Notice: This is the author's version of a work that was accepted for publication in *Psychology and Aging*, Vol 32(2), 192-201 DOI: 10.1037/pag0000157

Spontaneous or Intentional? Involuntary versus Voluntary Episodic Memories in Older and Younger adults

Dorthe Berntsen, Anne S. Rasmussen, Amanda N. Miles, Niels Peter Nielsen & Stine B. Ramsgaard

Center on Autobiographical Memory Research
Department of Psychology and Behavioural Sciences
Aarhus University, Denmark

Corresponding Author
Dorthe Berntsen
Center on Autobiographical Memory Research
Department of Psychology and Behavioural Sciences
Aarhus University, Denmark
Bartholins Allé 9
8000 Aarhus C.
dorthe@psy.au.dk

Notice: This is the author's version of a work that was accepted for publication in *Psychology and Aging*, Vol 32(2), 192-201 DOI: 10.1037/pag0000157

Abstract

Involuntary episodic memories are memories of past events that come to mind with no preceding attempt of retrieval. Such memories have received little attention in relation to aging compared with voluntary episodic memories (i.e., intentionally retrieved memories of past events). It is well documented that older compared with younger adults have reduced access to episodic memories, when retrieval is voluntary, but little is known about their involuntary episodic recall. Recent evidence suggests that involuntary autobiographical memories are at least as frequent as voluntary autobiographical memories in daily life, but this research has been limited to younger adults. Here older and younger adults recorded involuntary and voluntary episodic memories in relation to a film of a simulated event (Study 1) and during a normal day in their lives (Study 2). Across both studies, no age differences were found regarding the frequency of involuntary episodic memories, whereas older adults showed slower (Study 1) and less frequent (Study 2) voluntary remembering compared with younger adults. The findings suggest that involuntary relative to voluntary episodic remembering is enhanced in older adults, consistent with reduced executive functioning and increased processing of task irrelevant information with aging. Involuntary episodic remembering may provide an adaptive compensation for reductions in strategic retrieval in later adulthood.

Notice: This is the author's version of a work that was accepted for publication in *Psychology and Aging*, Vol 32(2), 192-201 DOI: 10.1037/pag0000157

Spontaneous or Intentional? Involuntary versus Voluntary Episodic Memories in Older and Younger adults

It is widely accepted that episodic memory declines with aging (e.g., Craik, 1986; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; Nilsson, 2003). Yet, most research on episodic memory, both in general as well as in relation to aging, has focused on strategically and intentionally retrieved memories (i.e., voluntary memories) examined in a laboratory context (e.g., Cabeza & Dennis, 2012, for a review). Although frequently overlooked, this is not the only way in which memories of past events can be recalled. An accumulating number of studies document that we often retrieve autobiographical memories involuntarily, that is, with no preceding attempts of retrieval. The memory simply occurs spontaneously, typically in response to situational cues (e.g., Ball & Little, 2006; Berntsen, 1996, 2009, 2010; Berntsen & Hall, 2004; Kvavilashvili & Mandler, 2004; Mace, 2004, 2005, 2007; Rubin, Boals & Berntsen, 2008; Schlagman & Kvavilashvili, 2008; Schlagman, Kliegel, Schulz and Kvavilshvili, 2009). Although involuntary episodic memories are retrieved unintentionally, they are conceptually different from the notion of implicit memory by involving conscious recollection, and, thus, autonoetic awareness (Wheeler, Stuss, & Tulving, 1997).

Recent evidence suggests that involuntary autobiographical memories are at least as frequent in daily life as their voluntary counterparts in younger adults (Rasmussen & Berntsen, 2011; Rasmussen, Ramsgaard & Berntsen, 2015). However, the effect of aging on such spontaneously arising episodic memories is little studied (Berntsen, Rubin & Salgado, 2015; Rubin & Berntsen, 2009; Schlagman et al., 2009).

Here we are interested in how frequently and effortlessly older and younger adults engage in the two forms of episodic remembering. We pursue the hypothesis that older adults show a decline in voluntary (intentional) episodic memory retrieval, whereas little, if any, age-related decline is present for involuntary (spontaneous) remembering. We examine involuntary and voluntary episodic memories among older and younger adults in relation to a film of a simulated event (Study 1) and during a normal day in their lives (Study 2).

Aging and Involuntary Episodic Remembering

Findings from research on mechanisms underlying involuntary memory retrieval in combination with evidence of an age-related increase in distractibility and in the tendency to process task-irrelevant information (e.g., Amer & Hasher, 2014; Anderson, Jacoby, Thomas &

Balota, 2010; Campell, Hasher & Thomas, 2010; Weeks & Hasher, 2014) suggest that the frequency of involuntary episodic memories may increase in older adults, relative to the frequency of strategically retrieved episodic memories. First, a number of studies have demonstrated that involuntary memories involve less retrieval effort, both when measured in terms of retrieval time (Berntsen et al., 2013; Staugaard & Berntsen, 2014; Schlagman & Kvavilashvili, 2008) and brain activity (e.g., Hall et al., 2014; Kompus, Eichele, Hugdahl & Nyberg, 2011). Thus, although the ability to strategically search for memories declines with aging, due to age-related decline in executive processes (e.g., Cabeza & Dennis, 2012), this need not affect the ability to have involuntary episodic memories, consistent with what is found in other areas of memory research comparing intentional and automatic processes in relation to aging (e.g., Hasher & Zacks, 1979; Jennings & Jacoby, 1993) or self-initiated versus environmentally facilitated processes (Craik, 1986). Second, the retrieval of most involuntary memories is facilitated by concrete cues in the current situation (e.g., Berntsen, 2009, for a review), and these cues are most frequently peripheral to the ongoing task or activity (e.g., a song played in the background on the radio while reading a newspaper; Berntsen, 1998). Thus, the fact that older adults show greater processing of task irrelevant information (e.g., Weeks & Hasher, 2014, for a review) would increase their exposure to potential memory cues and thereby enhance their likelihood of having involuntary memories relative to younger adults. Third, it is well-established that involuntary autobiographical memories most frequently come to mind during periods of non-focused attention, that is, during dull tasks or in situations that require little concentration or when attention has drifted (Berntsen, 2009, 2010, for a review). The fact that older compared with younger adults have less efficient inhibitory mechanisms (Weeks & Hasher, 2014) would imply that they more frequently than younger individuals are in states of awareness that would increase their likelihood of having involuntary recollections.

Alternatively, involuntary autobiographical memories might be impeded by a general decline in cognitive resources (e.g., Craik, 1986; Craik & Byrd, 1982). This possibility would be consistent with findings showing age-related decline in the frequency of other forms of spontaneous thought processes, such as daydreaming or mind wandering (Berntsen et al., 2015; Giambra, 1989, 1993; Maillet & Schacter, 2016, for a review). However, a number of differences between involuntary autobiographical memories and daydreaming speak against this possibility. First, daydreaming or mind wandering can be initiated intentionally in that a person can choose to disengage from an external task in order to pursue an internal stream of thought (e.g., McMillan,

Kaufman & Singer, 2013), whereas involuntary autobiographical memories by definition are unintentional. Second, brain imaging studies show that sustained mind wandering involves the recruitment of a frontal-parietal control network (Smallwood, Brown, Baird & Schooler, 2012), whereas involuntary episodic memories take place with little neural activation associated with strategic control (Hall et al., 2014; Kompus et al., 2011). Third, having an involuntary autobiographical memory is usually contingent upon a feature overlap between the present situation and the past event, whereas the initiation of daydreaming and mind wandering appears less context-dependent; indeed, the content of daydreaming may be quite foreign to the present situation (Singer, 1966, 1975). There are a number of other conceptual and empirical differences between mind wandering and involuntary episodic remembering that render generalization from one to the other problematic (see Berntsen et al., 2015; Maillet & Schacter, 2016), although involuntary remembering obviously can be part of a concrete mind wandering episode.

Research on Involuntary Episodic Memories in Older Adults

The scarce research on involuntary episodic recollections in older adults lends mixed support to the assumption of an enhanced frequency of involuntary relative to voluntary episodic memories among older adults (see Maillet & Schacter, 2016, for a review). In a structured diary study, Schlagman et al. (2009) found that older compared with younger participants reported fewer voluntary memories, but not fewer involuntary memories. However, an age-related decline in the reported frequency of involuntary memories was found when uncompleted memory records (marked off with a tick) were included in the analyses (see Schlagman, Kvavilashvili & Schultz, 2007, for similar findings). Interestingly, Schlagman et al. (2009) found an age-related decline in episodic specificity for voluntary, but not for involuntary autobiographical memories, suggesting that involuntary retrieval of episodic information is less affected by aging. Rubin and Berntsen (2009) surveyed a large representative sample of Danes between the ages of 15 and 96 years. They found no age effects on the reported frequencies of involuntary and voluntary remembering of a specific recent and remote personal event. In another survey study involving a large stratified sample, Berntsen and Rubin (2002) observed a general trend toward a decrease in the reported frequency of involuntary memories across age groups. However, this decline was caused by slightly higher scores among participants in their 20s and 30s. An actual aging effect in terms of a decline specifically in older adults was not present. More recently, Berntsen, Rubin and Salgado (2015) administered the Involuntary Autobiographical Memory Inventory (IAMI) to younger and older

adults and found that frequency of involuntary autobiographical remembering did not decline with age, whereas measures of voluntary recall, future episodic thinking, daydreaming, suppression of unwanted thoughts and dissociative experiences all showed an age-related decline.

In sum, there are some suggestions that involuntary relative to voluntary episodic recall is less affected by aging. However, the evidence is mixed and derives from survey studies with substantial retrospective assessments or structured diaries with quite extensive recording, which has been found to interfere with obtaining frequency measures (Rasmussen et al., 2015). The present studies were undertaken to examine involuntary and voluntary episodic memories in younger and older adults using a simulated event paradigm (Study 1) and a naturalistic, real life approach (Study 2).

Study 1

We used a first person perspective film paradigm to simulate the activation of involuntary memories in daily life. In this paradigm, the participants first watched a short film from a first person perspective that represents an everyday episode from a perspective as if the participant were experiencing it him- or herself. We used a film generated from a computer game that realistically simulates an everyday event; here driving through a town and into the country side. Later during the experiment, the participants watched another first person perspective film that was different from, but reinstated the context of, the first film and shared many of its features. Immediately after watching the second film they were asked if, while watching this film, they had any involuntary (spontaneously arising) memories of the first film and they were asked to estimate the approximate number of memories that came to their minds while watching the second film.

This retrospective recording procedure is a version of the probe-caught method (reporting instances of mental events retrospectively when probed by the experimenter) that is often used in research on spontaneous thought processes (e.g., Maillet & Schacter, 2016, for a review). Here, this choice of method was motivated by research showing that reporting the frequency of spontaneous thoughts through a probe-caught method places less demands on ongoing thought monitoring and awareness and therefore may be more suitable in relation to older adults than a self-caught method (i.e., monitoring own thoughts and indicate every time an involuntary memory is noticed) especially during a short film sequence, allowing little time for recording (e.g., Maillet & Schacter, 2016). Recent research suggests that these two types of recording arrive at similar frequency estimates (Jalbert, Blythe, Hyman, & Staugaard, 2016).

With regard to simulating the experience of involuntary memories during a short film sequence, the present paradigm capitalizes on the robust finding that everyday involuntary autobiographical memories typically are facilitated by distinct feature overlaps between the current situation and the remembered event (e.g., Berntsen, 2009; 2010; Berntsen et al., 2013). Such overlap is here ensured by a general contextual reinstatement and several distinctive features being shared between the two films.

To provide a measure of voluntary (strategic) remembering of the film, we use a method developed in previous research examining voluntary recall of details of a single autobiographical event (Berntsen, 2002; Talarico, Berntsen & Rubin, 2009). The participants are asked to record as many details as possible from the first film, with a detail defined as any unit of information that the participant remembers. Thus, the participants themselves decide what they perceive as units of information to be recorded. We use such lenient definition, consistent with previous research (Berntsen, 2002; Talarico et al., 2009), in order to have a measure of voluntary memory that matches the unconstrained recording of the involuntary memories.

We expect no group differences regarding the frequency with which younger versus older adults report involuntary memories of the first film while watching the second one. However, we expect older adults to have reduced access to strategically retrieved memories compared with younger adults. This age difference would be reflected in either fewer voluntary memory records or longer time invested in recording voluntary memories in the older adults compared with the younger adults.

Methods

Participants. Participants were recruited through Qualtrics Panels [https://www.qualtrics.com/online-sample/], which is an internet based service platform allowing targeting specific populations for answering on-line questionnaires.

Qualtrics Panels provided a total of 220 responses, with older and younger participants matched on gender and years of education. Of these 17, participants were excluded based on the following criteria: (1) the participant clearly had not put an effort into solving the given tasks (e.g., writing nonsense, personal statements or providing no, or very limited, responses to one or more tasks); (2) the participant did not have English as their native language; (3) the participant filled out the survey on a smartphone; (4) the participant failed an attention check (i.e., failed to correctly

answer a question about a distinctive film detail), or (5) the participant did not satisfy the age requirements. After having excluded the 17 participants for the above reasons, additionally four older adults were excluded because they had a PhD degree, which none of the younger adults matched, leaving a total of 100 older adults (*M*age = 69.86 years, *SD* = 4.86, range 65-89; 53 female) and 99 young adults (*M*age = 21.49 years *SD* = 2.62, range 17 - 25; 53 female). The average years of education was similar for the older (*M* = 14.91; *SD* = 2.88) and the younger adults (*M* = 14.89; *SD* = 2.01). A similar number of older and younger participants confirmed having a university degree (37% and 41%, respectively). However, more older than younger participants had obtained a master degree (17% versus 9%, respectively, $\chi^2(1) = 5.04$, $p<.05$). As expected, the older participants scored higher on Shipley's (1940) vocabulary tests (*M* = 34.98, *SD* = 3.35) than the younger participants (*M* = 31.10, *SD* = 5.26; $t(197) = 6.22$, $p < .001$, $d = 0.88$). As also expected, the older participants scored lower than the younger participants on two verbal fluency tasks (Salthouse, 1993); generating words beginning with s (Older: *M* = 11.22, *SD*=5.32 versus Younger: *M* = 16.63, *SD* = 5.31; $t(197) = 7.82$, $p < .001$, $d = 1.02$) and generating words ending with 'ay' (Older: *M* = 8.67, *SD* = 4.37 versus Younger: *M* = 11.70, *SD* = 4.95; $t(197) = 4.57$, $p < .001$, $d = 0.65$).

Materials

First-person perspective films. Two computer animated videos were created for the purpose of the present study through the built-in editor in a computer game allowing the creation of realistic environments. After having created the environment and the events in the editor, two videos, both lasting 1 minute and 35 seconds, were recorded. The videos depict first-person perspective views of driving a car through a town and into the countryside. The videos bear a number of similarities. First, the driver takes the exact same route in both of the videos, which ensures a high proportion of overlap of environmental details (e.g. the buildings, roads, trees), known to facilitate the activation of involuntary memories (e.g., Berntsen, 2010; Berntsen et al., 2013). Second, the driver encounters a number of events and details that are the same across the two videos. These events and details are: pedestrians walking or standing next to the road, a van honking, a police car that has pulled over a van, turning left in a roundabout and cars passing by. Both videos end immediately after the driver makes an emergency braking to avoid hitting a herd of sheep on the road. The videos do, however, differ in a number of ways. First, the order and the locations of the repeated details and events across the videos are different. Second, extra distinctive

details and events are added to the first video. These details are: roadworks, garbage on the side of the road, almost hitting a van in the roundabout and one extra oncoming car. We did this to increase the likelihood that the participants would experience having spontaneous memories of the first video when watching the second video.

Procedure

The data were collected through an internet-based survey platform administered by Qualtrics Panels. The participants were instructed to have their audio turned on, and they had to pass a sound test (identify an animal sound) in order to take part in the survey. The participants first gave informed consent to participate in the study. They were informed that the purpose of the survey was to study spontaneous and deliberate processes of memory. They answered a series of demographic questions, followed by the vocabulary test. They then proceeded to watch the first film, which lasted 95 seconds. They received the following instructions: "You are about to see a video that shows a first-person perspective view of driving a car. Imagine that you are the one driving the car. Please pay attention to the film." They were also told to watch the video in full screen mode and with the audio turned on. After watching the film, they answered two verbal fluency tests, each lasting 60 seconds. After completing this part, they moved on to watching the second film. The participants were told that they would be watching another film of driving through a town, and that this film was different from, but also quite similar to, the first film they had seen previously. The remaining instructions were the same as for the first film.

Immediately after the second film, the participants were asked three questions probing whether they had experienced spontaneous memories while watching the film: (1) "Did watching the second video at times spontaneously remind you of scenes that you had seen in the first video (without you consciously trying to remember)?" This was rated on a scale from 1 (Not at all) to 7 (Almost constantly). (2) "Please indicate the approximate number of memories of the first video that spontaneously came to your mind (without you trying to remember) while watching the second video." This was answered on a scale from 0 to 50. (3) "Were your memories of the first video triggered by certain sounds or scenes?" This was rated on a scale from 1 (The memories had no specific triggers) to 7 (The memories almost always had specific triggers).

The next phase of the experiment addressed the participants' ability to strategically recall the first film. Here we followed a procedure developed in previous work of autobiographical memory recall, where participants are asked to record as many details as possible referring to a

particular event (Berntsen, 2002; Talarico et al., 2009). Consistent with this previous research and in order to render the voluntary recall task comparable with the involuntary memory measure, we used a broad definition of memory details. A detail was simply any unit of information that the participant was able to remember from the first film. Thus, what counted as a detail was up to the participant to decide as long as it pertained to something he or she remembered seeing in the film. The details could be generated in any order, and could be described with as few words as the participant preferred, in order not to confound this memory measure with verbal abilities.

Each detail was entered into its own box in the survey. A total of 30 boxes were provided. The specific instructions were as follows: "In the following, please think back upon the first video. Please recall as many details as possible. A detail is any unit of information that you can remember from any part of the video (e.g., any objects you remember seeing, any actions you remember, any sounds you heard, etc.). Please list as many details as possible." The participants were told they had to spend at least three minutes on recording details, and could use more.

The survey was set up so that the participants could not move ahead in the survey before 180 seconds had passed. Importantly, they were not forced to move on after 180 seconds. In order to allow enough time for everyone, participants could stay on the page and keep generating details for up to five minutes (cf. Berntsen, 2002). However, the great majority of the participants in both age groups had left the page before the five minutes (300 seconds) had passed.

Before data analyses, the recorded details underwent a check for validity, leaving out details consisting of nonsense words, empty statement (e.g., "none, none, none") or comments on the task itself. A sum score for number of memory details was generated. As expected, this measure did not correlate with vocabulary score ($p > .2$) suggesting the details sum score satisfied our intention of having a relatively direct measure of strategic memory retrieval, largely independent of variations in verbal abilities in the present samples. We also calculated the total number of words used to describe the details (irrespective of the number of details). In contrast to the detail sum score (and not surprisingly) this word count measure correlated weakly, but reliably, with the participants vocabulary score ($r=.25$, $p<.001$, $N=199$).

Finally, the participants answered a forced choice accuracy task, where they were presented with 10 questions about the first film and for each asked to choose between three response options. Accuracy scores were generated.

Results

As hypothesized, the older and younger adults did not differ with regard to how frequently they experienced involuntary memories. According to their estimates, they experienced the same number of involuntary memories of the first film, while watching the second film (Older: $M = 6.60$, $SD = 4.24$ versus Younger: $M = 6.86$, $SD = 7.31$; $t(197) < 1$). They also had similar ratings regarding the amount of time during the film they experienced having involuntary memories (Older: $M = 5.90$, $SD = 1.19$ versus Younger: $M = 5.82$, $SD = 1.16$; $t(197) < 1$). However, they differed with regard to how often they noticed their memories were triggered by certain sounds or scenes. Here the older adults ($M = 4.70$, $SD = 1.72$) scored lower than the younger adults ($M = 5.46$, $SD = 1.30$; $t(195) = 3.50$, $p < .001$, $d = 0.50$) suggesting that the older adults may have been less aware of the feature overlaps between the two films and their potential role at facilitating the involuntary memories.

There were no age differences regarding the overall number of memory details recorded during the voluntary retrieval task (Older: $M = 12.16$, SD=4.41 versus Younger: $M = 12.17$, $SD = 6.44$; $t(197) < 1$). The same results were found with regard to the overall number of words used to describe the details (Older: $M = 33.76$, $SD = 25.24$ versus Younger: $M = 33.55$, $SD = 25.75$; $t(197) < 1$), and the forced choice accuracy test (Older: $M = 6.75$, $SD = 1.56$ versus Younger: $M = 6.93$, SD =1.83; $t(197) < 1$). However, the older adults spent longer time generating details than the younger adults (seconds spent: Older: $M = 230.98$, $SD = 44.44$ versus Younger: $M = 213.08$, $SD = 36.63$; $t(197) = 3.10$, $p < .01$, $d = 0.44$). Thus, after completing the obligatory 180 seconds of recording, more older than younger participants continued to stay on the task and generate additional details.

Together these findings suggest that the availability of memory details was not reduced in the older relative to the younger adults in that they produced the same amount of details and had similar accuracy scores. However, the accessibility was effected (cf. Tulving & Pearlstone, 1966) in that the older adults invested more time (suggesting more effort) at retrieving the same amount of details as the younger adults. This interpretation was also supported by significant correlations within the older adults group between the time spent on the task and the number of details recorded ($r = .29$, $p < .01$, $N = 100$) as well as time spent and number of words used in describing the details ($r = .39$, $p < .01$, $N = 100$). In contrast, within the group of younger adults, these variables showed no correlations with time spent on the task (rs = -.03, and -.02, respectively; $N = 99$).

Fifty-one of the younger adults spent less than 200 seconds on the detail recording task, whereas this was the case for 37 older adults. When these two subgroups were compared, the older adults generated reliably fewer details than the younger adults (Older: M = 10.11, SD = 3.18 versus Younger: M = 12.86, SD = 6.04; $t(86) = 2.53$, $p < .05$, d = 0.57) and elaborated with fewer words (Older: M = 22.11, SD = 10.32 versus Younger: M = 37.06, SD = 24.97; $t(86) = 3.43$, $p < .01$, d = 0.78). Numerical differences in the reverse direction were observed for the two subgroups that had spent more than 200 seconds on the task; showing a statistically significant effect only for word count with older participants having higher scores. (Older: M = 40.60, SD = 28.76 versus Younger: M = 29.81, SD = 26.30; $t(109) = 2.03$, $p < .05$, d = 0.39).

Consistently, when all four subgroups were contrasted in a 2 x 2 (Time [< 200 sec versus >200 sec] x Age group [old versus young]) Analysis of Variance (ANOVA) with time and age group as between subjects factors, significant interaction effects were found for both sum scores of detail, $F(1, 195) = 9.02$, $p < .01$, $\eta_p^2 = .04$, and word count, $F(1, 195) = 13.05$, $p < .001$, $\eta_p^2 = .06$. No main effects were found.

Discussion

Older and younger adults reported similar frequencies of spontaneous recollections during the 95 second film sequence, suggesting involuntary memory retrieval being little affected by aging. Older participants differed from younger participants only by less frequently observing their spontaneous memories being triggered by concrete feature overlaps between the two films. In contrast, voluntarily retrieving details of the film appeared to be a more effortful process for the older than for the younger adults, in that the older adults achieved the same level of performance as the younger adults only by spending more time on the task. No similar pattern was seen for the involuntary memories where both groups arrived at the same estimate of involuntary memories during the 95 second time frame.

Alternatively, rather than increased retrieval effort, might the longer recording time for voluntary memories shown by the older participants simply reflect reduced typing speed? A number of additional observations render this interpretation less likely. First, the older participants did not spend more time overall on the entire survey (Older: M_{minutes} = 25.21, SD = 17.32 versus Younger: M_{minutes} = 26.43, SD = 22.20; t (196) < 1), suggesting that the older participants did not experience greater difficulties typing and monitoring the overall series of computer-based tasks that were involved in participating in the survey. Second, within the group of older participants, those who

spent more than 200 sec. on recording details were not older (M_{years} = 69.17, *SD* = 4.16) than those who spent less than 200 sec. on the task (M_{years} = 71.03, *SD* = 5.74); in fact, a non-significant difference in the opposite direction was detected (*p* =.07). Third, previous research has shown that overall typing speed does not decrease with aging. Although some components do decline with aging, such as tapping speed, other factors appear to compensate, such that overall typing speed shows no age-related decline (Glisky, 2007; Salthouse, 1984). We therefore consider it unlikely that typing speed was a major factor for the slower recording of voluntary memories in the older adults. At any rate, reduced voluntary access to episodic memory in older age is well-established by previous research (e.g., Craik, 1986; Levine et al., 2002; Nilsson, 2003). The key finding of the present study is that this reduction did not generalize to involuntary memories.

It might be proposed that the involuntary memories task of providing retrospective frequency estimates was easier than actually recording memory details during the voluntary memory task. However, even if the involuntary memory recording was easier, this still would not have prevented the younger adults from reporting more involuntary memories than the older adults during the preceding film, had this corresponded to their actual experience. Although these frequency estimates were given retrospectively, we believe they are valid indices of the participants' memory experience. First, the probe-caught measure that we used to examine involuntary memories is a standard method in studies of spontaneous thought processes (Maillet & Schacter, 2016). Second, the film for which the retrospection was carried out was short (~ l.5 minute), which would make it easier to provide assessments. Third, the reporting was done immediately after the film had ended, again reducing retrospection.

We reasoned that it did not make sense to ask for retrospective assessments of voluntary remembering during the 95 sec. film sequence as the participants would seem to have little purpose in initiating strategic retrieval during watching the short film sequence. Instead, we employed a voluntary memory task that has been used previously in studies on voluntary recall of details from single autobiographical events. The number of recorded details in the present study was unaffected by measures of vocabulary, supporting its validity as a measure of memory.

Still, a more ideal comparison of age effects on involuntary and voluntary remembering would involve identical recording methods in the voluntary and involuntary memory conditions. Furthermore, although the first person films were created to simulate real life experiences and naturalistic cueing of involuntary memories, the films were nonetheless far from everyday life, for example regarding personal involvement, range of sensory stimulation, familiarity and duration.

Notice: This is the author's version of a work that was accepted for publication in *Psychology and Aging*, Vol 32(2), 192-201 DOI: 10.1037/pag0000157

Study 2 was undertaken to examine whether the findings from Study 1 would extend to a real life setting and with similar recording procedures for the two types of memories.

Study 2

Because we are interested in the experienced frequencies of involuntary and voluntary episodic memories among older and younger adults in everyday life, we adopt a naturalistic research methodology. Previous work has shown that using a mechanical counter to record naturally occurring involuntary and voluntary memories over a one day period is a feasible research strategy that produces replicable results (e.g., Rasmussen & Berntsen, 2011; Rasmussen et al., 2015; Finnbogadottir & Berntsen, 2013). Operating this recording device requires no technical skills, is extremely straightforward and interferes little with daily activities. We predict that older relative to younger adults will show a reduced frequency of voluntary episodic recollections but not a reduction in involuntary memories, when recording these two types of memories during a normal day in their natural environment.

Methods

Participants. The participants were 45 older adults (*M*age = 67.60, *SD* = 3.75, range 60-77; 28 females, 17 males) and 45 younger adults (*M*age = 23.36, *SD* = 3.11, range 19-38; 26 females, 19 males). The older adults were recruited from the community, and the younger adults were recruited from different educational institutions, representing both college and non-college education, in order to match the heterogeneous education levels of the older adults. Both groups received a gift certificate as compensation for their participation.

Data from four older participants were replaced because of scores below the cut off (< 27) on the Mini Mental State Examination (MMSE; Folstein, Folstein & Fanjiang, 2001). Data from three younger adults were replaced, because they failed to follow the instructions. The average scores on the MMSE were similar for the older (*M* = 29.31; *SD* = 0.90) and younger (*M* = 29.18; *SD* = 1.11, *t* (88) <1) adults. The average years of education tended to be higher for the older adults (16.25; *SD* = 4.84) than for the younger adults (*M* = 14.72; *SD* = 2.35), although this difference was not statistically significant, *t*(87) = 1.90, *p* = .06. Weshler's Adult Intelligence Test (WAIS-IV; Wechsler, 2008) digit span measure showed no difference between the older (*M* = 26.09; *SD* = 5.44) and the younger (*M* = 26.09; *SD* = 5.04, *t*(88) <1) adults, whereas the older adults (*M* = 16.03, *SD* = 3.15) performed better than the younger adults (*M* = 14.07, *SD* = 3.06) on the WAIS

Arithmetic test, $t(88) = 2.99$, $p < .01$, $d = 0.63$, possibly reflecting more emphasis on arithmetic skills in Danish schools, when the older participants went to school. The Geriatric Depression Scale (GDS; Black & Auerbach, 1995; Sheikh & Yesavaga, 1986) also showed no difference between the older ($M = 1.14$, $SD = 1.49$) and younger ($M = 1.51$, $SD = 2.01$) participants, $t(85) < 1$.

The older and younger participants were randomly assigned to the involuntary and voluntary memory conditions with the following *n*s: Involuntary, older = 24; Involuntary, younger = 23; Voluntary, older =21; Voluntary, younger = 22. Individuals assigned to the involuntary and voluntary conditions did not differ with regard to gender, age, years of education, or with regard to any of the included cognitive and clinical background measures described above.

Materials. The participants were equipped with a mechanical counter in order to assist them in keeping track of the number of involuntary/voluntary memories. The mechanical counter (www.elektronik-lavpris.dk/product_info.php?products_id=96168; product number: BN204041) is a thumb or finger-actuated counter that fits in the palm of a hand. It is lightweight (80 g.) and compact and easy to carry around, making it highly convenient for simple counting chores with minimal distraction on co-occurring activities (see also Rasmussen & Berntsen, 2011; Rasmussen et al., 2015).

Design. We employed a between subjects design with two factors: Group (Older versus Younger) x Condition (Involuntary versus Voluntary).

Procedure. The participants were instructed individually at a meeting with only the participant and the experimenter present. Both verbal and written instructions were given. The participants were informed that we were interested in how frequently they experienced involuntary, or, depending on task assignment, voluntary memories during a normal day. They were asked to record their memories on the following day, or, if that was inconvenient, on the first upcoming convenient day. They were presented with the mechanical counter and written instructions to take home.

The participants in the involuntary condition were carefully explained the notion of involuntary memories. They were told that an involuntary memory was a spontaneously arising memory about a past event, that is, a memory brought to consciousness with no preceding conscious attempts at retrieval. Involuntary memories could be cued by the present surroundings or aspects of current thought as long as the association in question had been established without intentional attempts. An everyday example was provided of spontaneously having a memory of an earlier bus ride while waiting at a bus stop.

The participants in the voluntary condition were carefully explained the notion of voluntary memories, which was defined as a memories retrieved in a goal-directed and controlled fashion. It was emphasized that the memory did not simply pop up by itself. Its retrieval had to be initiated consciously and in an intentional fashion in order for it to be considered a voluntary memory. An everyday example was provided of voluntarily recalling a memory of an earlier bus ride while waiting at a bus stop.

The above instructions have been used in previous work on younger participants (see Rasmussen & Berntsen, 2011; Rasmussen, Johannessen & Berntsen, 2014). However, initial piloting indicated that some older participants in both retrieval conditions needed more detailed instructions in order to understand the task. Specifically, they had problems understanding the difference between involuntary and voluntary retrieval, or participants in the voluntary condition misunderstood the task to be one of purposefully generating as many memories from their past as possible, instead of recording the ones they retrieved naturally during daily life. Hence, we added an elaboration to both conditions in both age groups. In the voluntary condition we added: "Imagine that someone asks you to tell about your high school years, or imagine that you have lost your keys, and you want to remember your whereabouts of the day in order to find them. In both situations, you would have to use a voluntary or intentional search in order to retrieve the relevant memories. These are the kind of memories we would like you to record by using the counter. On the other hand, one might also imagine that a sudden encounter with an old high school friend triggers a memory from your high school years, or that a cue in the environment activates a memory that helps you to discover, where you left your keys, even before you knew they were gone. These are *not* the kinds of memories we want you to record. We want you to record the memories you consciously search for. In the involuntary condition we added the exact same elaboration, but with the opposite instructions as to which types of memories to record.

The participants were instructed to press the button on the mechanical counter each time they had an involuntary or (depending on condition) voluntary memory, and make a note of the final number by the end of the day. In both conditions, it was stressed that the memories had to be autobiographical, that is, dealing with a personally experienced event. All memories satisfying the requirements of the condition (i.e., being involuntary or voluntary) should be included, regardless of the emotional valence, frequency of rehearsal, level of importance or age of the remembered event.

At a second meeting after the recording period, the participant again met individually with the experimenter. The participant returned the mechanical counter, was debriefed about the study and received a gift certificate in compensation for participating.

Results

As predicted, the older participants recorded fewer voluntary memories (M = 10.19, SD = 12.06) than the younger participants (M = 23.18, SD = 18.29). A less pronounced numerical difference in the opposite direction was found on the frequencies of the involuntary memories between the older adults (M = 24.75, SD =22.19) and the younger adults (M = 15.52, SD = 13.45).

Because substantial individual variability was observed on the raw frequencies, statistical analyses were based on a square root transformation of the data (but note that similar results were obtained with the analyses based on the raw frequencies). A 2 x 2 (Age Group [Older versus Younger] x Retrieval [involuntary versus voluntary]) ANOVA with age group and retrieval condition as between subjects factors showed no main effects, but a significant interaction effect between Age Group and Retrieval condition, $F(1.86) = 7.99$, $p < .01$, $\eta_p^2 = .08$. Follow up Fisher LSD tests showed a significant difference between the frequency of involuntary and voluntary memories within the older adults group ($p < .005$) and a significant difference in the frequencies of voluntary memories between the younger and the older adults ($p < .05$). No other comparisons were significant (ps > .15). See Figure 1.

Discussion

Study 2 was undertaken to examine the everyday frequencies of involuntary versus voluntary episodic memories in older and younger adults in a real life context. We found a significant interaction between memory type and age group, with older adults recording fewer voluntary memories than the younger participants, while no statistically significant age group difference was found on the frequency of involuntary memories. Study 2 thus replicated the absence of age differences for involuntary memories found in Study 1, while the age dependent reduction in voluntary memory frequency in the present study is consistent with voluntary episodic remembering taking more effort for the older adults in Study 1, as well as a large body of research showing age-related decline in voluntary episodic remembering (e.g., Cabeza & Dennis, 2012, for a review).

In addition to these age-related effects, the present findings replicated previous research showing a high frequency of involuntary memories among the younger adults that did not differ

reliably from the frequency of voluntary memories (Rasmussen et al., 2015). However, numerically, the present frequency of the voluntary versus involuntary memories were higher among the younger participants compared with previous studies (e.g., Rasmussen and Berntsen, 2011). This discrepancy may reflect that the instructions used in the present study were adapted to suit the older participants (see Methods).

General Discussion

We conducted two studies to examine the effects of aging on involuntary and voluntary episodic remembering. Across both studies, no age differences were found regarding the frequency of involuntary memories, whereas the retrieval of voluntary memories was affected by age, consistent with previous research. In Study 1, older adults spent longer time recording the same amount of memory details as the younger adults, suggesting that voluntary remembering was more effortful for the older participants. In Study 2, older adults reported less frequent voluntary autobiographical memories during daily life compared with younger adults.

These findings agreed with our expectation that with aging, involuntary episodic remembering becomes a more dominant way of accessing past events, possibly caused by two interacting factors. First, involuntary remembering requires little retrieval effort, and thus is less affected than strategic remembering by an age-related decline in executive processes. Second, in addition, involuntary remembering may be facilitated by older adults' greater tendency to process peripheral and task unrelated information (e.g., Weeks and Hasher, 2014), which most likely increases their exposure to potential memory cues. The finding that the older adults rated the presence of such triggers less frequent than the younger adults does not necessarily challenge such explanation. It might as likely reflect that the older adults were less aware of the feature overlaps between the two films and their potential role at facilitating the involuntary memories.

Speculatively, an increasingly dominant involuntary (relative to voluntary) retrieval mode in older adulthood may form an adaptive compensation for age-related difficulties with strategic retrieval of past events for at least three reasons. First, there is robust evidence that involuntary autobiographical memories typically access specific events, that is, events that took place at a particular time and location in the past (see Berntsen, 2009, 2010, for reviews). A preponderance of memories with a high level of episodic specificity has also been found in studies with older adults, when examining their involuntary memories. When comparing memories recorded by older and younger adults, Schlagman et al. (2009) found an age-related decline in episodic specificity for

voluntary, but not for involuntary, memories. Involuntary memories of specific events may aid problem solving, motivate and direct behavior and assist updating knowledge about specific encounters in the social and physical environment (e.g., Pillemer, 2003; Rasmussen et al., 2014).

Second, although the onset of involuntary remembering is uncontrollable by the individual, it is not random. There is robust experimental evidence that involuntary episodic memories most frequently are activated in response to cues that provide a unique feature overlap to a past event (e.g., Berntsen et al., 2013). This uniqueness of the encoding-retrieval match may be one important key to the adaptiveness of involuntary episodic memories. This mechanism likely prevents us from being flooded by involuntary memories, simply because cues with sufficiently high levels of memory discriminability are not constantly present in our environment (Berntsen et al., 2013). Furthermore, the unique encoding-retrieval match increases the probability that the remembered event will bear some functional relevance to the retrieval situation, for example by updating the person's knowledge of a particular location or use of a particular object (e.g., Hintzman, 2011).

Third, although involuntary memories with a stressful and negative content are observed in clinical settings (e.g., Ehlers, Hackmann & Michael, 2004; Rubin, Dennis & Beckham, 2011) they are not the norm. Everyday involuntary memories are predominantly emotionally positive and do not differ from strategically retrieved episodic memories regarding their emotional contents and distribution across the life span (Berntsen, 2009, 2010). Involuntary episodic memories therefore may serve many of the same social, instrumental and identity-related functions as do memories that are voluntarily retrieved (Bluck, Alea, Habermas & Rubin, 2005; Pillemer, 2003; Rasmussen et al., 2014).

The present studies have limitations that should be considered when evaluating the results. First, we used a probe-caught method in Study 1 to measure the frequency of involuntary memories. While this method may be more suitable for older adults than self-caught methods and especially useful during a short experimental trial as used in Study 1, it requires retrospection, which may introduce noise. However, any noise introduced by this recording technique most likely would have affected the younger and older participants in similar ways and thus not changed the basic findings. Second, we cannot rule out that general slowing contributed to older adults' extended recording time for voluntary memories in Study 1. Although a number of observations spoke against typing speed being a factor, the increased recording time in the older adults for this task nonetheless should be interpreted with caution. Third, in Study 2 we used a naturalistic design, which naturally allows for less experimental control than laboratory memory experiments. For example, the method we

employed did not allow us to distinguish between successful and unsuccessful retrieval attempts. Disentangling retrieval attempt from retrieval success within this line of research in an important task in future research. Fourth, measuring the frequency of naturally occurring memories (or the frequency of any naturally occurring mental phenomena) obviously is subject to error and measurement noise. We do not wish to claim that we here have measured the 'exact' daily frequencies of involuntary and voluntary episodic memories in younger and older adults; nor was this the goal of the study. Our aim was to examine age-related differences in the relative dominance of the two types of autobiographical memory retrieval in daily life. A naturalistic methodology was needed in order to address this research question, and the methods used in Study 2 have produced systematic and replicable results in the past (Finnbogadottir & Berntsen, 2013; Rasmussen & Berntsen, 2011; Rasmussen et al., 2015). Furthermore, the present findings converge with findings obtained when examining the frequencies of involuntary and voluntary autobiographical memories in younger and older adults through psychometric testing (Berntsen et al., 2015).

Viewed from a broader perspective, the research question pursued in the present work has been around for a long time. Some 40 years ago, Craik (1986) proposed that "self-initiated memory operations become increasingly more difficult to execute with increasing age" (p. 419). The present findings concur by showing that older compared with younger adults engage more effortlessly and more frequently in involuntary remembering of past events and less effortlessly and less frequently in intentional, voluntary recall in daily life. This pattern may reflect that a combined effect of reduced executive functioning and increased processing of task irrelevant, contextual information advances involuntary over voluntary recollection in older adults. However, the exact underlying mechanisms as well as potential adaptive values of involuntary memories in older age are questions for future research.

References

Amer, T., & Hasher, L. (2014). Conceptual processing of distractors by older but not younger adults. *Psychological Science, 25*, 2252-2258.

Anderson, B.A., Jacoby, L.L., Thomas, R.C., Balota, D.A. (2010) The effects of age and divided attention on spontaneous recognition. *Memory & Cognition, 39*, 725–735

Ball, C. T., & Little, J. R. (2006). A comparison of involuntary memory retrievals. Applied *Cognitive Psychology, 20*, 1167-1179.

Berntsen, D. (1996). Involuntary autobiographical memories. *Applied Cognitive Psychology, 10*, 435-454.

Berntsen, D. (1998). Voluntary and involuntary access to autobiographical memory. *Memory, 6*, 113-141.

Berntsen, D. (2002). Tunnel memories for autobiographical events: Central details are remembered more frequently from shocking than from happy experiences. *Memory & Cognition, 30*, 1010-1020.

Berntsen, D. (2009). *Involuntary autobiographical memories. An introduction to the unbidden past.* Cambridge University Press.

Berntsen (2010). The unbidden past: Involuntary autobiographical memories as a basic mode of remembering. *Current Directions in Psychological Science, 19*, 138-142.

Berntsen, D. & Hall, N.M. (2004). The episodic nature of involuntary autobiographical memories. *Memory & Cognition, 32*, 789-803.

Berntsen, D., & Rubin, D.C. (2002). Emotionally charged autobiographical memories across the lifespan: The recall of happy, sad, traumatic, and involuntary memories. *Psychology and Aging, 17*, 636-652.

Berntsen, D., Rubin, D.C., & Salgado, S. (2015). The frequency of involuntary autobiographical memories and future thoughts in relation to daydreaming, emotional distress, and age. *Consciousness and Cognition, 36*, 352-372.

Berntsen, D., Staugaard, S. R., Sørensen, L. M. T. (2013). Why am I remembering this now? Predicting the occurrence of involuntary (spontaneous) episodic memories. *Journal of Experimental Psychology: General, 142*, 426-444

Black, C. H., & Auerbach, H. (1995). A Danish version of the geriatric depression scale. *Clinical Gerontologist, 16*, 67–70.

Bluck, S., Alea, N., Habermas, T., & Rubin, D. C. (2005). A TALE of three functions: The self-reported uses of autobiographical memory. *Social Cognition*, 23, 97-117.

Cabeza, R. & Dennis, N.A. (2012). Frontal lobes and aging: Deterioration and Compensation. In Stuss, D.T. & Knight, R. T. (Eds.). *Principles of Frontal Lobe Function, 2nd Edition*. New York: Oxford University Press.

Campbell K. L., Hasher, L., Thomas, R. C. (2010). Hyper-binding: A unique age effect. *Psychological Science, 21*, 399-405.

Craik, F.I.M., (1986). A functional account of age differences in memory. In: K. Friedhart and H. Hagendorf (Eds.), *Human Memory and Cognitive Capabilities: Mechanisms and Performances* (pp. 409-422). Elsevier, Amsterdam.

Craik, F.I.M., & Byrd,M. (1982). Aging and cognitive deficits: the role of attentional resources.In: F. Craik,F.,and S.E. Trehub (Eds.). *Aging and Cognitive Processes* (pp. 191-211). Plenum Press, NewYork.

Ehlers, A., Hackmann, A. & Michael, T. (2004). Intrusive re-experiencing in post-traumatic stress disorder: Phenomenology, theory, and therapy. *Memory, 12*, 403-415.

Finnbogadottir, H., & Berntsen, D. (2013). Involuntary future projections are as frequent as involuntary memories, but more positive. *Consciousness and Cognition, 22*, 272-280.

Folstein, M. F., Folstein, S. E., & Fanjiang, G. (2001). MMSE Mini-Mental State Examination. Clinical Guide. Lutz, Fl: Psychological Assessment Resources, Inc.

Giambra, L.M. (1989). Task-unrelated-thought frequency as a function of age: A laboratory study. *Psychology and Aging, 4*, 136-143.

Giambra L. M. (1993). The influence of aging on spontaneous shifts of attention from external stimuli to the contents of consciousness. *Experimental Gerontologist, 28*, 485-92.

Glisky, E.L. (2007). Changes in cognitive function in human aging. In D.R. Riddle (Ed.). *Brain Aging: Models, Methods, and Mechanisms*. Boca Raton (FL): CRC Press/Taylor & Francis.

Hall, S. A., Rubin, D. C., Miles, A., Davis, S. W., Wing, E. A., Cabeza, R., & Berntsen, D. (2014). The Neural Basis of Involuntary Episodic Memories. *Journal of Cognitive Neuroscience. 26*, 2385-2399.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General, 108*, 356-388.

Hintzman, D.L. (2011). Research strategy in the study of memory: Fads, fallacies, and the search for the "coordinates of truth." *Perspectives on Psychological Science, 6*, 253-271.

Jalbert, M.C., Blythe, J.S., Hyman, I.E., Staugaard, S.R. (2016). Who let's the thoughts in. Manipulating voluntary, involuntary and intrusive thoughts. **Manuscript under review.*

Jennings, J.M. & Jacoby, L.L. (1993). Automatic versus intentional uses of memory: Aging, attention and control. *Psychology and Aging, 8,* 283-293.

Kompus, K., Eichele, T., Hugdahl, K., Nyberg, L.. (2011). Multimodal imaging of incidental retrieval: The low route to memory. *Journal of Cognitive Neuroscience, 23,* 947-960.

Kvavilashvili, L. & Mandler, G. (2004). Out of one's mind: A study of involuntary semantic memories. *Cognitive Psychology, 48,* 47-94.

Levine, B., Svoboda, E., Hay, J.F., Winocur, G., Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging, 17,* 677-689.

Mace, J. H. (2004). Involuntary autobiographical memories are highly dependent on abstract cuing. The Proustian view is incorrect. *Applied Cognitive Psychology, 18,* 893-899.

Mace, J.H. (2005). Priming involuntary autobiographical memories. *Memory, 13,* 874-884.

Mace, J.H. (2007) (Ed.). *Involuntary Memory*. Malden: Blackwell.

Maillet, D. & Schacter, D.L. (2016). From mind wandering to involuntary retrieval: Age-related differences in spontaneous cognitive processes. *Neuropsychologia, 80,* 142-156.

McMillan, R., Kaufman, S.B., & Singer, J.L. (2013). Ode to positive constructive daydreaming. *Frontiers in Perception Science, 4,* 626.

Nilsson, L-G. (2003) Memory function in normal aging. *Acta Neurologica Scandinavica, 107* (Suppl. 179): 7–13.

Pillemer, D. B. (2003). Directive functions of autobiographical memory: The guiding power of the specific episode. *Memory, 11,* 193-202

Rasmussen, A. S., & Berntsen, D. (2011). The unpredictable past: Spontaneous autobiographical memories outnumber autobiographical memories retrieved strategically. *Consciousness and Cognition, 20,* 1842-1846.

Rasmussen, A. S., Johannessen, K. B., & Berntsen, D. (2014). Ways of Sampling Voluntary and Involuntary Autobiographical Memories in Daily Life. *Consciousness and Cognition, 30,* 156-168.

Rasmussen, A.S., Ramsgaard, S. B., & Berntsen, D. (2015). The frequency and functions of involuntary and voluntary autobiographical memories across the day. *Psychology of Consciousness: Theory, Research, and Practice, 2,* 185-205.

Rubin, D.C., Dennis, M.F., & Beckham J.C. (2011). Autobiographical memory for stressful events: the role of autobiographical memory in posttraumatic stress disorder. *Consciousness and Cognition, 20,* 840-856.

Rubin, D. C. & Berntsen, D. (2009). The frequency of voluntary and involuntary autobiographical memory across the life span. *Memory and Cognition, 37,* 679-688.

Rubin, D.C., Boals, A., & Berntsen, D. (2008). Memory in Posttraumatic Stress Disorder: Properties of voluntary and involuntary, traumatic and non-traumatic autobiographical memories in people with and without PTSD symptoms. *Journal of Experimental Psychology: General, 137,* 591-614

Salthouse, T.A. (1984). Effects of age and skill in typing. *Journal of Experimental psychology: General, 54,* 345-371.

Salthouse, T.A. (1993). Speed and knowledge as determinants of adult age differences in verbal tasks. *Journal of Gerontology: Psychological Sciences, 48,* 29-36.

Schlagman, S., Kliegel, M., Schulz, J., & Kvavilashvili, L. (2009). Effects of age on involuntary and voluntary autobiographical memory. *Psychology and aging, 24,* 397-411.

Schlagman, S., Kvavilashvili, L., Schulz, J. (2007). Effects of age on involuntary autobiographical memories. In John H. Mace (Ed.): *Involuntary Memory* (pp. 87-112). Malden: Blackwell.

Schlagman, S., & Kvavilashvili, L. (2008). Involuntary autobiographical memories in and outside the laboratory: How different are they from voluntary autobiographical memories? *Memory and Cognition, 36,* 920-932

Sheikh, J.I. & Yesavage, J,A. (1986). Geriatric Depression Scale (GDS): recent evidence and development of a shorter version. *Clinical Gerontology, 5,* 165-173.

Shipley, W. C. (1940). A self-administered scale for measuring intellectual impairment and deterioration. *The Journal of Psychology, 9,* 371-377.

Singer, J.L. (1966). *Daydreaming. An introduction to the experimental study if inner experience.* New York: Random House.

Singer, J.L. (1975). *The inner world of daydreaming.* New York: Harber & Row.

Smallwood, J., Brown, K., Baird, B. & Schooler, J. W. (2012). Cooperation between the default mode network and the frontal-parietal network in the production of an internal train of thought. *Brain Research, 1428,* 60-70

Staugaard, S.R. & Berntsen, D. (2014). Involuntary memories of emotional scenes: the effects of cue discriminability and emotion over time. *Journal of Experimental Psychology: General, 143*, 1939-1957

Talarico, J.M., Berntsen, D., & Rubin, D.C. (2009). Positive emotions enhance recall of peripheral details. *Cognition and Emotion, 23,* 380-398.

Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.

Tulving, E., & Pearlstone, Z. (1966). Availability versus accessibility of information in memory for words. *Journal of Verbal Learning and Verbal Behavior, 5,* 381-391.

Wechsler D. (2008). *Wechsler Adult Intelligence Scale – Fourth Edition*. San Antonio: Pearson.

Weeks, J. C., & Hasher, L. (2014). The disruptive - and beneficial - effects of distraction on older adults' cognitive performance. *Frontiers in Psychology, 5,* 133.

Wheeler, M. A., Stuss, D. T., & Tulving, E. (1997). Toward a theory of episodic memory: The frontal lobes and autonoetic consciousness. *Psychological Bulletin*, 121, 331 354.

Notice: This is the author's version of a work that was accepted for publication in *Psychology and Aging*, Vol 32(2), 192-201 DOI: 10.1037/pag0000157

Author Note

We thank Astrid Nørmark Gregersen, Lea Tangelev Greve, Lotte Kofod and Anna Nørgaard for assistance with data collection, and David C. Rubin for helpful comments. This work was supported by the Danish National Research Foundation (DNRF89) and the MindLab UNIK initiative at Aarhus University, which is funded by the Danish Ministry of Science and Technology and Innovation. Some of theoretical ideas motivating the present work have been presented at conferences and in work previously published by Berntsen and colleagues. The data included here have not been disseminated elsewhere.

Notice: This is the author's version of a work that was accepted for publication in *Psychology and Aging*, Vol 32(2), 192-201 DOI: 10.1037/pag0000157

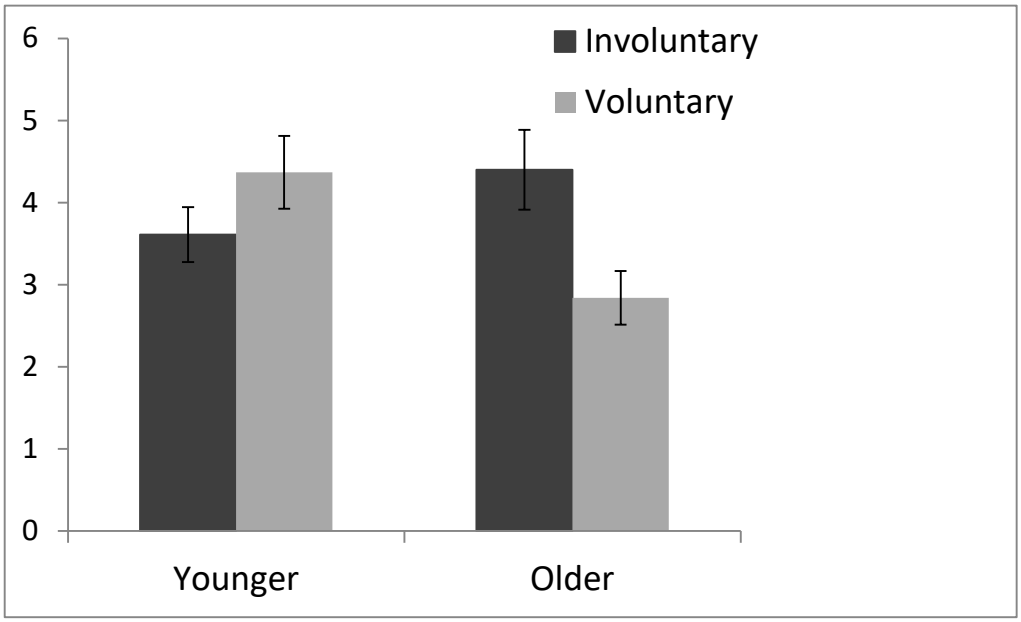

Figure 1

Frequencies of involuntary and voluntary episodic memories (square root transformed) in younger and older adults. Error bars indicate standard error of the means.