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Age-Related Changes in Everyday Forms of Involuntary and Voluntary Cognition

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Preliminary findings of this study have been disseminated at the 15th International Conference on Music Perception and Cognition/10th triennial conference of the European Society for the Cognitive Sciences of Music (Graz, Austria, July 2018) and the 59th annual meeting of the Psychonomic Society (New Orleans, U.S.A., November 2018).

Abstract

A growing body of evidence suggests that the reported frequency of certain everyday involuntary and voluntary forms of cognition decreases as people get older. Research in this field has focused on mind-wandering and autobiographical memory, typically exploring them independently of each other; future thinking, semantic memory, and musical imagery remained largely unexplored. Furthermore, the findings about contributing factors to age-related frequency changes remain inconclusive, whereas phenomenological characteristics such as vividness and affective valence have been overlooked. Our study investigates, for the first time, the relation between chronological age and simultaneously the frequency and phenomenological characteristics of involuntary and voluntary mind-wandering, autobiographical memory, future thinking, semantic memory, and musical imagery. In addition, we explore attentional control and confidence ratings as factors that could explain age-related frequency changes in involuntary and voluntary forms of cognition. A sample of 675 individuals, ranging in age from 18 to 90 years, completed an online questionnaire about the characteristics of their involuntary and voluntary forms of cognition, as well as measures of reported attentional control, and confidence in their responses. Our findings point to an age-related decrease in reported frequency for all forms of involuntary and voluntary cognition, which could not be accounted by attentional control or confidence ratings. Vividness and affective valence of involuntary and voluntary cognition forms were associated differentially with age. We discuss the findings in relation to theories of cognitive aging and socioemotional development and their implications for involuntary and voluntary cognition research.

Keywords: aging, mind-wandering, autobiographical and semantic memory, future thinking, musical imagery

Age-Related Changes in Everyday Forms of Involuntary and Voluntary Cognition

The last decade has seen a marked increase in research on everyday cognition across several related but independent domains of inquiry. Results from this research, focusing on a diverse set of phenomena, show that personal thoughts about the past, present, or future and semantic knowledge, in the form of music and words, can be brought to mind not only voluntarily, when we think deliberately about something (Halpern, 2012), but also involuntarily, when there is no prior intention to have these thoughts at the time when they spring to mind (Berntsen, 1996; Smallwood & Schooler, 2006). Traditionally, research has focused on voluntary thought processes that are more conveniently studied in the lab. However, advances in research methodologies inside and outside the lab have facilitated the study of involuntary forms of cognition, sometimes investigated simultaneously with their voluntary counterparts (Barzykowski & Staugaard, 2018; Cole & Berntsen, 2016; Berntsen, Rubin, & Salgado, 2015).

Everyday involuntary and voluntary forms of cognition range from instances of mind-wandering, when our attention shifts from an external activity to internal task-unrelated thoughts (Smallwood & Schooler, 2015), to autobiographical memory of personal past events and future thinking about possible future events (Berntsen et al., 2015). Other common but less studied examples include semantic memory (Kvavilashvili & Mandler, 2004), which is experienced as isolated fragments of semantic knowledge (e.g., words and images), and musical imagery, i.e., the internal experience of music in the absence of a corresponding stimulus from the physical environment (Halpern, 2012; Liikkanen, 2012). Despite the diversity and heterogeneity of these self-generated thoughts in terms of content, temporal focus, and relevance to the task, certain similarities among them have been identified, such as their occurrence in association with non-focused states of attention (Floridou, Williamson, & Stewart, 2017; Mazzoni, 2018; Vannucci et al., 2015). Theoretical accounts of mind-

wandering (Christoff et al., 2016; Seli et al., 2018) further acknowledge the heterogeneity as well as the relatedness of these everyday cognition forms. In particular, the family-resemblances framework (Seli et al., 2018) emphasizes the need for these cognition forms to be studied together rather than in isolation. Adopting a broad conceptual approach will increase intellectual and methodological connections among related phenomena in the mind-wandering family and deepen our understanding about the dependent and independent underlying mechanisms related to their intentionality onset (involuntary and voluntary) and form (e.g., mind-wandering and autobiographical memory).

Two important questions remain about everyday forms of involuntary and voluntary cognition: how their frequency and phenomenological characteristics manifest across the adult lifespan and whether different forms follow a common trajectory. Other open questions are how the evidence fits in with theoretical accounts of cognitive aging as well as the factors that underlie the existing pattern of findings. A recent review on aging and several different involuntary cognition forms states (Maillet & Schacter, 2016, p. 143) “greater insight regarding age-related differences in spontaneous thoughts may emerge from considering these phenomena together rather than separately” and calls for distinguishing between involuntary and voluntary cognition forms in these considerations. In the present study, we employed a novel unified approach to investigate how the reported frequency, vividness, and affective valence of several everyday involuntary as well as voluntary cognition forms such as mind-wandering, autobiographical memory, future thinking, semantic memory, and musical imagery, are experienced by people of different ages. Furthermore, we explored, for the first time, self-reported measures of attentional control and confidence ratings, as potential contributing to changes in the frequency and self-reported frequency, respectively, of involuntary and voluntary cognition forms in relation to aging.

Aging and the Frequency of Involuntary and Voluntary Forms of Cognition

The majority of the aging literature regarding everyday involuntary and voluntary forms of cognition comprises reports on the reported frequency of mind-wandering and autobiographical memory, whereas studies on future thinking and musical imagery are sparse, and research on semantic memory is non-existent. A comprehensive review of the literature on several forms of involuntary cognition (Maillet & Schacter, 2016) concluded that, with some exceptions, overall their reported frequency declines with age. This includes mind-wandering (Berntsen et al., 2015; Giambra, 1989; 1993; 2000; Gyurkovics, Balota, & Jackson, 2017; Maillet et al., 2018; Seli, Maillet, Smilek, Oakman, & Schacter, 2017; Stawarczyk, Majerus, Van der Linden, & D'Argembeau, 2012), autobiographical memory (Berntsen & Rubin, 2002; Schlagman, Schulz, & Kvavilashvili, 2006; Schlagman, Kvavilashvili, & Schulz, 2007; Schlagman, Kliegel, Schulz, & Kvavilashvili, 2009), future thinking (Berntsen et al., 2015), and musical imagery (Liikkanen, 2012). However, some findings suggest that there are no age effects in the frequency of involuntary memory and future thinking (Berntsen et al., 2015; Berntsen, Rasmussen, Miles, Nielsen, & Ramsgaard, 2017; Rubin & Berntsen, 2009; Warden, Plimpton, & Kvavilashvili, 2018), and one study even reports increases in the reported frequency of future-oriented thoughts in older adults (Gardner & Ascoli, 2015).

The explanations that have been proposed for the discrepancies regarding frequency changes over the age span for the same forms of involuntary cognition include: (a) different methodological approaches employed across studies, which might result in different frequency estimates due to participants' varying monitoring processes or memory biases [e.g., Schlagman et al. (2009) used a diary method and found age-related differences in the frequency of involuntary autobiographical memory, whereas Bernsten et al. (2015) used a retrospective survey and found no age differences], (b) dissimilarities in the years of

education between younger and older adults (e.g., above studies), and (c) the absence of distinction between involuntary and voluntary cognition forms [e.g., Maillet et al. (2018), did not distinguish between involuntary and voluntary mind-wandering and reported a decline in frequency with age, whereas Warden et al. (2018) did distinguish between the same forms and found no age-related changes]. On the other hand, the explanation proposed to account for the discrepancies in findings between different forms of involuntary cognition is that, despite their similarity in terms of involuntary onset, these forms reflect different types of thought processes (Berntsen et al., 2017). The fact that aging studies in general investigate cognition forms independently of each other and in isolation hinders generalization of their findings. The observed discrepancies highlight an urgent need for research that uses the same methodology to assess different cognition forms.

In contrast to the above picture, findings are more consistent on aging and the frequency of everyday voluntary cognition forms; however, relevant research is extremely limited and focuses on specific cognition forms. The few available findings from retrospective and experience sampling studies in daily life indicate that the frequency of voluntary mind-wandering and autobiographical memory declines with age (Berntsen et al., 2015; 2017, Seli et al., 2017; Schlagman et al., 2009). However, one recent study did not find age effects in the frequency of voluntary thoughts about the past and the future (Warden et al., 2018). It is clear that more research is needed on the frequency of multiple everyday voluntary cognition forms in relation to aging, ideally evaluated simultaneously with their involuntary counterparts to address discrepancies in this literature.

Explaining Age-related Reductions in the Frequency of Involuntary and Voluntary Cognition Forms

The most prevalent explanations for age-related reductions in everyday cognition have been discussed with regard to (a) theoretical accounts of cognitive aging and (b) the validity

of self-reports in older adults. The most prominent cognitive aging accounts, which have been developed based on lab studies of voluntary cognition and then adjusted to accommodate findings about age-related changes in everyday cognition, are the theories of attentional resources (Craik & Byrd, 1982) and memory process (Craik, 1983; 1986). As regards the former, Craik and Byrd (1982) suggested that, compared to younger adults, older adults have fewer attentional resources available, and thus age-related voluntary memory changes could be associated with a general decline in cognitive processing resources. As involuntary cognition occurrence is more common during activities that do not require much attention (Floridou et al., 2017; Mazzoni, 2018; Vannucci, Pelagatti, Hanczakowski, Mazzoni, & Paccani, 2015) and is associated with attentional resource consumption (Smallwood & Schooler, 2006), it is anticipated that involuntary cognition frequency will also be depleted in older adults. The memory process theory (Craik, 1986) describes memory retrieval in older adults as an interaction between self-initiated mental operations and environmental support/constraints in the form of cues and context provided by the task. When environmental support is minimal, retrieval relies more on voluntary self-initiated operations, with older adults finding it more difficult than younger adults to execute tasks that depend on memory retrieval under such circumstances. However, when environmental support increases, then self-initiated processes are more automatic and require less effort, so age-related decrements are minimal or absent. Since involuntary forms of cognition, e.g., involuntary mind-wandering, are unrelated to the completion of the task at hand (cue-independent), and constitute attentional resource-demanding processes (Smallwood & Schooler, 2006) resembling the load of voluntary self-initiated processes, frequency of involuntary cognition is predicted to decrease in older adults similarly to voluntary cognition. In our study, we assess for the first time self-reported attentional control, as a proxy to investigate the potential explanatory role of cognitive aging accounts, in relation to everyday

involuntary cognition forms, but also voluntary forms, which have never been investigated in an everyday context.

An additional explanation proposed for the reported frequency reduction of involuntary cognition with age relates to reduced validity of self-reports of older adults owing to memory bias and lower meta-awareness (Jackson & Balota, 2012; Zavagnin, Borella, & DeBeni, 2014). Older adults may experience more difficulty in remembering correctly and reporting accurately on the frequency of involuntary forms of cognition. As research on involuntary and voluntary cognition forms typically depends on subjective self-reports, one concern relates to how valid these reports are in the absence of objective measures, especially for older adults who could be prone to memory biases. A factor that may prove instrumental in capturing the validity of introspective self-reports is the confidence participants have in their responses. Seli et al. (2015) found that medium and high confidence self-reports reflect more accurate appraisals of people's mind-wandering than low-confidence self-reports, an observation that they then confirmed by using objective measures of mind-wandering during behavioral tasks (though see Meier, (2018) for an alternative interpretation). In our study, we examine confidence ratings associated with frequency responses as a proxy to investigate the validity of self-reports in relation to aging. Our study will be the first to investigate confidence ratings in such a retrospective context, as a way to examine whether validity of self-reports could be a contributory factor to the reported pattern of age-related decrease in the frequency of voluntary and/or involuntary forms of cognition.

Aging and Phenomenological Characteristics of Involuntary and Voluntary Forms of Cognition

Research on aging and everyday involuntary and voluntary cognition forms has primarily focused on their frequency and has largely overlooked their phenomenological characteristics. Among the characteristics studied are vividness, which refers to the clarity

and realism of the cognition form (Childers, Houston, & Heckler, 1985), affective valence as expressed by content valence, which describes the extent to which a positive or negative appraisal is attributed to the content of the cognition, and reaction valence, which indicates how positive or negative the person feels the moment that she or he experiences the cognition. Research on the phenomenological characteristics is important as they have been associated with risks and benefits for the individual (Andrews-Hannah et al., 2013; Smallwood & Andrews-Hannah, 2013). In some cases, for example in repetitive thinking, it is the affective valence and not the frequency that distinguishes positive from negative outcomes in anxiety and depression. Hence, investigation of phenomenology is particularly useful in considering more and less successful aging outcomes.

The few available findings on involuntary and voluntary autobiographical memory agree that, with increasing age, vividness ratings become higher (Schlagman et al., 2006; 2007; 2009) and content valence ratings become more pleasant (Berntsen et al., 2015; Schlagman et al. 2006; 2009). There are no reported changes in the content valence of involuntary future thinking (Berntsen et al., 2015) or voluntary autobiographical memory (Schlagman et al., 2009). One study found that mind-wandering is rated as more pleasant with increasing age (Maillet et al., 2018), however there are no available findings on content valence and vividness in aging. As regards reaction valence, mind-wandering and involuntary autobiographical memory, research points to a reduction of the negativity effect with increasing age: older adults report negative involuntary autobiographical memories less frequently than young adults, and when they do, they rate them as neutral or even pleasant, appearing to be less emotionally involved in or affected by such experiences (Giambra, 2000; Schlagman et al., 2006). To the best of our knowledge, there is no research on the phenomenological characteristics of involuntary and voluntary semantic memory and musical imagery in relation to aging. Shedding light on the relation between aging and the

phenomenological characteristics of several everyday involuntary and voluntary cognition will help us further understand the cognition form-dependent and -independent mechanisms as well as costs and benefits associated to increasing age.

The Current Study

The first aim of the current study was to examine, for the first time simultaneously, the reported frequency of everyday involuntary and voluntary mind-wandering, autobiographical memory, future thinking, semantic memory, and musical imagery, across the adult lifespan using reliable and validated questionnaires where possible. Diverse cognition forms that have been studied in various degrees in relation to aging, either more extensively (e.g., mind wandering) or not at all (e.g., semantic memory), were considered together to determine whether these cognition forms, which bear several similarities, follow a common trajectory in relation to aging. In line with theoretical accounts of cognitive aging (Craig & Byrd, 1982; Craig, 1982; 1986) and previous findings on mind-wandering, autobiographical memory, future thinking, and musical imagery (Berntsen & Rubin, 2002; Giambra, 1993; 2000; Jackson & Balota, 2012; Liikkanen, 2012; Maillet et al., 2018; Seli et al., 2017; Schlagman et al., 2006; 2007; 2009), we hypothesized that the reported frequency of these involuntary cognition forms, as well as their voluntary counterparts, would decrease with age, whereas for involuntary and voluntary semantic memory and voluntary musical imagery, our research was exploratory due to lack of background literature. Furthermore, we investigated for the first time self-reported attentional control and confidence ratings as potential factors that could account for the observed relations between age and the frequency of involuntary and voluntary cognition forms.

The second aim of our study was to extend the simultaneous investigation and examine for the first time, the phenomenological characteristics of everyday involuntary and voluntary forms of cognition across the adult lifespan. Studies on the phenomenological characteristics

of involuntary and voluntary cognition forms are limited and focus on autobiographical memory, hence we predicted that the reported vividness of involuntary autobiographical memory would increase with age, in line with previous findings (Schlagman et al., 2006; 2007; 2009). We then extended the investigation to the other cognition forms, which was exploratory in nature given the absence of literature. Furthermore, following the literature, we hypothesized that content valence would be reported as more pleasant for mind-wandering and involuntary autobiographical memory as age increases (Berntsen et al., 2015; Schlagman et al. 2006; 2009; Maillet et al., 2018), but would not be associated with voluntary autobiographical memory (Schlagman et al., 2009) or involuntary future thinking (Berntsen et al., 2015), whereas for the remaining forms of cognition the investigation was exploratory. Finally, the study of the reaction valence of the different cognition forms and its relations to aging was exploratory in nature.

Method

Design

A correlational design was used and a battery of self-report retrospective questionnaires was set up online. Involuntary and voluntary cognition questionnaires constituted two distinct sets, within which the questionnaires were randomized. The purpose of this was to facilitate participants' understanding of the distinction between involuntary and voluntary cognition forms and allow them to focus on one form of cognition at a time.

Participants

Participants were recruited via various methods (university intranet mailing lists, social media advertisements, and a participant recruitment platform) and Internet-based panels (Qualtrics and SoundOut). Participation in the study was voluntary, but individuals who completed the full survey could opt into a prize draw to win one of four £50 Amazon

vouchers. Qualtrics and SoundOut panels were paid according to the rates set by the companies.

A total of 1289 individuals commenced participation in the online survey. We excluded the responses of 614 participants based on quality control using the following exclusion criteria, which were set in advance of data collection: (1) incomplete surveys and duration of survey completion (less than 1/3 of the median duration; 366 participants), (2) attention filters (e.g., “In this statement, please reply by selecting 0”; 43 participants) (3) significant mental and physical conditions reported as having been diagnosed by a physician (serious head injury, stroke, or mental health/memory issues; 9 participants), (4) English language fluency (we enrolled only native English speakers and non-native speakers reporting greater than advanced speaking level; 146 participants), and (5) self-reported hearing impairment (current hearing loss that presents difficulty in everyday life; 50 participants).

Following the quality control checks, the final sample was 675 participants (320 female, 350 male, 3 non-binary, and 2 prefer not to answer), whose age ranged from 18 to 90 years ($M = 42.17$, $SD = 19.78$). The self-reported level of education was high (e.g., undergraduate degree = 28.7%, postgraduate degree = 24%, still in education = 9.04%), with the years in education of the participants until the point of terminal degree averaging 14 years. Participants were either not working (students, 28.6%; retired, 21%; temporary layoff/looking for work/disabled, 8.7%) or paid employees/self-employed (40.8%), while 0.9% preferred not to answer. Our sample was ethnically diverse, representing 49 nationalities although the majority of participants were from English-speaking countries (e.g., UK = 40.9%, USA = 34.5%).

The sample did not differ significantly in years of education between young (18-59 years; $M = 14$ years) and older adults (60-90 years; $M = 14$ years), $t(673) = -.14$, $p = .89$. The

reported current health of younger adults ($M = 4.13$, $SD = .75$) was significantly better than that of the older adults ($M = 3.64$, $SD = .90$), $t(673) = 7.01$, $p < .001$. The average reported current health status of older adults was higher than the middle point of the response scale, indicating that older adults were in good health in general. The reported health status of younger adults in relation to their peers ($M = 3.43$, $SD = .86$) was not statistically significantly different from the comparable measure used by older adults ($M = 3.54$, $SD = 1.03$), $t(673) = -1.39$, $p = .16$).

Ethics Statement

The study protocol was approved by the Ethics Committee of the Department of Music of the University of Sheffield. Informed consent was obtained online from all participants in the form of checkboxes on the first page of the survey before commencement of the study.

Materials

Demographic Information

The first section of the online survey included items on participants' age, gender, nationality, education (highest level and years), employment status, current health ("How would you describe your current health?" 1 = *Poor*, 5 = *Excellent*,), and health compared to peers ("How would you rate your health in relation to your peers?"; 1 = *Worse* 3 = *Same*, 4 = *Significantly better*), as well as items used as exclusion criteria (fluency in English, hearing impairment, mental and physical health conditions).

Questionnaires of Involuntary Cognition

Involuntary Mind-Wandering: The Mind-Wandering, Spontaneous scale (MW-S, $\alpha = .88$; Carriere, Seli, & Smilek, 2013) is a four-item scale, which measures the frequency of involuntary mind-wandering (e.g., "I mind wander even when I'm supposed to be doing something else"). The response scale ranges from 1 (*Rarely*) to 7 (*A lot*) for items 1, 2, and 4

and from 1 (*Almost never*) to 7 (*Almost always*) for item 3. We modified the original instructions to reflect more accurately instances of involuntary (as opposed to voluntary) mind-wandering, as initial piloting showed that participants could not differentiate between the two forms using the original instructions. The original instructions were “For the following statements please select the answer that most accurately reflects your everyday mind-wandering”, and we altered them to “For the following statements please select the answer that most accurately reflects your everyday spontaneous (unintentional) mind-wandering. This refers to instances when a particular thought or train of thoughts suddenly occupies your mind and is unrelated to what you are doing”.

Involuntary Autobiographical Memory and Future Thinking: The Involuntary Autobiographical Memory Inventory (IAMI; Berntsen et al., 2015) consists of two subscales, which measure the frequency of (1) involuntary autobiographical memory of the past (e.g., “Memories of personal events pop into my mind by themselves – without me trying to remember them”; IAMI-past, $\alpha = .92$), (2) involuntary future thinking (e.g., “When I’m relaxing or doing routine work, imaginary future events come to mind by themselves – without me consciously trying to evoke them”; IAMI-future, $\alpha = .94$), and (3) a general factor measuring both past and future thinking (IAMI-total, $\alpha = .95$). The response scale is from 0 (*Never*) to 4 (*Once an hour or more*).

Involuntary Semantic Memory: The Mind-Popping Questionnaire (MPQ; Kvavilashvili & Mandler, 2004) assesses the frequency of involuntary semantic memory (mind-pops) by providing a brief description of the phenomenon and asking participants if they have ever experienced this phenomenon (Yes/No). Participants who respond affirmatively are then asked to rate the frequency of the occurrence (“How often do you have these mind-pops?”) on a response scale from 1 (*Only a few times in my entire life*) to 8 (*Three or more times a day*). In addition, participants are asked to indicate from a list of

examples of involuntary semantic memory (e.g., “a word in your native language”, “a sound”, or “a melody”) which ones they have experienced at least once in their life, and finally to provide one or two examples of involuntary semantic memory they have experienced in an open-ended question.

Involuntary Musical Imagery: The Involuntary Musical Imagery Scale (IMIS; Floridou, Williamson, Stewart, & Müllensiefen, 2015) is a 15-item self-report questionnaire, which measures characteristics of involuntary and repeated experiences of internal music (known as having “an earworm”). It consists of four subscales measuring phenomenological characteristics of IMI such as “Negative Valence” (IMIS-NV, $\alpha = .91$; e.g., “I wish I could stop my earworms”), “Movement” (IMIS-MVMNT, $\alpha = .88$; e.g., “When I get an earworm I move to the beat of the imagined music”), Personal Reflections (IMIS-PR, $\alpha = .76$; e.g., “Personal issues trigger my earworms”), and Help (IMIS-HLP, $\alpha = .84$; e.g., “I find my earworms help me focus on the task that I’m doing”). The response scale is from 1 (*Never*) to 5 (*Always*). In addition, there are three items that measure frequency (1 = *Never* to 6 = *Almost continuously*), duration of the section (1 = *Less than 5 seconds* to 5 = *More than 1 minute*), and duration of the episode (1 = *Less than 10 minutes* to 5 = *More than 3 hours*).

Questionnaires of Voluntary Cognition

Voluntary Mind-Wandering: The Mind-Wandering, Deliberate scale (MW-D, $\alpha = .90$; Carriere, et al., 2013) is a four-item scale measuring the frequency of deliberate mind-wandering (e.g., “I allow my thoughts to wander on purpose, I enjoy mind-wandering”). The response scale ranges from 1 (*Rarely*) to 7 (*A lot*) for items 2, 3, and from 1 (*Not at all true*) to 7 (*Very true*) for item 1. We altered the original instructions to reflect more accurately instances of deliberate mind-wandering from “For the following statements please select the answer that most accurately reflects your everyday mind-wandering” to “For the following statements, please select the answer that most accurately reflects your everyday voluntary

(intentional) mind-wandering. This refers to instances of willful attempts to disengage from the here and now, when you voluntarily start thinking of a particular thought or train of thoughts that is unrelated to what you are doing.”

Voluntary Autobiographical Memory and Future Thinking: To measure voluntary autobiographical memory frequency, we administered the 10 items used as voluntary control questions when developing the IAMI (Berntsen et al., 2015). The questions were similar in content to the IAMI, but the emphasis was on voluntary retrieval from the past (e.g., “When I’m bored or doing dull work, I willfully and deliberately think to past experiences and try to remember them”) and future (e.g., “When I’m bored or doing dull work, I willfully and deliberately think ahead to possible events in my future and try to imagine them”). The response scale is from 0 (*Never*) to 4 (*Once an hour or more*).

Voluntary Semantic Memory: We created one item to measure frequency of voluntary semantic memory in everyday life (“How frequently do you voluntarily recall pieces of general knowledge without accompanying personal information?”). The response scale was the same as for the MPQ, ranging from 1 (*Never*) to 9 (*Three or more times a day*).

Voluntary Musical Imagery: We created an item that measures frequency of voluntary musical imagery in everyday life (“How frequently do you voluntarily recall music in your mind?”). The response scale was the same as in the IMIS, ranging from 1 (*Never*) to 6 (*Almost continuously*).

Phenomenological Characteristics of Involuntary and Voluntary Cognition

Vividness, content valence, and reaction valence were assessed for all forms of involuntary and voluntary cognition, immediately after the corresponding questionnaire. We created items for the vividness of the experiences (e.g., “On average, how vivid is the music of your earworms?”, response scale: 1 = *Very vague, almost no music at all*, 2 = *Vague and dim*, 3 = *Moderately clear and vivid*, 4 = *Clear and reasonably vivid*, 5 = *Perfectly clear and*

almost as vivid as listening to actual music), content valence (e.g., “On average, how pleasant or unpleasant are your spontaneously arising memories of past events?”, response scale: 1 = *Very unpleasant*, 2 = *Unpleasant*, 3 = *Neutral*, 4 = *Pleasant*, 5 = *Very pleasant*), and reaction valence (e.g., “On average, how pleasant or unpleasant do your mind-pops make you feel?”, response scale 1 = *Very unpleasant*, 2 = *Unpleasant*, 3 = *Neutral*, 4 = *Pleasant*, 5 = *Very pleasant*).

Other Measures

The Attentional Control Scale (ACS; Derryberry & Reed, 2002) measures two trait factors: attentional distraction/focusing (ACS-D, e.g., “It's very hard for me to concentrate on a difficult task when there are noises around.”; $\alpha = .82$) and attentional shifting (ACS-AS, e.g., “After being interrupted or distracted, I can easily shift my attention back to what I was doing before.”; $\alpha = .71$) as well as a total factor (ACS-TOT, $\alpha = N/A$). High scores on the ACS represent good reported capacity to voluntarily control attention, whereas low scores are associated with attentional rigidity. The response scale ranges from 1 (*Almost never*) to 5 (*Always*). As the protocol of the ACS does not provide specific instructions we used the following: “For the following statements, please select the answer that most accurately reflects your everyday attention, meaning how easy or hard it is to concentrate on tasks depending on external and internal distractors.”

Confidence ratings were obtained for the ratings of frequency in relation to each type of involuntary and voluntary cognition assessed. Confidence ratings were presented immediately after each item measuring frequency (e.g., “How confident are you about your response above?”; response scale 1 = *Not at all confident*, 2 = *Somewhat confident*, 3 = *Very confident*).

Procedure

The questionnaires were presented via the online survey platform Qualtrics (Provo, UT). In the beginning participants read an information page explaining that the study was about involuntary and voluntary thoughts, which also contained short descriptions for each type of thought. Participants provided informed consent by ticking checkboxes and then proceeded to the main survey. First, they completed the demographic questions. Next, they were presented with either a general description of involuntary cognition followed by a more detailed description of each type of involuntary cognition prior to the presentation of the corresponding questionnaires (mind-wandering: MW-S, autobiographical memory and future thinking: IAMI, semantic memory: MPQ, musical imagery: IMIS), or with a general description of voluntary cognition followed by a detailed description of each voluntary form of cognition, prior to the presentation of the corresponding questions (mind-wandering: MW-D, autobiographical memory, future thinking, semantic memory, musical imagery). At the end of each involuntary and voluntary questionnaire, participants were asked to provide confidence ratings for each of their responses as well as to respond to additional items about vividness, content valence, and reaction valence. The last questionnaire to be completed was the ACS. Finally, participants were presented with a debrief page and were thanked for their participation. The median completion duration of the survey was 25 minutes.

Results

Statistical Analyses

The data were not normally distributed, therefore we employed Spearman correlations using the Holm-Sidak method (Aickin & Gensler, 1996) to correct for multiple correlations.

Descriptive Statistics

As age was one of our main variables, Figure 1 shows a histogram displaying the distribution of participants' chronological age (range 18-90 years), as well as descriptive

statistics (skewness and kurtosis values). Table 1 shows the descriptive statistics of all involuntary and voluntary measures assessing frequency. The psychometric values for all measures are comparable to those reported in previous published work. Next, we present descriptive statistics for the ACS, which shows good psychometric properties in terms of internal consistency in our sample (Table 2).

Figure 1. Histogram displaying the distribution of participants' age.

Note. $M = 42.17$, $SD = 19.78$, Skewness $SE = .09$, Kurtosis $SE = -1.27$, Skewness = .33, Kurtosis = -1.27

Table 1

Descriptive Statistics (M = Mean, SD = Standard Deviation, Skewness and Kurtosis z-scores, α = Cronbach's alpha reliability where relevant) of all Involuntary and Voluntary Cognition Frequency Measures Included in the Study

Frequency	M	SD	Skewness	Kurtosis	α
Involuntary					
Mind-Wandering (MW-S)	4.39	1.56	-.47	-.44	.86
Autobiographical Memory (IAMI-Past)	1.88	.82	-.01	-.34	.94
Future Thinking (IAMI-Future)	1.56	.94	.06	-.84	.95
Semantic Memory (MPQ)	4.42	1.62	.09	-.30	N/A
Musical Imagery (IMIS)	3.35	1.28	-.09	-.67	N/A
Voluntary					
Mind-Wandering (MW-D)	4.85	1.47	-.66	-.03	.89
Autobiographical Memory	1.71	.91	.05	-.67	.92
Future Thinking	1.72	.99	-.04	-.82	.91
Semantic Memory	6.01	2.06	-.61	-.15	N/A
Musical Imagery	3.74	1.30	-.27	-.71	N/A

Note. N = 675; Questionnaires used: MW-S: Spontaneous Mind-Wandering, IAMI: Involuntary Autobiographical Memory Inventory (Past, Future), MPQ: Mind-Popping Questionnaire, IMIS: Involuntary Musical Imagery Scale, MW-D: Deliberate Mind-Wandering.

Table 2

Descriptive Statistics (Mean, Standard Deviation, z-scores for skewness and kurtosis, and alpha reliability) for ACS (Attentional Control Scale: Switch, Focus, and Total)

	M	SD	Skewness	Kurtosis	α
ACS-Switch	12.91	2.77	.12	.10	.73
ACS-Focus	19.52	4.27	-.33	-.06	.84
ACS-Total	53.33	8.73	-.02	.17	.86

Bivariate Correlations: Age and Frequency of Involuntary and Voluntary Cognition

Forms

We examined bivariate Spearman correlations between chronological age and reported frequency of involuntary and voluntary mind-wandering, autobiographical memory, future thinking, semantic memory, and musical imagery. Spearman rho of .10, .30, and .50 are considered small, medium, and large effect sizes, respectively (Cohen, 1988). A visual display of the correlations between age and the characteristics of all types of involuntary and voluntary cognition can be seen in Figure 2. As shown in the top left panel of Figure 2 and in line with our hypothesis, there were negative correlations (ranging from small to medium) between age and frequency for all involuntary cognitions: mind-wandering ($r(673) = -.34, p < .001$), autobiographical memory ($r(673) = -.34, p < .001$), future thinking ($r(673) = -.39, p < .001$), semantic memory ($r(673) = -.15, p < .001$), and musical imagery ($r(673) = -.27, p < .001$).

.001), semantic memory ($r(673) = -.14, p < .001$), and musical imagery¹ ($r(673) = -.37, p < .001$). We found a similar pattern of age-related reductions consisting of negative correlations (small to medium) between age and the frequency of all voluntary cognition forms: mind-wandering ($r(673) = -.24, p < .001$), autobiographical memory ($r(673) = -.32, p < .001$), future thinking ($r(673) = -.43, p < .001$), semantic memory ($r(673) = -.11, p = .004$), and musical imagery ($r(673) = -.30, p < .001$).

Figure 2. Spearman correlations between age and the frequency (top left), vividness (top right), content valence (bottom left), and reaction valence (bottom right) of involuntary and voluntary forms of cognition. The asterisks indicate significant relations, the dark gray colour negative correlations, and the light gray positive correlations.

¹ Correlations between age and IMIS factors: INMI duration section: ($r(673) = .22, p < .001$); INMI duration episode: ($r(673) = -.21, p < .001$); IMIS-NV: ($r(673) = -.19, p < .001$); IMIS – MVMNT: ($r(673) = -.18, p < .001$); IMIS-PR: ($r(673) = -.02, p = .004$); IMIS-HLP: ($r(673) = -.01, p = .34$).

Bivariate Correlations: Age with Attentional Control Scale and Confidence Ratings

Age was significantly associated with ACS-focus ($r(673) = .28, p < .001$), ACS-shift ($r(673) = .15, p < .001$), and ACS-total ($r(673) = .26, p < .001$) indicating that, as age increased, greater attentional control was reported. However, age was not associated with how confident participants were about their reports in relation to how frequently they experience either involuntary cognition forms ($r(673) = -.05, p = .34$) nor voluntary cognition forms ($r(673) = .01, p = .90$).

Partial Correlations with Attentional Control Scale

Finally, we ran partial correlation analyses for all the observed relations between age and the frequency of all involuntary and voluntary forms of cognition while controlling for ACS scores (Attention Control Scale: Focus, Shifting, and Total). All the relations described above remained qualitatively unaltered.

Bivariate Correlations: Age and Phenomenological Characteristics

Next, we explored the bivariate correlations between chronological age and the phenomenological characteristics of involuntary and voluntary forms of cognition such as vividness, content valence, and reaction valence. The size of the correlations between age and the vividness of involuntary cognition forms can be seen in the top right panel of Figure 2. Small but statistically significant correlations were obtained for mind-wandering ($r(673) = -.19, p < .001$) and musical imagery ($r(616) = -.10, p = .02$), indicating that older adults reported reduced vividness, whereas for semantic memory the corresponding association was positive ($r(417) = .19, p < .001$). For voluntary cognition, only two statistically significant correlations obtained, a negative correlation for mind-wandering ($r(673) = -.16, p < .001$) and a small but positive correlation for autobiographical memory ($r(673) = .09, p = .02$). Thus, contrary to our hypothesis, increasing age was not associated with higher vividness for involuntary autobiographical memory.

The correlation coefficients between age and the content valence can be seen in the bottom left panel of Figure 2. Small but statistically significant positive correlations obtained for involuntary autobiographical memory ($r(673) = .14, p < .001$) and involuntary semantic memory ($r(417) = .17, p = .001$), and voluntary semantic memory ($r(645) = .15, p < .001$), indicating that with increased age these cognition forms were reported as more positive. Finally, correlations between age and reaction valence were examined (see the bottom right panel of Figure 2). The observed pattern of significant correlations was similar to that obtained for content valence, showing that reported reaction valence increased with age only for involuntary autobiographical memory ($r(673) = .15, p < .001$), involuntary semantic memory ($r(417) = .20, p < .001$), and voluntary semantic memory ($r(645) = .09, p = .02$).

Discussion

The main aim of the current study was to investigate for the first time the relation between chronological age and concurrently the reported frequency of a range of everyday involuntary and voluntary forms of cognition, namely mind-wandering, autobiographical memory, future thinking, semantic memory, and musical imagery. Furthermore, we explored factors that could help explain frequency decrements in relation to aging, such as attentional control and confidence in self-reports. Our findings replicate previous results but also contribute novel key findings. First, we found that the reported frequency of all involuntary and voluntary forms of cognition we investigated decreased as age increased, in accordance with theoretical accounts of cognitive aging. Secondly, we found that reported attentional control and confidence ratings did not account for any of the observed relations between age and the frequency of involuntary or voluntary cognition forms.

The second aim of our study was to explore for the first time the relation between chronological age and the phenomenological characteristics of everyday involuntary and voluntary forms of cognition. First, we found that, for involuntary and voluntary cognition, there was no consistent pattern relating vividness to age across the forms of cognition.

Secondly, content valence and reaction valence became more pleasant with age for involuntary autobiographical memory and involuntary and voluntary semantic memory, whereas these characteristics were not associated with aging for the rest of the cognition forms examined. Below we synthesize these findings in relation to the existing literature and discuss their implications for future research on cognitive aging as well as involuntary and voluntary forms of cognition.

Aging and the Frequency of Involuntary and Voluntary Cognition Forms

Our findings support our hypothesis, replicate the majority of previous findings, and add to a growing body of evidence showing an age-related decrease in the reported frequency of everyday involuntary and voluntary mind-wandering, autobiographical memory, future thinking, and musical imagery. In addition, we report that the frequency of so far unexplored everyday involuntary and voluntary semantic memory and voluntary musical imagery, also decreases with age. Our findings are especially robust for mind-wandering (involuntary and voluntary) as they replicate the results of previous studies that used the same validated measure (Carriere et al., 2013; Seli et al., 2017) as well as studies that used behavioral and in vivo measures (Giambra, 1989; Jordano & Touron, 2017; Maillet & Rajah, 2013; Maillet et al., 2018; McVay et al., 2013). Our results are also in line with early findings on autobiographical memory (Berntsen & Rubin, 2002; Schlagman et al., 2006; 2007; 2009) but not some recent studies reporting no age-related effects in the frequency of involuntary (Berntsen et al., 2015, 2017; Warden et al., 2018) and voluntary (Warden et al., 2018) autobiographical memory. Possible explanations for the discrepancy with Berntsen et al. (2015), despite using the same measure (IAMI), could be that we treated age as a continuous variable whereas they created different age groups, a procedure that can result in loss of statistical power. On the other hand, our discrepancy with Warden et al. (2018) may be due to

the different methodologies used, as they used in vivo measures whereas we used a retrospective survey.

Our findings agree with prior results showing a decrease in reported frequency of involuntary musical imagery with increasing age (Liikkanen, 2012). They also provide new insights on voluntary musical imagery as well as involuntary and voluntary semantic memory. It is intriguing that, although involuntary musical imagery has been suggested to constitute a form of involuntary semantic memory (Kvavilashvili & Mandler, 2004), the relation with age was much stronger for the former ($r = -.37$) than the latter ($r = -.14$) in our data. A potential explanation could lie in the fact that, although semantic memory is relatively unaffected by aging (Salthouse, 1991), involuntary musical imagery is particularly boosted by current exposure and engagement in music (Floridou et al., 2015; Liikkanen, 2012), especially in younger people, factors that in turn decrease with age (Müllensiefen et al., 2014). As involuntary musical imagery is one of the few forms of cognition where multiple cues and situational antecedents related to its occurrence have been identified (Williamson et al., 2012), future studies should investigate whether age-related changes in cues that can trigger it, such as engagement in music, potentially account for the decrease with age of both involuntary and voluntary musical imagery.

The finding that the reported frequency of all forms of everyday involuntary and voluntary cognition that we investigated decreases as age increases is important. Despite the differences between cognition forms under investigation, e.g., in terms of their content, our findings support that their reported frequency follows a common trajectory. This could be an indication of a common onset-independent mechanism, which is similarly affected by aging. An alternative explanation could be related to the self-report and retrospective nature of the questionnaires and how the perception and meta-awareness of the reported frequency of involuntary and voluntary cognition might be similarly affected by aging, which requires

further investigation. To place the present findings in context, we next consider factors that we explored that could help explain the reported frequency decrease of all involuntary and voluntary cognition forms with age.

Explanations for Age-related Changes in Frequency of Involuntary and Voluntary Forms of Cognition

The observed decrease in the frequency of involuntary and voluntary cognition forms is aligned with the cognitive aging accounts of attentional resources as well as memory processes (Craik, 1986; Craik & Byrd, 1982), both of which predict frequency decreases with age. However, the decrease in the present study could not be attributed to changes in reported attentional control as measured by the ACS. It is worth noting that all factors related to attentional control correlated positively with age, meaning that older adults report that they modulate their attention better than younger adults. If the attentional resources account is valid, this could mean that, although attentional resources may be more limited in older adults, those resources are allocated more efficiently by older adults when engaged in a task. This finding, which might at first seem implausible, is in accordance with behavioral and electrophysiological findings that show that, under certain circumstances, older adults can score higher in sustained attention tasks than younger adults (McVay, Meier, Touron, & Kane, 2013; Staub-Doignon-Camus, Bacon, & Bonnefond, 2014), which in turn has been shown to be associated with attentional control (Herrmann et al., 2003; Wiersema & Roeyers, 2009). Furthermore, previous studies have also reported small but significant correlations between age and the ACS (Olafsson et al., 2011), albeit in a sample with a restricted age range. Nevertheless, as the ACS measure did not account here for the observed frequency decrease, the explanatory power of this account associated to attentional control, seems low. As other researchers have suggested (Kane et al., 2015; Seli et al., 2017), a main limitation of the attentional resources account is that it can accommodate any direction of prediction, as

has happened in other studies that have used the theory to predict preservation of involuntary thought processes in older age (McDaniel & Einstein, 2000; Warden et al., 2018).

The next factor we explored was confidence ratings as a proxy for the validity of retrospective frequency self-reports. It has been argued that older adults' reports may not be veridical due to limited awareness and memory of how frequently involuntary cognition forms occur (Jackson & Balota, 2012; Zavagnin, Borella, & De Beni, 2014). Although these concerns form a reasonable basis for a reduced validity of self-reports, especially in older adults, our data do not support this idea; confidence ratings of reported frequency of all involuntary and voluntary cognition forms were not associated with age. This is in agreement with the findings of previous studies on mind-wandering that used eye tracking as well as behavioral self-reports. These supported the position that that objective and subjective measures in older adults are valid and therefore thought reports of this population do not suffer from reporting bias (Frank et al., 2015) although these reports are in-vivo behavioral that can be different than our retrospective self-reports. This finding about confidence ratings is promising given the implication for research on the links between involuntary and voluntary cognition forms and aging, although more research is needed to confirm the validity of confidence ratings (Meier, 2018).

An alternative explanation for the decrease in frequency of involuntary and voluntary cognition forms in combination with the increased attentional control in older age is that older adults may have developed mechanisms to be more mindful, i.e., in a mental state characterized by present moment awareness, non-judgmentally. This interpretation is in accordance with the socioemotional selectivity theory (Carstensen, 1992, 1995), which suggests that people become more fully oriented in the present with aging. Indeed, studies on dispositional mindfulness have found that it increases with age (Baer, Smith, & Allen, 2009; Frank et al., 2015; Prakash et al., 2015). Higher mindfulness has been associated with

reduced mind-wandering frequency across age groups (Mrazek et al., 2013; Mrazek, Smallwood, & Schooler, 2012; Prakash et al., 2014), with older adults reporting higher trait mindfulness and less mind-wandering than young adults (Fountain-Zaragoza, Puccetti, Whitmoyer, & Prakash, 2018). Although our finding of increased attentional control with age supports such an interpretation in terms of mindfulness, further investigation is required as this state goes beyond factors of attentional control. Other key factors that may drive these changes and have been reported to be associated with decreased reported frequency, at least for mind-wandering, are related to higher interest and motivation about the task at hand (Seli et al., 2017) and fewer current concerns (McVay et al., 2013) in older age.

Phenomenological Characteristics of Involuntary and Voluntary Forms of Cognition

Our findings regarding the phenomenological characteristics of involuntary and voluntary cognition across the lifespan follow a more diverse set of trajectories relative to that concerning frequency. Reported vividness was not related to age for half of the involuntary and voluntary cognition forms we assessed (involuntary: autobiographical memory and future thinking; voluntary: future thinking, semantic memory, and musical imagery). We found small increases with age only for involuntary semantic memory and voluntary autobiographical memory, and decreases for mind-wandering (involuntary and voluntary) as well as involuntary musical imagery. Our findings contradict our hypothesis about involuntary autobiographical memory, which predicted vividness increases with age (Schlagman et al., 2006; 2007; 2009). However, our findings do agree with reports in the mental imagery literature, which do not typically report associations, or find very small associations, between age and the vividness of various mental imagery stimulus-modalities (Floridou, Peerdeman, & Schaefer, 2019; Lima et al., 2015; Mailouin et al., 2010; Mulder et al., 2007; Saimpont et al., 2012). It has been argued that mental imagery is a fundamental feature of voluntary autobiographical memory and contributes to several of its

phenomenological characteristics (Conway, 2009; Greenberg & Knowlton, 2014) such as vividness (D'Argembeau & Van der Linden, 2006). Previous studies have revealed similarities between imagining the future in an episodic simulation sense and recalling the past in terms of the neurocognitive correlates (Conway, Loveday, & Cole, 2016; Thakral, Madore, & Schacter, 2017) and that mental imagery is associated with mind-wandering (Medea et al., 2018) and semantic memory (Kvavilashvili & Mandler, 2004). Such findings indicate that these cognition forms could be represented in the mind through mental imagery, something that could explain the similarity of our to prior findings in vividness in relation to age. Future investigations on this hypothesis could build on studies that have explored the link between mental imagery and involuntary and voluntary cognition forms together (Floridou, Williamson, & Emerson, 2018; Vannucci et al., 2016, Medea et al., 2018).

Finally, content and reaction valence were found to increase with age for involuntary autobiographical memory as well as involuntary and voluntary semantic memory. These findings are in agreement with those of Berntsen et al. (2015), who found that older adults experience more positive involuntary autobiographical memory. It is currently unclear whether this is due to a positivity bias, i.e., an enhanced tendency to recall positive autobiographical memories, or to an absence of a negativity effect in old age (decrease of negative memories without an increase in positive ones; Mather et al., 2004; Schlagman et al., 2006), something vital for emotional wellbeing (Erikson, 1982; Erikson & Erikson, 1997), or both. It is interesting to note that involuntary musical imagery content and reaction valence were not associated with age. However, we found that "Negative Valence", a 7-item comprehensive factor of the involuntary musical imagery scale (IMIS), which measures the subjective evaluation of involuntary musical imagery experiences, decreases as age increases (Footnote 1). This finding supports the notion of Schlagman et al. (2009) who although did not find any tendency for people to report more pleasant involuntary autobiographical

memories when getting older, observed that older adults were less likely to report memories of negative nature, in harmony with our findings for involuntary musical imagery.

Regarding reaction valence, our findings on involuntary autobiographical memory, and involuntary and voluntary semantic memory, corroborate literature reports about positive affect increasing with age (Mroszeck & Kolarz, 1998). Furthermore, our findings on involuntary musical imagery support the reports that negative affect for this form of cognition specifically decreases with age (Carstensen et al., 2000). Taken together, and in conjunction with the trend we found for the reported frequency of involuntary cognition forms to decrease as age increases, these findings speak to the heart of cognitive aging and affect. Increased mind-wandering frequency has been linked to increased unhappiness (Kane et al., 2017; Killingsworth & Gilbert, 2010; Maillet et al., 2018), implying that our observation of reduced frequency for all cognition forms and increases in content and reaction valence, at least for some cognition forms, may reflect more effective emotion regulation in older adults (Mather & Carstensen, 2005; Urry & Gross, 2010). Furthermore, this would explain the increase we found in reported attentional control as older adults who show the fewest signs of cognitive decline are the ones who are more likely to show positivity effects that help regulate emotion (Mather & Carstensen, 2005). It would be of interest for future studies to explore separately the frequency rates of positive, neutral, and negative involuntary and voluntary forms of cognition across the lifespan. Finally, future studies should look at emotional regulation and general wellbeing in relation to these characteristics throughout the adult lifespan and explore whether they also increase with age.

Limitations

Several caveats must be considered when interpreting our findings. The first relates to the use of retrospective questionnaires. Calculating the average of characteristics in a trait-level manner might be susceptible to retrospective memory biases, especially for older adults.

Indeed, previous studies have found discrepancies between retrospective and in-vivo reports of involuntary semantic memory (Kvavilashvili & Mandler, 2004) and involuntary musical imagery (Floridou & Müllensiefen, 2015). To address this issue, where possible we used measures with robust psychometric profiles that have been found to validate well with in vivo reports of frequency of involuntary and voluntary mind-wandering (Seli, Risko, & Smilek, 2016) and involuntary musical imagery (Cotter & Silvia, 2016). We also employed confidence ratings, a measure previously shown to be a good indicator of the validity of the participant reports. Future studies could investigate all these cognition forms simultaneously with in vivo measures and explore whether they can replicate the current findings.

Furthermore as the size of some of the reported correlation coefficients are small, our findings require replication to be interpreted with confidence. In addition, as our findings depend on people's reports, we cannot be certain that the observed relations are due to how these cognition forms are experienced or, instead, are related to certain reporting styles, an issue inherent to all studies that depend on subjective self-reports. As there is still no consensus on the most valid approach to the study of these phenomena, in our study we measured confidence ratings. Future studies could use other objective measures, such as eye-tracking, as measures of pupil size have been found to associate with mind-wandering occurrence (Frank et al., 2015; Konishi et al., 2017; Smallwood et al., 2011). Finally, another limitation of our study relates to the significant difference in the reported health between young and old adults. Although such variation can be considered normal, as aging is associated with health changes, future studies could aim to control for this difference, beginning at the stage of recruitment.

Concluding Remarks and Future Directions

Our findings support a growing consensus in research that increasing age is associated with a decrease in the reported frequency of certain everyday involuntary and voluntary

forms of cognition. Taken together, the results support the hypothesis that all involuntary and voluntary cognition forms follow a common trajectory with age and that, potentially, a common underlying mechanism that is associated with their onset is similarly affected by aging. Our findings also suggest that the observed decreasing frequency with age for all cognition forms, although in agreement with theoretical accounts of cognitive aging, is not explained by changes in self-report attentional control nor can it be attributed to the reporting style of older adults as measured by confidence ratings. Although the reported frequency decrease could be seen as a negative consequence of aging, our data also indicate that some of these cognition forms are experienced as more pleasant, or at least not unpleasant, in older adults. These observations point to more positive outcomes associated with older adults being more mindful and present in the moment. Alongside results relating to frequency, we show that reported vividness, content and reaction valence have varied age-related patterns for different cognition forms. This heterogeneity in outcome indicates that the mechanisms associated with their phenomenological experience are dependent on the cognition form and the intentionality of the cognition form. They are therefore likely to be differentially affected by aging due to different content, temporality, and modality of the cognition forms.

As the first study that has applied a family-resemblances approach at the methodological level, we invite researchers of involuntary and voluntary cognition forms to adopt the unified approach we have taken and expand it to other cognition forms. This approach will further clarify the connections between the onset as well as the cognition form dependent and independent mechanisms that underlie these cognition forms and subsequently increase conceptual and methodological understanding both in general and more specifically in relation to aging.

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Footnotes

¹ Correlations between age and IMIS factors: INMI duration section: $r(673) = .22, p < .001$; INMI duration episode: $r(673) = -.21, p < .001$; IMIS-NV: $r(673) = -.19, p < .001$; IMIS – MVMNT: $r(673) = -.18, p < .001$; IMIS-PR: $r(673) = -.02, p = .004$; IMIS-HLP: $r(673) = -.01, p = .34$.

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