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Absence of age effects on spontaneous past and future thinking in daily life

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Abstract

Previous research on voluntary mental time travel (i.e., deliberately thinking about the past or future) has resulted in negative age effects. In contrast, studies on spontaneous past thoughts (i.e., involuntary autobiographical memories) have reported small or no age effects. The aim of the present research was to investigate the effects of age on the nature and frequency of spontaneous future thoughts in everyday life. In two studies, we examined whether older adults reported spontaneous future thoughts as often as younger adults, and whether these thoughts were predominantly goal-oriented and less dependent on incidental cues than thoughts about the past. In Study 1, young and old participants kept a diary of spontaneous thoughts of upcoming prospective memory tasks and involuntary autobiographical memories for two weeks. In Study 2, a 1-day experience sampling method was used to investigate spontaneous and deliberate task-unrelated future and past thoughts, by having young and old participants complete a questionnaire in response to 30 random signals. In both studies, no age effects were found in the frequency of spontaneous future thoughts, which were reported as frequently as thoughts about the past (Study 2) and referred predominantly to upcoming tasks and goals rather than future events or hypothetical events (Study 2). Results concerning the triggers of reported thoughts provide initial support for the idea that representations of future thoughts may be more activated than memories of past events. Taken together, these results have important implications for research on cognitive ageing, mind-wandering, prospective memory and involuntary autobiographical memories.

Key words: Spontaneous future thinking, age effects, mind-wandering, prospective memory, involuntary autobiographical memories

Absence of age effects on spontaneous past and future thinking in daily life

Thinking about future goals, tasks and events is a distinctly human activity (Suddendorf, Addis, & Corballis, 2009). Most research on episodic future thinking has focused on deliberate forms of mental time travel, whereby laboratory participants are asked to construct possible future events or scenarios in response to word cues or other stimuli (Szpunar, 2010; Lehner & D'Argembeau, 2016; but see Jeunehomme & D'Argembeau, 2016). In line with findings on voluntary forms of episodic and autobiographical memories, this research has found negative effects of age: in comparison to young adults, older participants take longer to construct such events, and their future events are less specific (Schacter, Gaesser, & Addis, 2013).

In everyday life, however, future thinking does not always occur while people engage deliberately in planning or thinking about the future. Instead, such thoughts often come to mind spontaneously while performing relatively mundane tasks that allow the mind to wander to matters unrelated to the current activity. For example, while doing the washing up, thoughts about an upcoming job interview or what one needs to buy at the supermarket on Sunday, may come to mind suddenly either in response to incidental cues or no cues (Berntsen & Jacobsen, 2008).

Despite their prevalence in everyday life, very little is known about the effects of age on spontaneous thoughts about the future. Such thoughts have been studied independently in the fields of mind-wandering and prospective memory, before the study of spontaneous episodic future thinking started to emerge as a new area of research with the publication of Berntsen and Jacobsen's (2008) seminal paper. Moreover, somewhat contradictory findings have emerged regarding the effects of ageing, with laboratory studies of mind-wandering showing significant negative effects of age (Maillet & Schacter, 2016a), while prospective memory research has demonstrated a more varied pattern of results (for reviews see Kliegel, Jäger, & Phillips, 2008; Maillet & Schacter, 2016a). For example, negative age effects have been reported in nonfocal prospective memory tasks that require effortful strategic monitoring of target events, but small or no age effects have been found in focal tasks in which the processing of the target event as

part of the ongoing task may spontaneously trigger retrieval of the intended action (Kliegel et al., 2008; Mullet et al., 2013, Experiment 1). Some studies also showed preserved retrieval of intentions to target cues by older adults in laboratory tasks that isolated spontaneous retrieval (Mullet et al., 2013, Experiments 2 and 3; Scullin, Bugg, McDaniel & Einstein 2011). Most importantly, two naturalistic studies which used diary and experience sampling methods respectively, found either no age effects in spontaneous thoughts about an upcoming prospective memory task assigned by the researcher (Kvavilashvili & Fisher, 2007) or positive age effects with older adults reporting more prospective thoughts than young adults (Gardner & Ascoli, 2015).

Consequently, the aim of the present research was to conduct the first systematic investigation of the effects of age on the nature and frequency of spontaneous future thoughts in everyday life. In Study 1, young and old participants kept a diary of their spontaneous thoughts of upcoming future tasks and goals (i.e., prospective memory tasks) as well as spontaneous thoughts about the past (i.e., involuntary autobiographical memories) for a 2-week period (self-caught method). This study examined only a subset of spontaneous future thoughts (i.e., upcoming prospective memory tasks) due to their reported prevalence over other types of future thoughts (e.g., Plimpton, Patel & Kvavilashvili, 2015) and their functional significance regarding the execution of future intentions (Kvavilashvili & Fisher, 2007). In Study 2, a 1-day experience sampling method was used to investigate spontaneous and deliberate task-unrelated future and past thoughts, by having young and older adults complete a questionnaire in response to random signals from a wristwatch 30 times throughout a day (probe-caught method). The two studies addressed the following questions: (a) are there any age effects in spontaneous future thinking in everyday life? (b) are older adults more likely to think about the future than the past as recently reported by Gardner and Ascoli (2015)? (c) are the representations of future thoughts more active than those of past thoughts? and (d) are people more likely to engage in spontaneous compared to deliberate future thinking in everyday life, irrespective of their age (Study 2)?

These are important research questions, because they allow us to test the predictions of current theories of cognitive ageing in relation to the frequency of spontaneous future thinking in

everyday life. According to Craik's (1986; 1994) influential theory, increased age is associated with diminished attentional resources and so large age effects should be obtained in cognitive tasks that lack environmental support (e.g., cues) and rely on attentionally demanding self-initiated strategic processes (e.g., free recall). Conversely, minimal or no age effects should be observed in tasks that rely on less effortful and automatic retrieval processes (e.g., recognition, priming tasks). Based on this theory, the attentional resources of older adults would be much less taxed while performing everyday activities at their own pace, compared to fairly demanding cognitive tasks in the laboratory. Consequently, in contrast to laboratory findings of mind-wandering that are based on attentionally demanding vigilance or Go/No-Go tasks (which show negative age effects), the effects of age on experiencing spontaneous future or past thoughts in everyday life should be absent or less pronounced (*cf.* Berntsen, Rasmussen, Miles, Nielsen, & Ramsgaard, 2017). The inhibitory theory of ageing by Hasher and colleagues (Hasher et al., 1979; Hasher & Zacks, 1988), however, predicts that due to increased distractibility in response to irrelevant stimuli, older adults should experience higher rates of task-unrelated thoughts, which is more in line with Gardner and Ascoli (2015) findings of higher rates of future thoughts in older than younger adults.

If, in line with Craik's (1986) theory, age effects are absent in everyday spontaneous future thinking, this may have significant practical implications for the older adult population. Indeed, preserved spontaneous cognitive processes in everyday life may have functional value in supporting the organisation of daily activities and effective execution of plans, hence contributing to the efficient and successful functioning of older adults at home or in the workplace (*cf.* Berntsen et al., 2017).

Study 1

There is growing evidence to suggest that spontaneous future oriented thoughts predominantly refer to future goals and planned actions. For example, D'Argembeau, Renaud, and Van Der Linden (2011) asked participants to record and indicate the function of any 10 future oriented thoughts (including deliberate thoughts) experienced over a 5-day period, and showed that 70% of these thoughts concerned planning an action or setting a goal. These

findings were replicated and extended in a laboratory study by Plimpton, Patel, and Kvavilashvili, (2015), which specifically focused on future-oriented mind-wandering thoughts that occurred spontaneously, and found that 60% of spontaneous future thoughts reported during an undemanding vigilance task referred to intended actions and plans, such as “*need to start a diet after my revision period*” or “*must buy a new duvet cover set*”. A further 38% of thoughts referred to upcoming planned events in the absence of a specified intention, for example, “*family dinner this weekend*” or “*job interview I have next week*”. Two other laboratory studies demonstrated that the majority of mind-wandering thoughts were future oriented, and comprised of a combination of self-relevant and goal directed content (Baird, Smallwood, & Schooler, 2011), and goal-oriented functions such as planning (35%), decision making (8%), and the appraisal of events (10%) (Stawarczyk, Majerus, Maj, Van der Linden, & D’Argembeau, 2011).

These findings suggest that spontaneous future thoughts may hold important functional value in helping people to carry out their intended tasks at the time and place as originally planned. Indeed, evidence from the memory literature is showing that the act of retrieving information is a powerful facilitator of subsequent successful retrieval of that information (Bjork & Whitten, 1974; Buschke, 1974; Ritchie, Skowronski, Walker, & Wood, 2006; Roediger & Karpicke, 2006; Walker, Skowronski, Gibbons, Vogl, & Ritchie, 2009). In line with these findings, several laboratory studies of prospective memory have demonstrated that thinking about a given prospective memory task during the unrelated ongoing task improves people’s ability to remember to carry out this task in response to particular target event (e.g., Guynn, McDaniel, & Einstein, 1998; Taylor, Marsh, Hicks, & Hancock, 2004).

More compelling evidence for the beneficial effects of spontaneous retrieval of intended prospective memory tasks comes from several naturalistic studies in which participants were asked to carry out a particular prospective memory task in the future and had to record any instances in which they happened to spontaneously think about this upcoming task during the delay interval. For example, in a series of five studies, Mason and Reinholtz (2015) demonstrated that participants with increased future intention related thoughts were more likely

to perform the instructed prospective memory task (e.g., to send a text-message to the researcher at a pre-arranged date and time) (see also Sellen, Louie, Harris, & Wilkins, 1997).

Of particular importance to the present investigation are the findings of Kvavilashvili and Fisher (2007, Study 2), who examined possible age effects in the nature and frequency of future-oriented thoughts about calling a researcher in seven days time. All participants were explicitly asked to refrain from using external reminders, and record in a diary any instances in which they thought about this upcoming prospective memory task. Results showed that there were no age effects in the number of reported spontaneous thoughts about the upcoming prospective memory task, or the likelihood of remembering to call the researcher within 10 minutes of the pre-arranged time.

These findings provide the first empirical evidence in support of the idea that spontaneous retrieval of upcoming prospective memory tasks is preserved in ageing (see also Mullet et al., 2013). Interestingly, a recent experience sampling study of past and future thinking in everyday life found that older participants exhibited an increase in future-oriented thoughts compared to younger participants (Gardner & Ascoli, 2015). Importantly, Gardner and Ascoli (2015) did not ask participants to indicate whether their thoughts were spontaneous or deliberate.

The aim of Study 1, therefore, was to replicate and extend the initial findings of Kvavilashvili and Fisher (2007) by examining possible age effects in participants' future oriented spontaneous thoughts of their own real-life prospective memory tasks in general, rather than one particular task assigned by the researcher. The second important goal of Study 1 was to compare the nature and frequency of such spontaneous future thoughts with involuntary autobiographical memories, to examine whether older participants would record more future than past oriented thoughts as reported by Gardner and Ascoli (2015). The third aim was to examine the activation levels of past and future oriented thoughts by comparing the frequency of thoughts occurring without any triggers to those reported in response to incidental external or internal triggers. For example, Kvavilashvili and Fisher (2007, Studies 2 and 3) found that participants reported thoughts about future prospective memory task without any apparent triggers more often than thoughts triggered by incidental external and internal cues. In addition,

such non-cued thoughts were positively related to remembering to carry out the task. These results contrast sharply the findings on involuntary autobiographical memories, which have been shown to be less goal-oriented (Cole & Berntsen, 2016) and predominantly triggered by easily identifiable external and internal cues (Berntsen, 1998; Kvavilashvili & Schlagman, 2008; Mace, 2004). However, no previous study has directly compared the nature of triggers in spontaneous past and future thoughts. If due to their functional importance, representations of future prospective memory tasks are highly activated and thus periodically reach the level of conscious thought without any apparent trigger (Kvavilashvili & Fisher, 2007), then future thoughts would be more likely to occur without any internal or external triggers compared to thoughts about the past. To address these three aims, young and older participants kept a diary of their spontaneous thoughts of future prospective memory tasks and involuntary autobiographical memories for a 2-week period. Their task was to carry the diary with them and complete a questionnaire on a diary page every time they experienced an involuntary past or future thought.

Method

Participants

Twenty-one young adults (14 female, 7 male) with a mean age of 21.71 years ($SD = 3.61$, range = 18-33) and 19 older adults (12 female, 7 male) with a mean age of 72.32 years ($SD = 6.59$, range = 65-86) took part in the study. Participants were recruited through personal contacts, word of mouth, and an advert on the university intranet. The young sample was comprised of 16 students and 5 individuals in full time employment, and the older sample consisted of 14 retired individuals and 5 in employment (3 full time, 2 part time).

All participants reported English as their first language, and exclusion criteria included serious head injury, stroke and memory problems diagnosed by a clinician. Table 1 presents the means of background variables as a function of age, and the results of one-way ANOVAs between these means. There were no age effects regarding self-reported health, but younger adults reported significantly more years in formal education than older adults.

Materials and Procedure

Participants were briefed individually the day before starting the task. Following an introduction to the general aims of the study (i.e., investigating spontaneous memories that may be experienced in everyday life), participants were informed that their task was to keep a paper diary for a period of 2 weeks, recording all experiences of spontaneous thoughts of upcoming prospective memory tasks and involuntary autobiographical memories. These thoughts were described to participants as two broad classes of spontaneous memories, which are experienced without any deliberate attempt to retrieve them: *“Spontaneous autobiographical memories are memories of an event, situation or experience from your past. An example of a spontaneous past memory would be a summer holiday to the seaside during your childhood, or the birth of a family member. In contrast, a spontaneous memory of a future intention is when you suddenly remember something you have to do in the future, such as making a phone call later on that day. Sometimes, when you are performing a completely unrelated activity, the intention of what you have decided to do pops up randomly in your mind and this is what I would like you to record. So if you deliberately think about your upcoming plans (e.g., check your diary or calendar), that would not qualify as a spontaneous memory of a future intention”*.

Participants were given detailed instructions on how to keep the diary (a summary of these instructions was included in the diary), which was to be kept from the moment they woke up the following morning until the moment they went to bed on the final day of the 2-week period. It was made explicit that there were no expectations as to how many thoughts would be recorded during this time. They were asked to carry the diary with them at all times and record instances of spontaneous thoughts as quickly as possible. Upon each entry in the diary, participants were required to answer a questionnaire on one page, first indicating whether the thought experienced was an involuntary autobiographical memory or a spontaneous thought of an upcoming prospective memory task, and the time and date of the experience. Participants then had to provide a description of their thought, and a description of what they were doing when the thought occurred, along with a rating of how much they were concentrating on this activity on a 5-point scale (1 = *minimum concentration*, 5 = *maximum concentration*). They had to indicate whether there was a trigger (environment, thoughts, no trigger) and provide a

description, as well as providing an estimate of when the future intention was initially formed or when the past event originally took place. If it was not possible for the participant to record their spontaneous thought immediately, they were asked to make a mental note of the experience and complete a questionnaire as soon as possible. If by the time they were able to record the thought, they had forgotten aspects of their experience, they were asked instead to acknowledge the thought by ticking the appropriate box referring to the type of thought (past or future) in a grid provided in the inner side of the diary cover page (*cf.* Schlagman & Kvavilashvili, 2008).

After the 2-week diary period, participants returned their diaries and had to indicate, on a 7-point scale, how easy or difficult they found keeping the diary (1 = *very easy*, 7 = *very difficult*), how much keeping the diary disrupted their everyday activities (1 = *not disruptive*, 7 = *very disruptive*), the level of confidence that they recorded or ticked the majority of spontaneous thoughts experienced (1 = *not confident*, 7 = *very confident*), and estimate on how many occasions they failed to record or acknowledge their spontaneous thought.

Results and discussion

The rejection level for all analyses reported in this and the subsequent study was set at 0.05, and the effect size was measured using partial eta squared (η_p^2). All 40 participants kept the diary for the 2-week period, however, the data of one older female participant was excluded due to consistent errors in the recording of spontaneous thoughts of upcoming prospective memory tasks. There were no reliable age effects in participants' ratings of disruption to everyday activities caused by keeping the diary, confidence that most spontaneous thoughts were either recorded or acknowledged, and the number of occasions on which their spontaneous thoughts were not recorded or acknowledged (see Table 2). Although younger adults' ratings of difficulty of keeping the diary were nominally higher than in older adults, the difference between the means was not statistically significant, $F(1, 37) = 3.58, p = .066, \eta_p^2 = .09$.

Frequency of recorded and acknowledged thoughts

Participants produced a total of 715 valid fully recorded entries: 406 involuntary autobiographical memories (e.g., *seeing a band in concert; my first driving test*), and 309 spontaneous thoughts of upcoming prospective memory tasks (e.g., *I need to pack for holiday*

and buy sun lotion; must make telephone call to friend) (see Table 3). Young and old participants recorded at least three and seven entries respectively, and all participants recorded both involuntary autobiographical memories and spontaneous thoughts of upcoming prospective memory tasks, with the exception of one older participant who reported no past thoughts, and one younger participant who reported no future thoughts.

The numbers of fully recorded spontaneous thoughts were entered into a 2 (Age: young, old) x 2 (Thought Type: autobiographical memories, prospective memories) mixed ANOVA with repeated measures on the last factor (see Table 3 for means). There was a significant main effect of thought type, with the number of involuntary autobiographical memories being significantly higher ($M = 9.86$, $SD = 5.89$) than spontaneous thoughts of prospective memory tasks ($M = 7.50$, $SD = 6.40$), $F(1,37) = 7.91$, $p = .008$, $\eta_p^2 = .18$. Neither the main effect of age, nor the age by thought type interaction were significant, $F(1,37) = .14$, $p = .71$, $\eta_p^2 = .004$ and $F(1,37) = .49$, $p = .49$, $\eta_p^2 = .01$, respectively. Regarding the number of recorded ticks, there were no significant effects of age, temporal focus, or age by temporal focus interaction (all $F_s < 1$) (see Table 3).

Taken together, these findings replicate and significantly extend the initial findings of Kvavilashvili and Fisher (2007), who did not give their participants an option to acknowledge their unrecorded thoughts via ticks. Hence, if younger adults in Kvavilashvili and Fisher's (2007) study omitted more thoughts from the diaries due to their busy schedule and could not acknowledge such thoughts later on, this could have resulted in no age effects in their study. However, the results of the present study do not support this conjecture, as there were no age effects even when the option of acknowledging thoughts via ticks was provided.

In line with our laboratory findings on spontaneous past and future thinking (Plimpton et al., 2015), both young and older adults recorded significantly more involuntary thoughts about the past than the future. However, this effect could be mainly due to participants being asked to record only a sub sample of spontaneous future thoughts (i.e., thoughts about upcoming prospective memory tasks, thus excluding thoughts about upcoming events or hypothetical events/scenarios).

Types of reported triggers

Table 4 shows the mean number of involuntary autobiographical memories and prospective memories, which were reported by young and old participants as being triggered by external cues (environmental), internal cues (in one's own thoughts) or no obvious cues. The data were entered into a 2 (Age: young, old) by 2 (Thought Type: autobiographical memories, prospective memories) by 3 (Trigger Type: external, internal, no trigger) mixed ANOVA with repeated measures on the last two factors. As in the previous analysis, there was a significant main effect of thought type with more autobiographical memories than prospective memories recorded ($F(1,35) = 9.59, p = .004, \eta_p^2 = .22$), but no significant effect of age ($F < 1$) or the age by thought type interaction ($F = 1.20$). Importantly, there was a significant main effect of type of trigger ($F(2,70) = 7.82, p = .001, \eta_p^2 = .18$), which was qualified by a significant interaction with the type of thought ($F(2,70) = 5.83, p = .005, \eta_p^2 = .14$), but not with age ($F = 1.07$). Tests of simple main effects showed that the main effect of type of trigger was significant for involuntary autobiographical memories ($F(2,70) = 11.84, p < .001, \eta_p^2 = .41$), with post hoc tests indicating that significantly more external ($M = 5.11, SD = 3.86$) and internal triggers ($M = 3.92, SD = 3.10$) were reported in comparison to no triggers ($M = 1.81, SD = 2.41$) ($p < .001$ and $p = .001$, respectively), while the difference between external and internal triggers was not significant ($p = .19$). In contrast, the main effect of trigger type was not significant for prospective memories ($F = 1.31$), indicating that participants reported thoughts with no triggers ($M = 2.24, SD = 2.99$) as often as thoughts with external ($M = 2.78, SD = 2.74$) and internal triggers ($M = 3.11, SD = 2.89$). A three-way interaction between the independent variables was not significant ($F = 1.00$).

These results replicate the findings reported separately in the literature on involuntary autobiographical memories (e.g., Mace, 2004) and on thoughts about a pending prospective memory task (Kvavilashvili & Fisher, 2007) by showing a contrasting pattern across past and future thoughts within the same sample of young and old participants. Together, they provide initial support for the hypothesis that representations of prospective memory tasks may be more highly activated than those about the past, and are thus just as likely to manifest as conscious thoughts in the absence of triggers as in response to obvious triggers (compared to past thoughts

which are significantly more likely to be in response to external and internal rather than no trigger).

Attentional demands of ongoing tasks (ratings of concentration)

To examine age effects on levels of attentional resources required by ongoing activities at the time of experiencing past and future thoughts, for each participant, we calculated mean ratings of concentration on a 5-point scale (1 = minimum concentration, 5 = maximum concentration) for past and future thoughts (see Table 5 for mean concentration ratings averaged across participants as a function of thought type and age group). In line with previous research, the means in both young and old participants show fairly low levels of concentration (below the mid point on the scale). However, a 2 (Age: young, old) x 2 (Thought type: autobiographical memories, prospective memories) mixed ANOVA with repeated measures on the last factor, resulted in a significant main effect of age ($F(1,35) = 4.49, p = .04, \eta_p^2 = .11$), with older participants reporting higher ratings of concentration ($M = 2.94, SD = .81$) than young adults ($M = 2.49, SD = .72$). This finding replicates results of Kvavilashvili and Fisher (2007, Study 2), who showed that although older adults were more often engaged in undemanding habitual tasks (e.g., brushing teeth, having a cup of tea), their mean ratings of concentration were higher than in younger adults. The main effect of thought type and the age by thought type interaction were not significant ($F_s < 1$).

Study 2

The most important finding of Study 1 was the absence of any age effects in the number of recorded thoughts about participants' own upcoming prospective memory tasks in everyday life. Despite replicating and extending Kvavilashvili and Fisher's (2007) findings of no age effects in the reported frequency of thoughts about a single prospective memory task prescribed by the researcher, there are a couple of limitations to consider. First, given that younger participants were either students (76%) or in full time employment (24%) and most of the older participants were retired (74%), it is possible that younger participants were busier and more frequently engaged in cognitively demanding work-related activities than older participants, thus

resulting in reduced spontaneous thoughts which would eliminate existing age effects.¹ Second, and more importantly, the self-caught nature of the task required participants to monitor their stream of thoughts over the 2-week period and make decisions regarding what to record or not record, which could have resulted in erroneous omissions of some thoughts and/or biases in recording certain types of thoughts (e.g., some participants could be more prone to noticing one type of thought over another).

To address these issues, we conducted an experience sampling study over the period of a single non-working day (10 hours), in which participants were prompted 30 times at random to record the nature, content, and context of their current thought in a diary. Unlike Study 1, participants did not know that we were specifically interested in future and past task-unrelated thoughts, they were simply asked to answer a questionnaire in a page of a diary about their current thought every time they felt the vibration of a specially designed wristwatch. We chose a non-working day to reduce the possibility that younger adults would engage in work and study-related activities, hence minimising the chance of not obtaining age effects due to younger adults being busier than older adults.

The probe caught method has often been used to study age effects on mind-wandering in the laboratory. It is not clear, however, whether the age-related decline in task-unrelated thoughts observed in the laboratory (for review, see Maillet & Schacter, 2016a) would generalise to naturalistic settings. Gardner and Ascoli (2015) conducted the only exploration of age effects on past and future thoughts in naturalistic settings, in which they found an age-related increase in future oriented thoughts. Importantly, they did not distinguish thoughts that occurred spontaneously and deliberately, and so their finding could be attributed to older adults engaging in more deliberate future thoughts than younger adults (for studies emphasising the importance

¹ However, young and old groups did not differ in the percentage of participants who were employed (24% and 26%, respectively), and given that students often have a lot of self-managed time outside of university work, it could be argued that the groups were comparable and similar to the samples used in previous naturalistic and experience sampling studies of spontaneous past and future thoughts (e.g., Berntsen & Jacobsen, 2008; Gardner & Ascoli, 2015; Kvavilashvili & Fisher, 2007).

of distinguishing intentional and unintentional or spontaneous forms of mind-wandering see Seli, Cheyne, Xu, Purdon, & Smilek, 2015; Seli, Wammes, Risko, & Smilek, 2016).

Consequently, the aim of Study 2 was to replicate and extend the findings of Study 1 by using the probe caught method to capture a one-day snapshot of the full range of spontaneous future thoughts that occur when attention is decoupled from the current environment and/or task at hand in everyday life. We wanted to extend Gardner and Ascoli's (2015) findings by determining the extent to which younger and older people engage in spontaneous compared to deliberate future task-unrelated thought, and compare this to the occurrence of past task-unrelated thought. In addition, we wanted to examine the triggers of future and past task-unrelated thought to further explore the idea that future thoughts are more highly activated than past thoughts due to their functional importance.

Based on the findings in Study 1, it was predicted that young and older participants would report equal numbers of future task-unrelated thoughts, the majority of which would refer to future plans (*cf.* Plimpton et al., 2015). In addition, we expected the majority of future task-unrelated thoughts to occur spontaneously, in line with previous laboratory research (Forster & Lavie, 2009; Seli et al., 2015; Seli, Wammes, et al., 2016; Stawarczyk, Cassol, & D'Argembeau, 2013; Stawarczyk et al., 2011). Given that we were sampling all types of future thoughts rather than a subset as in Study 1, we expected to observe equal numbers of spontaneous future and past task-unrelated thought (Berntsen & Jacobsen, 2008; Finnbogadóttir & Berntsen, 2013). Finally, in line with the findings in Study 1, we expected participants to report spontaneous past thoughts to be triggered by external or internal cues more often than by no cues at all, while thoughts about the future would be reported without triggers as often as external or internal triggers.

Method

Participants

Twenty-four young adults (16 female, 8 male) with a mean age of 25.00 years ($SD = 2.28$, range = 18-28) and 23 older adults (11 female, 12 male) with a mean age of 74.35 years ($SD = 6.97$, range = 67-90) took part in this study. All older participants and 17 young

participants were recruited from the general population, through personal contacts, social media and the local community. The remaining 5 young participants were recruited through adverts on the university intranet. Seventeen younger participants were in full time employment and 7 were students (3 undergraduates, 4 postgraduate). All older participants were retired, with the exception of one participant who was in part time employment. All participants reported English as their first language.

All participants were healthy, and exclusion criteria included past experiences of a serious head injury, stroke, serious mental health problems or memory problems diagnosed by a clinician, and sight problems that would interfere with keeping a diary. Table 1 presents the means of background variables as a function of age, and the results of one-way ANOVAs. There were no age effects regarding years in education, self-reported health ratings, or scores on the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983; scores on both scales vary from 0 to 21 with higher scores indicating higher levels of anxiety and depression). According to scores on the Martin and Park Environmental Demands Questionnaire, young participants reported significantly higher levels of busyness, but not routine compared to older adults (Martin & Park, 2003; on the Busyness and Routine scales, scores vary from 0-35 and 0-20 respectively with higher scores indicating higher levels Busyness and Routine).

All participants were cognitively healthy as measured by the Modified Telephone Interview for Cognitive Status (Brandt et al., 1993; Prince et al., 1999; a 13 item test of cognitive functioning with scores varying from 0 to 39, with a clinical cut-off of 21), the Isaacs Set Test (Isaacs & Kennie, 1973; a one minute verbal category fluency task with scores varying from 0 to 40, with the lowest quartile < 25) and the Wechsler's Similarities Test (Wechsler, 1981; evaluates abstract thinking with scores ranging from 0 to 8, with the lowest quartile < 4.8) administered over the phone during the initial screening. Young participants performed significantly better than older participants on the Telephone Interview for Cognitive Status and the 10-item immediate and delayed free recall subset, but equally well on the Isaacs Set Test and Wechsler's Similarities Test. Four older participants (1 female, 3 male) had borderline scores according to the clinical cut-off on the Modified Telephone Interview for Cognitive Status, but

were included in the dataset due to scoring well on the other two cognitive tests. One older male participant scored below the lowest quartile in the Wechsler's Similarities Test, but scored sufficiently well on the other two cognitive tests and so the data was maintained.

Materials and Procedure

Following the initial telephone screening and satisfaction of the exclusion criteria, participants were asked to familiarise themselves with the participant information sheet (sent by email or post), which detailed what the study would involve. The first author then met with participants individually or in small groups of 2-4 at 9.00 am or 10.00 am on the day of the task, which was a non-working day to make the days more comparable across age groups.

Participants were first reminded of the general aim of the study (i.e., exploring how the mind wanders in everyday life), but were not informed of our more specific interest in spontaneous past and future thoughts. Written consent was obtained, and participants completed the Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983) and the Martin and Park Environmental Demands Questionnaire (Martin & Park, 2003).

Participants were asked to wear a specially designed 'WatchMinder3' wristwatch (<https://www.watchminder.com/>) for a period of 10 hours and were told that it would vibrate randomly between 20-35 times, to prompt them to record their thoughts at that exact moment in a page of a pocket-sized diary. The exact number of prompts ($n = 30$) was concealed from participants to maintain uncertainty, thus limiting the monitoring of prompts. Participants could choose to wear the watch and keep the diary between 11.00 - 21.00 or 12.00 - 22.00. For each time slot, a set of random times was generated in Excel with minimum and maximum intervals of 15 and 25 minutes respectively, and the watch was programmed to vibrate at these times.

Participants were then given detailed verbal instructions on how to operate the watch and keep the diary (a summary of these instructions was included in the diary). They learned that the watch was waterproof and that it was necessary to wear the watch and keep the diary with them at all times throughout the 10-hour period. Participants were informed that the watch would vibrate for 10 seconds, with the word "THOUGHTS" appearing on the screen. They were instructed on how to deactivate the vibrations. Whenever the watch vibrated, participants were

asked to immediately stop or freeze for a moment to identify what was going through their mind at that exact moment, and then answer 8 questions on one page of the diary (see Kane et al., 2007 and McVay et al., 2009 for similar instructions). The transient nature of thoughts and the importance of recording the thought immediately, were emphasised to increase the chances that participants would accurately capture each thought. When participants could not complete the diary immediately, they were asked to memorise the experience and fill in a questionnaire as soon as possible. If they then forgot aspects of the experience, they were told to leave the page blank, instead recording a short explanation of why they were unable to complete the diary page.

In the diary, participants were asked to record a description of the thought, indicating whether it occurred spontaneously (i.e., simply popped into their mind) or they deliberately chose to think about it. If they were engrossed in an activity and had no additional thoughts, they were instructed to state this and provide a brief description of the activity they were focussed on. Participants had to indicate with a brief description the presence of any trigger (environment, preceding thoughts, no trigger) and the temporal focus of the thought (past, present, future or no particular time). Thoughts focussed on the present were outlined as either what the participant was currently doing (e.g., engrossed in current task, or an evaluative thought about current activity) or a general thought about an on-going situation or present circumstance in the participant's life (e.g., current financial status). Future oriented thoughts were specified as those relating to future plans, upcoming events or hypothetical future events. Thoughts referring to no particular time were described as thoughts that do not relate to the past, present or future (e.g., *wondering why the grass is green*). If the thought related to the past or future, participants had to indicate when the original event took place, or how far into the future they were projecting. Participants had to record what they were doing when the watch vibrated, and in the event that they were having a conversation, they were asked to provide a description of the conversation context, as well as indicate in the thought description the specific content of their thought. They had to rate how much they were concentrating on their current activity on a 5-point scale (1 = *not concentrating at all*, 5 = *fully concentrating*), and indicate the time.

Following this detailed briefing, participants were given a practice trial consisting of 3 prompts over a period of 10 minutes. Participants were told they could do what they wanted during this time, and they recorded their responses in a practice booklet. After the trial, the researcher read the entries giving feedback where necessary, and answering any further questions. The researcher left at least 30 minutes before the start of the task.

After the task was completed, participants returned the watch and diary and completed a post-experimental questionnaire. Participants recorded whether they wore the watch for the entire day, and recorded on a 7-point scale, levels of confidence in the accuracy of their entries (1 = *not confident*, 7 = *very confident*), how difficult (1 = *very easy*, 7 = *very difficult*) and disruptive the task was (1 = *not disruptive*, 7 = *very disruptive*), how busy (1 = *not busy*, 7 = *very busy*) and stressed (1 = *not stressed*, 7 = *very stressed*) they were on the day of the task, and their main activities on the day of the task.

Results and discussion

All participants kept the diary and wore the watch for the full 10 hours, with the exception of one older male participant who removed the watch for 2.5 hours at the end of the task, due to having guests. His data was included because he provided a substantial number of valid probes ($n = 22$). The data of one older male participant was excluded due to consistent errors in recording thoughts. In total, 1272 valid probes were recorded by 24 young and 22 older participants. The mean number of valid probes did not differ between the groups ($F < 1$), with both young and old recording a high proportion of the possible 30 probes (see Table 2).

Compliance was excellent, with 82% and 95% of entries recorded within 3 and 10 minutes of the probe, respectively.² There were no reliable age effects regarding ratings of confidence that thoughts were captured accurately, difficulty in capturing thoughts, disruption caused by the task, and stress experienced on the day of the task. However, ratings of busyness on the day of the task (1 = *not busy*, 7 = *very busy*) were reliably higher in older ($M = 5.00$, SD

² A small percentage of entries were reported at times that occurred before the prompt time, and may have been due to simple perceptual errors or time differences in participants' own clocks. These cases were excluded from the percentage of compliance times recorded above.

= 1.38) than young participants ($M = 3.79$, $SD = 1.74$) (see Table 2 for means and the results of one-way ANOVAs).

Frequency and types of recorded thoughts

Before coding the data, the first author (EAW) developed a detailed coding scheme derived from the mind-wandering literature, distinguishing task-related thought, task-related interference, task-unrelated thought, external distraction, and no thoughts (Forster & Lavie, 2008a, 2008b; Jackson, Weinstein, & Balota, 2013; Lustig, Hasher, & Tonev, 2001; Maillet & Schacter, 2016b; Maillet, Seli, & Schacter, 2017; McVay, Meier, Touron, & Kane, 2013; O’Callaghan, Shine, Lewis, Andrews-Hanna, & Irish, 2015; Smallwood, 2003; Smallwood, O’Connor, Sudbery, & Obonsawin, 2007; Smallwood & Schooler, 2015; Stawarczyk et al., 2013; Stawarczyk et al., 2011; Unsworth, Redick, Lakey, & Young, 2010; Vannucci, Pelagatti, & Marchetti, 2017). Following this, the third author (LK) used participants’ thought descriptions to code into these 5 categories, blind to participant group. In addition to thought descriptions, other data provided by participants was used to inform the coding process (e.g., what they were doing at the moment of the prompt). The second author (BP) coded 523 entries (41%), and agreement between coders was good ($Kappa = .75$). Disagreements were resolved by discussion.

The majority of thoughts recorded were task-related in both young (42%) and older (48%) participants, which referred to instances in which attention and thoughts were fully focussed on what the participant was doing, including thoughts to guide action (e.g., “*what library book to choose*” while they were “*choosing library book*”). Task-related interference constituted 24% and 19% of young and old participants’ thoughts respectively, which represents a response that was highly dependent on stimulus attributes or demands, but was not directly involved with successful task execution. These were thoughts focussed on the nature of the task in an attempt to understand or appraise the task (e.g., “*Thinking whether other people put salt in salad dressing*” while “*making salad dressing*”) or a thought that was simultaneously directed towards an aspect of the task and one’s self (e.g., “*Thinking how relaxed I am while painting*” while they were “*painting a mug*”) (Smallwood, 2003).

In both young and older adults, 23% of thoughts were task-unrelated,³ which refer to instances in which attention was decoupled from the current task and/or external environment, representing an inward shift towards one's own private thoughts and feelings (e.g., “*I need a shower, before I go out to dinner tonight*” while “*reading a journal*”). Due to recent research indicating that environmental stimuli regularly trigger task-unrelated thought, both stimulus independent and stimulus dependant task-unrelated thought were included in this category (Maillet et al., 2017). In both young and older participants, external distraction and no thoughts constituted 9% and 1%, respectively. External distraction was defined as exteroceptive and interoceptive perceptions caused by stimuli irrelevant to the task (e.g., “*I was thinking about how cold I was*” while “*my sister and A were chatting about something*”). The category of no thoughts referred to when the participant explicitly stated that they were not thinking about anything or they were engrossed in the task.

A 2 (Age: young, old) x 5 (Thought type: task-related, task-related interference, task-unrelated, external distraction, no thought) mixed ANOVA with repeated measures on the last factor revealed a main effect of thought type, $F(4, 176) = 84.68, p < .0001, \eta_p^2 = 0.66$. Pairwise comparisons, with the Bonferroni correction, showed that the mean number of task-related thoughts ($M = 12.48, SD = 4.40$) was significantly higher than the mean number of task-related interference ($M = 5.98, SD = 3.25$), task-unrelated thoughts ($M = 6.41, SD = 3.66$), external distractions ($M = 2.54, SD = 2.27$) and no thoughts ($M = .24, SD = .71$) (all $p_s < .0001$). Statistically equivalent frequencies of task-related interference and task-unrelated thoughts were recorded ($p = 1.00$), which were both significantly more frequent than external distraction and no thoughts ($p_s < .0001$). Finally, participants recorded external distractions more often than no thoughts ($p < .0001$) (See Figure 1). No main effect of age or age by thought type interaction was found ($F_s < 1$).

³ The finding that 23% of the thoughts sampled were task-unrelated is modest compared to other experience sampling studies that indicated that people spent between 25% and 50% of their day engaged in task-unrelated thought (Kane et al., 2007; Killingsworth & Gilbert, 2010). Previous studies, however, relied on participants' own categorization of their thoughts, which could have resulted in biases (e.g., incorrectly interpreting task-related interference as mind-wandering). Additionally, the current study adopted very stringent criteria, and borderline cases were coded as task-related rather than task-unrelated.

Frequency, types and content of task-unrelated thoughts

As task-unrelated thoughts were the primary focus of the present study, subsequent analyses were based on task-unrelated thoughts only. Out of 295 task-unrelated thoughts recorded, 199 were classed by participants as spontaneous and 96 as deliberate. The mean number of these thoughts are presented in the bottom row of Table 6. In line with our predictions, a 2 (Age: young, old) x (Thought type: spontaneous, deliberate) mixed ANOVA resulted in a significant main effect of thought type, $F(1,44) = 22.85, p < .0001, \eta_p^2 = .34$, with participants reporting more spontaneous ($M = 4.33, SD = 2.67$) than deliberate task-unrelated thoughts ($M = 2.09, SD = 2.14$). Importantly, neither the main effect of age ($F < 1$) or the age by thought type interaction were significant ($F = 1.80$)

Temporal focus of spontaneous and deliberate thoughts. The mean numbers of spontaneous and deliberate thoughts in each of the temporal categories as a function of age are presented in Table 6. The following analyses are based on thoughts about the past and future, as these categories were the main focus of the study. To compare the frequencies of past and future thoughts, two separate 2 (Age: young, old) x 2 (Temporal focus: past, future) mixed ANOVAs were conducted for spontaneous and deliberate thoughts. Given that the data were not normally distributed, square root transformed data were used (*cf.* Berntsen et al., 2017). The analysis on spontaneous thoughts did not result in any significant main or interaction effects (all $F_s < 1.21$), indicating that both young and old participants reported equal numbers of spontaneous past and future thoughts. In contrast, the analysis on deliberate thoughts resulted in the main effect of thought type ($F(1, 44) = 27.61, p < .0001, \eta_p^2 = .39$) with significantly more future ($M = .69, SD = .70$) than past thoughts ($M = .17, SD = .41$) being reported. Main effects of age and age by thought interaction were not significant ($F_s < 1$). These findings suggest that when people engage in deliberate task-unrelated thought, they tend to think about the future more often than past, whereas when they experience task-unrelated thoughts spontaneously, they are equally likely to think about the past and the future (*cf.* Seli, Ralph, Konishi, Smilek, & Schacter, 2017). These findings contrast the age-related increase of future thoughts reported by Gardner and Ascoli (2015), but replicate the results of two naturalistic diary studies by Berntsen and Jacobsen (2008)

and Finnbogadóttir and Berntsen (2013) in which equal numbers of spontaneous past and future task-unrelated thought were observed.

Content of future thoughts. Next, we wanted to examine the idea that in everyday life, most task-unrelated thoughts about the future refer to intended actions and plans rather than upcoming events or hypothetical events/scenarios (Plimpton et al., 2015). All 113 future thoughts (69 spontaneous and 44 deliberate) were independently coded by the first (EAW) and the third author (LK) as thoughts about future tasks/plans, upcoming events or hypothetical events using a previously used coding scheme (Plimpton et al., 2015). The coders were blind to participant group, and the process involved considering information from participants' thought description, the trigger description, and the indication of when the future event was supposed to occur. Inter-rater reliability was excellent ($Kappa = .89$) and disagreements were resolved by discussion. 'Future planning' referred to goal-oriented thoughts that reflected an intention to complete a particular activity (e.g., *Need to give my mum a call*) or to inform which course of action to take (*What DVD shall I watch tonight?; What am I going to cook for dinner?*). 'Upcoming events' consisted of thoughts about scheduled future events, but with no particular intention expressed (e.g., *I wonder what games they'll have at the party tonight; Was thinking how long until dinner will be ready*). Thoughts categorised as 'hypothetical events' included those that were speculative in nature (e.g., *What characteristics me and my partner would choose in a child if given the choice; How it would be fun to go to the comedy club one night*).

Given that we had relatively small numbers of cases across three types of future thoughts, the analysis was carried out on data pooled across spontaneous and deliberate thoughts. To normalise the data, it was square root transformed before conducting a 2 (Age) x 3 (Future thought type: planning, upcoming, hypothetical) mixed ANOVA with repeated measures on the last factor (see Figure 2). This analysis resulted in the main effect of type of future thought, $F(2,88) = 12.71, p < .0001, \eta_p^2 = .22$. Planned comparisons indicated that significantly more planning thoughts were recorded than upcoming ($p = .01$) and hypothetical events ($p < .0001$), and thoughts regarding upcoming events outnumbered those concerning hypothetical events ($p = .01$). The main effect of age and the interaction were not significant ($F_s < 1.16$).

Types of reported triggers

The types of triggers (external, internal, no trigger) could be examined only for those participants who reported at least one spontaneous task-unrelated past or one spontaneous task-unrelated future thought. Mean numbers of past thoughts as a function of trigger type are based on the data of 16 young and 14 old participants, and the means for future thoughts are based on the data of 16 young and 15 old participants (see lower panel of Table 4). To normalise the data, it was square root transformed before entering it into two 2 (Age: young, old) x 3 (Trigger Type: external, internal, no trigger) mixed ANOVAs with repeated measures on the last factor separately for past and future thoughts. The analysis for past thoughts resulted in a significant main effect of trigger type ($F(2,56) = 4.67, p = .01, \eta_p^2 = .14$) with the mean number of reported thoughts with external triggers ($M = .93, SD = 1.05$) being significantly higher than internal triggers ($M = .30, SD = .47$) ($p = .028$) and no triggers ($M = .27, SD = .45$) ($p = .017$), while the difference between the internal and no trigger categories was not significant ($p = .89$). The main effect of age and the age by trigger type interaction was not significant ($F_s < 1.34$). In contrast, the analysis on future thoughts did not result in any significant effects (all $F_s < 1$). In other words, in line with the results of Study 1, future thoughts were reported as occurring without any apparent trigger ($M = .90, SD = 1.01$) as often as external ($M = .74, SD = .97$) or internal ($M = .58, SD = .72$) triggers, which provides further support to the idea that spontaneous future thoughts may be less dependent on external and internal triggers than thoughts about the past.

Attentional demands of ongoing tasks (ratings of concentration)

As in Study 1, we calculated mean concentration ratings for participants who reported at least one past or one future task-unrelated thought. Means presented in Table 5 are based on 16 young and 13 old participants for past thoughts, and on 16 young and 15 old participants for future thoughts. Two separate one-way ANOVAs on ratings of concentration with age as an independent variable resulted in significant main effects of age for both past thoughts ($F(1,27) = 9.00, p = .006, \eta_p^2 = .25$) and future thoughts ($F(1,29) = 10.82, p = .003, \eta_p^2 = .27$) with older adults reporting higher levels of concentration than younger adults. Given that all participants took part on a non-working day, these results are consistent with the idea that greater attentional

resources are needed with increasing age, reflected in higher levels of concentration for everyday habitual activities (Kvavilashvili & Fisher, 2007; Schlagman et al., 2009).

General Discussion

The broad aim of the present investigation was to conduct the first systematic investigation of spontaneous future thoughts as a function of age in everyday life, and to assess the theoretical prediction that age effects would be absent or less pronounced for spontaneous cognitions. In two studies, using diary and experience sampling methods, we indeed found no age effects in terms of the number of spontaneous future or past thoughts recorded. Moreover, in Study 2, in which all future thoughts were examined rather than only spontaneous thoughts of one's upcoming prospective memory tasks (as in Study 1), young and older adults recorded equal numbers of spontaneous future and past task-unrelated thoughts. In contrast, deliberate task-unrelated thoughts (which were reported much less frequently than spontaneous future thoughts) were more future- than past-oriented. Furthermore, results also showed that both spontaneous and deliberate future thoughts were more often about intended actions and goals (i.e., upcoming prospective memory tasks), than upcoming events (without a specified intention) or hypothetical events. Finally, while spontaneous past thoughts were predominantly triggered by external and internal triggers rather than no trigger, spontaneous future thoughts were triggered equally often by external, internal and no triggers. These findings suggest that future thoughts could have been more highly activated than past memories as they were likely to spring to mind even without easily identifiable triggers on one third of the probes classed as task-unrelated future thoughts. Taken together, these findings have important implications not only for research on spontaneous future thinking and cognitive ageing, but also for related areas of research on mind-wandering, prospective memory and involuntary autobiographical memory.

Absence of age effects on spontaneous thoughts in everyday life

No significant effects of age were found in the frequency of everyday spontaneous thoughts about the future and the past (Study 1 and 2). Findings about past thoughts replicate recent results by Berntsen et al. (2017) on involuntary memories, while findings about future thoughts significantly extend the initial findings reported by Kvavilashvili and Fisher (2007) and

Gardner and Ascoli (2015) who focused only on thoughts about a single upcoming prospective memory task or future thoughts in general (i.e., not on spontaneous thoughts per se), respectively. Taken together, the results support Craik's (1986; 1994) theory of ageing, which predicts small or no age effects in cognitive tasks and phenomena that are mediated by automatic rather than attentionally demanding strategic retrieval processes. Indeed, spontaneous thoughts about the past or future rely on automatic spreading activation processes as they are not preceded by any deliberate attempts at retrieval, and they are recalled significantly faster than their voluntary counterparts as demonstrated by Cole et al (2016). In their study, young participants were significantly faster at spontaneously recalling past and future thoughts in response to incidental cue words during the boring vigilance task than deliberately recalling past and future events in response to cue words provided by the experimenter (see also Schlagman & Kvavilashvili, 2008). This reliance on incidental cues should further facilitate the retrieval process and may be particularly beneficial for older adults who, according to Hasher and colleagues (Hasher et al., 1979; Hasher & Zacks, 1988), are more distractible than younger adults. Older adults, however, did not report a higher number of external or internal triggers for their task-unrelated past and future thoughts as would be predicted by this theory, nor did they report past and future task-unrelated thoughts more frequently than younger adults, indicating that young and old adults equally benefitted from incidental cues.

Another possibility is that older adults benefitted more from incidental cues, but this benefit was offset by somewhat higher levels of concentration reported by older adults, when carrying out their everyday activities. This is in line with our findings from previous diary studies (Kvavilashvili & Fisher, 2007; Schlagman et al., 2009) and suggests that despite the habitual nature of many ongoing tasks reported, older adults found them more effortful than younger adults (e.g., a simple activity of walking down the stairs may be more demanding for older adults especially if they have mobility problems). Given that task difficulty negatively affects the occurrence of mind-wandering and spontaneous thoughts in general, the net result of these two variables may be the absence of age effects obtained in our study. The investigation of the joint effects of incidental distracters and ongoing task difficulty is clearly an interesting

avenue for research on ageing and spontaneous task-unrelated thoughts about the past and future.

The absence of age effects on spontaneous thoughts contrasts sharply the robust age-related decline in task-unrelated thoughts observed in laboratory studies of mind-wandering (for review, see Maillet & Schacter, 2016a). It has been proposed that the tasks employed by researchers in the laboratory, and the laboratory context itself, may have contributed to the observed age-related reductions in mind-wandering (Maillet & Schacter, 2016a; Plimpton et al. 2015). For example, in laboratory studies, older adults usually find the ongoing tasks (e.g., go/no-go tasks) more difficult and perform worse on these tasks than younger adults (Jackson & Balota, 2012). In addition, older adults report higher levels of interest in the ongoing task (Krawietz, Tamplin, & Radvansky, 2012; Maillet & Rajah, 2013), as well as higher motivation (Frank, Nara, Zavagnin, Touron, & Kane, 2015; Krawietz et al., 2012; Seli, Maillet, Smilek, Oakman, & Schacter, 2017), conscientiousness (Jackson & Balota, 2012), and anxiety about their performance (Frank et al., 2015), all of which may contribute to reduced mind-wandering in the laboratory setting.

A similar pattern of contrasting age effects across laboratory and naturalistic studies has also been found in research on prospective memory in which negative effects of age have often been obtained in laboratory tasks, in contrast to no age effects or even positive age effects in everyday life (Rendell & Craik, 2000; Henry, McLeod, Phillips & Crawford, 2004; Phillips, Henry & Martin, 2008). This highly counterintuitive pattern has been termed the Age - Prospective Memory paradox and has been subject to increased investigation over the past decade (e.g., Aberle et al., 2010; Kvavilashvili, Cockburn & Kornbrot, 2013; Niedźwieńska & Barzykowski, 2012; Niedźwieńska, Janik & Jarczyńska, 2013; Schnitzspahn et al., 2011). Although several explanations have been proposed and tested (e.g., use of reminders, motivation), there is currently no clear understanding about the precise set of variables that contribute to older adults' superior performance in everyday life compared to laboratory tasks. As in the case of mind-wandering, it may be a combination of variables such as task difficulty, motivation and noticing incidental cues. One explanation suggested in the literature is that in

everyday life older adults may be spontaneously or deliberately thinking about future prospective memory tasks more frequently than younger adults (Dismukes, 2008; Ihle et al., 2012), and the findings of Gardner and Ascoli (2015) seemed to provide initial support for this idea. However, the results of Kvavilashvili and Fisher (2007) and the current studies show that there are no age effects in the frequency with which younger and older adults think about their upcoming prospective memory tasks and plans in everyday life. Thus, it does not seem to be the case that older adults are compensating for any deficits in everyday prospective memory performance by thinking about future tasks more frequently than younger adults.

The frequency, nature and contents of spontaneous future thoughts

Although in Study 1 more past than future spontaneous thoughts were recorded, this could be attributed to participants recording only a sub-class of future thoughts (i.e., upcoming prospective memory tasks). In Study 2, where all types of task-unrelated future thoughts were recorded, younger and older participants reported spontaneous past and future thoughts with equal frequency, which supports the findings of previous diary studies by Berntsen and Jacobsen (2008) and Finnbogadóttir and Berntsen (2013). However, when participants indicated deliberate engagement in task-unrelated thoughts, then both age groups were more likely to think about the future than the past.

These findings are consistent with recent results of a laboratory study by Seli, Ralph et al. (2017), which showed that when young participants reported intentional (i.e., deliberate) mind-wandering in response to thought probes during a simple choice reaction task, the thoughts were significantly more future- than past-oriented compared to when they reported unintentional (spontaneous) mind-wandering. Taken together, the findings of Seli, Ralph et al. (2017) and our results on young and older adults suggest that perhaps the well documented predominance of future over past thoughts, reported in the mind-wandering literature, is due to the lack of distinction between spontaneous and deliberate thoughts in most studies, and these findings actually reflect a future bias in deliberate, but not spontaneous task-unrelated thoughts. For example, in Study 2, had we adopted the common assumption that participants' reports of mind-wandering reflect spontaneous task-unrelated thought (e.g., Kane & McVay, 2012; Seli et al.,

2014; Seli, Cheyne, & Smilek, 2013; Smallwood & Schooler, 2006), we would have incorrectly concluded that spontaneous thoughts were predominantly future-oriented.

Another possible (but not mutually exclusive) explanation for the well-documented predominance of future over past task-unrelated thoughts concerns the absence of (meaningful) cues in the tasks used in most mind-wandering laboratory experiments. Indeed, recent studies by Vannucci et al. (2017) and Maillet et al. (2017), showed that when the ongoing tasks did not contain verbal cues, participants were more likely to think about the future than the past. In contrast, when cues are present (e.g., in everyday life), the prospective bias in spontaneous thought disappears (Berntsen & Jacobsen, 2008; Finnbogadóttir & Berntsen, 2013).

An important additional finding that emerged from Study 2 was that the majority of spontaneous and deliberate future thoughts were about upcoming tasks and plans (i.e., prospective memory tasks), which is in line with the results of several earlier laboratory and experience sampling studies of mind-wandering (Baird et al., 2011; D'Argembeau et al., 2011; Plimpton et al., 2015; Stawarczyk et al., 2011). When Seli, Risko, and Smilek (2016) discussed the importance of distinguishing intentional and unintentional mind-wandering, they suggested that during undemanding ongoing tasks people may deliberately engage in thinking about future goals and plans, which is likely to be adaptive and have functional benefits in helping people to remember to carry out upcoming tasks. Several researchers have discussed the possible adaptive value of future thinking (Baumeister, Vohs & Oettingen, 2016; Mooneyham & Schooler, 2013; Schacter, 2012), and Szpunar, Spreng and Schacter (2014) have proposed a novel taxonomy of episodic future thoughts which distinguishes simulation, prediction, intention and planning. While most laboratory studies on deliberate future thinking have focused on the simulation of possible or hypothetical future events, our results show that in daily life, when sampling peoples' actual spontaneous and deliberate thoughts about the future, they may be predominantly about intended actions and plans rather than simulations and predictions (see also Plimpton et al., 2015).

This finding fully concurs with Baumeister et al.'s (2016) pragmatic theory of prospection, which states that planning may be the most common form of prospection in

everyday life. For example, in an experience sampling study of Baumeister, Hofman and Vohs (2015, cited in Baumeister et al., 2016) with 492 participants (aged 18 to 67) and over 6,500 thought probes, 75% of reported future thoughts involved planning (defined as specifying actions to achieve a goal). However, Baumeister et al.'s (2016) theory is somewhat vague about the nature of future thoughts regarding intentionality. If anything, participants in Baumeister et al.'s (2015) study reported being more in control when thinking about the future, which implies that future thoughts may be more deliberate than spontaneous. In contrast, the novel contribution of our findings to this line of research is to show that the majority of task-unrelated future thoughts in everyday life were reported as occurring spontaneously rather than deliberately by both young (72%) and older adults (63%). In other words, the pragmatic theory of prospection appears to apply to both spontaneous and deliberate forms of prospection.

The role of cues in eliciting spontaneous future thoughts

Finally, we addressed an important theoretical question about the nature of underlying representations of future thoughts and whether they were different from representations of past thoughts. Research on prospective memory has addressed this question by comparing participants' speeded recall of all those prospective memory tasks they intend to perform in their daily life within a specific future time period (e.g., in the next seven days) with all the tasks that they have already completed in the past period of the same duration (i.e., past seven days) (the so called *intention superiority effect*). Results of these studies have shown that young participants recall more to-be-performed than already completed actions, demonstrating that representations of upcoming prospective memory tasks may be more highly activated than the representations of completed tasks (Freeman & Ellis, 2003; Maylor, Darby & Della Sala, 2000). It is interesting that for older adults, a similar intention superiority effect was not obtained by Freeman and Ellis (2003), while Maylor et al. (2000, Study 2) reported an intention inferiority effect (i.e., older adults recalled more past than future tasks). However, in these studies

participants had to deliberately recall their completed and upcoming prospective memory tasks in response to experimenter's instructions to do so.⁴

In the present investigation, we wanted to compare representations of thoughts about the future (including thoughts about upcoming prospective memory tasks) and thoughts about one's personal past (i.e., involuntary autobiographical memories) that come to mind spontaneously in one's everyday life. Specifically, we assumed that if future thoughts were more activated than past memories, participants would be more likely to experience them in the absence of obvious triggers in comparison to involuntary autobiographical memories. In two studies using very different methodology, we found that for past thoughts, more external and internal triggers were reported than instances of no triggers (i.e., when the thought comes to mind for no apparent reason). This pattern is broadly in line with previous findings on involuntary autobiographical memories (e.g., Berntsen, 1998; Mace, 2004; Schlagman & Kvavilashvili, 2008). In contrast, involuntary thoughts about the future were reported to occur without any triggers as often as thoughts with external and internal triggers (see Table 4). These findings are important in the context of previous laboratory studies (with objectively verifiable incidental cues presented during the vigilance task), in which both young (Plimpton, et al., 2015; Cole et al., 2016) and older participants (Kvavilashvili, Niedźwieńska, & Kliegel, 2016) were quite good at identifying incidental cues for their reported spontaneous past and future thoughts. Therefore, the slightly increased frequency of "no triggers" reported for future thoughts in the present study is likely to represent cases when cues were absent rather than difficult to notice.

Taken together, the findings concerning the triggers provide initial support for the idea that representations of future thoughts may be more highly activated than memories of past events as they appear to come to mind even when there are no relevant and/or immediately obvious cues in one's thoughts or environment. Although this pattern emerged consistently across the two studies, the analysis in Study 2 was underpowered due to a small number of

⁴ For laboratory studies in which the Intention Superiority Effect is measured via speeded reaction times to the content of to-be-carried out tasks see Dockree and Ellis (2001), Goshcke and Kuhl (1993) and Marsh, Hicks and Bink (1998).

participants who reported at least one spontaneous future thought and one past thought.

Therefore, this finding needs to be replicated on larger samples to examine in more detail whether this heightened activation is characteristic of spontaneous future thoughts in general or only the thoughts of upcoming prospective memory tasks.

Some methodological considerations

Estimates of the number of spontaneous future and past thoughts observed in our 2-week diary study (Study 1) were relatively low compared to estimates from our experience sampling study (Study 2) in which we captured only a snapshot of thoughts (30 probes) over a 10-hour period. These results indicate that the experience sampling method is superior to the diary method in capturing a higher number of spontaneous past and future thoughts, as well as avoiding possible selection bias in diary studies. Additionally, it is possible that people are more engaged with, and aware of their thoughts when asked to track and record their thoughts over shorter periods of time (e.g., Laughland & Kvavilashvili, in press), which may partially explain the lower than expected number of thoughts recorded in Study 1. A particular strength of Study 1, however, was the inclusion of ticks, allowing participants to acknowledge their thoughts when they were unable to fully record them, which represents an improvement over previous diary studies (e.g., Kvavilashvili & Fisher, 2007).

Furthermore, a couple of methodological aspects of Study 2 are worth mentioning. First, unlike other experience sampling studies, which have used fewer probes per day over prolonged periods of time (e.g., a week or longer), we used an intensive 1-day sampling method, which resulted in excellent compliance rates both in terms of the percentage of completed thought probes (92%) and the speed with which the diaries were completed in response to the probes. Using waterproof watches instead of mobile technology (e.g., smartphones) also contributed to the success of the method as the vibrations could be felt immediately and the chances of not responding to the signals, due to the device not being at hand (e.g., in a different room), were minimized. On the other hand, because we tested participants on one day only, it is possibility that the results were not representative of other days. Future research could extend this intensive

sampling method by sampling participants on at least 3 different days (e.g., one week apart), which would increase the total number of probes and representativeness of the data.⁵

Second, unlike many previous studies on mind-wandering which asked participants to indicate whether their thoughts were on task or off task (for review, see Weinstein, 2018), in Study 2 our participants recorded the actual content of their thoughts, which were then coded by independent raters as task-related, task-related interference, task-unrelated, external distraction and no thoughts following a detailed coding scheme (*cf.* Plimpton et al., 2015). While coding thoughts into these categories may be relatively straightforward in the laboratory setting where there is a clearly defined ongoing task (e.g., Stawarczyk et al. 2011), making such fine-grained distinctions in everyday life would be much more difficult for participants due to the complex and fluid nature of tasks performed in everyday life. Therefore, in future research using the experience sampling method, participants should be asked to describe their ongoing thoughts rather than provide judgments about the types of thoughts experienced that can not be verified by researchers (*cf.* Stawarczyk, 2018). In addition, researchers will need to use standardized and detailed coding schemes when coding participants' thought descriptions to ensure the generalizability of findings across the studies.

Finally, the absence of age effects on spontaneous past and future thinking (or any other type of coded thought) was not due to having unusual samples of older adults with increased cognitive abilities compared to samples used in other mind-wandering studies. Indeed, in Study 1, older adults had significantly fewer years of education than younger adults. In addition, in Study 2, where education levels were matched, we obtained standard negative effects of age for the overall scores on the test of cognitive status (TICs-M) and on its memory sub-component of recalling 10 words (see Table 1) with large effect sizes ($\eta_p^2 = .16$ and $\eta_p^2 = .14$, respectively). This pattern was in stark contrast to the absence of age effects observed in types of thoughts experienced in everyday life (see Figure 1). The absence of age effects and especially of interaction effects in the two studies, is in line with similar findings from laboratory studies of

⁵ It is, however, worth pointing out that we chose one non-working day to make the samples of young and old participants more comparable in terms of the nature of activities involved.

prospective memory that have not obtained age effects for focal prospective memory tasks or for the spontaneous detection of target events outside the retrieval context (see Mullet et al., 2013).⁶

In conclusion, to our knowledge, this is the first investigation of age effects in spontaneous future thinking using diary and experience sampling methods, which resulted in comparable findings across the two studies despite the differences in methods used and the modest sample sizes. Results are in line with recent findings on the absence of age effects on involuntary autobiographical memories (Berntsen et al., 2017) and suggest that in everyday life, spontaneous thoughts about the future may be spared from deleterious effects of ageing. This finding has important theoretical and practical implications and opens up interesting avenues of research not only on spontaneous future thinking, but in several related areas of research on spontaneous cognition that have been studied largely independently from each other (e.g., mind-wandering, prospective memory).

⁶ Our sample sizes were comparable to those used in previous diary studies of involuntary past and future thinking in which 20 - 25 participants have been used per condition (e.g., Berntsen & Jacobsen, 2008; Finnbogadóttir, & Berntsen, 2011; Kvavilashvili & Fisher, 2007; Rasmussen & Berntsen, 2011). Power calculations using G*Power 3 (Faul, Erdfelder, Lang & Buchner, 2007), showed that with the sample size we had in Study 1 (based on at least 19 participants in each condition), for the 2 age (young vs. old) x 2 thought type (past vs. future) mixed ANOVA, the power to detect a medium to large effect of age as measured by partial eta-squared ($\eta_p^2 = .10$) was .61, and the power to detect an interaction of medium size ($\eta_p^2 = .06$) was .85 (with the correlation between the dependent variables of .58 and the non sphericity correction of 1.00). In Study 2, with the existing sample size of at least 22 participants per group, in the 2 age (young vs. old) a 5 thought type (Task-related, task-unrelated interference, task-unrelated, external distraction, no thought) mixed ANOVA, we had the power of .80 to detect a medium size age effect of $\eta_p^2 = .06$, and the power of .75 to detect a medium to large size interaction of $\eta_p^2 = .10$ (with the correlation between the dependent measurements of .17 and the sphericity correction of .25). These calculations show that we had sufficient power to detect medium to large size effects that have been often reported in the cognitive ageing literature.

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Compliance with Ethical Standards

Conflict of interest: The authors declare that they have no conflict of interest.

Research involving human participants: All procedures carried out in this investigation with human participants were in accordance with the ethical standards of institutional ethics committee and with the 1964 Helsinki Declaration.

Informed consent: Informed consent was obtained from all the participants who took part in Studies 1 and 2.

Data availability: The datasets generated in this investigation are not publicly available, but are available from the corresponding author upon request.

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Table 1

Means (Standard Deviations) of Background Variables as a Function of Age in Study 1 and Study 2, and Results of One-Way ANOVAs

	Age group		F value	Partial η^2
	Young	Older		
Study 1	N = 21	N = 19	(1, 38)	
Education (years)	16.45 (2.35)	11.95 (2.46)	35.06****	.48
Self-reported health ^a	4.00 (.71)	3.84 (.83)	.42	.01
Self-reported health vs. peers ^b	3.19 (.75)	3.63 (.76)	3.41	.08
Study 2	N = 24	N = 23	(1, 45)	
Education (years)	17.65 (2.28)	16.83 (3.11)	1.07	.02
Self-reported health ^a	4.08 (.83)	3.78 (.85)	1.51	.03
Self-reported health vs. peers ^b	3.25 (.68)	3.65 (.98)	2.70	.06
HADS anxiety ^c	7.50 (3.64)	5.74 (2.82)	3.43	.07
HADS depression ^c	2.33 (2.22)	3.70 (2.55)	3.83	.08
MPED busyness ^d	21.42 (4.24)	18.04 (4.51)	6.99**	.13
MPED routine ^d	13.00 (3.20)	13.57 (2.47)	.46	.01
TICS-M ^e	30.88 (2.46)	28.09 (3.95)	8.52**	.16
TICS-M recall ^f	12.25 (2.36)	10.09 (3.15)	7.14**	.14
Isaacs Set Test	37.00 (3.11)	36.04 (3.59)	.96	.02

Wechsler's Similarities Test	7.79 (.72)	7.22 (1.45)	3.01	.06
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Note. ^a Self-reported health was rated on a 5-point scale (1 = *poor*, 3 = *average*, 5 = *excellent*); ^b Health vs. peers was rated on a 5-point scale (1 = *worse*, 3 = *same*, 5 = *significantly better*); ^c HADS - Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983); ^d MPED - Martin and Park Environmental Demands Questionnaire (Martin & Park, 2002); ^e TICS-M - Modified Telephone Interview for Cognitive Status (Brandt et al., 1993; Prince et al., 1999); ^f TICS-M recall – immediate and delayed recall of 10 words.

** $p \leq .01$; **** $p < .0001$

Table 2

Means (Standard Deviation) of Compliance Measures as a Function of Age in Study 1 and 2 and Results of One-Way ANOVAs

	Age group		F value	Partial η^2
	Young	Older		
Study 1	N = 21	N = 18	(1, 37)	
Difficulty ^b	3.90 (1.09)	3.28 (.96)	3.58	.09
Disruption ^c	3.67 (1.25)	3.17 (1.47)	1.30	.03
Confidence ^d	3.86 (1.53)	4.00 (1.41)	.09	.00
Number of times thought not recorded	5.79 (5.16)	4.53 (3.24)	.80	.02
Study 2	N = 24	N = 22	(1, 44)	
Number of valid probes ^a	27.96 (2.91)	27.32 (3.48)	.46	.01
Difficulty ^b	3.71 (1.46)	3.91 (1.48)	.22	.01
Disruption ^c	3.46 (1.32)	3.50 (1.50)	.01	.00
Confidence ^d	5.75 (.68)	5.55 (1.06)	.62	.01
Stress ^e	2.50 (1.67)	2.45 (1.34)	.01	.00
Busyness ^f	3.79 (1.74)	5.00 (1.38)	6.71**	.13

Note. ^a Number of completed thought probes out of a possible 30; ^b Difficulty of keeping a diary (1 = *very easy*, 7 = *very difficult*); ^c Disruption caused by diary keeping (1 = *not disruptive*, 7 = *very disruptive*); ^d Confidence that most spontaneous thoughts were recorded or acknowledged (1 = *not confident*, 7 = *very confident*); ^e How stressed participant was on the day of recording (1 = *not stressed*, 7 = *very stressed*); ^f How busy participant was on the day of recording (1 = *not busy*, 7 = *very busy*)

** $p = .01$

Table 3

Mean Number (Standard Deviation) of Fully Recorded and Acknowledged (Ticked) Spontaneous Thoughts as a Function of Thought Type (autobiographical memories vs. prospective memories) and Age Group (Young vs. Old)

	Age Group			
	Young		Old	
	Autobiographical Memories	Prospective memories	Autobiographical Memories	Prospective memories
Fully recorded entries				
Mean	10.43	8.52	10.39	7.22
SD	6.40	7.20	5.04	5.55
Minimum	2	0	0	1
Maximum	23	26	22	19
Acknowledged entries				
Mean	5.52	5.19	6.78	5.67
SD	6.78	6.70	5.38	5.30
Minimum	0	0	0	0
Maximum	15	30	24	18

Table 4

Mean (Standard Deviation) Number of Spontaneous Thoughts as a Function of Trigger Category (External vs. Internal vs. No trigger), Thought Type (Past vs. Future) and Age Group (Young vs. old) in Study 1 and Study 2

	Past thought		Future thought	
	Young	Old	Young	Old
Study 1				
External (environment)	4.96 (3.87)	4.94 (3.60)	2.96 (2.85)	2.50 (2.33)
Internal (thoughts)	3.29 (2.79)	4.18 (3.42)	2.63 (2.48)	3.50 (3.09)
No trigger	1.67 (1.79)	1.88 (2.98)	2.96 (3.24)	1.22 (1.93)
Study 2				
External (environment)	1.13 (1.31)	.71 (.61)	.81 (1.05)	.67 (.90)
Internal (thoughts)	.38 (.50)	.21 (.43)	.63 (.72)	.53 (.74)
No trigger	.13 (.34)	.43 (.51)	1.06 (1.18)	.90 (1.02)

Table 5

Mean (Standard Deviation) Concentration Ratings as a Function of Temporal Focus (Past vs. Future) of Spontaneous Thought and Age Group (Young vs. Old)

	Temporal Focus	
	Thought about past	Thought about future
Study 1		
Young	2.63 (.80)	2.49 (.64)
Old	2.85 (.80)	3.02 (.82)
Study 2		
Young ^a	2.34 (.83)	2.33 (.78)
Old ^b	3.50 (1.24)	3.43 (1.06)

Note. Ratings were made on a 5-point scale (1 = *minimum concentration*, 5 = *maximum concentration*). ^a Means are based on 16 young participants who had at least one spontaneous past thought and on 16 young participants who had at least one spontaneous future thought. ^b Means are based on 13 old participants who had at least one spontaneous past thought and on 15 old participants who had at least one spontaneous future thought.

Table 6

Mean (Standard Deviation) Number of Task-Unrelated Thoughts as a Function of Intentionality (Spontaneous vs. Deliberate), Temporality (Past vs. Present vs. Future vs. Atemporal) and Age Group (Young vs. Old) in Study 2

	Spontaneous		Deliberate	
	Young	Old	Young	Old
Past	1.08 (1.14)	.82 (.73)	.17 (.48)	.23 (.53)
Present	.83 (.96)	1.36 (1.43)	.46 (.78)	.86 (1.17)
Future	1.67 (1.86)	1.32 (1.62)	1.04 (1.40)	.86 (.99)
Atemporal	1.13 (1.54)	.36 (.58)	.21 (.51)	.36 (.95)
Total	4.71 (3.06)	3.91 (2.16)	1.87 (2.29)	2.32 (1.99)

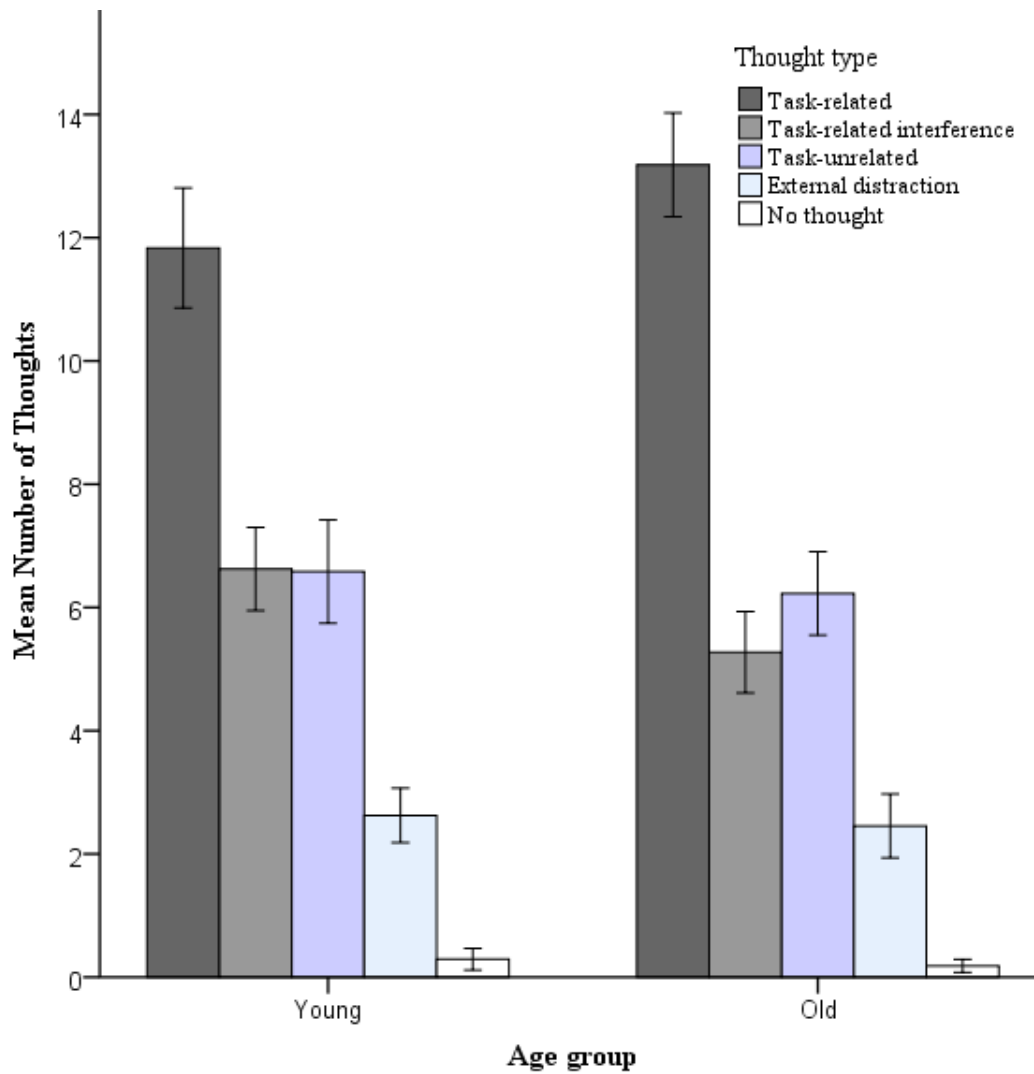


Fig. 1 Mean numbers of Recorded Thoughts as a Function of Thought Type (Task-related vs. Task-related interference vs. Task-unrelated vs. External distraction vs. No thought) and Age Group (Young vs. Old) in Study 2. Error Bars Represent $\pm 1SE$

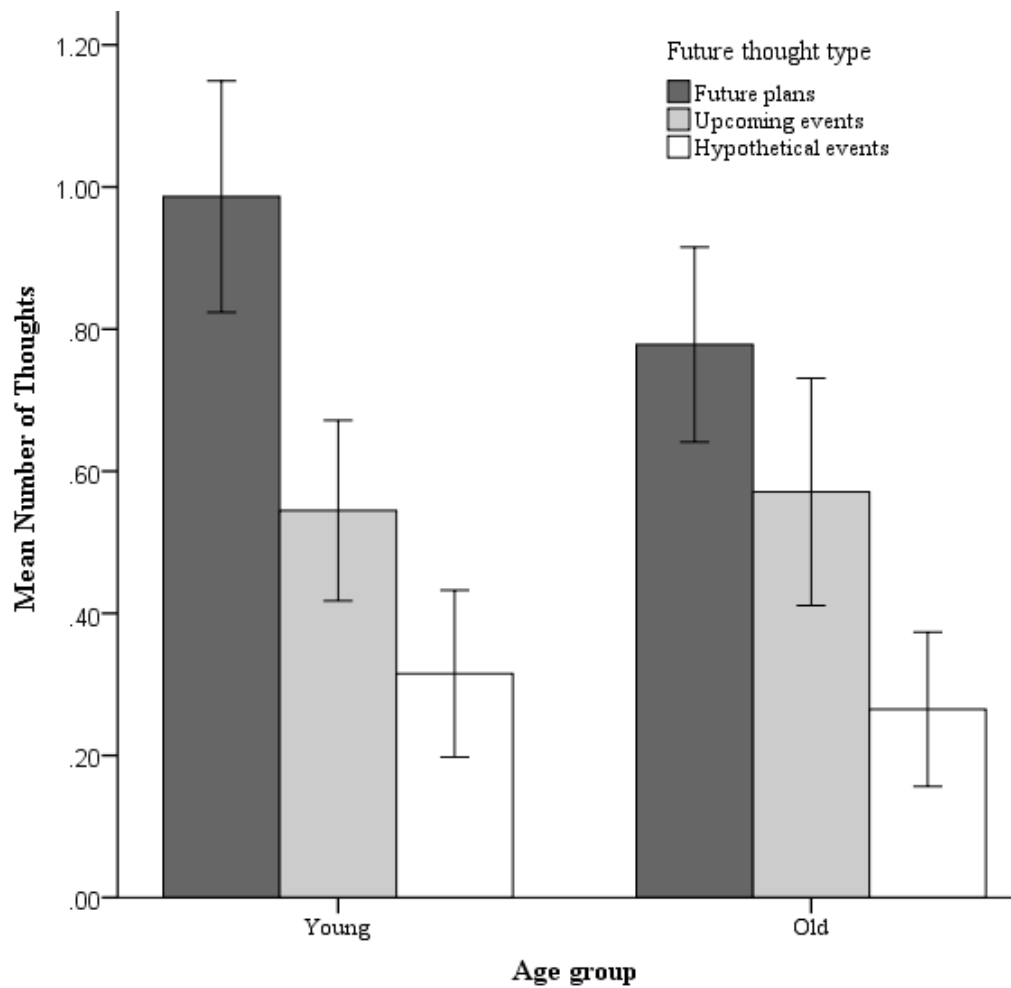


Fig. 2 Mean Number of Spontaneous and Deliberate Task-unrelated Future Thoughts (Square Root Transformed) as a Function of Future Thought Type (Future plans vs. Upcoming events vs. Hypothetical events) and Age Group (Young vs. Old) in Study 2. Error Bars Represent $\pm 1SE$