory. The second reason is that these two forms of memory are easy to measure through the internet.

## 1.2. Basic-systems approach

One theory of autobiographical memory that builds on the idea that different memory systems are often functionally related is the basic-systems approach (Rubin, 2005, 2006). The approach states that autobiographical memory is supported by other cognitive systems, because autobiographical memories are multimodal entities. They can involve seeing, hearing, smelling, tasting, touching and language, and can vary greatly in spatial, temporal, emotional and narrative content. This approach argues that deficiencies in one of these cognitive systems will lead to deficiencies in the content or phenomenology of autobiographical memories.

These cognitive processes are reflected by the brain areas that are activated when people retrieve autobiographical memories (St. Jacques, 2012): lateral pre-frontal cortex (control processes), dorsal and ventral parietal cortex (top-down and bottom-up attention), medial pre-frontal cortex (self-referential processes), hippocampus and retrosplenial cortex (recollection), amygdala (emotion), and occipital, cuneus and precuneus regions (visual imagery). Although each basic system has its own functions, processes, and neural substrates, the systems interact to form autobiographical memories.

The approach has several similarities with other theories of autobiographical memory, such as Conway's Self-Memory System (Conway, 2005; Conway & Pleydell-Pearce, 2000). Both theories regard autobiographical memory as a reconstructive process with specific neural substrates. However, the theories differ on how the self is represented. In contrast to the Self-Memory System, the self is, according to the basic-systems approach, not a single entity but distributed among the individual systems.

On the basis of Rubin's basic-systems approach (Rubin, 2005, 2006), we hypothesize that cognitive abilities are related to autobiographical memory. Many of the basic systems are known to be affected by age (e.g., Cerella & Hale, 1994; Fiore et al., 2012; Li et al., 2004; Murre et al., 2013; Park et al., 2002; Salthouse, 2004). These age-related changes are expected to have an effect on autobiographical memory performance, because deficiencies in one or more of the basic systems influence the properties of autobiographical memories. Several individual difference studies have found strong relationships between cognitive abilities, such as processing speed and working memory, and episodic memory (e.g., Clarys, Bugaiska, Tapia, & Baudouin, 2009; Hertzog, Dixon, Hultsch, & MacDonald, 2003; Park et al., 1996). However, participants in these studies were required to recall or recognize word lists or short stories with no or only a short delay (e.g., 5 min). As these studies did not measure personally relevant information or over longer retention intervals (e.g., days, weeks, months, or even years and decades), they do not inform us about the relationship between cognitive abilities and autobiographical memory. To offer support for the basic-systems approach to autobiographical memory, we therefore examined the relationship between individual differences in verbal and visuospatial memory performance to the formation and retrieval of autobiographical memories. As far as we are aware, this study is the first one to investigate this relationship.

### 1.3. The reminiscence bump

Besides the facts that the relation between verbal and visuospatial memory and autobiographical memory has not been examined previously and that such relation would offer support for the basic-systems approach to autobiographical memory (Rubin, 2005, 2006), there is a third reason why examining this relation is important. The presence of such relation might tell us something about the possible causes of the reminiscence bump in the temporal distribution of autobiographical memory as well.

The reminiscence bump is one of the most consistently observed effects in autobiographical memory research. Whereas people have hardly any memories of personal events from the first 3 or 4 years of their lives (i.e., childhood amnesia), they recall many memories from the 5 to 10 most recent years of their lives (i.e., increased recall of recent events) as expected from the course of normal forgetting, first shown by Ebbinghaus (1885/1913) and since then by many others (e.g., Rubin & Wenzel, 1996). Besides these two principal effects, people also tend to recall more personal events from the period in which they were between 10 and 30 years old, which is called the reminiscence bump (Rubin, Wetzler, & Nebes, 1986).

The reminiscence bump is very robust. It has been observed with several methods and in many different populations. It has, for example, been identified when participants report the most important events from their lives (e.g., Berntsen & Rubin, 2002; Fitzgerald, 1996; Rubin & Berntsen, 2003) and with the Galton–Crovitz cueing technique, in which participants are given a series of cue words and asked to describe for each cue word the personal event that comes to mind first (e.g., Crovitz & Schiffman, 1974; Galton, 1879; McCormack, 1979; Robinson, 1976). Besides in the distributions of autobiographical memory of many North-American and European samples, the reminiscence bump has also been identified in the distributions of Asian participants (e.g., Conway & Haque, 1999; Kawasaki, Janssen, & Inoue, 2011; Maki, Janssen, Uemiyama, & Naka, 2013; Maki & Naka, 2006). Furthermore, it has been observed with both men and women (e.g., Niedźwieńska, 2003; Rubin, Schulkind, & Rahhal, 1999) and with both middle-aged and older adults (e.g., Hyland & Ackerman, 1988; Jansari & Parkin, 1996). It has even been found in the distributions of young adults when their distribution is corrected for the increased recall of recent events (e.g., Janssen, Chessa, & Murre, 2005).

Despite this wealth of research, the causes of the reminiscence bump are still much debated. Although there are some other recent accounts for the reminiscence bump (e.g., Brown et al., 2009; Demiray, Gülgöz, & Bluck, 2009), four explanations have often been cited in the literature (e.g., Rubin, Rahhal, & Poon, 1998): the cognitive, the identity-formation, the self-narrative, and the cultural life script account. The cognitive account assumes that more novel and distinct events occur in adolescence and early adulthood (Pillemer, 2001; Robinson, 1992), such as first driving lesson or first kiss. These first-time experiences are stored more strongly into memory, because they are distinct. They are also retrieved more often, because they are used as exemplars when people encounter similar events later in life. According to the identity-formation account, people form their identity in adolescence and early adulthood (Conway, 2005; Conway & Pleydell-Pearce, 2000). From adolescence onward, young people start to realize who they were in the past, who they are now, and who they want to be in the future. Self-defining memories, which are vivid and emotional memories of personal events that have a large impact on a person's identity (Conway, Singer, & Tagini, 2004), often occur in the reminiscence bump period. The self-narrative account is similar to the identity-formation account, but it assumes that the concept of identity takes the form of a narrative about the self (Fitzgerald, 1988, 1996). According to the cultural life script account, more transitional events tend to occur during late adolescence and early adulthood (Berntsen & Rubin, 2002; Rubin & Berntsen, 2003). When people are asked to tell their life story or report the most important events of their lives, they use semantic information (e.g., Janssen & Rubin, 2011; Janssen, Uemiyama, & Naka, 2014) about the structure of life stories to recall highly significant events (Berntsen & Rubin, 2004).

Besides these four accounts, there is a fifth explanation, called the cognitive abilities account. It hypothesizes that the reminiscence bump is caused by differences in encoding efficiency throughout the lifespan. This account postulates that general memory abilities, such as working memory, and their neural substrates, to which encoding efficiency is assumed to be linked, function optimally in adolescence and early adulthood (e.g., Cerella & Hale, 1994; Fiore et al., 2012; Li et al., 2004; Murre et al., 2013; Park et al., 2002; Salthouse, 2004) and assumes that those general memory abilities influence autobiographical memory retention, which causes more memories to be stored (or memories to be stored more strongly) in those lifetime periods (Janssen & Murre, 2008; Janssen, Murre, & Meeter, 2008; Rubin et al., 1998). So far, this assumption has not been tested directly. The results of the current study can therefore also be viewed as a preliminary test of the main assumption of the cognitive abilities account, namely that general memory abilities and autobiographical memory are related.

### 1.4. Relation between verbal and visuospatial memory and autobiographical memory

The main goal of the present study was to examine whether verbal and visuospatial memory and autobiographical memory are related. There were two reasons why we expected this to be the case. First, the basic-systems approach (Rubin, 2005, 2006) assumes that autobiographical memory is supported by other cognitive systems. Second, the effect of age in results of the verbal and visuospatial memory tests of Murre et al. (2013) mirrors the reminiscence bump in the temporal distribution of autobiographical memory, suggesting that the correspondence between these two findings might reflect a functional relationship.

One way to measure autobiographical memory performance is to compare the recall of a personal event directly after its occurrence to the recall of the event after a certain interval. This technique is frequently employed with diaries (e.g., Catal &

Fitzgerald, 2004; Linton, 1975; Wagenaar, 1986; White, 1982). Whereas most of these diary studies use a small number of participants who record a large number of events, one can also have many participants who each record a single event (Kristo, Janssen, & Murre, 2009; Murre, Kristo, & Janssen, 2014).

Like the study of Murre et al. (2013), the study of Kristo et al. (2009) was conducted through the Internet. On the same website, a total of 878 participants recorded one recent personal event (which had happened in the last three days), answered a series of questions about the content (i.e., what, who and where), the time (i.e., when) and details (i.e., important and unimportant detail) of the event and rated the event on importance, emotionality, valence and frequency of occurrence. Participants were contacted after 2, 7, 15, 30–31 or 45–46 days and, with the help of cues, answered the same questions. These retention intervals were chosen, because there is evidence suggesting that the memory consolidation process may take up to six weeks in humans (Frankland & Bontempi, 2005; Murre, Graham, & Hodges, 2001). Autobiographical memory performance became worse as the retention interval between the recording of the event and its recall increased. It was also affected by other event variables, such as valence, frequency of occurrence and reminiscing. These findings were replicated in a follow-up study (i.e., Murre et al., 2014), which showed that autobiographical memory was also affected by age, with young adults performing better than middle-aged and older adults.

To assert whether participants with stronger memory abilities also perform better on autobiographical memory tests, the results of participants who took at least one test of Murre et al. (2013) and who completed the diary study of Kristo et al. (2009) are combined in the present study. In the analyses, event variables, such as retention interval, importance and frequency of occurrence, and participant variables, such as education and gender, will be taken into account. On the basis of previous findings (e.g., Catal & Fitzgerald, 2004; Kristo et al., 2009; Wagenaar, 1986), we expected that retention interval negatively affects autobiographical memory performance, whereas the other event variables were expected to affect autobiographical memory performance positively. Furthermore, we expected that age would influence autobiographical memory performance negatively (e.g., Murre et al., 2014). Finally, in agreement with the basic-systems approach (Rubin, 2005, 2006) and the cognitive abilities account (Janssen & Murre, 2008; Janssen et al., 2008; Rubin et al., 1998), it was expected that performance on the verbal and visuospatial memory tests would predict the retention of the personal event. Due to the complexity of autobiographical memory retrieval (e.g., Rubin, 2005, 2006), this effect is, however, expected to be small.

Because the performances on the verbal memory tests were more strongly correlated with performances on other verbal memory tests than with performances on visuospatial memory tests (Murre et al., 2013), we explored whether verbal or visuospatial memory was related more strongly with autobiographical memory. It was expected that scores on the verbal memory tests would be more strongly related with the retention of the personal event than scores on the visuospatial memory tests, because the study that was used to measure the retention of the personal event did not contain questions that specifically measured the visuospatial aspects of the memory.

## 2. Method

### 2.1. Participants

In the present study, the results of 617 participants who completed the diary study and took at least one verbal or visuospatial memory test were analyzed. The age of the participants ranged from 18 to 80 years ( $M = 45.99$ ,  $SD = 14.62$ ) when taking the autobiographical memory test. The participants were divided over one three-year age group (18–20 years) and twelve five-year age groups (21–25, 26–30, 31–35, etc.). The majority of the participants was female (74.1%), and the participants tended to be well educated, with 60.4% having completed tertiary education.

Participants could come into contact with the website on which the tests were presented in at least five ways. The website was submitted to search engines, links to the website were added on other websites about psychology, and the website was promoted in traditional media, such as magazines and newspapers. Furthermore, participants who had taken other tests on the website, such as the Galton–Crovitz test (Janssen, Chessa, & Murre, 2006; Janssen & Murre, 2008; Janssen, Rubin, & St. Jacques, 2011; Janssen et al., 2005), were invited to participate in the current study. Finally, participants could invite family, friends and colleagues to participate in the current study by sending them a standardized message at the end of the tests.

### 2.2. Materials and procedure

When participants visited the website for the first time, they were required to register. At subsequent visits, they only had to log in. With this registration system, the results of different tests taken at different times by the same participant could be combined.

#### 2.2.1. Autobiographical memory

To measure autobiographical memory performance, participants completed a diary study. All participants completed this study, which consisted of a recording and a recall session. At the first session, they described one personal event which had happened in the last three days. They then indicated *what* the event was about, *who* was involved, and *where* it had taken place (e.g., Lancaster & Barsalou, 1997). Subsequently, the participants indicated *when* the event had occurred (i.e., month, day of the month, day of the week, and time of the day) and they described one important detail and one unimportant detail

of the event. The important detail referred to aspects of the event that made the event distinguishable from similar events, whereas the unimportant detail referred to aspects that the event shared with similar events. Finally, the participants rated the importance and the emotional impact of the event on five-point scales and the emotional valence and the frequency of occurrence of the event on seven-point scales.

After 2, 7, 15, 30–31 or 45–46 days, participants were contacted by email for the second session, in which they answered the same questions with the help of cues (e.g., [Dijkstra & Misirlisoy, 2006](#)). They were first asked one of the three content questions. They were then given the correct answer to this question and asked to answer one of the two remaining content questions. Subsequently, they were given the correct answers to the first two questions and asked to answer the remaining content question. After answering the three content questions, participants were asked to describe the important and unimportant detail and to date the personal event. Finally, participants rated the event on reminiscing (i.e., how often they had thought about the event) and social sharing (i.e., how often they had talked about the event) on seven-point scales.

Two independent referees (SJ and GK), who were not aware of which retention interval the participants had been assigned to and what the participants' scores on the verbal and visuospatial memories tests were, compared the answers from the second session to the answers from the first session (Cohen's Kappa,  $\kappa = .754$ ). Participants could receive two points for each of the three content questions (i.e., what, who and where) and the two detail questions (i.e., important and unimportant detail). A score of two points was given when the answers were similar. When the answer of the second session was partially similar or less specific than the answer of the first session, one point was awarded. No points were given when the answers were not similar. Furthermore, participants could receive another four points for correctly identifying at the second session when the event had taken place (i.e., month, day of the month, day of the week, and time of the day). More elaborate descriptions of the materials and procedure are given in [Kristo et al. \(2009\)](#).

### 2.2.2. Verbal and visuospatial memory

To measure verbal and visuospatial memory performance, participants completed at least one verbal or visuospatial memory test. Participants could complete a maximum of 10 tests, but on average they completed 4.62 ( $SD = 3.10$ ) tests. Six of the 10 tests were verbal tests ( $M = 2.93$ ,  $SD = 1.88$ ), whereas four were visuospatial tests ( $M = 1.69$ ,  $SD = 1.37$ ). These

**Table 1**

Names and descriptions of the six verbal and four visuospatial memory tests.

Test name	Test description
Ten-Words Test	Participants were shown ten unrelated words which they had to memorize. After a short distractor task, participants freely recalled the words. The cycle of presentation, distraction and recall was repeated three times with the same words
Digit Span Task	Participants were shown a sequence of two digits. Immediately after the second digit, they had to reproduce the sequence using a row of nine digits. If participants had twice reproduced the sequence correctly, the length of the sequence increased
Pattern Span Task	Participants were presented a two-by-two grid with white squares. When participants clicked a button, half the squares turned black. After 2 s, the squares turned white again. Participants had to select the squares which had changed color. If participants had twice selected the correct squares, the size of the grid increased
Corsi Block Tapping Task	Participants saw nine white squares which were seemingly-randomly positioned on the screen. When participants clicked a button, a sequence started in which five squares changed color one by one. Participants had to reproduce the sequence by clicking on the squares of the seemingly random layout. If participants had twice reproduced the sequence correctly, the length of the sequence increased
DRM Immediate Recall test	Participants were shown four lists of twelve related words which were strong associates of a word that was not included (i.e., critical lure). Participants had to study the words and, immediately after each list, freely recall the words
Memory Game	This test was presented after the DRM Immediate Recognition test. Participants were presented a four-by-five grid with white squares. When they clicked on a square, it changed its color. There were ten pairs of colors, and participants had to find the matching squares. When they selected two matching squares, the squares kept their colors, but, when they selected two different squares, both turned white again. The task was repeated three times with the same underlying color configuration
DRM Delayed Recognition test	This test was presented after the Memory Game. Participants were shown four lists of seven words. Each list consisted of two words from the earlier immediate recall test, the critical lure, two weakly associated words and two completely unrelated words. Participants indicated on a four-point scale how confident they were whether each word had been presented during the preceding immediate recall test
Story Telling Immediate Recognition test	Participants had to learn ten sentences that formed a short story. After a short distractor task, they received ten sentences from the story that had or had not been slightly altered. Participants indicated whether each sentence used the exact same wording as the sentence from the story
Texture Span Task	This test was presented after the Story Telling Immediate Recognition test. Participants were shown a sequence of two pictures with lines and other patterns that were hard to encode verbally. Immediately after the second picture, they had to reproduce the sequence using a row of eleven pictures that included the pictures of the sequence. If participants had twice reproduced the sequence correctly, the length of the sequence increased
Story Telling Delayed Recognition test	This test was presented after the Texture Span Task. Participants received correct or incorrect paraphrases of the sentences learned during earlier immediate recognition. Participants indicated whether the gist of each sentence was the similar to the gist of the story

tests were either typical working memory or typical episodic memory tests with delays up to 15 min. Short descriptions of the tests are given in [Table 1](#), but a more detailed description of the materials can be found in [Murre et al. \(2013\)](#).

Participants were randomly assigned to either one of four single tests (Ten-Words Test, Digit Span Task, Pattern Span Task, and Corsi Block Tapping Task) or one of two blocks of three tests (DRM Immediate Recall test, Memory Game, and DRM Delayed Recognition test, and Story Telling Immediate Recognition test, Texture Span Task, and Story Telling Delayed Recognition test). In these blocks, the first and third tests were directly related, whereas the second test involved a different type of memory. Because the first and third test in both blocks involved verbal memory, the second test in both blocks involved visuospatial memory. When participants had completed a single test or a block of tests, they could take another single test or block of tests or they could end their participation. They could also return to the website at a later time and take the remaining tests.

Although the results of the verbal and visuospatial memory tests had been published later, these data were collected earlier than the data of the autobiographical memory test ( $M = 22.06$  months,  $SD = 20.41$  months). However, the time between the two measurements did not affect the performance on the autobiographical memory test,  $r(617) = -.053$ ,  $p = .185$ , the performance on the verbal memory tests,  $r(617) = -.032$ ,  $p = .445$ , or the performance on the visuospatial memory tests,  $r(617) = .010$ ,  $p = .824$ .

### 3. Results

#### 3.1. Verbal and visuospatial memory

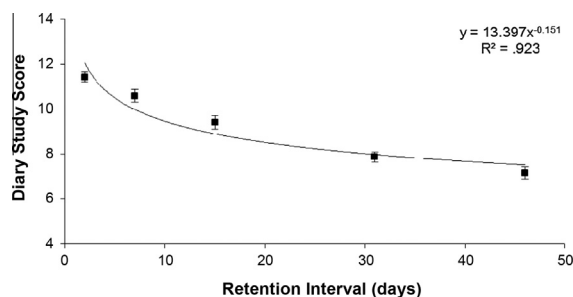
We first examined whether the scores on the verbal and visuospatial memory tests were affected by participant variables (i.e., age group, gender, level of education). Because the scores on the verbal and visuospatial memory tests had different ranges, the scores on each test were transformed to z-scores. Subsequently, three scores were calculated for each participant by averaging the z-transformed scores of (1) the six verbal memory tests, (2) the four visuospatial memory tests, and (3) all ten verbal and visuospatial memory tests.

These scores were included as the dependent variables in three regression analyses, in which age group, gender and level of education were the independent variables. Verbal memory was affected by age group ( $Beta = -.203$ ,  $p < .001$ ), gender ( $Beta = .101$ ,  $p = .014$ ) and level of education ( $Beta = .128$ ,  $p = .002$ ),  $F(3, 579) = 14.57$ ,  $p < .001$ ,  $R^2 = .070$ . Visuospatial memory was affected by age group ( $Beta = -.160$ ,  $p < .001$ ) but not by gender ( $Beta = -.089$ ,  $p = .054$ ) or level of education ( $Beta = .062$ ,  $p = .165$ ),  $F(3, 486) = 5.44$ ,  $p = .001$ ,  $R^2 = .032$ . Verbal and visuospatial memory was affected by age group ( $Beta = -.210$ ,  $p < .001$ ) and level of education ( $Beta = .125$ ,  $p = .002$ ) but not by gender ( $Beta = .049$ ,  $p = .218$ ),  $F(3, 613) = 14.01$ ,  $p < .001$ ,  $R^2 = .064$ . Although the effects of gender and level of education did not reach significance on the visuospatial memory tests, all results were in the same direction as the results of [Murre et al. \(2013\)](#).

#### 3.2. Autobiographical memory

We then examined the scores on the autobiographical memory test. The scores on the diary study could range from 0 to 14 ( $M = 8.95$ ,  $SD = 3.32$ ) and displayed a classic retention function (see [Fig. 1](#)), which fitted a power function well ( $y = 13.397x^{-0.151}$ ,  $R^2 = .923$ ). The number of days between recording and recalling of the personal event had a strong effect on autobiographical memory performance ( $Beta = -.485$ ,  $p < .001$ ),  $F(1, 615) = 189.33$ ,  $p < .001$ ,  $R^2 = .235$ . Participants recalled more information about the event at shorter retention intervals than at longer retention intervals.

We subsequently examined whether autobiographical memory performance was affected by the event variables with a hierarchical regression analysis, in which retention interval was entered in the first step and the event variables in the second step,  $F(7, 609) = 33.92$ ,  $p < .001$ ,  $\Delta R^2 = .045$ . Besides retention interval ( $Beta = -.477$ ,  $p < .001$ ), the scores on the diary study were influenced by reminiscing ( $Beta = .179$ ,  $p = .003$ ), importance ( $Beta = -.131$ ,  $p = .002$ ), valence ( $Beta = .112$ ,  $p = .002$ ) and frequency of occurrence ( $Beta = .128$ ,  $p = .001$ ). The scores on the diary study were not influenced by social



**Fig. 1.** Mean diary study score (with standard-error bars) as a function of retention interval.

**Table 2**

Standard Beta values and significance levels of the final step of the hierarchical regression analyses, in which age group was not entered as a variable, verbal and visuospatial memory were entered as one variable, and either all participants were included (left side), participants with a score less than 4 were excluded (middle), or only participants who completed all 10 tests were included (right side).

	N = 617			N = 554			N = 72		
	Beta	t	Sig.	Beta	t	Sig.	Beta	t	Sig.
Constant		10.23	.000		12.76	.000		4.81	.000
Retention interval	-.478	13.80	.000	-.433	11.41	.000	-.459	4.12	.000
Importance	-.127	3.07	.002	-.101	2.20	.028	-.149	1.06	.295
Emotionality	.026	0.60	.549	.034	0.70	.485	.013	0.08	.934
Valence	.107	3.01	.003	.130	3.36	.001	.102	0.89	.377
Frequency	.126	3.31	.001	.102	2.43	.016	.096	0.73	.468
Social sharing	-.081	1.36	.175	-.108	1.69	.092	-.026	0.16	.876
Reminiscing	.176	2.94	.003	.130	2.02	.044	.042	0.25	.806
Gender	.035	1.01	.313	.016	0.42	.678	.048	0.43	.669
Education	-.001	0.02	.987	-.047	1.23	.220	-.096	0.90	.374
Verbal and visuospatial	.074	2.11	.035	.108	2.85	.005	.261	2.40	.019

sharing (Beta =  $-.080$ ,  $p = .180$ ) or emotionality (Beta =  $.028$ ,  $p = .646$ ). Valence, frequency of occurrence and reminiscing had a positive effect on autobiographical memory performance, but importance had, surprisingly, a negative effect.

We also examined whether autobiographical memory performance was related to the participant variables with a hierarchical regression analysis, in which retention interval was entered in the first step and the participant variables as the second step,  $F(4,612) = 50.68$ ,  $p < .001$ ,  $\Delta R^2 = .061$ . Age group affected the scores on the diary study (Beta =  $-.109$ ,  $p = .002$ ), showing that older participants performed poorer than younger participants on the autobiographical memory test. In contrast, gender (Beta =  $.023$ ,  $p = .530$ ) and level of education (Beta =  $.016$ ,  $p = .649$ ) did not affect the scores on the diary study.

The effects of the event and the participant variables did not change when we conducted a hierarchical regression analysis, in which retention interval was entered in the first step, the event variables in the second step, and the participant variables in the third step,  $F(10,606) = 25.43$ ,  $p < .001$ ,  $\Delta R^2 = .015$ .

### 3.3. Relation verbal and visuospatial memory and autobiographical memory

We then examined whether verbal and visuospatial memory performance and autobiographical memory performance were related. The z-transformed scores of verbal and visuospatial memory tests were entered with other independent variables into a hierarchical regression analysis examining the score on the diary study. In the first step of the analysis, retention interval was entered. In the second step, event variables (i.e., importance, emotionality, valence, frequency of occurrence, social sharing, and reminiscing) were entered. In the third step, participant variables (i.e., education and gender but not age – see Section 3.4) were entered. Because the participant variables did not affect the event variables ( $ps \geq .115$ ), no interactions were included in the analysis. In the final step of the analysis, the average z-score on the verbal and visuospatial memory tests was entered.

For brevity, only the results of the final step of the analysis are given on the left side of Table 2,  $F(10,606) = 24.45$ ,  $p < .001$ ,  $\Delta R^2 = .005$ . Retention interval was the strongest influence (Beta =  $-.478$ ), followed by reminiscing (Beta =  $.176$ ), importance (Beta =  $-.127$ ), frequency of occurrence (Beta =  $.126$ ) and valence (Beta =  $.107$ ). The results on the verbal and visuospatial memory tests were less strong (Beta =  $.074$ ) but still had a significant influence on the diary study score ( $p = .035$ ), suggesting that the retention of personal events is indeed related to verbal and visuospatial memory performance. The scores on the verbal and visuospatial memory tests were also entered separately in the final step of the analysis,  $F(11,455) = 19.85$ ,  $p < .001$ ,  $\Delta R^2 = .017$ . Performance on the visuospatial memory tests did not have an effect on the diary score (Beta =  $-.004$ ,  $p = .916$ ), but performance on the verbal memory tests had (Beta =  $.133$ ,  $p = .001$ ).<sup>1</sup>

After the scores on the diary study had been plotted against the average z-scores on the tests, it became apparent that some participants performed extremely poorly on the diary study (see Fig. 2). Even after participants were given information about what the event was, who was involved and where it had occurred, some participants ( $N = 63$ ) had still difficulties recalling when the event had happened or what the details of the event were. It is likely that, for these participants, none of the cues elicited the appropriate event.

These poorly performing participants did not differ from the other participants on age ( $p = .540$ ), level of education ( $p = .104$ ), and gender ( $p = .267$ ). Their personal events were also not less important ( $p = .748$ ), less emotional ( $p = .129$ ) or more negative ( $p = .837$ ), but there was a significant difference of frequency of occurrence. Participants who scored 4 or less on the diary study reported events that were less unique ( $M = 3.79$ ,  $SD = 1.65$ ) than participants who scored more than 4 on the diary study ( $M = 4.28$ ,  $SD = 1.62$ ),  $t(615) = 2.26$ ,  $p = .024$ , Cohen's  $d = 0.299$ . Most important, there was no difference on

<sup>1</sup> These two regression analyses were also conducted with the time between the measurements included (i.e., all participants without age group as variable), but the inclusion of the delay did not change the results,  $\Delta R^2 = .002$ ,  $p = .176$  (verbal and visuospatial memory performance entered as one variable) and  $\Delta R^2 = .003$ ,  $p = .184$  (verbal and visuospatial memory performance entered as separate variables).



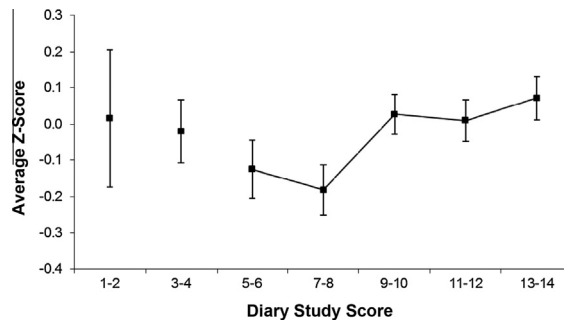


Fig. 2. Average z-score (with standard-error bars) on the verbal and visuospatial memory tests as a function of the score on the diary study.

the verbal memory ( $p = .392$ ) and visuospatial memory tests ( $p = .687$ ) between the participants who scored 4 or less and the participants who scored more than 4 (also see Fig. 2).

When the participants who scored 4 or less on the diary study were dropped from the hierarchical regression analysis,  $F(10,543) = 16.98$ ,  $p < .001$ ,  $\Delta R^2 = .011$ , the effect of verbal and visuospatial memory increased (Beta = .108,  $p = .005$ ). The results of the final step of this analysis are given in the middle of Table 2. The exclusion of these participants did not change the outcomes of the hierarchical regression analysis in which verbal and visuospatial memory were entered separately,  $F(11,398) = 13.34$ ,  $p < .001$ ,  $\Delta R^2 = .015$ . Performance on the visuospatial memory tests was not significant (Beta = .010,  $p = .814$ ), whereas performance on the verbal memory tests was (Beta = .125,  $p = .005$ ).

There were 78 participants who completed all ten verbal and visuospatial memory tests. When only their results were included in the hierarchical regression analysis,  $F(10,67) = 2.73$ ,  $p = .007$ ,  $\Delta R^2 = .061$ , the effect of verbal and visuospatial memory on the retention of personal events became much larger (Beta = .261,  $p = .019$ ). The results of the final step of this analysis are given on the right side in Table 2. The results on the verbal and visuospatial memory tests were also analyzed separately for these participants,  $F(11,66) = 2.52$ ,  $p = .010$ ,  $\Delta R^2 = .067$ . Again performance on the visuospatial memory tests was not significant (Beta = .049,  $p = .653$ ), but performance on the verbal memory tests was (Beta = .259,  $p = .020$ ).

### 3.4. Age group

Finally, age group was initially not included in the analyses, because the performances on both the diary study and the verbal and visuospatial memory tests were assumed to be partly affected by age. We repeated the three hierarchical regression analyses (with all participants, without participants who had difficulties recalling the event, only with participants who completed all ten cognitive abilities tests) with age group included in the third step. Before these analyses were conducted, we had tested whether age group correlated with any of the event variables. Because no event variable correlated with age group ( $ps \geq .226$ ), again no interactions were entered into the analyses.

The final steps of these three hierarchical regression analyses are given in Table 3,  $F(11,605) = 23.35$ ,  $p < .001$ ,  $\Delta R^2 = .002$ ,  $F(11,542) = 16.44$ ,  $p < .001$ ,  $\Delta R^2 = .007$ ,  $F(11,66) = 2.75$ ,  $p = .005$ ,  $\Delta R^2 = .040$ . As reported earlier, age group affected autobiographical memory retention. The betas for age group were, as reported earlier, negative (with all participants: Beta =  $-.107$ ,  $p = .003$ ; without participants who had difficulties recalling the event: Beta =  $-.114$ ,  $p = .003$ ; only with participants who

Table 3

Standard Beta values and significance levels of the final step of the hierarchical regression analyses, in which age group was entered as a variable, verbal and visuospatial memory were entered as one variable, and either all participants were included (left side), participants with a score less than 4 were excluded (middle), or only participants who completed all 10 tests were included (right side).

	N = 617			N = 554			N = 72		
	Beta	t	Sig.	Beta	t	Sig.	Beta	t	Sig.
Constant		10.53	.000		12.78	.000		5.08	.000
Retention interval	-.479	13.92	.000	-.434	11.53	.000	-.436	3.91	.000
Importance	-.131	3.20	.001	-.103	2.26	.024	-.156	1.12	.269
Emotionality	.030	0.71	.481	.039	0.81	.417	.035	0.24	.814
Valence	.108	3.07	.002	.132	3.44	.001	.139	1.19	.237
Frequency	.127	3.36	.001	.102	2.45	.015	.118	0.90	.373
Social sharing	-.080	1.35	.176	-.107	1.69	.092	-.052	0.31	.755
Reminiscing	.182	3.06	.002	.135	2.11	.036	.060	0.35	.728
Gender	.017	0.47	.637	-.004	0.10	.920	.051	0.46	.647
Education	.001	0.29	.977	-.044	1.16	.247	-.106	1.00	.323
Age group	-.107	3.02	.003	-.114	2.93	.003	-.170	1.52	.132
Verbal and visuospatial	.051	1.44	.149	.084	2.17	.031	.219	1.97	.053

completed all ten tests:  $Beta = -.170, p = .132$ ), showing that older participants tended to perform worse on the diary study than younger participants. The betas for verbal and visuospatial memory performance ( $Beta = .051, p = .149$ ;  $Beta = .084, p = .031$ ;  $Beta = .219, p = .053$ ) were, as expected, lower when age group was included in the analyses, but the other event and participant variables did not change noticeably when age group was included.

The three hierarchical regression analyses were also repeated with verbal and visuospatial memory performance entered separately in the final step,  $F(12,443) = 18.57, p < .001, \Delta R^2 = .012$ ,  $F(12,397) = 12.62, p < .001, \Delta R^2 = .010$ ,  $F(12,65) = 2.59, p = .007, \Delta R^2 = .050$ . The betas for verbal memory performance ( $Beta = .113, p = .006$ ;  $Beta = .103, p = .023$ ;  $Beta = .236, p = .033$ ) were, as expected, lower, whereas the betas for visuospatial memory performance did not change ( $Beta = -.015, p = .702$ ;  $Beta = -.003, p = .948$ ;  $Beta = .007, p = .953$ ), because they were already low.

## 4. Discussion

### 4.1. Relation verbal and visuospatial memory and autobiographical memory

The present study examined whether individual differences in general memory abilities, which were measured with verbal and visuospatial memory tests, could account for individual differences in autobiographical memory performance, which was measured with a diary study. As far as we are aware, the present study is the first one that has examined the relation between verbal and visuospatial memory and the formation and retrieval of autobiographical memories. Although studies have found a relation between cognitive abilities and episodic memory (e.g., Clarys et al., 2009; Hertzog et al., 2003; Park et al., 1996), none of these studies included a measure of autobiographical memory (i.e., personally relevant information recalled over long retention intervals).

We found that performance on the cognitive abilities tests was affected by the three participant variables. First, younger participants performed better on both the verbal and visuospatial memory tests. Second, female participants performed better on the verbal memory tests, but male participants performed better on the visuospatial memory tests. Third, participants with higher educational attainment performed better on the verbal memory tests. Furthermore, performance on the autobiographical memory test was only affected by age. Younger participants retained more information about the personal event than older participants. Finally, performance on the verbal and visuospatial memory tests was, as predicted, related to the retention of the personal event. The size of the effect was, however, small, possibly because autobiographical memory is a complex process to which many participant variables (age, gender, educational attainment) and event variables (importance, emotional valence, frequency of occurrence, etc.) contribute.

A small proportion of the participants (10.2%) could seemingly not recall the personal event and could therefore not be given a meaningful score on the autobiographical memory test. These participants did not differ from participants who performed within the normal range, but the personal events that they reported had occurred more frequently. The cues that were given could not help these participants distinguish the event from similar events. Removing the participants who performed extremely poorly on the diary study made the already significant relationship between cognitive abilities and retention stronger. Furthermore, when age group was entered in the regression analyses, the relation became as anticipated less strong, because both scores were partly related to age. The relationship remained significant with age group partialled out, suggesting it also exists—although less strongly—within age groups. This finding suggests that participants who performed well on the verbal and visuospatial memory tests performed better on the autobiographical memory test than participants from the same age group who performed poorly on the verbal and visuospatial memory tests. Finally, retention of the personal event was related to the scores on the verbal memory tests but not to the scores on the visuospatial memory tests. This last finding will be discussed below (see Section 4.3).

The results of the present study indicate that cognitive abilities, such as the ability to retain verbal and visuospatial information over short durations of time, are related to the ability to remember personal events over long durations of time. This relation supports the basic-systems approach (Rubin, 2005, 2006), which states that autobiographical memory is supported by other cognitive systems. Although each basic system has its own functions, processes, and neural substrates, autobiographical memories are constructed from interactions among vision and language, and other aspects of cognition, such as audition, olfaction and other senses, spatial imagery, emotion, narrative, motor output, explicit memory, and search and retrieval processes. In individuals with certain strong cognitive abilities, the corresponding basic systems may process information more effectively, which in turn may facilitate the formation and retrieval of autobiographical memories.

### 4.2. The cognitive abilities account

Besides offering support for the basic-systems approach (Rubin, 2005, 2006), the results of the present study also form a preliminary test of the main assumption of the cognitive abilities account for the reminiscence bump in the temporal distribution of autobiographical memory. This account hypothesizes that the reminiscence bump is caused by differences in encoding efficiency throughout the lifespan (Janssen & Murre, 2008; Janssen et al., 2008; Rubin et al., 1998): middle-aged or older adults tend to recall more personal events from adolescence and early adulthood, not because the events from these lifetime periods are more often novel, more important, more emotional or more positive (as predicted by other existing accounts) but because the autobiographical memory system was operating more efficiently and stored more events in these lifetime periods.

The results of the present study provide the first support to the cognitive abilities account by addressing its underlying assumption. Verbal and visuospatial memory abilities were related to autobiographical memory retention, which, when combined with previous findings that cognitive abilities function optimally in adolescence and early adulthood (e.g., Cerella & Hale, 1994; Fiore et al., 2012; Li et al., 2004; Murre et al., 2013; Park et al., 2002; Salthouse, 2004), suggests that the account might be a viable alternative to the existing accounts for explaining the reminiscence bump in the temporal distribution of word-cued memories.

However, the account would ideally be tested with a longitudinal study in which participants' cognitive abilities would be tested twice. The first time would be when the participants would be around 20 years old, whereas the second time would be 30 years later when the participants would be around 50 years old. At the second test, participants would also complete the Galton–Crovitz test. Participants who showed the strongest cognitive decline are predicted to recall relatively more personal events from adolescence and early adulthood, whereas participants who showed the weakest cognitive decline are predicted to recall relatively more personal events from the last 5 to 10 years. Despite the absence of such a longitudinal study, the cognitive abilities account seems to be a promising explanation for the reminiscence bump in the temporal distribution of word-cued memories.

It is important to emphasize that the current findings do not suggest that event variables, such as valence, importance or frequency of occurrence, are not good predictors for memory retrieval. On the contrary, these event variables were just as predictive for the retention of the personal event as the performance on the verbal memory tests, but these event variables do not seem to be able to explain changes across the lifespan. Positive events are, for example, remembered better than negative events, but older adults do not recall more positive or more negative events than young adults when memories are elicited with the Galton–Crovitz technique (e.g., Janssen & Murre, 2008) and older adults do not seem to be more likely than young adults to report positive or negative events in diary studies (i.e., the present study). However, the current findings seem to indicate that the relation between cognitive abilities and autobiographical memory exists above and beyond those event variables. Similarly, the current findings do not contradict the findings that external factors, such as wars or natural disasters, might cause a higher prevalence of personal events as well (e.g., Benson et al., 1992; Brown et al., 2009; Conway & Haque, 1999). Those events have such a large impact on daily life that they supersede age-related changes in encoding efficiency.

#### 4.3. Limitations

Although the results are promising, the present study has several limitations. First, there were no questions in the autobiographical memory task specifically measuring the visuospatial aspects of the memories. Participants had to recall an important and an unimportant detail, but these details were not necessarily visuospatial, such as what a person was wearing or what the background looked like. This absence might explain why autobiographical memory performance was more strongly related with scores on the verbal memory tests than with scores on the visuospatial memory tests. Future research should include questions or other manipulations that specifically measure visual and spatial aspects of the memory.

Second, each participant had to record and recall only one personal event and complete only one verbal or visuospatial memory test to be included in the analyses. When only the results of participants who completed all tests were examined, the relation between cognitive abilities and autobiographical memory already became notably stronger. If participants would have been required to recall more than one personal event in the autobiographical memory test, then those results would probably have become more reliable as well. Furthermore, there was considerable variance in the time between the measurements. Although the time between the measurements did not affect performance on the autobiographical memory test or the verbal and visuospatial memory tests, the variance may have made the results less reliable.

Third, the intervals in the diary study (i.e., days, weeks, months), although longer than the intervals often used to measure episodic memory (e.g., 5 min), are shorter than the intervals generally used in research into autobiographical memory and the reminiscence bump (i.e., years, decades). Autobiographical memory may operate differently on shorter than on longer time intervals. However, previous research (Frankland & Bontempi, 2005; Murre et al., 2001) has found that the memory consolidation process may take up to six weeks, which was the interval used in the present study. Moreover, findings gathered with intervals between 2 and 46 days (i.e., Kristo et al., 2009; Murre et al., 2014) replicated findings of studies that used intervals of up to 4 years (Linton, 1975; Wagenaar, 1986; White, 1982), which suggests that performance on the diary study is a good indicator of autobiographical memory performance on longer intervals.

Finally, whereas the cognitive abilities account assumes that events are encoded more strongly in adolescence and early adulthood, the results of the diary study do not distinguish between encoding and retrieval. It could be that the age-related differences on the diary study are caused by retrieval rather than encoding processes. Although many studies have reported age-related differences during encoding of episodic memory (e.g., Park, Kennedy, Rodrigue, Hebrank, & Park, 2013; Shing et al., 2010), disentangling encoding and retrieval processes in autobiographical memory has been proven to be more difficult.

#### 4.4. Conclusions

The present study is the first one that has found that verbal and visuospatial memory are related to autobiographical memory. This relationship between these general memory capacities and autobiographical memory supports the basic-sys-

tems approach (Rubin, 2005, 2006), which assumes that autobiographical memory is supported by other cognitive systems. Furthermore, the present results offer preliminary support for the view that personal events might be stored more strongly in adolescence and early adulthood, because the memory system is working at an optimum during those periods. Despite the relatively small effect size and the study's limitations, the cognitive abilities account seems to be a promising explanation for the reminiscence bump in the temporal distribution of word-cued memories. However, the account needs to be examined further in studies in which the limitations of the present study are addressed.

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