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ORIGINAL INVESTIGATION

The distribution and the functions of autobiographical memories: Why do older adults remember autobiographical memories from their youth?

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Abstract In the present study, the distribution of autobiographical memories was examined from a functional perspective: we examined whether the extent to which long-term autobiographical memories were rated as having a self-, a directive, or a social function affects the location (mean age) and scale (standard deviation) of the memory distribution. Analyses were based on a total of 5598 autobiographical memories generated by 149 adults aged between 50 and 81 years in response to 51 cue-words. Participants provided their age at the time when the recalled events had happened and rated how frequently they recall these events for self-, directive, and social purposes. While more frequently using autobiographical memories for self-functions was associated with an earlier mean age, memories frequently shared with others showed a narrower distribution around a later mean age. The directive function, by contrast, did not affect the memory distribution. The results strengthen the assumption that experiences from an individual's late adolescence serve to maintain a sense of self-continuity throughout the lifespan. Experiences that are frequently shared with others, in contrast, stem from a narrow age range located in young adulthood.

Keywords Reminiscence bump · Lifespan distribution · Functions of autobiographical memory · Older age · Long-term autobiographical memories

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Introduction

The present study aimed to bring together two hitherto relatively unrelated areas of autobiographical memory (AM) research: the lifespan distribution of AMs and the use of AMs in daily life. Studies that examined the distribution of AMs across the lifespan show a very robust finding, namely the recall of a disproportional high number of events dating from an individuals' adolescence and young adulthood years. This phenomenon is referred to as the *reminiscence bump* of AM (e.g. Rubin et al. 1986). In turn, the primary concern of a functional perspective on AM is to ask *why* individuals remember their personal past (Bluck and Alea 2009), and the use of AMs in daily life has been categorised into three broad functions, namely the self-, directive, and social functions of AM (e.g. Bluck and Alea 2002; Cohen 1998; Pillemer 1992). In the present study, we transferred the functional approach to the investigation of the distribution of long-term AMs: AMs were elicited using the cue-word technique (Crovitz and Schiffman 1974; Galton 1879) and participants rated how frequently they recall these word-cued AMs for self-, directive, and social purposes. We then examined whether the location (average age at which AMs were encoded) and the scale (standard deviation of ages at which AMs were encoded) of the memory distribution vary according to the mean frequency of using these long-term AMs for these three AM functions.

The distribution of long-term autobiographical memories

The distribution of AMs can be examined by plotting the number of AMs from certain age bins across the lifespan. The observed frequencies of AMs then form the so-called lifespan retrieval curve (Rubin et al. 1986), which is characterised by four components. Experiences from the recent past are most frequently recalled (*recency effect*). The number of memories then declines from the present back to the periods of young adulthood (*forgetting*). The smallest number of memories stems from the first years of life (*childhood amnesia*). The distribution of AMs, however, deviates from a standard forgetting curve (i.e. the older a memory, the less accessible) by showing an increase in the number of memories from participants' adolescent and early adult years. This *reminiscence bump* phenomenon has been considered to be one of the defining characteristics of AM (Koppel and Berntsen 2015). Because these long-term AMs remain highly accessible throughout the lifespan, they may be qualitatively different from more recent memories which lose accessibility with time (Conway 2005) and, thus, may or may not turn into AMs that can be accessed even after years. Consequently, theoretical accounts that aim to explain the reminiscence bump phenomenon have mainly focused on characteristics of adolescence and young adulthood. For instance, the *cognitive mechanism* account argues in favour of novelty. Novel experiences are expected to be more distinct than repeated events and, thus, lead to more distinctive memory traces (e.g. Eysenck and Eysenck 1980). From this perspective, events from an individual's youth are remembered better because they are often novel and, therefore, more distinct than experiences from later life periods. Moreover, first-time events may be recalled more frequently than repeated events—which may further increase their accessibility in memory—because they can function as exemplars for similar experiences in later life (Janssen et al. 2011). According to an *identity-formation* account, the novelty of experiences from the reminiscence bump period may lie in their subjective newness for an individual's self (Conway 2005). In order to maintain a coherent self across the lifespan, experiences from one's youth, that is, the time in which individuals are expected to form an independent identity (e.g. Conway and Holmes 2004; Erikson 1950; Habermas and Bluck 2000), are frequently recalled (Conway 2005; Rathbone et al. 2008). The *life script* account, in contrast, postulates that the retrieval of AMs is shaped by culturally shared representations of the timing in which important transitional life events (e.g. starting a career) are most likely and expected to occur (Rubin and Berntsen 2003; Berntsen and Rubin 2004). Experiences from young adulthood are remembered more frequently because the majority of these transitional events are located in this life period. Note, however, that these accounts are not mutually exclusive (e.g. Janssen and Murre 2008; Rubin et al. 1998). In fact, the more recently proposed *life story* account (Glück and Bluck 2007) integrates central components of these accounts by hypothesising that the reminiscence bump period includes more novel, more distinctive, more self-relevant, and more transitional events than other life periods (Demiray et al. 2009). In the present study, we do not aim to test these different accounts against each other but to examine whether the distribution of AMs varies according to the functions that these long-term memories still serve in daily life.

Functions of autobiographical recall across the lifespan

Hypothesised functions of AM recall mostly fit into three broad categories. AMs are recalled in daily life in order to create a sense of self-continuity, to direct present or future behaviour and for social purposes (e.g. Bluck and Alea 2002).

Self-function

Put simply, being able to recall the personal past enables people to form a sense of self-continuity through time. This sense of self-continuity can be either *experienced* by mentally travelling through time or *created* by interpreting experiences in the context of an individual life story (Prebble et al. 2013). Integrating past, present, and envisioned selves of an individual, a coherent life story explains how a person "came to be who he or she is and projects a sense of purpose and meaning into the future" (Pasupathi and Mansour 2006, p. 798). Therefore, a coherent life story is not only assumed to represent the most complex level of the AM system (Conway 2005) but also of an individual's identity (e.g. McAdams and Olson 2010). The emergence of a personal life story and the formation of an individual's identity (Erikson 1950) are both associated with the period of adolescence (e.g. Habermas and Bluck 2000). Therefore, adolescent and early adult years are associated with the frequent use of AMs in order to create self-continuity (e.g. Bluck and Alea 2009). Although a number of cross-sectional studies have shown that the use of AMs for self-functions decreases from young adulthood onwards (Harris et al. 2014; Webster and Gould 2007; Wolf and Zimprich 2014), AMs from one's youth may serve to maintain a sense of self-continuity throughout the lifespan, that is, also in older age (see the *identity-formation* account).

Directive function

AMs can also be used to guide current and future behaviour or to solve problems (Cohen 1998; Pillemer 2003; Webster 1993). According to Pillemer (2003), the directive power of past events is critically important for novel instances in which "well-established scripts do not exist or when they fail to do the job" (p. 194). Because transitional events, per definition, describe a change in an individual's life, they may be likely to entail conscious recall of past experiences in order to cope with the novel situation. According to the before-mentioned *life script* account (Berntsen and Rubin 2004; Rubin and Berntsen 2003), the majority of important transitional events are expected to occur in young adulthood. Correspondingly, the use of AM for directive purposes has been found to be most frequent during young adulthood (Bluck and Alea 2009; Harris et al. 2014; Webster and Gould 2007; Wolf and Zimprich 2014). At the same time, experiences from young adulthood may serve directive purposes throughout the lifespan. First, memories of transitional events can function as models that offer possible strategies for dealing with novel situations (e.g. Janssen et al. 2011). Second, decisions made during this life period—especially those concerning the professional and personal future—may have an impact on the entire adulthood (Ebner et al. 2006). Experiences associated with this life period may, therefore, serve to direct behaviour throughout the lifespan.

Social functions

According to Nelson (1993), p. 12, "the initial functional significance of AM is that of sharing memory with other people". Memories can be shared for various communicative purposes: to facilitate social bonding, to maintain intimacy in existing relationships (Cohen 1998; Webster 1993), to elicit empathy (Bluck et al. 2013), to inform other people, or to teach lessons (Alea and Bluck 2003; Webster 1993). To cover the majority of possible social functions and to keep the conceptual overlap with the other functions at minimum, we refer to social AMs as memories that are frequently shared with others (see also Alea and Bluck 2003; Rasmussen and Berntsen 2009). While some studies found no age differences (e.g. Bluck and Alea 2009; Webster and Gould 2007), others reported an age-related decrease in the use of AMs for social functions (e.g. Alea et al. 2014a; Harris et al. 2014; Wolf and Zimprich 2014). According to Alea and Bluck (2003), (long-term) AMs that serve central social functions are probably those that an individual considers as personally meaningful.

Distribution and functions of autobiographical memories

The present study aimed to add to the literature on AM by bringing together research on the distribution of long-term AMs and research on the functions that AMs may serve in daily life. There are, naturally, different ways of linking these areas of research. In the present study, we examined whether the location and the scale of the AM distributions vary according to the frequencies of using these long-term AMs for self-, directive, and social functions. Differences in the location of memory distributions represent differences in the average age at which AMs were encoded and differences in the scale represent differences in the spreading of AMs around this location.[1] Figure 1 shows four different distributions that visualise how differences in location and scale can look like. For instance, the distributions shown in Panel A and Panel B have different locations: the distribution in Panel B is shifted to the right, implying that the AMs of this distribution have a later mean age. The scale, however, is the same. In contrast, the distributions shown in Panel A and Panel C have the same location but different scales: the scale of the distribution shown in Panel C is smaller, implying that these AMs are more narrowly distributed across different ages. Panel D differs from Panel A in that both location *and* scale are different.

The location of AM distributions can differ which has been shown in conjunction with the valence of AMs, for instance. Asking participants for their age in their happiest and saddest memories, Berntsen and Rubin (2002) reported a bump in the distribution of older participants' happiest AMs located in their 20 s, while their saddest AMs showed a monotonically decreasing retention function. Similarly, Alea et al. (2014b) found two peaks in the number of word-cued positive AMs, an early bump located between the ages of 6 and 15 years and a later one in the mid-twenties. Negative AMs, in contrast, only showed a later peak. Using a mixed model to investigate differences in the distributions of word-cued AMs, Wolf and Zimprich (2015) found higher proportions of positive events to be associated with a younger mean age and, at the same time, greater age variability. Differences have also been reported with respect to gender and age. Janssen et al. (2005), for instance, found women to show a slightly earlier bump than men. Wolf and Zimprich (2015) found no gender differences in the average age but in the age variability of AM distributions: The distribution of women covered a broader age range than the distribution of men. They also found the variability to increase with increasing age.

But why should the location and the scale of AM distributions differ according to the functions that AMs serve in daily life? Based on the *identity-formation* account, long-term AMs serving self-functions may mainly stem from adolescence, because a coherent and continuous self is expected to evolve during that life period. Thus, one might hypothesise that the more AMs serve self-functions,

[1] Naturally, distributions (of AM) might differ in more respects than location and scale. However, many probability distributions—notably those distributions from the exponential dispersion family (Jørgensen 1987)—can be described by two parameters that correspond to location and scale of the distribution.

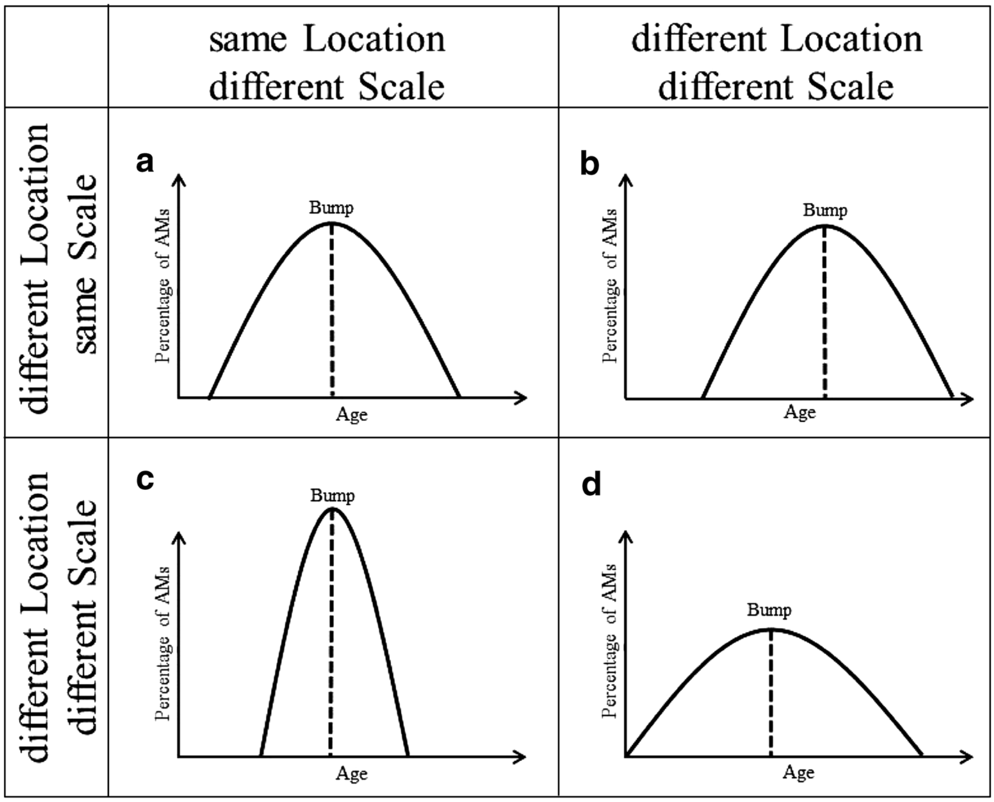

Fig. 1 Schematic visualisation of four possible distributions of autobiographical memories (AMs) across age which differ from each other according location and/or scale (e.g. the distributions of Panels A and C have the *same* location, but *different* scales; see text)

the more their distribution is shifted to the left (into younger age). By contrast, long-term AMs that frequently serve directive or social functions may stem from later time periods. Compared to childhood and adolescence, young adulthood is associated with greater numbers of transitional life events than other life periods (Rubin and Berntsen 2003) and involves making enduring decisions concerning an individual's professional and personal future (e.g. Ebner et al. 2006). Because of their potential influence for an individual's entire life, AMs from young adulthood onwards may not only serve directive purposes throughout the lifespan but also be frequently talked about. Thus, one might hypothesise that the more AMs serve directive and social functions, the more the location of their AM distribution is shifted to the right (into older age). Pertaining to the scale (i.e. the spreading) of the distribution, predictions are less clear because most studies do not take the scale of AM distributions into account.

To investigate whether the location and the scale of the distribution of long-term AMs vary according to the functions that these AMs still serve in daily life, we used an analysis approach developed by Lesaffre et al. (2007), which as a generalised linear model allows including categorical and continuous predictor variables—such as the mean frequency of using the reported AMs for self-, directive, and social functions—directly and simultaneously into a regression-like model. As a result, we could investigate the effect of each memory function while controlling for possible effects of the other two functions as well as of age and gender, and the mean valence of the reported AMs (e.g. Alea et al. 2014a; Wolf and Zimprich 2015).

Method

Sample

The sample comprised 149 adults aged between 50 and 81 years from Germany.[2] On average, adults were 61.7-year old (SD = 7.68 years). About 52 % were women, in which 80 % reported to be married. The sample of the present study had a strong educational background, with 60 participants (40 %) reporting to have graduated from university. On a scale ranging from 1 = "excellent" to 5 = "poor", subjective health was judged as 2.46, on average (SD = 0.83).

[2] Another 54 participants completed the first measurement occasion only and were, therefore, not included into the present study.

Procedure

Data were collected online on two measurement occasions within a week, in order to minimise participants' strain. Participants received the link to the website on which the study was hosted via e-mail. At first measurement occasion, participants gave their informed consent and provided demographic (e.g. age, gender, and education) and health information. Subsequently, participants were presented with 21 cue-words—one at a time—and asked to briefly describe the first AM coming to their mind. They were told explicitly that the personal event did not have to be extraordinary, but specific and distinct. The order of cue-words was randomised anew for each participant. After all events were described, participants were presented with each of their 21 event descriptions and asked for their age at the time of event and whether the event had happened once or repeatedly. Subsequently, they judged the emotional quality of the event on a scale ranging from 1 = "very negative" to 5 = "very positive". Participants also rated how frequently they remembered each event in order to *share it with other people* (social function), to *handle present or future situations, respectively, problems* (directive function), and to *reassure themselves of their identity* (self-function). The frequency scales ranged from 1 = "almost never" to 5 = "very frequent".

The next day, participants received a link to enter the second part of the study. At second measurement occasion, participants were presented with additional thirty cue-words. The procedures of generating and rating AMs were identical to that at the first measurement occasion. On average, participants completed the study within 6 days.

Memory cues

The 51 cue-words consisted of 17 nouns (e.g. "clock"), 17 verbs (e.g. "hike"), and 17 adjectives (e.g. "shady") from the Berlin affective word list (BAWL; Võ et al. 2006). Cue-words were selected on the basis of high imageability and neutral emotional valence. On a scale ranging from 1 = "not at all imageable" to 7 = "completely imageable", the 51 cue-words had a mean of 5.46, indicating high imageability. On a scale ranging from −3 = "completely negative" to 3 = "completely positive", the selected cue-words had a mean of 0.26, indicating emotional neutrality.

Autobiographical memories

Due to a few missing values (some participants did not report an AM to some cue-words), there were not 149 (sample size) × 51 (number of cue-words) = 7599 AMs in total, but 7259 data points (implying that 4.47 % of the data were missing). Because the present study focused on long-term AMs, we excluded another 1661 memories that were stemming from the last 10 years of participants' lives.[3] The remaining 5598 memories were, on average, rated as being slightly more positive ($M = 3.35$, SD = 0.447). On average, they were relatively seldom remembered for self- ($M = 1.62$, SD = 0.578) and directive functions ($M = 1.77$, SD = 0.523) but more frequently shared with others ($M = 2.38$, SD = 0.417). As it was done in other studies that focused on the lifespan distribution of AMs (e.g. Rubin et al. 1998), age at the time of events was grouped into 5-year age bins, so that a frequency distribution of AMs resulted. Frequencies of AMs within a 5-year bin were transformed into percentages by dividing them through the total number of AMs. As a consequence, the percentage values across all five-year bins sum up to 100 %.

Modelling approach

Age bins represent a coarsened version of the original age variable. Moreover, age bins are bounded by zero and the current age of a participant because individuals cannot report an AM from before their birth or from an age higher than her or his age at the time of study. Also, AMs are not equally distributed across age bins, but the distribution is typically skewed to the left.

To account for these characteristics of the outcome variable, we used a regression analysis approach developed by Lesaffre et al. (2007), which relies on the logitnormal distribution. The logitnormal distribution is very flexible and can take a number of different shapes—either symmetrical or skewed—depending on the choice of μ and σ^2 (Frederic and Lad 2008). In addition, the logitnormal distribution is bounded: Predictions will always fall between the boundaries of 0 and 1. In the present study, participants' age at the time when an event happened was grouped into 5-year age bins that fall into the [0, 1] interval. For instance, events experienced between the ages of 16 and 20 years fall into the age bin 0.2. Because age bins represent a coarsened version of the original age variable, the logitnormal regression model was further

[3] The decision to exclude AMs older than 10 years represents a rather conservative criterion. However, we aimed to eliminate the recency effect for two reasons. First, more recent memories may be qualitatively different from long-term AMs because their distribution closely resembles a forgetting function (where accessibility decreases with the passage of time), and it remains an open question whether recent memories ever (and if so, which of them) turn into AMs that can be accessed many years later. Second, an increase of recent memories would be difficult to handle methodologically, because this would require the underlying probability distribution to increase in its right tail—which is impossible with common probability distributions.

specified in terms of *cumulative* comparisons across the age bins. The cumulative probabilities for the C age bins of Y were defined as $P_{ijc} = Pr(Y_{ij} < c) = \sum_{k=1}^{c} p_{ijk}$, where $i = 1,\ldots, N$ denotes the different participants, $j = 1,\ldots, n_i$ the number of recalled memories, $c = 0, 1,\ldots, C$ the different age bins, Y_{ij} the age bin the jth autobiographical event recalled by participant i falls into, and p_{ijk} the individual age bin probabilities.

The logitnormal regression model for the cumulative age bin probabilities is then given in terms of their cumulative logits λ_{ijc} ($c = 1,\ldots, C - 1$) as

$$\lambda_{ijc} = \log\left[\frac{P_{ijc}}{1 - P_{ijc}}\right] = \Phi\left[\frac{z_c - \beta_0}{\sigma_e}\right], \quad (1)$$

where z_c is the logit of the cut point a_c separating age bins c and $c + 1$, i.e. $z_c = \log\,[a_c/(1 - a_c)]$, β_0 is the regression intercept, σ_e is the residual standard deviation, and $\Phi[.]$ is the distribution function of the standard normal distribution. As written in Eq. (1), the estimate of β_0 represents the location of the distribution. If β_0 is smaller (larger) than zero, this would imply that the distribution of age bins is positively (negatively) skewed. The residual standard deviation σ_e captures the differences between the actual age bins memories fall into and the predicted age bins as based on Eq. (1). Moreover, σ_e sets the *scale* of the logitnormal distribution underlying the model. The smaller (larger) the residual standard deviation becomes, the narrower (broader) is the logitnormal distribution.

Predictor variables for both location and scale can be included as

$$\lambda_{ijc} = \Phi\left[\frac{z_c - (\mathbf{x}'_i\boldsymbol{\beta})}{\exp(\mathbf{w}'_i\boldsymbol{\gamma})}\right], \quad (2)$$

where $\mathbf{x}_i$ is the vector of predictor variables of subject i for location and $\boldsymbol{\beta}$ is the vector of regression coefficients for location, $\mathbf{w}_i$ is the vector of predictor variables of subject i for scale, and $\boldsymbol{\gamma}$ the vector of regression coefficients for scale. Note that standard deviations must be larger than zero. For this reason, the exponential function is incorporated into Eq. (2) to guarantee that estimates are positive. A positive regression coefficient for a predictor variable in the numerator would imply that as values of the predictor variable increase so would the odds that the reported age falls into age bin c or a greater age bin. For the denominator, a positive regression coefficient for a predictor variable would indicate that the age bins AMs fall into are more variable.

We modelled the (logitnormal) distribution of all reported AMs as well as the effect of judging these AMs as having a more or less of self-, directive, or social functions on the AM distributions—after controlling for age, gender, and the valence of AMs. The location and scale parameters, which define the logitnormal distribution of the reported AMs, were treated as the dependent variables in a logitnormal regression, whereas age, gender, valence, and the three functions (self-, directive, social) of AMs entered the model as independent, respectively, predictor variables. All predictor variables were included grand mean-centred except for gender, which was dummy-coded (0 = male and 1 = female). The logitnormal regression model was estimated using the SAS procedure NLMIXED (SAS Institute Inc. 2008). Pseudo-R^2 was calculated according to an index by McFadden (1974).

Table 1 Parameter estimates of the logitnormal regression model

	Parameter estimate	Standard error	t value
Location			
Intercept (β_0)	−1.2577	0.0134	−93.85*
Age (β_1)	0.0253	0.0016	15.77*
Gender (β_2)	−0.0276	0.0241	−1.14*
Valence (β_3)	−0.1270	0.0266	−4.78*
Self (β_4)	−0.1059	0.0377	−2.81*
Directive (β_5)	−0.0199	0.0441	−0.45*
Social (β_6)	0.1882	0.0340	5.53*
Scale			
Intercept (υ_0)	−0.1296	0.0109	−11.82*
Age (υ_1)	0.0103	0.0014	7.32*
Gender (υ_2)	0.1545	0.0212	7.29*
Valence (υ_3)	0.0533	0.0229	2.32*
Self (υ_4)	0.0435	0.0341	1.28*
Directive (υ_5)	0.0005	0.0398	0.01*
Social (υ_6)	−0.1146	0.0292	−3.92*

All predictor variables are mean-centred except for gender which is dummy-coded (0 = male, 1 = female)

* $p < 0.05$

Results

Table 1 shows the parameter estimates resulting from the logitnormal regression model. The location and scale intercepts define the average memory distribution in which all predictor variables have a value of 0 (note that predictor variables were mean-centred, respectively, dummy-coded, before entering the model). Transformed back from the logit scale to the original scale,[4] the location intercept becomes 0.22, implying that AMs were, on average,

[4] To obtain these results, one calculates $\frac{\exp(\beta_0)}{1+\exp(\beta_0)} = \frac{\exp(-1.2577)}{1+\exp(-1.2577)} = 0.22$ for the location of and $\frac{\exp(\upsilon_0)}{1+\exp(\upsilon_0)} = \frac{\exp(-0.1296)}{1+\exp(-0.1296)} = 0.468$ for the scale of the memory distribution.

encoded at the age bin of 0.22, that is, between the ages of 21–25 years. The scale parameter was estimated as −0.1296, which, transformed back, becomes 0.468, implying that the standard deviation around the location of 0.22 was 0.468. These results are depicted in Fig. 2, where the solid line represents the average distribution of AMs.

Controlling for age, gender, and valence

Age affected both the location and the scale of memory distributions: Older adults showed a later mean age and a greater standard deviation. To illustrate, for an individual of average age (i.e. 62 years), the location would be estimated as 0.22, whereas for an individual 15 years older the location estimate would be 0.29, implying that, on average, these memories were stemming from a later age bin (26–30 years). Likewise, the scale estimate would be 0.468 for an individual of average age and 0.506 for an individual 15 years older.[5] Gender only affected the scale of AM distributions in the sense that women showed a broader memory distribution than men as indicated by the positive regression coefficient.

The mean valence of the reported AMs affected both the location and the scale of AM distributions: A more positive valence was associated with an earlier mean age and, at the same time, a more variable memory distribution. To illustrate, for individuals with a valence-score one standard deviation above the mean, the location would be 0.20 and the scale 0.481. In contrast, for individuals with a valence-score one standard deviation below the mean, the location and scale would become 0.24 and 0.454, respectively.[6] Together, age, gender, and valence accounted for approximately 7 % of the variance in the location and 5 % of variance in the scale of the AM distribution (Pseudo-R^2).

[5] For an individual of average age (i.e. 62 years), mean-centred age is 0, and thus the location estimate in original age units can be calculated as $\frac{\exp(\beta_0+\beta_1\times age)}{1+\exp(\beta_0+\beta_1\times age)} = \frac{\exp(-1.2577+0.0253\times 0)}{1+\exp(-1.2577+0.0253\times 0)} = 0.22$. For an individual 15 years older than the average age (i.e. 77 years), the location can be calculated as $\frac{\exp(-1.2577+0.0253\times 15)}{1+\exp(-1.2577+0.0253\times 15)} = 0.29$ Likewise, the scale estimate in original age units can be calculated as $\frac{\exp(\upsilon_0+\upsilon_1\times age)}{1+\exp(\upsilon_0+\upsilon_1\times age)} = \frac{\exp(-0.1296+0.0103\times 0)}{1+\exp(-0.1296+0.0103\times 0)} = 0.468$ for an individual of average age and $\frac{\exp(-0.1296+0.0103\times 15)}{1+\exp(-0.1296+0.0103\times 15)} = 0.506$ for an individual 15 years older.

[6] To obtain these results, one calculates $\frac{\exp(\beta_0+\beta_3\times valence)}{1+\exp(\beta_0+\beta_3\times valence)} = \frac{\exp(-1.2577-0.1270\times 1)}{1+\exp(-1.2577-0.1270\times 1)} = 0.20$ for the location and $\frac{\exp(\upsilon_0+\upsilon_3\times valence)}{1+\exp(\upsilon_0+\upsilon_3\times valence)} = \frac{\exp(-0.1296+0.0533\times 1)}{1+\exp(-0.1296+0.0533\times 1)} = 0.481$ for the scale of a valence-score one standard deviation above the mean. For valence-scores one standard deviation below the mean, one calculates $\frac{\exp(-1.2577+0.1270\times 1)}{1+\exp(-1.2577+0.1270\times 1)} = 0.24$ for location and $\frac{\exp(-0.1296-0.0533\times 1)}{1+\exp(-0.1296-0.0533\times 1)} = 0.454$ for scale.

Functions of autobiographical memories

In addition to the control variables, the functions accounted for approximately 13 % of variance in the location and 10 % of variance in the scale of the AM distribution.[7] With respect to the self-function, a more frequent use of AMs was, on average, associated with an earlier mean age. The location can be estimated as 0.20 for individuals scoring one standard deviation above and 0.24 for individuals scoring one standard deviation below the mean frequency of using AMs for self-functions. The mean frequency of using AMs for directive purposes affected neither the location nor the scale of the memory distribution. Finally, more frequently sharing AMs with others was associated with a later mean age and a narrower memory distribution. For individuals with a score one standard deviation above the mean frequency of using AMs for social functions, the location would be 0.26 and the scale 0.439. In contrast, for individuals with a score one standard deviation below the mean, the location and scale would become 0.19 and 0.496, respectively. These results are depicted in Fig. 2, where the solid line represents the average AM distribution and the two dotted lines show the distributions for individuals scoring one standard deviation above the mean frequency of using AMs for self- and social functions, respectively.

Discussion

In the present study, we approached the distribution of long-term AMs from a functional perspective by examining whether the location and the scale of AM distributions differ according to the functions that these AMs serve in daily life. More precisely, we modelled the (logitnormal) distribution of AMs as well as the effect of judging these AMs as having a self-, a directive, or a social function on the memory distribution. Using an analysis approach that allows including (continuous) predictor variables simultaneously into a regression-like model, we could investigate the effect of each memory function while controlling for possible effects of the other two functions.

With respect to the functions of AM recall, we found memory distributions to vary according to the frequency of using AMs for self- and social functions. As expected, more frequently using AMs for self-functions was, on average, associated with an earlier mean age. Put differently, the more (less) AMs were used for self-functions, the more their mean age decreased (increased). These findings

[7] More specifically, self-functions accounted for 4 %, directive for 1 %, and social for 8 % of variance in location. In the scale parameter, the self-, directive, and social functions explained 2.5, 0, and 7.5 % of variance, respectively.

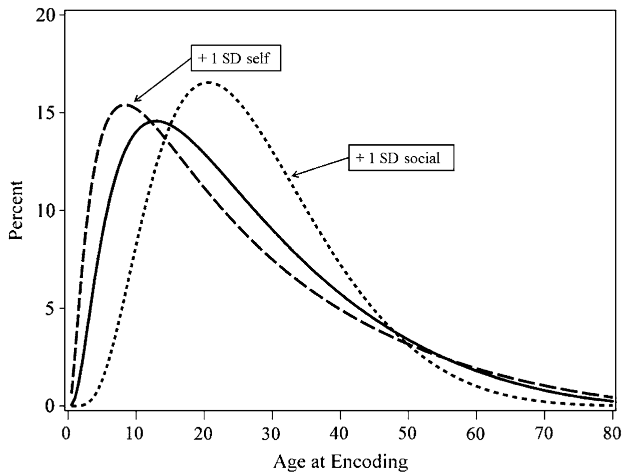

Fig. 2 The effects of using reported autobiographical memories for self- and social functions on their memory distribution. The *solid line* represents the average distribution, the *dotted lines* represents the autobiographical memory distributions for individuals scoring one standard deviation above (+1 SD) the respective means

suggest that long-term AMs that serve self-functions into older age are associated with an earlier life period than AMs that are less frequently used for self-functions. Thus, our findings support the assumption that especially experiences from adolescence—the life period in which individuals are concerned with forming and consolidating their identity—serve to maintain a sense of self-continuity throughout the adult lifespan. Although the *identity-formation* account may not fully explain the occurrence of the reminiscence bump (e.g. Janssen and Murre 2008), it accounts for differences in the location of the distribution of word-cued AMs used for self- versus other functions, as found in the present study. The scale, however, did not differ according to the mean frequency of using AMs for self-functions.

More frequently sharing AMs with others, in contrast, was associated with a later mean age and, at the same time, a narrower memory distribution: The more AMs were talked about, the narrower they were distributed around a later mean age. Correspondingly, AMs that were less frequently shared were more evenly distributed around an earlier mean age. As mentioned before, individuals may especially share those AMs that they consider to be meaningful for their lives (see Alea and Bluck 2003). With respect to long-term AMs elicited with cue-words, this may include AMs stemming from a narrow age range located in young adulthood. Our results would then correspond to earlier findings that found important AMs to mainly stem from the time between the ages of 20 and 30 years (e.g. Berntsen and Rubin 2004; Rubin and Schulkind 1997), thus spanning a relatively narrow age range of the early adult years. Note, however, that earlier findings are usually based on the aggregate data that combine the most important AMs of all participants into one *aggregate* memory distribution. In the present study, however, we modelled an *average* AM distribution based on the AMs that each of the 149 participants reported in response to 51 cue-words.

The location and the scale of AM distributions did not vary according to the mean frequency of using word-cued AMs for directive purposes (versus other functions): Neither the mean age of AMs nor their age range differed between individuals who used their AMs more frequently for directive functions and those individuals who used their AMs at an average level or less frequently. Put differently, AMs that frequently serve directive functions were not associated with a different life period than AMs that are less frequently used along this function. Irrespective of the actual amount, AMs were, on average, encoded at the age bin covering the ages from 21 to 25 years, that is, the early adult years. Thus, AMs that frequently serve directive functions were, on average, located between (earlier) AMs that frequently serve self-functions and (later) AMs that are frequently shared with others.

In focusing on the distribution of long-term AMs based on the memories of an age-heterogeneous sample, we took into account that age ranges could vary between participants. As mentioned earlier, because individuals cannot report an AM from before their births or from an age higher than their ages at the time of study, age bins are bounded by zero and the current ages of participants. Consequently, the number of possible age bins increases with increasing age which might affect both the location and the scale of the AM distribution. In the present study, we thus controlled for possible effects of age on the AM distribution. Indeed, older adults had more variable distributions with a later mean age. We also controlled for possible effects of gender as well as the valence of the reported AMs: women showed a more variable distribution than men, and higher valence-means—indicating a more positive emotional valence—were associated with an earlier mean age and a more variable memory distribution (see Zimprich and Wolf 2016 for a more detailed discussion of age- and gender-related differences in AM distributions).

Limitations, future directions, and conclusions

In the present study, AMs were elicited with the cue-word technique. Participants provided their age at the time of events and rated how frequently they recall events for self-, directive, and social purposes. This is but one way of investigating the functions of long-term AMs that may lead to moderate levels of using AMs for different functions—simply because functions are asked for post hoc and are, thus, not part of the retrieval process. Alternatively, participants could generate (long-term) AMs that map directly onto each of the three memory functions (e.g. Maki et al.

2014; Rasmussen and Berntsen 2009). However, while asking for particular AMs, such as functional memories, may involve more strategic, top–down processes, an associative bottom-up search process—as associated with the cue-word technique—may result in a relatively unbiased sample of AMs (see Koppel and Berntsen 2015). In addition, considering the presence of each function "as a matter of degree rather than a binary decision" (Rasmussen and Berntsen 2009, p. 478), as it was done in the present study, takes into account that each AM could serve more than one memory function (e.g. Bluck and Alea 2002). Therefore, we used an analysis approach that allows including (continuous) predictor variables simultaneously into a regression-like model.[8] As a result, we could investigate the effect of each memory function while controlling for possible effects of the other functions. In addition to the control variables, the functions accounted for 13 and 10 % of variances in the location and the scale of AM distributions suggesting that differences in the distribution of long-term AMs may, of course, depend on more than these three memory functions. Future research may therefore consider examining these AM functions in more detail. In the present study, for instance, we used a broad definition of the social function that only captures the frequency of sharing AMs with others (see also Rasmussen and Berntsen 2009). As mentioned earlier, however, AMs can be shared for various social purposes ranging from facilitating conversation to giving advice or eliciting empathy and intimacy (e.g. Alea and Bluck 2003). The results may differ when these narrower conceptualisations are used. In addition, possible other functions of AM recall could be included which become more relevant with increasing age, such as using memories to regulate emotions (Pasupathi 2003; Wolf 2014), to leave a legacy and to feel a sense of fulfilment (Harris et al. 2014), or to prepare for one's death (Webster 1993).

To summarise, our results show that word-cued AMs generated by middle-aged and older adults serve self-, directive, and social functions throughout the lifespan. Moreover, different functions are associated with different life periods. More frequently using AMs for self-functions is associated with an earlier mean age located in adolescence, the time, in which individuals form and consolidate their identity (e.g. Habermas and Bluck 2000). In contrast, more frequently sharing AMs with others is associated with a narrower distribution around a later mean age. Taken together, the present study offers a new approach to link two prominent areas of AM research, namely the distribution and the functions of AMs.

[8] Zimprich and Wolf (2015, 2016) used a very similar approach to model individual differences in the distribution of autobiographical memories. See their study for a detailed discussion of possible advantages and drawbacks.

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