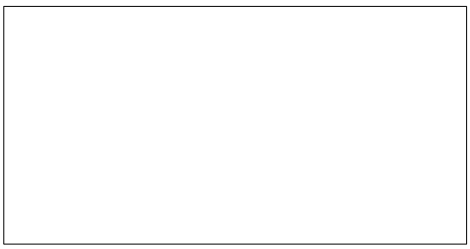

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Spontaneous future cognition: The past, present and future of an emerging topic

Cole, Scott[1] & Kvavilashvili, Lia[2]

York St John University[1], University of Hertfordshire[2]

Correspondence should be sent to:
Dr. Scott Cole
Senior Lecturer, Psychology,
School of Psychological and Social Sciences
York St John University
York, YO31 7EX
Email: cole.s.n80@gmail.com
Office Phone: 01904 876680

Abstract

In this Editorial, we discuss the past, present and future of an emerging and fast-developing field – spontaneous future cognition. In tracking the past of this research, the trajectories of research on mind-wandering, episodic future thinking and prospective memory are briefly examined, and their relation with spontaneous future cognition demarcated. Three broad methodological approaches (*questionnaire*, *naturalistic* and *laboratory*) used to study spontaneous future thoughts are described, providing an overview of the field. The present state of this research is represented by a themed analysis of the articles included in this Special Issue. The breadth of studies (covering cognitive mechanisms, developmental stages and psychopathology) have already led to important insights, especially concerning the conditions in which spontaneous future thoughts most commonly arise and who may be predisposed to experiencing them. In the future, greater effort should focus on developing a theoretical account of spontaneous future cognition – this may increase our understanding of *how* and *why* spontaneous future thoughts occur. If future research in this area reflects the diversity and depth within this Special Issue, a flourishing of research on spontaneous future cognition will be on the horizon in years or perhaps decades to come.

Spontaneous future cognition: The past, present and future of an emerging topic

In the last decade, there has been an explosion of interest among cognitive psychologists and neuroscientists towards studying involuntary or spontaneous cognitive phenomena in the form of conscious thoughts and memories that come to mind without a deliberate intention to have them (e.g., having a thought about an upcoming exam while driving to work). A second stream of research has examined the nature and characteristics of how humans deliberately imagine the future (termed *future thinking*). From a synergy of these two research streams a new topic has now emerged that can be referred to as *spontaneous future cognition* or, more specifically, as *spontaneous episodic future thinking*. A key motivator for this special issue was the workshop on 'Spontaneous Future Projections in Healthy Individuals and in Psychological Disorders' held in York (UK) in July, 2017. The number, diversity and quality of research presented at this workshop demonstrated a vibrant and emerging area, prompting us to bring together most recent research in a special issue, and showcasing the 'state of play' of the field.

In this collection of papers, we demonstrate that this relatively new field has (1) already attracted researchers from diverse areas (e.g., developmental, clinical and experimental psychology) and (2) has started to deliver insights on how, when and to whom spontaneous future thoughts occur. However, we also appreciate that the area is in an embryonic state, and, as such, requires a solid evidence-based conceptual framework from which to understand its history, clarify its present and guide its future. To this end, this Editorial presents a brief timeline and conceptual framework for *spontaneous future cognition*, and summarises the diverse contributions within the Issue. Foreshadowing some of this paper, we believe the emerging research in this area presents some challenges for related and more traditional approaches to research on episodic future thinking, mind-wandering and prospective memory, but we also

focus on the various new and exciting opportunities this creates for researchers examining basic science and those interested in clinical applications.

The Past: Brief Historical Overview

If interest in spontaneous cognition were plotted on a frequency graph with time on the x-axis, it would form two 'peaks'. The first peak occurred in the 1960s. Following a deterioration in belief that behaviourism could offer a fundamental understanding of psychology, a flurry of research emerged interested in the internally-generated contents of the mind, eschewing psychology's tradition of examining task-related cognitive processes (hence the term *stimulus-independent thought*, Singer, 1966). In the midst of the 'cognitive revolution' of the 1960s were several ground-breaking studies on the contents of the meandering mind, broadly concerned with understanding *spontaneous thought* (Antrobus, 1968; Antrobus, Singer & Greenberg, 1966). This first 'peak' led to important books and periodicals subsequently published in the 1970s and 1980s (Giambra, 1977; Klinger & Cox, 1978; Klinger, 1971, 1978), but with interest waning thereafter.

The second peak came with the emergence of a striking finding that a distinct and dissociable neuroanatomical network becomes active when people are ostensibly off-task, and is deactivated when they are on-task (Andreasen, O'Leary, Cizadlo, Arndt, & Rezai, 1995; Raichle, Macleod, Snyder, Powers, Gusnard & Shulman, 2001; Shulman et al., 1997). This initiated a vibrant upsurge of research on the neuroscience of the *default mode network* (a distributed brain network including medial prefrontal cortices, medial temporal lobes, and posterior cingulate) characterised as a set of interconnected nodes in the brain that support spontaneous, unconstrained task-unrelated thoughts or mind-wandering (e.g., Buckner & Carroll, 2007; Vincent et al., 2006; Spreng & Schacter, 2012).

In addition to neuroscientific research, the idea that ongoing internal thought was the 'mental baseline' (Klinger, Marchetti & Koster, 2018) led to an expansion in cognitive research on spontaneous thought or mind-wandering, as it is now commonly termed (see Smallwood & Schooler, 2006; Smallwood & Schooler, 2015 for informative reviews). With the finding of a large prevalence of unconstrained thought in everyday life (see Killingsworth & Gilbert, 2011, Klinger & Cox, 1978), estimated at 1,300-2000 spontaneous thoughts per day (Klinger, 1990), much of this research aimed to first characterise the content of spontaneous thought, in addition to examining when, where and why these thoughts occur (e.g., Baird, Smallwood & Schooler, 2011; Kane et al., 2007; see also a recent edited book by Fox & Christoff, 2018a). Intriguingly, the word 'default' was used across these two peaks (Klinger, 1971; Kane & McVay, 2010; Raichle et al., 2001; Buckner & Carroll, 2007) suggesting that humans have unique neuropsychological processes that are responsible for a 'basic' mode of thought that is unintended, prevalent and relatively automatic (see Berntsen, 2012, for a similar argument concerning involuntary memories and future thinking). Importantly, a large number of studies on mind-wandering have reported that unconstrained thoughts have a tendency to be oriented to the person's future than the past. This prospective bias in the temporal focus of mind-wandering has been documented both inside (e.g., Baird et al., 2011; Smallwood, Nind & O'Connor, 2009) and outside (e.g., Andrews-Hanna, Kaiser, Turner, Reineberg, Godinez et al., 2013) controlled laboratory conditions (for review, see Stawarczyk, 2018).[1]

[1] It is, however, important to note that several studies, including some papers in this issue, have not found the prospective bias in task-unrelated spontaneous thoughts. Some of these studies have reported the prevalence of spontaneous thoughts about the past (e.g., Berntsen, Rubin, Salgado, 2015; Krans, de Bree & Moulds, 2015; Plimpton, Patel, & Kvavilashvili, 2015), while others have reported equal numbers of past and future thoughts (e.g., Mason et al., 2007; McVay, Unsworth, McMillan & Kane, 2013).

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In parallel, but often *not* in synergy, is research on future thinking, where the focus has been specifically on the cognitive processes and characteristics of future thinking (variously termed *future mental time travel*, *prospection* or *episodic future thinking*). The standard paradigm used in this field involves the cue-word method in which individuals voluntarily access their long-term memory and flexibly create plausible future events related to specific words (e.g., Addis, Wong & Schacter, 2007; D'Argembeau & Van der Linden, 2004; Irish, Addis, Hodges & Piguet, 2012). Using this paradigm, several influential studies within cognitive, neuropsychological and neuroscientific literature, have found intrinsic links between episodic memory and episodic future thinking, often referred to as mental time travel (Wheeler, Stuss & Tulving, 1997), which has been assumed to indicate common underlying neuropsychological processes (Addis et al., 2007; D'Argembeau & Van der Linden, 2004; Hassabis, Kumaran, Vann & Maguire, 2007).[2] Research on episodic future thinking has since become a 'major growth industry' (p. 65, Klein, 2013), with hundreds of published studies, several special issues (e.g., *Cognitive Development, European Journal of Social Psychology, British Journal of Clinical Psychology, Quarterly Journal of Experimental Psychology*), and two edited books (Michaelian, Klein & Szpunar, 2016; Oettingen, Sevincer & Gollwitzer, 2018) on the topic. We make a simple point: Just as we cannot comprehend human psychology from studying only males, we can never understand future thinking by studying only deliberate cognition.

Echoing this sentiment, there is now a small but growing number of studies that have started to explore the *who*, *when*, and *how* questions of involuntary or spontaneous future thought (e.g., Cole, Staugaard & Berntsen, 2016; Berntsen & Jacobsen, 2008; Plimpton, Patel &

[2] However, there is also a large body of research, which shows important asymmetries between the two process (for discussion, see Irish & Piguet, 2013; Klein 2016; Suddendorf, 2010).

Kvavilashvili., 2015; Vannucci, Pelagatti & Marchetti, 2017). This research has mainly evolved from the study of involuntary autobiographical memories, adopting its methodological tools (diary and lab methods) to examine its future counterpart in the form of involuntary thoughts about imaginary future events. The first study to systematically examine the existence and characteristics of spontaneous future thoughts in healthy adults was carried out in Dorthe Berntsen's lab (Berntsen & Jacobsen, 2008) in which 'involuntary future representations' were compared with their voluntary counterparts (in addition to voluntary and involuntary memories). In Berntsen and Jacobsen's study, participants were asked to (1) briefly describe a spontaneous future thought whenever it occurred along with completing several rating scales, (2) complete a detailed questionnaire on each report (this was completed retrospectively, later in the day), and (3) report deliberately constructed future events using the cue-word method described above. Results showed that spontaneous future thoughts were reported fairly frequently, often referred to specific events and were generally associated with feelings of mental time travel (or 'pre-living'). As with involuntary autobiographical memories (Berntsen, 1998), the content of the event was often semantically related to some aspects of the context in which it occurred. This work drew largely on the concept of mental time travel, but emphasised that it could be achieved *spontaneously*.

For further insights, we may look to different, but related, research areas, which have nonetheless examined forms of spontaneous future cognition. For example, the study of spontaneous future thought has also been embedded in research and theories of prospective memory, even if methods often do not permit evaluation of the 'episodic nature' and mental time travel aspect of the future thoughts (Klein, 2013; Tulving, 2005). In the field of prospective memory, researchers study the ability to remember to carry out an action in response to a specific

event or time in the future (e.g., passing on a message to colleagues at the next meeting or phoning a friend at 7pm tomorrow) (Kvavilashvili & Ellis, 2004; McDaniel & Einstein, 2007). This involves several discreet stages and processes: (1) deliberately forming a representation of intended action and the context, in which it will be carried out, in the mind's eye at the time of encoding; (2) a delay interval in which a person is engaged in other unrelated tasks, but may nevertheless spontaneously or deliberately think about their upcoming task, and, (3) retrieving and executing the intended action in response to the right event or the time (Ellis, 1996).

Most prospective memory research has been conducted in the laboratory and focussed on variables affecting the retrieval of intentions when the appropriate event or time arrives, in other words, how the attention shifts from an ongoing task to a to-be-performed task. The influential multiprocess framework (originally introduced by McDaniel & Einstein, 2000; see also Scullin, McDaniel & Shelton, 2013) attempts to explain event-based prospective memory by indicating two routes to remembering an intention, one self-initiated (based on strategic search processes) and one spontaneous (when the intention pops into mind in response to the target event). However, the potential role of episodic future thinking at encoding stages of prospective memory tasks was emphasised as early as in 2001 by Atance and O'Neill, when they introduced the concept of episodic future thinking, and indeed, several studies have now demonstrated how future thinking at the encoding stage enhances subsequent prospective memory performance (for a review, see Kvavilashvili & Rummel, 2019).

Most importantly, several diary and experience sampling studies have now also demonstrated that in everyday life, where prospective memory tasks usually involve long retention intervals of hours and days, people often spontaneously experience thoughts about their future (as yet uncompleted) prospective memory tasks while performing other unrelated

activities (e.g., Anderson & McDaniel, 2019; Kvavilashvili & Fisher, 2007; Szarras & Niedźwieńska, 2011; Warden, Plimpton & Kvavilashvili, this issue). The evidence for such spontaneous prospective memory task related thoughts has also been documented in laboratory studies of mind-wandering where participants are stopped intermittently during the monotonous and easy vigilance tasks and asked to report any thoughts they had at the time (Mazzoni, this issue; Plimpton et al., 2015). For a schematic diagram of how the three main fields of episodic future thinking, mind-wandering, and prospective memory relate to or incorporate spontaneous future cognition, see Figure 1. The main idea behind this diagram is that parts of the phenomena studied under the umbrella terms of mind-wandering and prospective memory overlap with the core of the phenomenon that is now being studied as the newly emerging topic of spontaneous future cognition, and that the field of episodic future thinking needs to incorporate research on both voluntary and involuntary aspects of the phenomenon.

Further evidence of spontaneous future thoughts can be found in the literature on psychological disorders (for review, see Berntsen, this issue). Since a landmark study, demonstrating that individuals with a history of attempted suicide, experience ‘flash-forwards’, representing vivid imagery of future suicide attempts (Holmes, Crane, Fennell & Williams, 2007), clinical research focussing on spontaneous future thinking has gained momentum. For instance, recent studies have examined the qualities of spontaneous future thoughts in bipolar disorder (DiSimplico, Renner, Blackwell, Mitchell, Stratford et al., 2016), post traumatic stress disorder (Berntsen & Rubin, 2015), and obsessive compulsive disorder (Seli, Risko, Purdon & Smilek, 2016).

-INSERT FIGURE 1 HERE-

By investigating spontaneous future cognition, we may be able to increase understanding of the psychological processes underlying spontaneous thoughts more generally and the default mode network with which they are associated (Christoff, Irving, Fox, Spreng, Andrews-Hanna, 2016). Moreover, if we know that future thinking accommodates a large proportion of all spontaneous thoughts, and future thinking has primarily been explored in paradigms emphasising voluntary mechanisms, the large gap in the research (and our knowledge) becomes clear. Given the considerable scientific breakthroughs already evident from voluntary forms of episodic future thinking (e.g., Addis et al., 2007; Schacter, Benoit, & Szpunar, 2017), the opportunities for similar innovative findings in its spontaneous variant are now difficult to ignore. Spontaneous future cognition may have important, yet undiscovered, roles in specific populations (healthy or clinical, see Holmes et al., 2007; Hoffmann, Banzhaf, Kanske, Bermpohl & Singer, 2016, for initial insights on depression) and across developmental stages of life (see McCormack, Burns, O'Connor, Jaroslawska & Caruso, this issue; Warden et al., this issue). Spontaneous future cognition may also be affected in unique ways by environmental, social and personality factors. In establishing a special issue explicitly concerned with *spontaneous future cognition*, our hope was to energise research in this area and encourage cross-talk between areas that have operated relatively independently.

Towards a Conceptual Definition

Defining spontaneous future cognition will prove a challenge if we attempt to simply combine previous definitions of spontaneous thought and future thinking, because both involve multiple terminologies resulting from their links with unique and heterogenous research fields (note recent debates within the field of mind-wandering, see Christoff, Mills, Andrews-Hanna, Thompson, Fox et al., 2018; Seli, Kane, Smallwood, Maillet, Schooler et al., 2018; Seli, Kane,

Metzinger, Maillet, Schooler et al., 2018). As we are presenting a new topic of research (albeit arising from different academic-historical trajectories), it is important to establish basic principles of what spontaneous future thought is and is not. In defining this term, we outline its spontaneous- and future- related components, individually.

Throughout the past fifty years of research on spontaneous thought, a multitude of terms have been used to describe it. *Mind wandering* (Smallwood & Schooler, 2006), *daydreaming* (Klinger & Cox, 1977-78), *random episodic silent thought* (Andreasen et al., 1995), *task-unrelated thought* (Giambra, 1995), *stimulus-independent* (Antrobus,1968), and *self-generated thought* (Smallwood, 2013) have all been applied to describe spontaneous mental content and related phenomena. To provide a conceptual definition that encapsulates research on spontaneous future cognition so far, we use the most parsimonious and consensual account of spontaneous thought, defining the spontaneous component of future thought as *unintended thought that comes to mind with little effort and little control over its content* (see Fox & Christoff, 2018b; Klinger, 2009). At this early stage, we see it appropriate to leave open the relevance of other aspects such as task-relatedness (i.e., task-related versus task-unrelated thought), stimulus-relatedness (stimulus-independent versus stimulus-dependent), and cuing (i.e., internal versus external, see Klinger et al., 2018), as we believe that these factors may offer independent insights into the phenomenon (e.g., the extent to which external stimuli cues internal trains of thought that appear spontaneous), but are not yet central to our current working conceptualisation (in fact, they could be orthogonal to the spontaneous nature of future thought, in that whether a thought is cued internally or externally is independent of whether it is experienced as spontaneous) (see also Berntsen, this issue, for further discussion). Ultimately, we associate spontaneous mental processes with what has been termed System 1 processes, which stand in contrast to deliberate

mental processes (termed System 2 processes, associated with high effort, and slow, analytic processes, such as planning one's weekly groceries or calculating 25 x 12. For reviews see Evans, 2008; Kahneman, 2011; Sripada, 2018).

Broadly conceived, future thinking can be described as any thought that is about the future, which could be personal or non-personal, specific or abstract. However, researchers have largely concerned themselves with personal or autobiographical future scenarios, whether that be a future event, complete with spatio-temporal clarity (e.g., Schacter & Addis, 2007; Hassabis & Maguire, 2007) or more general, semantic or factual elements concerning one's future (e.g., Irish & Piguet, 2013). Indeed, all studies in this Issue examine phenomena that are spontaneous and future-related, as defined here, albeit with variability in their operationalisation and forms of measurement. Thus, our definition of involuntary[3] or spontaneous future cognition can be phrased as *unintended thought, related to the future, that comes to mind with little effort and little control over its content*. We hold that this conceptual definition allows its application among a wide variety of studies covering mental time travel, mind-wandering, prospective memory and clinical disorders (but see Berntsen, this issue, who considers spontaneous future thinking as separate from the phenomenon of mind-wandering on the grounds that the latter can be intentional, while the former is by definition, unintentional). In our view, definitional clarity will not only strengthen our understanding of prior research, but can instigate and consolidate more focussed research on the topic in years to come.

Methodology

[3] Even though there are subtle differences in dictionary definitions of 'involuntary' and 'spontaneous', because these phrases are used interchangeably in the literature, we adopt the same approach here (i.e., both denote the same phenomena when concerning the topic of the special issue). It is also reflected in the articles within the special issue, with some using involuntary and some using spontaneous when referring to the same phenomena.

Here, in order to contextualise studies in this Issue, we describe three prominent methods used to examine spontaneous thought: *questionnaires, naturalistic diaries and experience sampling*, and *laboratory-based* methods (see Klinger, 1978; Smallwood & Schooler, 2006; 2015 for informative reviews of measuring spontaneous thought).

Questionnaire Methods

Borrowing from the individual differences approach, several studies have used a questionnaire method to obtain retrospective estimates and reflections on one's experiences of spontaneous thoughts (e.g., Berntsen, Rubin & Salgado, 2015; Giambra, 1977; Singer & Antrobus, 1963). To date, validated questionnaires have focussed on various aspects of spontaneous thoughts, such as involuntary future thoughts (Berntsen et al., 2015), task-unrelated thought (Matthews, Joyner, Gilliland, Campbell, Huggins et al., 1999), daydreaming (Singer & Antrobus, 1963), intrusive spontaneous imagery (Berntsen & Rubin, 2015) and mind-wandering (Mrazek, Phillips, Franklin, Broadway & Schooler, 2013). Many of these scales are validated against naturalistic or laboratory methods (e.g., Mrazek et al., 2013) and provide a useful way to assess trait-level tendencies to experience spontaneous thoughts. However, as has been indicated previously (Klinger, 1978), retrospective methods rely on memory, which may fade or change over time, especially when dealing with such transient and dynamic cognitive processes as involved in spontaneous thought flow. Also, individuals may not be aware of one's mind-wandering tendencies, until they are probed (Smallwood & Schooler, 2006). Despite these limitations, convergent validity across on-line and retrospective methods indicate the usefulness of these measures.

Naturalistic Methods

One method, high in ecological validity, and often used in the study of spontaneous cognition, involves the measurement of spontaneous thoughts when participants are going about daily activities – providing real-world, real-time sampling of thoughts. Typically, in experience sampling studies of mind-wandering, a probe-caught method is being used, whereby participants carry a mobile device that 'beeps' at regular intervals, prompting participants to answer questions about the studied phenomenon at the time of the beep (Klinger, 1977-78; Killingsworth & Gilbert, 2010). In contrast, a self-caught method has been used in diary studies, where participants report the occurrence of mental phenomena as and when they occur by answering a questionnaire on a dairy page. Such diary methods have been very effective in providing essential information about the frequency and nature of involuntary memories and involuntary future thoughts in everyday life (e.g. Berntsen & Jacobsen, 2008; D'Argembeau, Renaud, Van der Linden, 2011; Finnbogadóttir & Berntsen, 2011).

Laboratory Methods

From its beginnings, the use of laboratory methods has been popular in research on spontaneous thoughts, as one is able to assess effects of manipulating task variables upon the frequency and characteristics of thoughts (see Smallwood & Schooler, 2006). Laboratory studies of spontaneous thoughts involve tasks designed as convenient analogues to mimic daily tasks in which the mind wanders (e.g., *driving*, Antrobus et al., 1966). Such methods have proved particularly valuable in examining the cognitive mechanisms underlying the occurrence of mind-wandering experiences, in particular the effect of mind-wandering on concurrent task performance (see Smallwood & Schooler, 2006; Kane & McVay, 2012). A range of cognitive tasks have been utilised, including vigilance tasks (e.g., *signal detection tasks*, Antrobus et al.,1966; *line detection tasks*, Plimpton et al., 2015, see also Giambra, 1995), reading tasks

(Schooler, Reichle, and Halpern, 2005), go/no-go tasks (e.g., the *Sustained Attention to Response Task*, or SART, Robertson, Manly, Andrade, Baddeley & Yiend, 1997; McVay & Kane, 2009), or choice reaction time tasks (Baird et al., 2011). In addition, O'Callaghan and colleagues have recently developed a novel shape expectations task, which may be particularly useful in studying spontaneous thoughts in ageing and clinical populations (O'Callaghan, Shine, Lewis, Andrews-Hanna, & Irish, 2015; O'Callaghan, Shine, Hodges, Andrews-Hanna, & Irish, 2019) (see also Irish, Goldberg, Alaeddin, O'Callaghan & Andrews-Hanna, this issue). Generally, tasks that require rapid perceptual processing (e.g., fast presentation rate, see Antrobus et al., 1966) and tax cognitive resources (see McVay & Kane, 2009) reduce frequencies of spontaneous thought, although how this relates to spontaneous future thought is an open question (but is addressed in Mazzoni, this issue, and Barzykowski, Radel, Niedźwieńska & Kvavilashvili, this issue; see also Smallwood et al., 2009).

At outset, it is important to clarify a key consideration within laboratory studies: Whether to use a *self-caught* or *probe-caught* method (as outlined in the highly-cited review by Smallwood & Schooler, 2006).[4] To characterise and examine the implications of these methods, we will explain them in an example of a vigilance task – a task that has been adopted in both first and second 'peaks' to capture and study spontaneous thought (Antrobus et al., 1966; Giambra, 1995; Plimpton et al., 2015). Vigilance tasks involve maintaining continuous attention in the service of detecting signals or stimuli which occur in an unpredictable sequence. The participant is presented with a continuous sequence of hundreds of slides (e.g., 600), each shown briefly (e.g., 1.5 or 2 seconds). In addition, verbal phrases (e.g., 'lucky find', 'coffee jar') are embedded

[4] It should be noted that this distinction also applies to naturalistic studies, but we focus on laboratory studies here as the majority of studies in this special issue employ laboratory paradigms (but see Beaty, Seli & Schacter, this issue; Warden et al., this issue).

on each slide (or some of the slides), as they have been shown to reliably trigger spontaneous thoughts (e.g., see Cole et al., 2016; Mazzoni, Vannucci & Batool, 2014; McVay & Kane, 2013; Schlagman & Kvavilashvili, 2008). The primary task involves identifying infrequently-presented targets (vertical line arrays) among frequently-presented non-targets (horizontal line arrays). A secondary aspect involves recording thoughts that arise at points throughout the task. If participants are asked to monitor their thoughts and report when spontaneous thoughts occur, they will be using the *self-caught* method. The advantage of this method is that, by using informative descriptions, only certain psychological phenomena directly of interest (e.g., *involuntary future projections*, Berntsen & Jacobsen, 2008) are noticed and recorded by participants. The explicit nature of this method also allows one to explore the latency between stimuli and the thoughts that are cued by it (see Cole et al., 2016). This method is limited, however, by increasing the level of self-monitoring processes than would be normally expected (Smallwood & Schooler, 2006), which may alter the characteristics and frequency of certain recorded thoughts (Vannucci, Batool, Pelagatti & Mazzoni, 2014; see also Barzykowski & Niedźwieńska, 2016; Barzykowski & Staugaard, 2018). Self-caught recording may also be affected by social desirability, because participants are informed about the nature of thoughts that the researcher is interested in. This may be particularly problematic in ageing research given the higher levels of social desirability in older adults (*cf.* Jordão, Ferreira-Santos, Pinho & St. Jacques, 2019).

Alternatively, in the *probe-caught* method, participants are asked to classify or describe any thought/s they had before being stopped by a specific signal or *probe* (for a review of different types of probes used, see Weinstein, 2018). Probes in such studies are typically set at random/pseudo-random sequences by the researcher, in part, to prevent participants from

predicting when they will occur. In contrast to the self-caught method, this method has the benefit of catching spontaneous thoughts as they occur naturally, requiring less self-monitoring, and thus may be seen as a purer form of 'experience sampling' of one's ongoing stream of thought (see Smallwood & Schooler, 2015). This method also removes a requirement necessary in self-caught methods to inform participants of the phenomena under investigation (see Vannucci et al., 2014 and Smallwood & Schooler 2006, for further discussion). It is also worth noting that while the results obtained from the probe-caught method have received validation from objective measures (e.g., eye movements in both young and older adults, see Frank et al. 2015), self-caught reporting is often unrelated to behavioural measures of mind-wandering (Smallwood, McSpadden, & Schooler, 2007, 2008). However, the disadvantage of the probe-caught method is that it can lead to very low frequencies of thoughts (per person) with some participants excluded for a lack of specific types of thought (e.g., 0-4 per thought type, see Plimpton et al., 2015; Vannucci et al., 2017), resulting in sparse participant-level data.

All three types of methods described above, have been used in the studies included in this issue, and several new variations of existing methods have also been reported to enable researchers to study spontaneous future thinking in very young children (Caza & Atance, this issue), older children and adolescents (McCormack et al., this issue) and older adults inside the laboratory (Jordão et al., this issue) and in everyday life (Warden et al., this issue). The development of new methods and techniques will inevitably stimulate further research on spontaneous future thinking (see e.g., O'Callaghan et al., 2015; Irish et al., this issue).

The Present: Major Themes and Content of the Special Issue

When introducing any new concept or topic of investigation, it is natural and theoretically relevant to make direct comparisons with other well-developed concepts, and satellite research

areas to demonstrate both its construct and discriminant validity. The field of spontaneous future cognition has followed this trend, with all articles in this issue making direct comparisons with related concepts, such as involuntary memory or spontaneous mind-wandering about the past on the one hand, and voluntary episodic future thinking, on the other (see Table 1). For instance, some researchers have compared spontaneous thoughts about the future with involuntary autobiographical memories to illustrate the potential similarities between involuntary past and future mental time travel (e.g., Barzykowski et al., this issue; Mazzoni, this issue), in step with earlier studies by Berntsen and Jacobsen (2008) and Cole et al. (2016). Others have compared spontaneous future thoughts with voluntary episodic future thinking to show potential differences between voluntary and involuntary processes (e.g., Caza & Atance, this issue), while Warden et al. (this issue, Study 2) have made comparisons across all four categories of thought illustrated in Table 1.

INSERT TABLE 1 ABOUT HERE

These comparisons have resulted in several interesting insights, which can enhance the understanding of where spontaneous future cognition stands in relation to other related phenomena, and encourage crosstalk between currently separate research fields depicted in Figure 1, a sentiment that is also expressed in the first of the papers presented in this issue by Berntsen. In her review paper, Berntsen provides a definition of spontaneous future cognition and illustrates how different manifestations of future thoughts (in terms of their content) have been studied within the fields of mind-wandering, spontaneous episodic future thinking and in psychopathology. She provides a comprehensive overview of maladaptive or dysfunctional future thoughts in individuals with addictions, various forms of anxiety disorders and persecutory delusions, as well as in post-traumatic stress disorder and depression. The fact that

these thoughts are spontaneous and difficult to control demonstrates the importance and potential role of spontaneous future cognitions in the development and maintenance of these disorders (an overlooked question in research and clinical practice), and will undoubtedly stimulate more research on clinical populations in future.

In relation to mind-wandering, Berntsen puts forward the view that research conducted on future oriented mind-wandering may not be tapping into spontaneous episodic future thinking because of a number of methodological and conceptual issues in terms of how mind-wandering has been defined and studied so far, and recent findings showing that a substantial amount of mind-wandering episodes are initiated intentionally. While we share Berntsen's concerns, there is ample evidence that the field of mind-wandering has entered into a new phase by introducing the distinctions between intentional vs. unintentional (e.g., Seli, Risko, Smilek & Schacter, 2016) and stimulus dependent vs. stimulus independent mind-wandering (e.g., Maillet, Seli & Schacter, 2017). With these distinctions and improved methodologies tapping into the precise content of thoughts (e.g., Irish et al., this issue; Warden et al., this issue), we believe that research on future oriented mind-wandering and spontaneous episodic future thinking will have much in common in terms of conceptual understanding and experimental findings. This is nicely reflected in the papers included in this special issue coming from different traditions of research on mind-wandering (e.g., Irish et al.; McCormack, et al.; Ji et al.) and spontaneous mental time travel or future thinking (e.g., Mazzonni; Vannuci et al.; Jordão et al.). Finally, Berntsen provides an interesting re-analysis of temporal distribution of spontaneous past and future episodic thoughts from her three published studies, and shows that future thoughts refer to events/scenarios in more immediate future compared to thoughts about the past. This asymmetry is explained by the

potential relationship of spontaneous future thoughts with people's goals and current concerns that are important for guiding one's behaviours in more immediate than distant future.

The remaining articles included in this special issue are empirical and largely fall into one of three broad themes, reflecting the existing and emerging research trends within the study of spontaneous future cognition. As will become clear, the section on *Underlying cognitive mechanisms* aids understanding of the section on *Development across the lifespan*, and developmental research can itself feed back into understanding of basic cognitive underpinnings. We conclude with studies which focus on individual differences and how *Psychopathology* is related to spontaneous future thinking, informing clinical models and the understanding of spontaneous cognitive phenomena in general.

Underlying cognitive mechanisms

One key finding that has consistently emerged in relation to spontaneous cognition is that spontaneous thoughts are more likely to be experienced during undemanding habitual cognitive activities (e.g., Antrobus et al., 1966; Kvavilashvili & Mandler, 2004; Smallwood et al., 2009; Vannucci, Pelagatti, Hanczakowski, & Chiorri, 2019). In addition, research on involuntary autobiographical memories and spontaneous future thinking has shown that the majority of such thoughts are triggered by easily identifiable external and internal cues (Berntsen & Jacobsen, 2008; Cole et al., 2016; Kvavilashvili & Schlagman, 2008; Mace, 2004). Given that in everyday life, people spend substantial amounts of time carrying out habitual cognitively-undemanding activities (e.g., Ellis & Nimmo-Smith, 1993) and are exposed to a myriad of cues, one key question that arises in relation to spontaneous past and future thinking is why we are not constantly flooded by such thoughts in daily life. Two papers in this special issue by Barzykowski et al., and by Mazzoni, directly address this question, using a similar experimental

paradigm (adapted from Plimpton et al., 2015), but manipulating different variables. For example, Barzykowski, et al.'s study tested the idea that it is the constantly operating *inhibitory mechanism* that normally keeps these thoughts 'at bay', and that depleting inhibitory resources (with a 60 min Stroop task with high percentage of incongruent trials) would enhance the number of spontaneous future (and past) thoughts recorded by participants during the undemanding vigilance task, compared to control participants who did not perform the Stroop task, or participants who performed an easy Stroop task (with 100% congruent trials). Despite the evidence of inhibitory resources being depleted in the experimental group, the results showed that the number of spontaneous future thoughts was largely unaffected by the depletion manipulation.

The research by Mazzoni, on the other hand, examined the role of perceptual (or cognitive) load on the number of task-unrelated thoughts about the future and the past during the undemanding vigilance task. The experiment was a conceptual replication and extension of a previous study by Vannucci, Pelagatti, Hanczakowski, Mazzoni, and Paccani (2015) on involuntary autobiographical memories, which showed that presenting irrelevant cue words (or cue words and simple arithmetic calculations) on 2/3 of the trials during the vigilance task, significantly reduced the number of reported involuntary memories, in comparison to a condition in which participants were presented with irrelevant cue words in only 20% of trials. This is an important finding, because it suggests that although cue words are important for triggering spontaneous thoughts, many cues may not be better than fewer cues because they also inadvertently increase the demand for available cognitive resources for processing distracter information within the vigilance task (i.e., despite instructions to ignore the irrelevant cues, participants will still be engaged in reading the words and/or checking the correctness of

arithmetic calculations). It is also noteworthy, that while the frequent presentation of distracter information (in the form of irrelevant words or arithmetic calculations) does not have any detrimental effect on performance on the actual vigilance task (i.e., the number of detected targets), their presence is sufficient to interfere with the formation of and/or reporting of involuntary autobiographical memories (for similar findings on involuntary musical imagery, see Floridou, Williamson & Stewart, 2017).[5]

Using different task parameters (e.g., fewer trials and a probe caught method), Mazzoni (this issue) wanted to find if similar results could be obtained for involuntary future thoughts. Results showed that although both past memories and future thoughts were more often reported in the condition with fewer cue phrases, the detrimental effect of frequent cues (or cues plus arithmetic calculations) in reducing spontaneous thoughts was significantly larger for future thoughts than past memories. This could suggest that despite their spontaneous nature, the appearance of future thoughts in participants' minds is a more resource demanding process than the spontaneous retrieval of past events. However, when spontaneous future thoughts were separated into thoughts about future plans and imaginary future scenarios (see also Anderson & McDaniel, 2019, Plimpton et al., 2015, Warden et al., this issue, who used a similar coding scheme to categorise the content of spontaneous future thoughts), the results showed that the detrimental effect of perceptual load manipulation on future thoughts was mainly due to a

[5] One way to explain this interesting finding, based on mind-wandering research, is to interpret it as an effect of perceptual (Forster & Lavie, 2009) and not cognitive load (e.g., McVay et al., 2013). Thus, the number of spontaneous task-unrelated thoughts may decrease not only because our resources are engaged in a demanding cognitive task, but also because an external stimulus is perceptually salient and disrupts the internal train of thought (i.e., causes an external shift of attention; Smallwood, 2013), even if it does not make the task more difficult. In other words, it is possible that even relatively undemanding tasks may disrupt mind-wandering if they include perceptually salient stimuli.

markedly stronger reduction in the number of reported future scenarios than future plans. This novel finding demonstrates the importance of distinguishing different types of spontaneous future thoughts, and raises an interesting possibility that spontaneous thoughts about upcoming plans may be less constructive and more similar to involuntary autobiographical memories (i.e., their representations are already formed and get simply re-activated by incidental cues in the environment).

The question about how much constructive and/or cognitively resource-demanding processing is involved in spontaneous future cognition, is of course a key but as yet unanswered question. The effortless and quick appearance in mind of spontaneous future thoughts, as demonstrated by Cole et al. (2016), suggests that they may be relying on similar types of associative spreading activation processes as documented in research on involuntary autobiographical memories and mind-wandering (Barzykowski & Niedźwieńska, 2018; Mace, 2005; McVay et al., 2013; Baird et al., 2011). The question about how nonconscious processes may lead to spontaneous future thoughts coming to mind is addressed in two papers by Jordão, Pinho and St. Jacques (this issue) and Vannucci, Pelagatti, Chiorri and Brugger (this issue).

Jordão et al. developed a new simplified version of the standard vigilance task in which participants were processing the words rather than the lines to detect infrequent target words printed in yellow, in a stream of slides with words printed in red. Given that vigilance tasks with words have been shown to result in higher numbers of spontaneous thoughts about the past than future (Cole et al., 2016; Plimpton et al., 2015; Vannucci et al., 2017), Jordão et al. wanted to test if the activation of participants' existing goals and current concerns would increase spontaneous future thoughts in the vigilance task. Additionally, the effect of age on the nature and frequency of spontaneous cognition under these task parameters was also investigated (see below the

section on *Development across the life span*). The results showed that young participants reported significantly higher number of spontaneous future thoughts in the second than the first half of the vigilance task, after they had completed a brief card sorting task between the two parts of the vigilance task (designed to activate participants' current concerns and life goals). Moreover, the number of spontaneous future thoughts in the second half of the task was significantly higher than in control participants, who were exposed to the same card sorting task with instructions that did not lead to goal activation, while no group differences were present in the first half of the task. Thus, the priming manipulation was successful, and the results demonstrate that it is possible to increase spontaneous future thinking without participants explicitly listing their existing unfinished projects and current concerns.

Finally, Vannucci et al. (this issue) went a step further in testing subtle priming effects by assessing if the occurrence of past and future thoughts could be sometimes triggered by abstract perceptual cues – that 'push' them toward the past or the future. Taking inspiration from studies demonstrating effects of perception on the temporal direction of thought (e.g., Santiago et al., 2007) and the concept of the "mental time line" (flowing left to right in visual space), they showed that detecting target slides (with straight lines) in a stream of slides with rightward facing arrows increased spontaneous future thoughts, while leftward facing arrows increased spontaneous thoughts about the past. These findings provide insights into how humans are unknowingly 'primed' by aspects of visual space, and imply an unnerving possibility that the content of our spontaneous thought can be 'nudged' towards past or future by incidental stimuli or perceptions in everyday life.

Development across the life span

Currently, evidence in relation to age effects on involuntary cognitions is mixed (for a review, see Maillet & Schacter, 2016), with studies of involuntary autobiographical memories showing small age effects (e.g., Schlagman, Kliegel, Schulz & Kvavilashvili, 2009) or the absence of age effects (Berntsen, Rasmussen, Miles, Nielsen & Ramsgaard, 2017) when comparing the number and characteristics of reported involuntary memories in young and old participants in the laboratory and everyday life (see also Gardner & Ascoli, 2016). In contrast, research on mind-wandering has resulted in significant negative age effects by showing that older adults report fewer instances of task-unrelated thoughts when engaged in vigilance or reading tasks (for reviews of these studies, see Jordão, Ferreira-Santos et al., 2019; Maillet & Schacter, 2016). In light of these discrepancies, and the absence of research on spontaneous future cognitions across the life span, especially at opposite ends of the developmental spectrum, it is perhaps not surprising that three papers, in this issue, examined young and older adults' ability to experience spontaneous future cognitions with novel laboratory and experience sampling methods (Jordão et al.; Irish et al.; and Warden et al.), while papers by Caza and Atance compared spontaneous future cognition in young children and McCormack et al. - in children, adolescents and young adults. Research on ageing and development of spontaneous cognition in children is also important theoretically, as it can provide further information about the potential mechanisms involved in the occurrence of spontaneous future thoughts. Indeed, if these thoughts are mediated by automatic spreading activation processes similar to processes involved in the retrieval of involuntary autobiographical memories, then one would expect an absence of age effects or relatively small age effects in comparison to what has been found in studies of voluntary episodic future thinking (for a review, see Schacter, Gaesser & Addis, 2013).

One of the aims of the study reported by Jordão et al. described earlier, was to develop a new version of the vigilance task that would elicit sufficient numbers of spontaneous task-unrelated thoughts in older adults. This was motivated by unpublished findings by Schlagman and colleagues (see Kvavilashvili, Niedźwieńska, & Kliegel, 2016), showing that a large proportion of older adults (58%) did not report any involuntary autobiographical memories in the original version of the vigilance task with line patterns and incidental cue words used by Schlagman and Kvavilashvili (2008). When queried after the task, older adults reported that the task was quite difficult in that they had to constantly suppress the irrelevant words in order to concentrate on the lines. Despite these self-reported differences in task difficulty, the actual performance on the vigilance task was at ceiling and not significantly different across age groups. To make the task parameters ageing-friendly, Jordão et al., presented participants with single words on the screen and participants had to indicate the occurrence of words printed in yellow and ignore the words in red. This manipulation reduced the need for participants to get distracted by irrelevant cue words, present in the standard version of the task. Perhaps most importantly, the task was made really easy (and boring) by presenting each word for 3 seconds and having a 7-second long inter-stimulus interval. Finally, the probe-caught method was used, to eliminate the need to monitor the consciousness for spontaneous thoughts. Under these new task parameters, no significant age effects were obtained in the number of spontaneous thoughts about the future and the past.

In line with these findings, Warden et al. also found no significant age effects in the number of recorded spontaneous thoughts about the past and the future in a naturalistic 1-day experience sampling study in which participants recorded their current thoughts in response to 30 signals emitted by a wrist watch. Moreover, Warden et al., did not find the prospective bias in

the number of spontaneous thoughts recorded (i.e., the number of future thoughts was not higher than past thoughts). However, the prospective bias was present for a significant minority of deliberate task-unrelated thoughts, suggesting that the prospective bias in mind-wandering studies could be at least partly explained by instances of intentional mind-wandering about the future (Seli et al., 2016). Taken together, findings from these two studies using laboratory and naturalistic methods appear to be replicating the results of Berntsen et al. (2017) on involuntary autobiographical memories, which also showed that older adults did not differ from young participants in the number of reported involuntary autobiographical memories in the laboratory (Study 1) and in everyday life (Study 2).

However, significant negative age effects in the number of reported spontaneous past and future thoughts were obtained in the study of Irish et al. (this issue). Their study was partly motivated by similar concerns as those expressed by Jordão et al., specifically, that negative age effects obtained in mind-wandering studies could be due to the cognitively demanding nature of the go/no-go and reading tasks used in studies of ageing and mind-wandering. To minimise the ongoing task difficulty for older adults, Irish et al. used their new method with no vigilance component, the shape expectations task (see O'Callaghan et al., 2015), in which participants observe simple shapes for various lengths of time, and at the end of each trial, are asked to report what was currently going through their mind. Their thought reports were subsequently categorised by researchers into four different categories ranging from 1 (fully on task) to 4 (fully off task or task-unrelated). The results showed that despite the cognitively undemanding nature of the task, older participants still reported significantly fewer task-unrelated thoughts (Level 4 responses). In addition, while younger adults reported significantly more future than past

thoughts (confirming the prospective bias in mind-wandering), older adults showed the opposite pattern (more past than future thoughts).

Given that both Jordão et al. and Irish et al. used such simple undemanding tasks, the absence and presence of age effects in spontaneous future thoughts in the two studies, respectively, is striking. However, one of the main differences between the tasks was the presence of cue words in the study by Jordão et al. and the absence of meaningful material (only geometric shapes) in the study by Irish et al. It is therefore possible, that the combination of undemanding ongoing tasks with distracting meaningful material is necessary to eliminate age effects on spontaneous past and future thinking, conditions which may be present in everyday life, and resulted in the absence of age effects in the study by Warden et al. (*cf.* Gardner & Ascoli, 2016; but see Maillet et al., 2018). Clearly, examining the role of cues (their presence vs. absence) in eliciting spontaneous thoughts about the future during undemanding tasks used by Jordão et al. and Irish et al. will be a very interesting avenue for future research.

Similar issues concerning the need for equating the difficulty of ongoing (vigilance) tasks in different age groups arise in relation to studying spontaneous future (and past) thoughts in children, and especially in very young children who may also have difficulties in meta-awareness or noticing and reporting spontaneous thoughts - more so than older adults (e.g., see Chen, 2013, cited in Ye, Song, Zhang & Wang, 2014). Because of these difficulties, there are currently less than a handful studies on mind-wandering in older children and adolescents (e.g., Ye et al., 2014; Van den Driessche et al., 2017; Stawarczyk et al., 2014; Zhang, Song, Ye & Wang, 2013), with virtually no developmental studies on children's spontaneous future thinking. The studies reported by McCormack et al. and Caza and Atance in this issue are therefore starting to fill this gap in the literature by developing and testing new methods that have resulted in important new

insights on children's spontaneous future thinking ability and its relationship with its voluntary counterpart.

Caza and Atance studied 3-, 4-, and 5-year old children's spontaneous and deliberate (prompted) episodic future thinking by using a 'two room' task (see Atance, Louw, & Clayton, 2015) in which children spent brief periods of time in two different rooms with and without toys (or food - smarties). At the end of the session, in the adjacent hall, children were told that they would be visiting the rooms again tomorrow. They were then shown new toys (or smarties) and asked which room they would like these toys to be placed during their future visit (correct answer would be the room with no toys or no smarties).

Results showed that in this deliberate future thinking test, children were more likely to provide a correct answer in the food than the toys condition, and 3-year olds were outperformed by 4- and 5- year olds, who did not differ from each other. However, the novel aspect of the study was that children's spontaneous verbal utterances about the future and past were recorded and the spontaneous 'solutions' of the future thinking task noted (e.g., if at any point a child mentioned that toys or the food needed to be moved to an empty room). Results showed that there were no age effects in the amount of spontaneous future utterances across the three age groups, nor in the spontaneous solutions of the future thinking test (although the rate of such solutions was low across all age groups especially in the food condition).

McCormack et al. also compared deliberate and spontaneous future thinking using two new tasks for assessing these constructs and testing 6-7 year olds, 9-10 year olds, 14-15 year olds and adults. The deliberate episodic future thinking task was unusual in that participants, after careful briefing, were free to produce either a past memory or a future event/scenario in response to each of the 10 words. These instructions would presumably favour more 'direct' or

spontaneous retrieval or construction of events than standard versions of episodic future task (see also Jeunehomme & D'Argembeau, 2016). Under these modified task instructions, the results showed a clear dominance for past than future events in all age groups and, surprisingly, no significant age effects in the number of past and future thoughts produced. The same participants also completed an undemanding and engaging colouring-in task, which was interrupted by intermittent thought probes to examine whether participants were on or off task by thinking about the past or future. In line with the findings from the cue word task, no age effects were obtained in the total number of on-task or off-task thoughts, suggesting that the colouring-in task was equally easy and engaging for all age groups. Importantly, however, there was an age by temporal focus interaction, with a clear prevalence of future thoughts than past thoughts in adults but not in any other groups. In other words, the prospective bias in mind-wandering was not found in children or adolescents in this study. However, as in many other mind-wandering studies, the intentionality of the past and future task-unrelated thoughts was not assessed in this task (presumably because younger children could struggle to distinguish such thoughts), and it is therefore possible that the prospective bias in adults was due to them having greater numbers of deliberate thoughts about the future compared to children and adolescents (see e.g., Warden et al., this issue).

Taken together, findings from Caza and Atance and McCormack et al. replicate and extend the results of studies on spontaneous episodic memories in young children, which also show small or no age effects and suggest that both past and future spontaneous thoughts may be a precursor of more deliberate forms of mental time travel in everyday life (*cf.* Krøjgaard, Kingo, Jensen & Berntsen, 2017). It is obvious that future research should investigate in more detail similarities and differences between the developmental trajectories of deliberate and spontaneous

future thinking while, at the same time, comparing it to the deliberate and spontaneous recall of past events.

Individual differences and psychopathology

One interesting finding that has emerged from numerous studies on involuntary autobiographical memories and mind-wandering is that there are usually large individual differences in people's propensity to experience and report involuntary memories and task-unrelated thoughts. Moreover, their experience has been related to various measures of personality, mood and psychopathology (e.g., Jones & Steel., 2012; Krans, de Bree, & Moulds, 2015; Marchetti, Koster, Klinger, & Alloy, 2016; Poerio, Totterdell & Miles, 2013). Although research on this topic in relation to spontaneous future thoughts is scarce, Berntsen's (this issue) comprehensive review demonstrates that spontaneous future thoughts may be crucially important in providing new insights about existing clinical disorders and for the development of new interventions. Emphasis on the importance of individual differences in spontaneous future cognitions and psychopathology has been reflected by the inclusion into the Special Issue of three papers on this topic by del Palacio-Gonzalez and Berntsen, by Beaty, Seli and Schacter, and by Ji, Holmes, MacLeod and Murphy which used questionnaire, naturalistic experience sampling and laboratory methods, respectively.

The paper by del Palacio-Gonzalez and Berntsen reports three large-scale correlational studies on American (Studies 1 and 3) and Danish (Study 2) samples whose tendency to experience spontaneous thoughts about the past and the future were assessed by a recently developed Involuntary Autobiographical Memory Inventory (IAMI; Berntsen, Rubin & Salgado, 2015). The primary focus in this exploratory study was on people's tendency to suppress unwanted thoughts (measured by the White Bear Suppression Inventory, Wegner & Zanakos,

1994), and its relation to spontaneous past and future mental time travel while controlling for ruminative thinking (brooding and reflection subscales), emotion regulation, mind-wandering and positive/negative daydreaming styles. Across all three studies, thought suppression scores significantly predicted higher scores on involuntary past and future thinking above and beyond indices of rumination and emotion regulation, even when controlling for participants' scores on mind-wandering and positive and negative daydreaming styles (Study 3). These findings are interesting because thought suppression has been linked to intrusive and negative thoughts often present in various clinical disorders, but it also appears to be linked with attempts to control more benign (and non-repetitive) spontaneous everyday past and future thoughts. The results also replicated and significantly extended the findings by Berntsen et al. (2015) by showing that while participants reported having spontaneous thoughts about the past more frequently than spontaneous thoughts about the future (for similar findings with a structured interview method, see Krans et al., 2015), scores on both sub-scales were highly correlated.

The aim of Beaty et al.'s study was to examine people's tendency to experience past and future thoughts in everyday life and their relation to emotional biases in thinking styles that are either past-oriented and negative (brooding rumination), or future-oriented and positive (optimism). An experience sampling method was used in which participants' thoughts (their temporal focus and phenomenological characteristics) were assessed during random calls eight times a day over a one week period. Results showed that participants who scored high on brooding rumination (but not on self-reflection) reported more past-oriented thoughts in everyday life, even when controlling for depression scores, and had reduced ratings of vividness for both past and future thoughts. In contrast, optimism scores did not predict rates of either past or future thinking, but those high in optimism had more vivid and more positive future thoughts,

but no such effects were observed for the characteristics of past thoughts. This pattern of findings only partially replicates the findings reported by del Palacio-Gonzalez and Berntsen (this issue), who found that both measures of rumination (brooding and reflection) predicted scores on both the past and future subscales of IAMI in Studies 1 and 3. Moreover, unlike del Palacio-Gonzalez and Berntsen (this issue), Beaty et al. did not find any differences in the rates of reported thoughts about the past and the future (see also Warden et al., this issue). Similarities across studies indicates that brooding rumination may be an important variable that needs to be investigated in more depth in relation to past and future mental time travel, while discrepancies highlight the importance of using complementary and diverse methods of enquiry, that enable the investigation of spontaneous phenomena in real time both in everyday life and in the laboratory.

Finally, the study by Ji et al. (this issue), examined the relationship between dysphoria, representational format (imagery vs. verbal) and the valence of self-caught spontaneous future-oriented thoughts, using a novel version of the go/no-go task in which participants were also exposed to irrelevant, auditorily-presented cue words. Compared to existing laboratory studies of spontaneous future thought (e.g., Mazzoni, this issue; Barzykowski et al, this issue) and those assessing dysphoria (Plimpton et al., 2015; Hoffmann et al., 2016), the novelty of this study was twofold: (a) it examined the reduced positivity bias in dysphoria by calculating the relative frequency of positive and negative future thoughts and (b) it decoupled verbal and imagery components of future thoughts. Further, although negatively-charged mental imagery has been associated with anxiety-related disorders, the relevance of spontaneous imagery to mood has been highlighted only recently (e.g., Hoffman et al., 2016). The findings indicated a specific role of imagery (versus verbal representations) in the reduced positive future thinking found in dysphoria.

In some ways, this is not a surprising result. As Ji and colleagues indicate, high levels of sensory-perceptual detail (e.g., simulating the embarrassment of a future failure) are linked with the degree to which an imagined scenario feels like genuine perceptual experience, and increases feelings of mental time travel (D'Argembeau & Van der Linden, 2012), thereby increasing the emotional 'impact' of the image (Barsics, Van der Linden & D'Argembeau, 2016). What is surprising here, however, is that emotionally-laden scenarios can operate in an unbidden way. Although previous findings have shown negatively skewed future thoughts in emotional disorders using deliberate construction of future scenarios (e.g., Williams, Ellis, Tyers, Healy, Rose & MacLeod, 1996), in Ji et al.'s study, a more basic mode of negative future thinking is described. These findings may have implications for understanding its clinical import and inform therapies, where the focus directly involves imagery (e.g., imagery rescripting). Further, such a system may require revision of cognitive explanations of depression which have been based upon deliberate event construction (e.g., MacLeod & Salaminiou, 2001; Williams et al., 1996).

The Future: Implications, Challenges and Directions

Here, we bring together this Editorial with reference to four possible questions: (a) when do spontaneous future thoughts occur; (b) how do they come to mind; (c) who is more likely to experience them, and finally, (d) why do we experience them at all? For each question, we review the challenges and directions within the field (see also Berntsen, this issue).

When and how do spontaneous future thoughts occur?

As stated above, an ongoing question is whether we can understand when spontaneous future thoughts arise by examining systematic effects of task demands and external cues. A key question in relation to cuing is if (or how), the stimuli we experience and perceive in everyday life - knowingly or unknowingly - influence our spontaneous thoughts about the future.

Preliminary evidence from laboratory vigilance tasks and experience sampling studies appears to suggest that spontaneous future thoughts may be less reliant on external cues than involuntary autobiographical memories. For example, in vigilance tasks with no verbal cues clear prospective bias in spontaneous thoughts has been found in several studies (Vannucci et al., 2017; see Stawarczyk, 2018 for a review), and in a naturalistic experience sampling study, Warden et al. (this issue) showed that, in comparison to spontaneous thoughts about the past, spontaneous thoughts about the future were slightly less dependent of external triggers (i.e., participants reported instances of external, internal and no triggers with equal frequency) (for other real-world studies where internally and externally cued thoughts were assessed, see Berntsen & Jacobsen, 2008; D'Argembeau et al., 2011; Finnbogadóttir & Berntsen, 2011)[6].

The findings that fairly large proportions of spontaneous future thoughts are reported by participants as having *no known cue* (20-30%, Cole et al., 2016; Jordão et al., this issue; Vannucci et al., this issue; Warden et al., this issue), or being triggered by internal thoughts (11% Mazzoni, this issue), or 'other' antecedents (12-15%, Cole et al., 2016; Jordão et al., this issue) are seemingly intractable to research involving certain experimental manipulations within vigilance tasks, and present a theoretical challenge: what are the cognitive origins of these spontaneous future thoughts and what affects their content and occurrence?[7]

One possible explanation of this pattern of findings is that external cues may interact with the spontaneity of future thoughts such that in the absence of meaningful external cues

[6] These studies are important as common findings from cue/task manipulations indicate that mind-wandering and mental time travel may be interpreted together and suggest that factors that influence their occurrence in the laboratory map on to how they arise in the real world – a critical aspect of cognitive science (Neisser, 1985; see also Kingston, Smilek, & Eastwood, 2008; Kvavilashvili & Ellis, 2004).

[7] Spontaneous future thoughts unrelated to external cues may also be relevant to maladaptive forms of spontaneous future cognition (see Berntsen, this issue).

participants may be more likely to engage in future thoughts deliberately rather than spontaneously (e.g., see Seli, Ralph, Konishi, Smilek & Schacter, 2017). To address this issue, a more general recommendation for future empirical studies of spontaneous future thoughts is that researchers include a measure of spontaneity, either as a dichotomous variable (Plimpton et al., 2015) or along a continuous scale (see Ji et al., this issue), as even if thoughts are task-unrelated, this does not always equate to spontaneousness (see Seli et al., 2017). If such measures are not included, as was the case for several studies in the special issue, assumptions that thoughts are truly spontaneous are difficult to verify post-hoc.

We have also observed how manipulating aspects of tasks before (Jordão et al., this issue; Barzykowski et al., this issue) or during (Mazzoni, this issue; Vannucci et al., this issue) the recording of spontaneous future thoughts not only affects their frequency, but also their content (Mazzoni, this issue) and temporal focus (Vannucci et al.). Theoretical progress has been made in the field of mind-wandering (McVay & Kane, 2009; Smallwood & Schooler, 2006) and prospective memory (Scullin, McDaniel & Shelton, 2013), and it is important that attempts are made to apply these to the area of spontaneous future cognition. For instance, studies have shown that increasing cognitive load in ongoing tasks decreases mind-wandering and prospective memory and we have observed similar findings related to spontaneous future cognition (see Mazzoni, this issue). We therefore recapitulate that a synergistic approach, capitalising on findings from mind-wandering, future thinking and prospective memory, outlined above, may be useful in future research for increasing the understanding of *when*, and perhaps *how*, these thoughts arise.

Additionally, one may ask whether specific configurations of the background task and stimuli leads to more spontaneous future thoughts. Tasks have so far included a variety of

stimuli, including visually-presented word phrases (e.g., Barzykowski et al., this issue), aurally-presented words (Ji et al., this issue) and simple geometric shapes (Irish et al., this issue) – most commonly as 'background' stimuli, but sometimes representing the main task focus (Jordão et al., this issue; Irish et al., this issue). Although one study has examined the effect of verbal cues versus no cues (Vannucci et al., 2017), the question of whether images or words are more effective in triggering spontaneous future thoughts is difficult to answer as no study has directly compared their effects on the nature and frequency of such thoughts (*cf.* Mazzoni et al., 2014).

Exploring the role of triggers is particularly important for distinguishing between the initiation and maintenance of spontaneous thoughts about the future. Smallwood (2013) has suggested that these different stages of the mind-wandering process may rely on different mechanisms, which may explain apparently contradictory findings in relation to executive resources and the frequency of spontaneous task-unrelated thoughts (Thomson, Besner, & Smilek, 2015). However, research on mind-wandering has rarely explored the initiation/maintenance distinction, probably because the absence of meaningful cues in the vigilance and go/no-go tasks, used in mind-wandering studies, has constrained the analysis of triggers that allow to identify the initiation of a spontaneous thought. The fact that several studies in the special issue analyse triggers seems to be an important first step to further distinguish processes involved in the initiation versus maintenance of spontaneous thoughts.

Finally, the relationship between the frequency and type of spontaneous thoughts, elicited using go/no-go and vigilance tasks and daily life experience sampling methods, is still unclear and it is recommended that studies employ either complex designs (involving methodological variants within one study) or a meta-analytic approach to address this issue (for a recent review of available methodological tools for studying mind-wandering, see Martinon, Smallwood,

McGann, Hamilton & Riby, 2019). This inclusive approach may uncover factors underlying inconsistencies in some of the findings obtained across methods (e.g., concerning the effects of cues or temporal focus of task-unrelated spontaneous thoughts).

Effects of individual differences, age, and neurological injury on spontaneous future cognition - the 'who' question

Knowledge of the link between types of psychopathology (e.g., rumination, thought suppression), on the one hand, and phenomenological qualities and frequency of spontaneous future thoughts, on the other, has increased in recent years (e.g., Berntsen et al., 2015, see Berntsen, this issue for a review; Beaty et al., this issue; del Palacio-Gonzalez & Berntsen, this issue). Additionally, effects of normal development have highlighted that reductions of spontaneous future thoughts, if present, are much less marked than in deliberate, constructive future thinking, providing insights into the neurocognitive differences between volitional and spontaneous future thinking (see Caza & Atance, this issue).

Although understanding spontaneous thoughts in ageing has improved (see *Development across the life span* above), there are still questions that need to be addressed to find a set of conditions or variables that reduce or eliminate negative age effects in the frequency of reported spontaneous future thoughts. As pointed out earlier, future research may need to concentrate on the role of external cues (by manipulating their presence or absence) and whether they are peripheral or not to the focus of attention when studying effects of age on spontaneous thoughts about the future (and the past) to resolve the discrepant findings in relation to ageing reported in the literature and in this special issue (see also Jordão, Ferreira-Santos et al., 2019).

The potential importance of cues has been also highlighted in two recent studies on pathological ageing and spontaneous mind-wandering using an easy, undemanding version of the

vigilance task with cue words (Niedźwieńska & Kvavilashvili, 2018) and the shape expectations task without verbal cues (O'Callaghan et all., 2019) (this task was used by Irish et al., this issue). While O'Callaghan et al. (2019) did not find a reliable reduction in spontaneous mind-wandering in patients with Alzheimer's disease, Niedźwieńska and Kvavilashvili (2018) reported marked reduction in spontaneous mind-wandering (especially thoughts about the past) in participants with Mild Cognitive Impairment compared to healthy controls. Niedźwieńska and Kvavilashvili (2018) suggested that the spontaneous processes of eliciting thoughts in response to incidental cues, which is preserved in healthy ageing, may be particularly disrupted at early stages of Alzheimer's disease (see also McDaniel, Shelton, Breneiser, Moynan, & Balota, 2011; Niedźwieńska, Kvavilashvili, Ashaye & Necar, 2017). Future research needs to examine this idea with a special focus on spontaneous future thinking.

Another related and important avenue for research is to study the nature and frequency of spontaneous future thoughts in acquired neurological disorders such as stroke or traumatic brain injury. For example, two recent studies on patients with focal lesions in the brain's default network (see Raichle et al., 2001; Buckner & Carroll, 2007) showed that while hippocampal damage affected the quality of spontaneous future thoughts (less episodic and less vivid than in controls) (McCormick, Rosenthal, Miller, & Maguire, 2018), damage to the ventromedial prefrontal cortex substantially reduced the quantity of mind wandering compared to controls – with future mind-wandering being affected most (Bertossi & Ciaramelli, 2016). In both studies, however, patients reported significantly more task-unrelated thoughts about the present, suggesting that damage to specific areas of the default network can shorten the temporal 'window' normally available when mind wandering (perhaps mirroring what happens during constructed mental time travel, e.g., Andelman et al., 2010).

Even though ageing and neuropsychological studies of spontaneous future cognition are currently small in number, they have started to uncover important similarities and differences to known phenomena (see Table 1). Further neuropsychological studies will complement the existing set of neuroscientific studies (see Fox & Christoff, 2018 for a review).

The 'Why' question.

As evidenced above, progress has been made on the *how* and *who* questions of spontaneous future thought. Though informative, a precise understanding of the mechanism underlying the occurrence and maintenance of spontaneous future thoughts, and its possible sub-types, has yet to be delineated.

However, such precise explanations of spontaneous future thought may be necessary to elucidate the *why* question, identifying how spontaneous future thoughts can manifest themselves in functionally beneficial ways (see Berntsen, this issue), and how they can also sometimes be dysfunctional (see Berntsen, this issue; Holmes et al., 2007; for a recent review, see Bulley & Irish, 2018). Concerning the beneficial functions of spontaneous future thinking, the link between personal goals and spontaneous future thinking has been demonstrated in previous studies (e.g., Baird et al., 2011; Cole & Berntsen, 2016; D'Argembeau et al., 2011, Study 2; Plimpton et al., 2015) and studies published in this Issue (Jordão et al.; Mazzoni; Warden et al.). However, the causal relation between the two is unknown, as is the dynamic interplay between current-concerns, cues and future thoughts (Berntsen, this issue), and the fact that no comprehensive theory has attempted to accommodate these findings shows that more research is required (*cf.* Kvavilashvili & Rummel, 2019).

Finally, although researchers have interrogated several aspects of this phenomenon (e.g., individual differences, priming effects), little is still understood about its content as it is rarely

measured or analysed (but see Anderson & McDaniel, 2019; Mazzoni, this issue; Plimpton et al., 2015; Warden et al., this issue, for exceptions). It is interesting that when Plimpton et al. (2015) carried out a thematic content analysis of task-unrelated spontaneous thoughts, reported by participants in response to thought probes during the vigilance task, they found that the majority of thoughts could be classified into two main categories of *intended actions/plans and upcoming events,* with a very small proportion of thoughts referring to the category of *simulated hypothetical events*. This finding contrasts the taxonomy of intentional forms of episodic future thinking by Szpunar, Spreng and Schacter (2014), which classifies the contents of future thoughts into *simulation, prediction, intention and planning*. Clearly, more systematic investigation is needed to study the precise contents and the subtypes of spontaneous future thoughts (*cf.* Weinstein, 2018), as this may provide important insights into how they occur (and perhaps why they occur *when they do*).

Conclusion

In this Editorial, we presented the past, present and future of a fast-developing field. We have shown synergy between traditionally independent areas (of mind-wandering, mental time travel and prospective memory) in studies past and present, and recommend such an approach going forward. Indeed, such an approach has been fruitfully employed in neuroscience, combining findings from episodic future thinking, goal processing and mind wandering, and finding commonalities (Stawarczyk & D'Argembeau, 2015). Findings presented in this special issue have covered a broad range of areas, showing the field is vibrant and has already made important insights, especially on the *when*, *who* and *how* questions. An important challenge will be to develop theoretical accounts of spontaneous future thought. To this end, benefits may accrue by juxtaposing findings with satellite research areas. We urge researchers to put forward

empirically-testable theoretical models of spontaneous future thought, which can be compared against each other. This may clarify *how*, but more importantly *why*, spontaneous future thoughts are so prevalent in daily life (Berntsen & Jacobsen, 2008; Warden et al, this issue). We hope that the articles contained here provide inspiration and the first-steps toward these laudable objectives.

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Compliance with Ethical Standards

Author SC declares that he has no conflict of interest. Author LK declares that she has no conflict of interest. Ethical approval: This article does not contain any studies with human participants performed by any of the authors.

Table 1

The positioning of spontaneous future cognition in relation to related areas of research.

	Temporal Focus	
	Future	*Past*
Mode of Elicitation		
Involuntary	Spontaneous Future Thoughts	Involuntary Autobiographical memory, spontaneous mind-wandering about the past
Voluntary	Episodic Future Thinking	Autobiographical memory

Figure Captions

Figure 1: The Intersection between Future Thinking, Prospective Memory and Mind-wandering Research, and their connection with Spontaneous Future Cognition