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# Spontaneous Simulation of Future and Past Events

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## Abstract

Spontaneous future and past events come to mind unintentionally. Previous research supports that environmental cues prompt spontaneous simulation, although the role of specific cues remains unaddressed. Previous work has found that involuntary autobiographical memories are generated in chained-event sequences, which refers to multiple, related events being generated consecutively. We addressed how event and location cues influence spontaneous future and past events, and whether future events occur in chains. In a boring vigilance task, 132 participants located a left-facing arrow amongst right-facing arrows. On 49 of 350 trials, participants encountered event or location cues. Ten times, participants audio-recorded off-task thoughts they felt comfortable sharing. Participants produced more future events for event than for location cues and produced more past events for location than for event cues. Unlike past chains, future chains occurred only for event cues. These results highlight how event and location cues contribute to the spontaneous simulation of events.



**Key words:**

Spontaneous episodic future thinking, involuntary autobiographical memory, chained-event sequences, event knowledge, event simulation, vigilance task

## Summary for Lay Audience

Individuals frequently think of their own personal future and past events. Often, these events come to mind unintentionally, described as spontaneous or involuntary thoughts. Although unintentional, these events can be cued by environmental information (Berntsen, 2019). For example, one could be watching their favourite movie in their living room when the characters begin discussing the destination they are about to travel to. The characters' discussion could spontaneously prompt an individual to think about their upcoming vacation. Similarly, as the characters enter an airport, the viewer may spontaneously remember the last time they were in an airport. This example illustrates how event (the characters' discussion) and location cues (airport scene), may elicit spontaneous thoughts about future and past events. This question has been investigated in voluntary autobiographical memory studies in which participants are asked explicitly to generate specific memories (Sheldon & Chu, 2017). The present thesis extended that question to spontaneous future and past events, while also investigating whether cues influence how multiple, related events emerge consecutively, described as chained-event sequences (Mace et al., 2013). One hundred, thirty-two participants completed a boring vigilance task in which they located a left-facing arrow amongst right-facing arrows. Participants encountered occasional cues, either events (*take a flight*) or locations (*airport*). Ten times during the 1-hour study, participants audio recorded any thoughts that they felt comfortable sharing. Future events were prompted more frequently by event than location cues, and were produced in chained-event sequences only when prompted by event cues. Past events were more frequently elicited by location than event cues, and occurred in chains for both types of cues. Together, these results indicate that the types of events that spontaneously emerge are dependent on what information is available in the environment.

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## List of abbreviations

| Abbreviation | Meaning |
|---|---|
| fMRI | Functional magnetic resonance imaging |
| *M* | Mean |
| ms | Milliseconds |
| *N* | Number of participants |
| *p* | Probability |
| *SD* | Standard Deviation |
| *t* | T test |

# Chapter 1

## 1 Introduction to episodic future thinking and autobiographical memory

People frequently think about memory in terms of the past, such as how an individual may remember a fond childhood experience, the adoption of their first pet, or what they did yesterday, but memory is also a function of the future. Episodic future thinking (EFT) is the process of simulating a personal event that could take place in one's future (Atance & O'Neill, 2001). In comparison, autobiographical memory refers to the memory of one's previous, personal experiences (Conway & Pleydell-Pearce, 2000). Episodic future thinking and autobiographical memory are similar, although they are differentiated by their temporal position relative to the present moment. Episodic future thinking involves pre-experiencing a future event whereas autobiographical memory involves re-experiencing a past event (Atance & O'Neill, 2001; Wheeler et al., 1997). For example, a person can re-experience a previous vacation by visualizing a museum in the city that they visited and remember how they felt when they saw their favourite painting. Similarly, someone can pre-experience an upcoming vacation by imagining the museum in the city that they will visit and anticipate how they will feel when they get to see their favourite painting. Future thinking provides several important functions, serving emotional regulation, and behavioural, self, social, and goal-directed purposes (Duffy & Cole, 2021). Like autobiographical memory, Episodic future thinking can be simulated spontaneously (without intention) or deliberately (with intention).

The present study focuses on spontaneous simulation of future and past events. We investigated how cue type, specifically event (*hang out with friends)* and location (*coffee shop*) cues influences the spontaneous simulation of these events. We also investigated whether future and past events are simulated in chained-event sequences and the role that event and location cues play in eliciting chains. A chained-event sequence describes when two or more related events are elicited consecutively (Mace et al., 2013). An example of a chain is, “I remembered when I studied abroad” followed by, “I also met my partner there.” These events are related because they involve a shared location, specifically where the individual studied abroad. Mace et al. (2013) found that involuntary autobiographical memories occur in chains. However, whether future events are simulated in chains, and the nature of the connections between chained event future thoughts, has not been investigated. Thus, the overall goal of this study was to identify how future and past events are spontaneously simulated from environmental cues.

Chapter 1 introduces spontaneous episodic future thinking and involuntary autobiographical memory. It describes the Constructive Episodic Simulation Hypothesis, which is the current theory of how simulations of future events are constructed. To understand how spontaneous events are elicited by environmental cues, the two most directly relevant studies, Sheldon and Chu (2017) and Mace et al. (2013), are discussed, including how these studies and their subsequent conclusions motivate the current study’s hypotheses and predictions.

### 1.1.1 Spontaneous episodic future thinking and involuntary autobiographical memory

As suggested by their labels, spontaneous future thoughts and involuntary memories come to mind without intention, in that they seem to “pop” into a person's mind (Berntsen, 2019; Cole & Kvavilashvili, 2019). Spontaneous thoughts about future and past events are common. For example, a student might be listening to a lecture when their upcoming weekend plans suddenly pop into their mind. An involuntary autobiographical memory would be similar, except it might consist of one's previous weekend activities unintentionally coming to mind.

Because there are multiple types of spontaneous cognition, it is important to identify how spontaneous simulations of future and past events differ from other forms of mind wandering and prospective memory. Episodic future thinking and involuntary autobiographical memory involve three elements in that they (1) are autobiographical (involving the self), (2) are associated with a specific time, and (3) involve autonoetic awareness (feelings of pre/re-experiencing events; Tulving, 2002). Mind wandering is conceptualized as the shift in thought from what currently is happening in the external environment to one's self-generated, internal thought processes and feelings (Smallwood & Schooler, 2015). Mind wandering does not necessarily involve any of the three elements required for episodic future thinking and involuntary autobiographical memory, as an instance of mind wandering may not specifically be autobiographical, tied to a specific time, or involve autonoetic awareness. Moreover, whereas prospective memory is tied to a specific time (the future) because it describes memory for completing future actions (e.g., remembering to put out the garbage first thing tomorrow morning; Ellis & Kvavilashvili, 2000), it does not necessarily have to be autobiographical or involve autonoetic awareness. Thus, episodic future thinking and involuntary autobiographical memory differ from general mind wandering and prospective memory, so researchers have used particular empirical methods and theories for studying and explaining them (Cole & Kvavilashvili, 2019).

Although *involuntary* has been used to describe how these memories emerge, it is not intended to be used to refer only to negative, intrusive, or unwanted memories. Rather it is used in contrast to the deliberate, or voluntary, mode of elicitation of future and past event simulations in which events are generated intentionally (e.g., when someone is asked "What did you do last weekend?" or an experimenter instructs a participant to simulate a possible future event). The deliberate mode of elicitation is typically studied using a version of the Autobiographical Interview (Levine et al., 2002). Participants are given a cue such as *airport* and then are asked to describe an event that may happen within a pre-determined timeframe such as the next 5 years (Cole & Kvavilashvili, 2019; refer to the following studies on deliberate EFT, Addis et al., 2007, 2009; D'Argembeau & Van der Linden, 2004, 2006; Hassabis & Maguire, 2007). The distinction between spontaneous and deliberate episodic future thinking is noted due to several differences that have been found between them.

Differences between spontaneous and deliberate episodic future thinking extend beyond just whether individuals do (deliberate) or do not (spontaneous) have intention when simulating future events (Berntsen & Jacobsen, 2008). In diary and laboratory studies, descriptions of spontaneous future and past events are given higher subjective ratings of vividness, involve more specific events, and have a greater impact on one's current mood (Berntsen & Jacobsen, 2008; Cole et al., 2016; Schlagman & Kvavilashvili, 2008). Importantly, these differences have been found when comparing the generation of spontaneous/involuntary and deliberate/voluntary future and past events. Together, these findings provide two insights into spontaneous and deliberate future and past event simulations. First, the content of participants' descriptions differ depending on whether the event was generated spontaneously or deliberately (Berntsen & Jacobsen, 2008; Cole et al., 2016; Schlagman & Kvavilashvili, 2008). Second, these spontaneous versus deliberate differences have been found for future and past events (Berntsen & Jacobsen, 2008; Cole et al., 2016; Schlagman & Kvavilashvili, 2008). That is, it is the mode of elicitation that underlies the differences, rather than whether the individual is describing a future or past event.

To study spontaneous future and past event simulation in the laboratory, researchers have used a boring vigilance task that is designed to elicit spontaneous thoughts (Schlagman & Kvavilashvili, 2008). Participants perform a simple search task while words that are designed to spontaneously prompt off-task thoughts occasionally are presented alongside distractor and target stimuli. Participants are informed that because the task is not particularly demanding, they may experience task-unrelated thoughts, and will be asked to record any off-task thoughts when prompted. Vigilance tasks have been used to study spontaneous episodic future thinking (Cole et al., 2016; Mazzoni, 2019; Plimpton et al., 2015) and involuntary autobiographical memory (Schlagman & Kvavilashvili, 2008; Vannucci et al., 2015). For the present study, we also used this type of vigilance task.

## 1.2 Constructive Episodic Simulation Hypothesis

The Constructive Episodic Simulation Hypothesis (Schacter & Addis, 2007) is the principal theory regarding how people simulate future events. According to the Constructive Episodic Simulation Hypothesis, deliberate simulations of both future and past events rely on the episodic memory system. Schacter and Addis (2007) argue that future events are simulated by deconstructing episodic memories and associated knowledge, which is then recombined into a novel, future event. Because the future is uncertain and is not a simple replay of one's memories (Atance & O'Neill, 2005; Schacter & Addis, 2007), people must simulate a future event for which they have no specific memory of how it will unfold.

To fill in details of events that have not yet happened, it has been suggested that individuals rely on semantic memory (Irish et al., 2012; Irish & Piguet, 2013; Schacter et al., 2012). The term "semantic memory" means different things to different researchers. For some, semantic memory refers primarily to word meaning, whereas to others, it refers to all of a person's general knowledge and facts about the world. Key to autobiographical memory and episodic future thinking is what is often termed "event knowledge", which might be considered to be part of semantic memory. Event knowledge refers to a person's knowledge about common events, including the actions, people, objects, and locations involved, as well as how an event tends to unfold over time (Binder et al., 2009; McRae et al., 2021). In many theories, event knowledge is represented by schemas (Ghosh & Gilboa, 2014; Robin & Moscovitch, 2017), although there also are neural network models of event knowledge (Elman & McRae, 2019).

This type of semantic knowledge typically is considered to be generalized, and it can therefore be applied to multiple situations (e.g., knowing how to cook pasta regardless of the location that skill was learned in; Irish et al., 2012; Mion et al., 2010). Thus, it aids in future event simulation by providing a semantic scaffold for which episodic details can be integrated (Binder & Desai, 2011; Irish et al., 2012; Irish & Piguet, 2013). Using semantic (event) knowledge to help facilitate the simulation of future events is especially important when there are gaps in how the event might unfold due to limited personal experience (Irish et al., 2012; Irish & Piguet, 2013; Schacter et al., 2012). Take for example, a young adult simulating their own wedding in the future. While they have never directly experienced their own wedding, it is likely that they have seen weddings in the media, heard about a relative's wedding, or attended weddings as a guest. Because of this knowledge gained, they would be aware of the typical proceedings of the events, including who would likely be there, what objects might be involved, what activities would occur, and how the event would begin and end. Their semantic knowledge helps facilitate the simulation of their future wedding, despite the individual never actually experiencing their wedding.

The importance of having access to this semantic knowledge in future event simulations has been demonstrated by patients diagnosed with semantic dementia. Semantic dementia is a neurogenerative condition in which individuals experience a severe loss of factual knowledge but their recent, autobiographical memories are relatively intact (Adlam et al., 2009). Individuals with semantic dementia experience profound deficits when asked to simulate future scenarios but can describe recent autobiographical memories relatively well (Irish et al., 2012). Without semantic knowledge to act as a scaffold, the ability to simulate novel future events is significantly diminished (Irish et al., 2012; Irish & Piguet, 2013).

A central component of the Constructive Episodic Simulation Hypothesis is that simulations of future and past events significantly overlap (Schacter & Addis, 2007). Supporting this claim, participants tend to describe both future and past events that are closer to the present, although future event simulations have a stronger bias to be closer to the present than do memories (Spreng & Levine, 2006). Comparisons have also been made by investigating individual differences, finding that participants who obtain higher scores on self-rated mental imagery scales similarly report more visual and sensory details in both future and past event simulations (D'Argembeau & Van der Linden, 2006). Finally, functional neuroimaging (fMRI) studies have supported the idea that episodic memory facilitates future and past event simulation. For example, activity within the medial temporal lobe and bilateral frontopolar regions significantly overlap when participants engage in episodic future thinking and describe autobiographical memories (Benoit & Schacter, 2015).

On the other hand, episodic future thinking is not simply a replay of past events. First, future events are emotionally more positive than past events (Berntsen & Jacobsen, 2008; D'Argembeau & Van der Linden, 2006; Newby-Clark & Ross, 2003). Second, research has found that past events are rated as more vivid compared to future event simulations (Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004, 2006). Third, fMRI studies have illustrated how areas such as the left posterior inferior parietal lobe and posterior dorsolateral prefrontal cortex have increased activity during future simulations compared to past event descriptions (Benoit & Schacter, 2015). In summary, these findings suggest that the episodic memory system plays a similar role in generating future and past autobiographical events, although future simulation is not just a replay of memories (Schacter & Addis, 2007).

The Constructive Episodic Simulation Hypothesis was not designed to account for spontaneous simulation of future or past events. As a result, the Constructive Episodic Simulation Hypothesis does not explicitly address how spontaneous events are simulated, why a future event or past thought may be more likely to be simulated, or how information in the environment and event knowledge are used to facilitate this process. Although we use the Constructive Episodic Simulation Hypothesis to motivate our hypotheses and predictions, it should be noted that the current study addresses issues that are highly related to, but not explicitly covered by, the Constructive Episodic Simulation Hypothesis.

### 1.3 The role of cues in future and past event simulations

Spontaneous future and past events often are related to cues in the environment (Berntsen, 2019; Cole & Kvavilashvili, 2019). Berntsen and Jacobsen (2008) first investigated whether future events can be spontaneously simulated. Using a diary study design, participants were instructed to record when they had a future or past event spontaneously pop into their mind. After recording their spontaneous event, participants filled out a short questionnaire to identify how these events came to mind. For example, participants documented the activities they were engaged in just before these thoughts emerged and identified any connections between their external surroundings to their spontaneous thoughts. Berntsen and Jacobsen (2008) confirmed that like involuntary autobiographical memories, future events can be spontaneously prompted and are related to environmental and internal (e.g., one's own thoughts) cues. Specifically, 76% of the future and 84% of the past events were reported as having an identifiable cue. Moreover, the environmental cues that participants selected as triggers for these spontaneous thoughts (objects, people, impersonal themes, places, sensory feelings, activities, words, and life themes) displayed a similar frequency pattern for both future and past events. Berntsen and Jacobsen (2008) concluded from their diary study that spontaneous future and past events are spontaneously simulated from identifiable cues.

The influence of cues on spontaneous event simulation has also been examined in laboratory settings during boring vigilance tasks in which participants are prompted occasionally to report any spontaneous thoughts that have come to mind. These studies have illustrated that the cues encountered during the vigilance task relate to participants' responses. Cole et al. (2016) found that 69% of past events and 58% of future events were related to the cues presented during the vigilance task. During a similar vigilance task investigating only future events, 56% were related to the cue phrases (Duffy & Cole, 2021). Although both studies affirmed that environmental stimuli are important for cuing spontaneous thoughts, they did not identify which specific cues were most effective. Furthermore, as indicated by Cole and Kvavilashvili (2019), specifically how this information triggers future event simulations remains an ongoing question.

To date, the literature has not investigated the role of specific cue types in prompting spontaneous simulations of future and past events. Although, the influence of specific environmental cues has been investigated in voluntary autobiographical memory (Sheldon & Chu, 2017) and the role of internal cues has been addressed in involuntary autobiographical memory (Mace et al., 2013). The current study builds upon these findings and corresponding theories to investigate how spontaneous future and past events are simulated from environmental cues.

### 1.3.1 Environmental cues

Sheldon and Chu (2017) provide insight into how environmental information may elicit voluntary autobiographical memories. Although differences exist between voluntary and spontaneous future and past event generation, using Sheldon and Chu's (2017) findings and theory provides a framework that can be applied to the current study to hypothesize how environmental information may cue spontaneous events.

Sheldon and Chu (2017) provided participants with either event – theme (*social outings, travelling*) or spatial – location (*park, coffee shop*) cues. Participants were given 90 seconds per cue to generate as many related memories and were asked to rate how vivid each memory was on a scale of 1-5. The authors found that event cues prompted more memories ($M$ = 7.3) than location cues ($M$ = 6.4). Furthermore, event cued memories were rated as more vivid ($M$ = 4.2) than location cued memories ($M$ = 3.9). To identify how cue type might influence the descriptions of these events, participants were also asked to describe in detail four of their event cued memories and four of their location cued memories. Sheldon and Chu (2017) found that event cued memories contained more details than location cued memories, although the location cued memories had a higher proportion of episodic details (described as information directly related to the event). Finally, location cued memories were generated faster. The authors hypothesized that event cues reinstate a concept, whereas location cues reinstate a context. Sheldon and Chu (2017) theorized that voluntary autobiographical memories are broadly structured through connections of event – themes and this allows individuals to remember these memories in multiple contexts. When context-specific knowledge is required location cues prompt more specific and detailed memories. For example, using context-dependent information to successfully navigate a new airport (Sheldon & Chu, 2017).

Although Sheldon and Chu (2017) did not discuss their findings and conclusions in the context of spontaneous future event simulation, they nonetheless can be used to guide hypotheses for how specific cues elicit spontaneous events. The Constructive Episodic Simulation Hypothesis hypothesizes that episodic memory similarly supports future and past event simulation (Schacter & Addis, 2007). Therefore, future and past event simulations should show a similar frequency pattern when prompted by the same cue types. Specifically, event cues should prompt a greater number of future events compared to location cues, as Sheldon and Chu (2017) found with voluntary autobiographical memories. The present study has investigated that specific argument in the context of spontaneous future events and applied these findings of voluntary autobiographical memory to involuntary autobiographical memories. Through doing so, greater insight into how specific cues (events and locations) influence spontaneous future and past event simulations is gained.

### 1.3.2 Internal cues

Research by Mace et al. (2013) has investigated the degree to which memories can internally cue other related memories. In these diary studies, participants are asked to record when a spontaneous memory arises and then record if that first memory prompted other related memories. Mace et al. (2013) found that participants can have multiple, consecutive related memories, which they conceptualized as chained-event sequences. A chained-event sequence describes when two or more memories are generated in succession. For example, one might first remember a concert that they and a friend had attended last year and then remember going out for dinner with that same friend last week.

Parallel to Sheldon and Chu's (2017) conclusions on voluntary autobiographical memory, Mace et al. (2013) concluded that involuntary autobiographical memories are organized through conceptual associations (e.g., memories sharing the same themes, people, activities, objects). This conclusion emerged from the finding that memory chains typically contain multiple memories from distinct time periods involving similar themes, as opposed to memories that all occurred on the same day (Mace et al., 2013). Mace and colleagues further argue that involuntary autobiographical memory chains provide evidence that involuntary memories are generated through a pattern of spreading activation. Environmental cues initially prompt one memory and then that memory evokes other related memories (Mace, 2005; Mace et al., 2013). For example, the location of one's *kitchen* may prompt an individual to have a specific memory of making cookies as a child with their mom (event A) and then event A could prompt them to think of visiting their mom during a recent vacation (event B). In this example, the location of the *kitchen* may not necessarily be related to event B, but event A and event B are connected by involving the individual's mother. Thus, it is suggested that it is the memory itself, not the initial cue, that prompts these subsequent related events (Mace & Clevinger, 2019). Examples of event sequences are found in Table 1.

Mace and colleagues' (2013) findings provide insight into how autobiographical memories can internally cue other related memories. However, the influence of environmental cues on this chaining process has not been studied. How environmental information (events and locations) may interact with the chained-event sequences is unknown. Perhaps, certain environmental information may be more effective at producing chains, especially if they produce events that are highly associated with other events (e.g., thinking of general travelling experiences). On the other hand, if certain

**Table 1**

*Examples of event sequences*

| Event type | Criteria | Examples |
|---|---|---|
| Chained event | Two or more events that are related | *Past:* [I remembered when I studied abroad.] [I also met my partner there.]<br><br>*Future:* [I am going shopping with my sister for her birthday later.] [I also would like to go shopping with my mom soon.] |
| Non-chained event | Two or more events that are unrelated | *Past:* [I had to make a reservation this morning] [I am already engaged.]<br><br>*Future:* [I was thinking I need to brush my teeth.] [I would like to see the Jurassic Park movie.] |

*Note.* This table describes the criteria and example event sequences for chained-event and non-chained event sequences (Mace et al., 2013). Because we are interested in future chains, examples of future chained and non-chained sequences are provided in this table. However, future chaining has not been investigated by Mace and colleagues.

environmental cues prompt more specific events that are less easily associated with other events, a chain could be less likely to form (e.g., thinking of a specific travelling experience). It could also be a possibility that whether spontaneous chaining occurs is not related to the type of environmental information encountered but rather solely dependent on the associations that the first memory provides. The study investigated these questions to gather further insight into this chaining process.

Whether future events are simulated in chains has also not been investigated. Potentially, future events are simulated in chains, which would provide evidence of further overlap in how spontaneous future and past events are generated. This would also suggest that future events can also be internally cued by other related future events. Alternatively, the absence of chaining in spontaneous future events could indicate that future events contain less structure and are less associated with other future event simulations. If future events do not occur in chained-event sequences this would also indicate that spontaneous future and past events differ in how they are simulated. Based on the finding that spontaneous future and past event simulations share similar properties (Berntsen, 2019), we wanted to apply these findings from involuntary autobiographical memory to spontaneous episodic future thinking to investigate if future events are simulated in chains.

## 1.4 The present study

The present study investigates how spontaneous future and past events are simulated to understand the mechanisms that support future and past event simulation. It also aims to provide a theoretical base for how future and past event simulations are generated in everyday interactions. To achieve this, the current study brings together the two above discussed findings, Sheldon and Chu (2017) and Mace et al. (2013), in conjunction with the theory that environmental information cues these spontaneous future and past events. We hypothesized that environmental cues activate existing knowledge and these cues prompt spontaneous future and past event simulations. We also hypothesized that like involuntary autobiographical memories, future events are simulated in chained-event sequences because spontaneous future and past events are simulated through similar mechanisms.

# Chapter 2

## 2 Introduction

We used a vigilance task to investigate our hypotheses that environmental information prompts spontaneous event simulations and that future events occur in chained-event sequences. During the vigilance task, participants were instructed to locate a left-facing arrow amongst right-facing arrows. Ten times during the experiment the vigilance task was stopped and participants were asked to report any off-task thoughts that they felt comfortable sharing and having audio recorded. To prompt spontaneous thoughts, cues appeared on 49/350 trials. Because we wanted to control the type of information participants encountered, participants were cued with either event (*hang out with friends*) or location (*coffee shop*) cues. Importantly, we were not focused on the specific cues within each cue condition that related to participants' off-task thoughts. Rather, we were broadly interested in how these cue types (events and locations) were related to the spontaneous events participants reported.

Although we used event and location cues like Sheldon and Chu (2017), our event cues slightly differed. Specifically, Sheldon and Chu (2017) used event – theme cues (*social outings, travelling, memorable meals*) that were more general themes compared to our event cues (*hang out with friends, go on vacation, make dinner*). However, our location cues were similar to theirs, and some were identical (e.g., *market, park, coffee shop, kitchen, classroom*; Sheldon & Chu, 2017). Furthermore, Sheldon and Chu used eight cues in each condition and we used 49 in each condition. The dissimilarities reflect differences in our study goals. Whereas Sheldon and Chu were interested in voluntary autobiographical memory and instructed participants to generate specific memories for each cue, we asked participants to locate the left-facing arrow while the cues were occasionally presented. Importantly, participants were not specifically instructed to use or pay attention to the cues.

### 2.1 Research questions and predictions

Two main questions were formulated from our hypotheses. Our first question was, how do event and location cues affect the future and past events participants report? To test this, we investigated how cue type interacted with the temporality of the events reported, the type of future events reported, and the phenomenological characteristics of these future and past events. Our second question was, do spontaneous future events occur in chained-event sequences, like involuntary autobiographical memories? In addition to investigating if future events were simulated in chains, we further looked at how cue type influenced the formation of future and past chains, as well as the type of connections used when multiple events were simulated in a chain.

The Constructive Episodic Simulation Hypothesis (Schacter & Addis, 2007) suggests that episodic memory similarly facilitates the simulation of future and past events and we used this hypothesis to motivate our predictions. We predicted that event cues would prompt a greater number of future and past events than location cues, based on similar findings from Sheldon and Chu (2017). We also predicted that future and past events would be simulated in chained-event sequences. If event cues produce a greater number of future and past events compared to location cues, we would provide further insight that event cues similarly facilitate the spontaneous simulation of future and past events. Additionally, if we found that future events were simulated in chains like involuntary autobiographical memories, this would provide evidence of overlap for how future and past events are simulated. Together, this study investigated the specific role of event and location cues to theorize how these spontaneous future and past events are generated based on what information in the environment is available.

## 2.2 Method

### 2.2.1 Participants

There were 166 participants, 34 of whom were removed from analyses due to not completing the study, as evidenced by failing to make a single keyboard response and reporting zero off-task thoughts during any of the interruption trials. Participants were aged 17-30 (*M* = 21 years, *SD* = 3.54), with 81 identifying as women, 3 individuals as nonbinary, and two preferring not to answer. Of the 132 participants whose data were used, 38 were recruited from the online participant recruiting platform, Prolific, 73 from the University of Western Ontario's undergraduate participant pool, and 21 from recruitment flyers around the University of Western Ontario's campus. Participants were from Canada or the United States. Participants were fluent English speakers, neurologically healthy, and had normal or corrected to normal visual acuity. Participants were compensated $10 CAD or course credit for participation and gave implied consent to participate by clicking a button to continue if they consented to participating. Participants who were shown the event cues ($n$ = 66) completed the study online whereas participants who were shown the location cues ($n$ = 66) completed the study in-person.

Both cue conditions were administered with an identical protocol. Participants in both conditions received the same consent and letter of information forms which they completed on the computer (see Appendix F). They also completed the same demographic questionnaire on the computer (see Appendix C). Participants received the same instructions for the vigilance task. The only difference in protocol was that for event cues, participants completed the study on their computer in a location of their choice. The location cues were completed in-person on a computer in an experimental room at the University of Western Ontario, and the experimenter was in the room with them listening to music on headphones. Participants were informed that the experimenter would not be able to hear them during the study.

### 2.2.2 Materials

***Vigilance task:*** The vigilance task was a search task created using the builder interface on PsychoPy (version 2022.1.1.). Because we could not specifically instruct participants to think of future events, we were concerned of the possibility that we would not obtain a sufficient number of future events to test our hypotheses. To hopefully prompt an adequate number of spontaneous future events we used the following method in our vigilance task. Vannucci et al. (2019) used a vigilance task in which the non-target stimuli were either right-facing arrows, left-facing arrows, or horizontal bars. Notably, right-facing arrows resulted in more future-oriented events compared to left-facing arrows or horizontal bars (Vannucci et al., 2019). Therefore, we used black right-facing arrows as the distractor stimuli to prompt participants to engage in spontaneous EFT. The target stimuli were black left-facing arrows, which appeared on 49 out of 350 trials. Left-facing arrows never appeared on a cue trial, cue trials occurred every seventh trial. The left-facing arrows randomly appeared on the other (non-seventh) trials, appearing four or five times in-between each interruption trial. Participants were instructed to press the spacebar when a left-facing arrow appeared on the screen. All stimuli appeared on a light grey background. Instructions for the vigilance task, including the description of task instructions, off-task thoughts, and the recording procedure were based on previous studies using the vigilance task in spontaneous episodic future thinking and involuntary autobiographical memory research (Cole et al., 2016; Cole & Berntsen, 2016; Mazzoni, 2019; Schlagman & Kvavilashvili, 2008; Vannucci et al., 2015, 2019). The vigilance task was the same for event and location cues. To create the vigilance task with location cues, the vigilance task with event cues was duplicated and the cues were changed to the locations. All other settings remained the same (e.g., both cue conditions were programmed with the same code).

***Cues:*** To evoke spontaneous future and past events, cues were presented during the vigilance task. An initial list of 100 event cues and 100 location cues was reduced to 49 cues per condition that were determined to be the most effective cues for the age demographic of our study (18-30). The best 49 cues for each cue condition were decided during a group discussion involving five individuals, three of whom were not directly involved in the study. During the vigilance task, 49 cues were presented across 350 trials, presenting a cue word every seven trials. The number of cues was based on previous vigilance tasks, where it has been found that presenting less frequent cues can increase the number of future events reported (Mazzoni et al., 2019). Under the prediction that future and past events occur in spontaneous chains, we theorized that presenting a cue every seven trials with six no cue trials in between would provide adequate time for chaining to occur during these non-cue trials. There were no exact duplicates of any cues between the event and location cues. However, the event and location cues were similar. For example, the event cue of *take an exam* was similar to the location cue of *classroom* and the event cue of *go to the office* was similar to the location cue of *boardroom.* See Appendix A for cues used.

***Follow-up questionnaire and phenomenology ratings:*** Participants completed an eleven-item questionnaire after they finished audio recording their responses during an interruption trial (10 in total). Participants first typed in a brief description of their recorded thoughts, which was used in case their audio recording did not work or was inaudible. Following that, participants were asked to indicate their age(s) during the event(s) that they had described. To answer these first two questions, participants typed in a white text box that appeared below the question, in the bottom middle of the screen.

Participants then completed nine phenomenological ratings regarding their most recently described events. The questionnaire was adapted from D'Argembeau and Van der Linden (2004). Participants were provided one phenomenological question at a time and rated each of the nine dimensions on a scale of 1-7, with 1 being the lowest value. The first three questions asked participants to rate how mentally vivid their sensory experiences were with respect to (1) visual, (2) sound, and (3) smell and/or taste details. They also rated the clarity of their representation of (4) the location of the event, the spatial arrangement of (5) objects and (6) people, and (7) clarity for the time of the event. Then, (8) how negative or positive the emotions of the event were (with 1 indicating very negative and 7 very positive). Finally, participants indicated (9) how often they have thought of the events before. See Appendix B for the full questionnaire.

## 2.3 Procedure

All participants were first directed to Qualtrics, a survey hosting platform. On Qualtrics, participants completed the consent form and demographic survey. Participants then were automatically redirected to Pavlovia, the study hosting platform. Once they were on Pavlovia and had clicked "start", participants were asked to provide microphone access. After reading the search task instructions, participants were presented with the following message, based on previous studies (Mazzoni, 2019; Schlagman & Kvavilashvili, 2008; Vannucci et al., 2015), “Finally, we would like to note that this is quite a boring task. You will likely find your mind wandering during it. This is completely normal. Throughout the experiment, you will be interrupted and asked to audio record your thoughts. During these interruptions, please report all of your thoughts that you feel comfortable with being audio recorded, that have emerged since the last interruption, or beginning of the experiment if it is the first interruption. Press ‘y’ to proceed.” After participants pressed the ‘y’ key, the task started. It began with a black fixation cross presented in the centre of the screen for 1.5 seconds. Five to seven black, right-facing arrows appeared on the screen for 2 seconds. On 49/350 trials, a black, left-facing arrow appeared amongst the right-facing arrows.

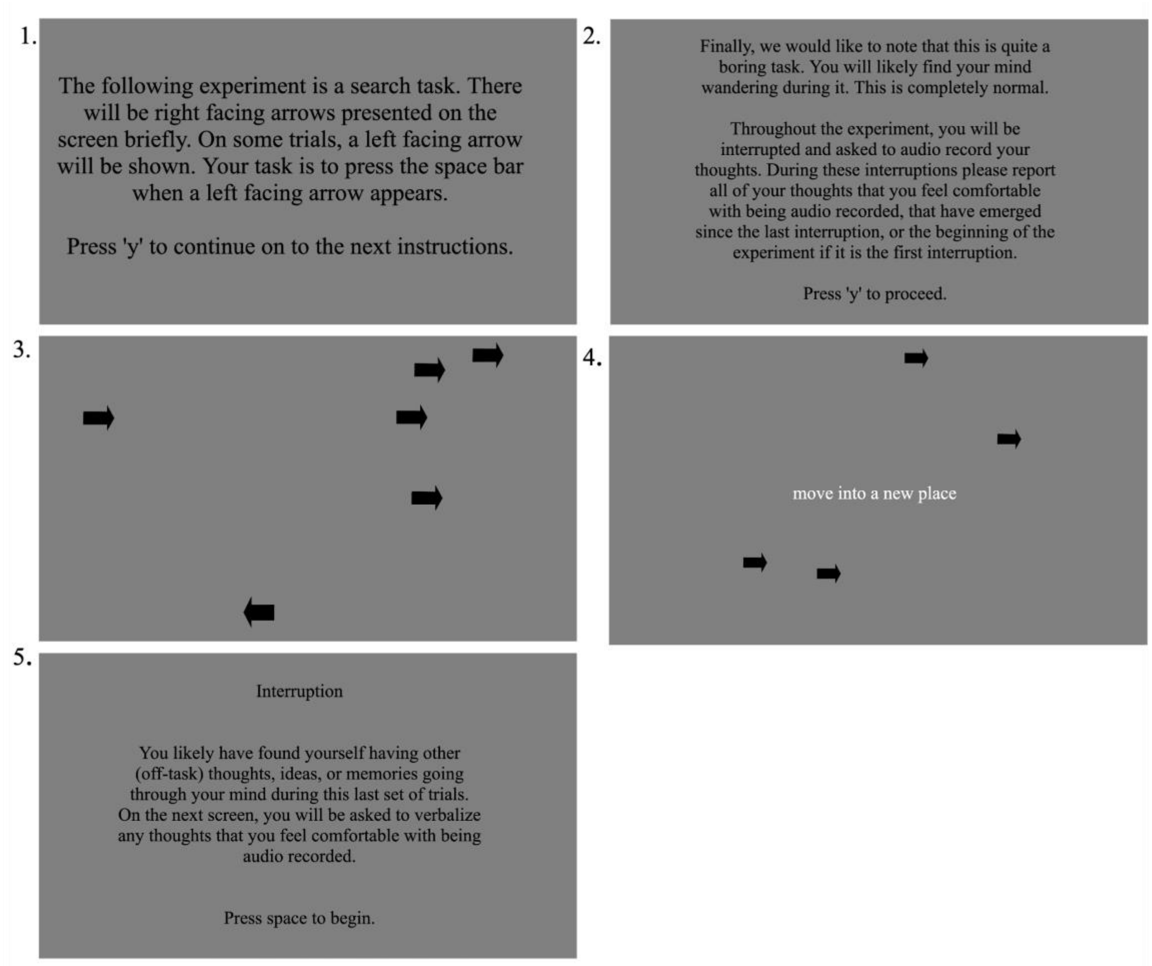
On 49/350 trials, a cue was also presented in the centre of the screen in white font. The cue appeared for 2 seconds, like the vigilance task stimuli. Cues appeared every seven trials. Participants were presented with 35 consecutive trials and after these 35 trials, participants were presented with the following message in black font in the middle of the screen, “You have likely found yourself having other (off-task) thoughts, ideas, or memories going through your mind during this last set of trials. On the next screen, you will be asked to verbalize any thoughts that you feel comfortable with being audio recorded. Press space to begin." The audio recording commenced immediately after participants pressed the spacebar to continue. Participants were free to talk for as long as they wished, and they pressed the 'd' key to indicate when they were done. The 'd' command immediately stopped the recording.

Participants then completed the 11-item questionnaire about their most recently recorded thoughts. Each question was presented in black font, in the upper middle of the screen. The rating scale was presented below the item question (e.g., *1 = Not at all, 4 = Moderate, 7 = A lot*). A white textbox with a black border was presented below the instructions. Participants used the keyboard to input their responses in the textbox. Below the textbox, participants pressed the right-facing arrow on their keyboard to continue to the next question. There was no time limit for answering these questions. After the eleven questions, participants resumed the search task by pressing the spacebar. They were reminded that they were to press the space bar every time they saw a left-facing arrow.

This sequence repeated for 350 trials, with ten interruptions. After the 350 trials, participants were presented with a debriefing form and the study concluded. The average duration was one hour. Key sample screens are presented in Figure 1.

**Figure 1**

*Participants view of the vigilance task*




*Note.* 1. Participants viewed the first instruction screen once they started the study. 2. This instruction screen appeared following the search task instructions, and before participants were prompted to begin the vigilance task. 3. An example of a trial with a left-facing arrow. 4. An example of a trial with an event cue. 5. After 35 trials, participants were shown the interruption trial screen.

## 2.4 Results and Discussion

***Analyses:*** We used chi-square tests of independence and goodness of fit when analyzing counts of the number of events that fit certain criteria. Because each event, or in other words, each response, could be classified in only one way, it contributed once to the criterion of interest (e.g., a response must be either a future or past event). The total counts depicted in the figures refer to the number of responses that fit each specified criterion. We used *t*-tests for the phenomenology ratings because these results were based on questionnaire data. Throughout, we used $p = .05$ as our significance threshold.

### 2.4.1 Vigilance task

All 132 participants whose data were analyzed completed the vigilance task successfully and participants found an average of 47 out of 49 targets. Participants had an overall mean reaction time of 860 ms for correctly identifying targets. On average, participants recorded at least one off-task thought on 7.79 ($SD = 2.21$) out of 10 trials for event cues and 7.62 ($SD = 2.84$) out of 10 trials for the location cues.

### 2.4.2 Cue type influence on future and past events results and discussion

We hypothesized that environmental cues activate existing knowledge and these cues prompt spontaneous future and past event simulations. Therefore, our first main question was how do event and location cues affect the number of future and past events reported? To test this, we investigated how cue type influenced the number of future and past events reported, the type of future event simulations reported, and the phenomenological ratings for future and past events.

### 2.4.2.1 Temporality of events

Participants’ audio recordings were first transcribed using the transcription function in Microsoft Word Online. All on-task thoughts were removed (e.g., comments about the task, or feelings evoked by the task) so that only off-task thoughts were analyzed. Participants' written descriptions of their most recent thoughts were consulted only when the audio quality was poor (e.g., a specific word needed to be confirmed via the typed response), and in one case, when the participant’s audio did not work. Aside from that one participant, all analyses were conducted using participants' audio recordings.

All thoughts were segmented into individual events. An individual event was the largest, unique group of information describing one action or behaviour. These events could be described in any number of words or sentences. For example, if a participant described making dinner in ten sentences, this was classified as one event, as would a participant describing making dinner in one sentence. We applied this criterion because of our interest in chained-event sequences. Our goal was to ensure that we were not segmenting individual events and classifying them as chained-event sequences if they were actually long descriptions of a single event.

After segmentation, we coded the temporality of the event (future, past, present, atemporal). Future events were those that would take place any time after the present moment (“I will be going on a trip with my friends later this summer”). Past events referred to those that had occurred any time before the present moment (“when I went to New York”). Present events occurred in the moment or during the vigilance task (“I had a song playing in my head”). Atemporal thoughts referred to statements that were not bound by a specific time period (“I love the water”). In the vast majority of cases, temporality was obvious and was determined based on participants' descriptions, use of tense ("I went", "I am going"), and on a few occasions, comparing their current age to their age at which the reported event occurred, or was potentially going to occur.

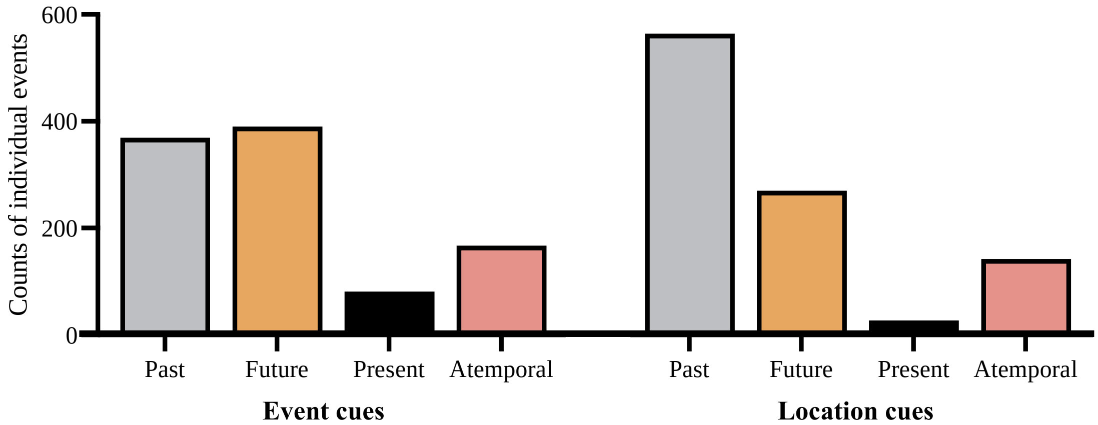
Participants reported a total of 1007 thoughts (*M* = 15.26; *SD* = 11.77) for the event and 1002 (*M* = 15.18; *SD* = 10.26) thoughts for the location cues. A chi-square test of independence using the variables of cue type (events vs. locations) and temporality (past, present, future, atemporal) revealed a significant relationship, $\chi^2$ (3) = 91.59, $p < .0001$. Figure 2 illustrates the distribution of events across each temporality for event and location cues.

Because our hypotheses focused on simulations of future and past events, we further analyzed those data. Out of the 132 participants whose data were analyzed, 126 participants recorded at least one future and/or past event during the vigilance task. Chi-square goodness of fit tests indicated that participants reported a greater number of future events for event (*M* = 5.91; *SD* = 4.89) than for location cues (*M* = 4.09; *SD* = 4.37), $\chi^2$ (1) = 21.82, $p < .0001$. In contrast, participants reported a greater number of past events for location (*M* = 8.55; *SD* = 8.26) than for event cues (*M* = 5.00; *SD* = 7.53), $\chi^2$ (1) = 40.76, $p < .00001$.

Our results provide novel insight into how specific cues (events versus locations) influence spontaneous future and past event simulations. The discussion on these noteworthy differences is prefaced by noting that the combined total of future and past events was quite similar for both cue conditions. Participants reported 1007 future and

**Figure 2**

*Temporality of all events reported for event and location cues*




*Note.* This figure illustrates the counts of individual events across the four temporalities for each cue type. Each response was categorized as either a future, past, present, or atemporal thought. Cue type had a significant influence on the temporality of events reported. Event cues elicited more future event simulations than location cues. Location cues prompted more past event simulations than event cues.

past event simulations for event cues and 1002 future and past event simulations for location cues. This indicates that the differences found in the number of future and past events reported for each cue type are a direct result of whether participants encountered event or location cues and not because of external variables (e.g., participants reporting fewer events in a condition or participants being more/less engaged in a certain cue condition).

The Constructive Episodic Simulation Hypothesis (Schacter & Addis, 2007) hypothesizes that future and past events are similarly supported by episodic memory. As such, we expected that like Sheldon and Chu's (2017) results for cue type and voluntary memories, event cues would prompt more future and past events compared to locations. However, we found that event cues elicited significantly greater future events than location cues and location cues prompted more past events than future simulations. A key element of spontaneous simulation is that they are prompted by cues (Berntsen & Jacobsen, 2008). Thus, the characteristics of the events or whether an event is even spontaneously prompted depends on what cues are available and what information is provided by the cues. We argue that event cues provide a scaffold that facilitates the spontaneous simulation of future and past events. In contrast, location cues provide information more suitable for spontaneously generating past events.

To facilitate episodic future thinking, individuals rely on their memories (Schacter & Addis, 2007) and event knowledge (Irish et al., 2012; Irish & Piguet, 2013; Schacter et al., 2012). This includes thinking about how the event might proceed, what people are involved, and what locations or objects might be present. However, there must be a starting point for which knowledge is relied on to simulate future events. For spontaneous future events, the cues provide this starting point. The scaffold that event cues provide includes two key components: (1) the event is directly provided, and (2) some elements (e.g., actions, people, locations) of the event are provided. For example, the event cue of *hang out with friends,* directly provides the event along with the people involved. Individuals likely have many memories that involve these events that they can draw on to successfully simulate a future event. They also likely have gained significant general knowledge of these events through other experiences, for example from the media and hearing about other people's friendships. Together, this information helps facilitate the simulation of future events.

In contrast, locations prompt more specific events because they provide a specific context (Sheldon & Chu, 2017). This is helpful when remembering past events in specific locations (Sheldon & Chu, 2017), however, it does not facilitate spontaneous future event simulation as effectively. Compared to the scaffold provided by event cues, location cues provide a specific element of the event (the location) and then the individual must use their event knowledge to fill in the gaps (Irish et al., 2012; Irish & Piguet, 2013; Schacter et al., 2012). To fill in the gaps, individuals must generate what activities, people, and objects might be involved and how a future event could unfold in that location. However, locations cue memories that contain a greater proportion of episodic details and fewer semantic details (Sheldon & Chu, 2017). Because of this focus to generate specific episodic details over the semantic knowledge that would be required to support the simulation of a future event (Irish et al., 2012; Irish & Piguet, 2013; Schacter et al., 2012), a past event would be more likely to emerge.

Although we did not ask participants to indicate their familiarity with these locations, we theorize that locations with limited experience were especially ineffective at generating future events. Because people do not have experience with unfamiliar locations, the characteristics of those locations are largely unknown or unreliable (Arnold et al., 2011). Thus, locations with limited experience would be unlikely to prompt a simulation of a future event because there may be limited experience and event knowledge to rely on to support this spontaneous simulation.

Turning to how cue type influenced spontaneous past events, we found the opposite pattern of Sheldon and Chu (2017). Location cues, not event cues, elicited more spontaneous past events. This interesting finding is prefaced with the acknowledgement that our study focused on *spontaneous* generation, compared to Sheldon and Chu (2017) who investigated *voluntary* generation. Because we were interested in different modes of elicitation and therefore used different paradigms, our results are not a direct replication of Sheldon and Chu's (2017) study. Nonetheless, drawing comparisons between our results and Sheldon and Chu's provides preliminary insight into how cue type may interact with the mode of elicitation (spontaneous versus voluntary). Location cues may be more effective at generating involuntary autobiographical memories and event cues may be better at producing voluntary autobiographical memories. This sensitivity to different cue types could be due to different characteristics of involuntary and voluntary autobiographical memory. Involuntary memories are typically more specific events and voluntary autobiographical memories are more frequently general events (Berntsen & Hall, 2004; Rasmussen & Berntsen, 2009). Using the argument that locations cue more specific memories (Sheldon & Chu, 2017), it is possible that the location cues were especially relevant for involuntary memories due to their tendency to be more specific.

#### 2.4.2.2 Types of future events

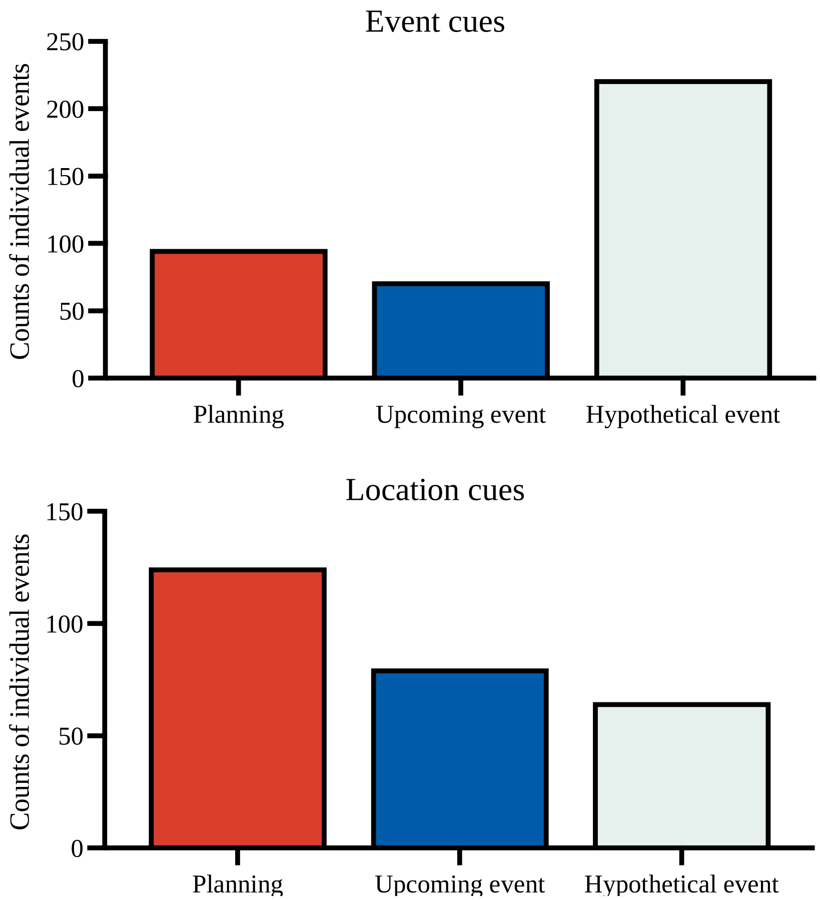
Two judges, one naïve to the study's goals, classified the future events into three types, plans, upcoming events, and hypothetical events, as in Plimpton et al. (2015). Plans referred to any future event that was goal-directed, and there was an intention to complete the activity ("I'm going to get groceries tonight"). An upcoming event referred to any event that the participant believed would happen in the future, but with no set time for when it may occur ("hanging out with my friends this summer"). A hypothetical event was one that was not planned, there was no current intention to complete it, or it was a general thought regarding the future ("I hope my partner and I will get engaged in the future").

A chi-square test of independence using the variables of cue type (events vs. locations) and type of future event (planning, upcoming event, hypothetical event) revealed a significant relationship, $\chi^2$ (2) = 70.63, $p < .00001$. Contrary to previous studies that have found spontaneous future events are typically categorized as plans or upcoming events (Mazzoni, 2019; Plimpton et al., 2015; Warden et al., 2019), event cues produced more hypothetical events (*M* = 3.36; *SD* = 3.85) than plans (*M* = 1.45; *SD* = 1.83) and upcoming events (*M* = 1.09; *SD* = 2.05). Although we replicated past findings (Mazzoni, 2019; Plimpton et al., 2015; Warden et al., 2019) because location cues produced more plans (*M* = 2.19; *SD* = 2.11) than upcoming events (*M* = 1.40; *SD* = 1.94) and hypothetical events (*M* = 1.14; *SD* = 2.52). Figure 3 presents the mean number of events reported in each category for event and location cues.

Our results reveal that the type of future event simulated (planning, upcoming event, or hypothetical event) depends on the environmental cue encountered. Furthermore, our study is the first study to indicate that spontaneous hypothetical events can be more common than plans and upcoming future events. Previous research utilizing the same categories of planning, upcoming events, and hypothetical events have consistently found that spontaneous future events are mostly classified as plans and

**Figure 3**

*Type of future events reported for event and location cues*




*Note.* This figure illustrates the counts of individual future events across the three categories for future event simulations in both cue conditions. Each simulation was categorized as either planning ("I'm going to get groceries tonight"), an upcoming event ("hanging out with my friends this summer"), or a hypothetical event ("I hope my partner and I will get engaged in the future"). Cue type had a significant influence on the type of future events that were simulated from event and location cues.

upcoming events (Mazzoni, 2019; Plimpton et al., 2015; Warden et al., 2019). For illustration, in a study by Plimpton et al. (2015), 60% of future events were categorized as planning ("I'm going to get a coffee after this") and 38% were labelled as upcoming events ("hanging out with my friends this summer"). In our study, event cues elicited future events that were 56% hypothetical events, 25% planning and 19% upcoming events. In contrast, our location cues replicated previous work because 46% of future events were planning and 30% were upcoming events.

Event cues prompted more hypothetical events compared to plans or upcoming events which further indicates that event cues provide a scaffold for future event simulation. Event cues directly provide more elements (e.g., people, location, activities) that are important for simulating future events. Because the event is directly provided, hypothetical events may be encouraged. Hypothetical events may be encouraged because once the event is directly provided, individuals can then begin simulating the event that is given, whether they have any current plans including it or not. For example, *go on vacation,* can have one simulate a possible vacation that they would like to go on. Based on their experiences and event knowledge, one would know the typical proceedings of events that would occur on vacation, including the locations, people, objects, and activities involved (Irish et al., 2012; Irish & Piguet, 2013; Schacter et al., 2012). Event cues likely also elicited more hypothetical events because of the age demographic of the sample (18-30). Many of the event cues these participants encountered are likely events they have not experienced but could predict may happen in the future. For example, *getting engaged, seeing nieces or nephews, getting a degree,* or *attending a reunion* are all events that they probably have not yet been involved in.

As opposed to event cues which directly provides the event and associated elements, location cues provide an element of an event. The element of the location is then used to simulate a future event. Because spontaneous future events are highly goal-related, it is likely that spontaneous future events are especially sensitive to goal-relevant cues (Cole & Kvavilashvili, 2021; Duffy & Cole, 2021). Therefore, whether a future event is simulated would depend on how goal-relevant these locations are. For example, given the cues *hair salon* or *market*, individuals who have already created plans for those locations could be reminded of the actions they will be completing, e.g., *"I need to book a haircut"* or *"My friends and I are going to visit the market this summer."* However, if an individual does not have any current future thoughts involving that specific location a future event may be unlikely to emerge.

Although considered hypothetical, future events for event and location cues were nonetheless highly goal-oriented, supporting previous arguments that spontaneous episodic future thinking is essential for goal-directed behaviour (Cole & Kvavilashvili, 2021; Duffy & Cole, 2021). For example, events such as *"I want to go on vacation"* and *"I hope to go to graduate school"* are considered hypothetical because they describe thoughts that individuals wish or hope to happen but are not yet planned to occur. However, these events remain highly reflective of personal goals and can still promote goal completion. For instance, having the thought of *"I want to go on vacation"* spontaneously elicited could encourage one to research potential destinations, set aside finances, and discuss their vacation ideas with friends or family.

### 2.4.2.3 Phenomenological ratings

Participants provided nine phenomenological ratings regarding their reported events. Only off-task, future and past event simulations were included in the phenomenological rating analyses. We removed present and atemporal events due to our specific interest in spontaneous future and past events. Participants also were asked to indicate their age(s) during the event(s) described. However, some participants misunderstood the instructions. Instead of providing their age during each event, they instead stated their current age. Some of these cases were obvious given their described events. For instance, some participants discussed a childhood memory and then reported their current age. Of the 126 participants who described at least one future and/or past event, 49 of those reported zero difference in time from the present (e.g., they only reported their current age). Although some of the cases were obvious that participants misunderstood the question, it would be impossible to confirm for every case whether they had misunderstood the instructions or only reported future or past events in the recent future or past. Because of this uncertainty, no analyses were conducted on the difference in time between the present and the events described.

Not all participants reported a future and past event (e.g., some only reported past events). Because of this, there was an unequal number of phenomenology scales when broken down into the future and past event simulations for event and location cues. To mitigate this issue, the conducted t-tests combined future and past phenomenology ratings. We conducted nine independent t-tests using the variables of cue type (event and location) and phenomenology item (e.g., visual details) and found no significant difference across the nine dimensions for cue type. Table 2 displays the results for the nine *t*-tests.

Phenomenology ratings did not significantly differ between event and location cues for the spontaneous events. This differs from Sheldon and Chu's (2017) findings because they found that event cued memories were rated as slightly more vivid. However, the lack of difference in phenomenology ratings could indicate the differences in spontaneous and voluntarily cued events. In addition to being more often about specific events (Berntsen & Hall, 2004; Rasmussen & Berntsen, 2009), spontaneous events are rated as more vivid compared to voluntarily cued events (Berntsen, 2019; Berntsen & Jacobsen, 2008; Cole et al., 2016). The absence of differences in phenomenological ratings could reflect that spontaneously generated events are more vivid overall, regardless of the type of environmental information cuing these events.

We did not conduct any analyses comparing future and past events on the phenomenology rating scale because there was an unequal number of phenomenology questionnaires, since not all participants reported a future and past event. Although, it is interesting to note that future and past events followed a similar pattern in how they were rated for each phenomenology item (see graphs in Appendix D). Finding this similar pattern in phenomenological characteristics supports the Constructive Episodic Simulation Hypothesis (Schacter & Addis, 2007). If episodic memory plays a similar role in future and past event simulation then future and past events should be similarly influenced by the environmental information prompting these events.

**Table 2**

*Results of phenomenology ratings for t-tests comparing event and location cues*

| Phenomenology Dimension | Event cues | | Location cues | | *t*(130) | *p* |
|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | | |
| Visual details | 4.47 | 1.79 | 5.08 | 1.98 | -1.84 | .068 |
| Sound details | 2.63 | 1.54 | 2.84 | 1.70 | -0.74 | .460 |
| Smell and/or taste details | 2.31 | 1.57 | 2.39 | 1.45 | -0.30 | .763 |
| Clarity of the location | 4.62 | 1.72 | 5.21 | 2.09 | -1.76 | .082 |
| Objects spatial arrangement | 3.74 | 1.69 | 4.31 | 2.03 | -1.75 | .083 |
| People spatial arrangement | 3.97 | 1.68 | 4.44 | 2.03 | -1.45 | .149 |
| Sense of time | 4.40 | 1.66 | 4.43 | 2.05 | -0.08 | .938 |
| Emotions (negative to positive) | 4.52 | 1.63 | 4.70 | 2.51 | -0.49 | .623 |
| Degree the event has been previously thought of | 4.09 | 1.81 | 3.74 | 1.74 | 1.13 | .262 |

*Note.* Participants completed a nine-item phenomenology questionnaire during the vigilance task immediately after they audio recorded their off-task thoughts. Participants rated their phenomenology between one and seven, with one indicating a lower value. There were no significant differences between the means for event versus location cued thoughts on any of the nine dimensions.

In summary, we conclude that the environmental cues encountered influence the type of spontaneous events elicited. Event cues provide a scaffold that facilitates the production of both future and past event simulations, whereas location cues provide a specific context that is more effective to facilitate the generation of past events.

### 2.4.3 Event sequences

We hypothesized that like involuntary autobiographical memories, future events are simulated in chained-event sequences because spontaneous future and past events are similarly supported by episodic memory. Therefore, our second key question investigated if future events were simulated in chains like involuntary autobiographical memories (Mace et al., 2013). We also investigated the type of connections between these multiple related events. Furthermore, we investigated the specific influence of event and location cues on the formation of chained-event sequences, which has not been investigated in the chaining literature.

#### 2.4.3.1 Event sequences

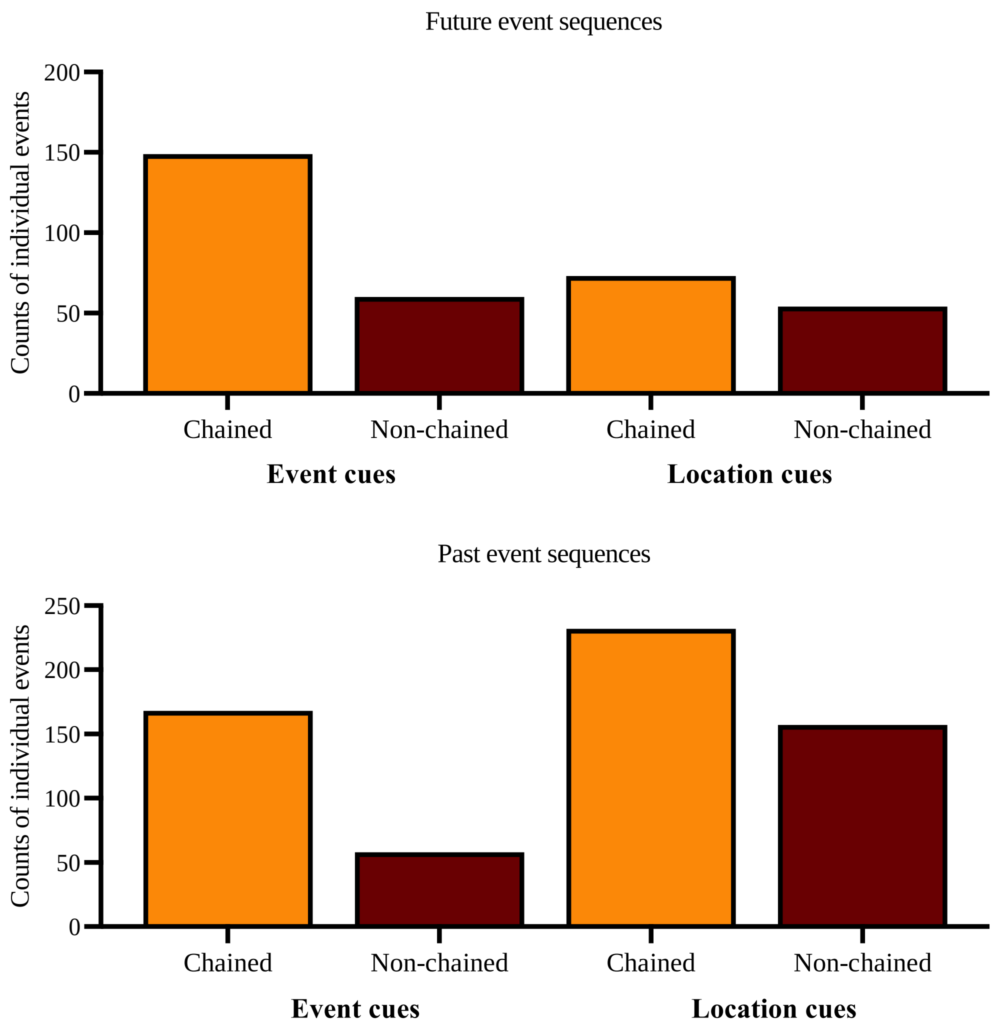
The criteria for determining chained and non-chained sequences were based on Mace et al. (2013). During this step, only future and past events were analyzed. For the events to be considered a chain, they had to be either conceptually related (e.g., involving the same people, places, or activities) or had a cause-and-effect relationship (e.g., event A happened, which caused event B). Importantly, the multiple, individual events had to be reported in the same interruption trial. If the multiple events were unrelated (e.g., "I would like to buy a car in the future" followed by "I will study for my exam tonight"), they were considered a non-chained sequence. If only one event was reported during an interruption trial, it was classified as a single event. Single events were excluded from the event sequence analyses.

Chi-square goodness of fit tests using the variables of cue type (events vs. locations) and event sequence (chained event vs. non-chained event) revealed that we replicated Mace et al.'s (2013) findings that involuntary autobiographical memories do occur in chained-event sequences for event, $\chi^2$ (1) = 53.54, $p < .00001$ and location cues $\chi^2$ (1) = 14.46, $p = .001$. Future events occurred in chains; however, there were a significantly greater number of chained future events only for event cues, $\chi^2$ (1) = 37.9, $p < .00001$. Location cues did not produce a significant difference in the number of future chains and non-chains reported $\chi^2$ (1) = 2.84, $p = .09$. Figure 4 presents the number of event sequences for each cue type.

Using the Constructive Episodic Simulation Hypothesis, if future and past events are similarly generated using episodic memories, we predicted that like involuntary autobiographical memories, spontaneous future events would also be simulated in chains. We replicated Mace et al.'s (2013) diary study findings with our vigilance task because involuntary autobiographical memories occurred in chains for event and location cues. Our prediction that future events would also occur more often in chains was supported for event but not location cues. Because we found that future events can be simulated in chained-event sequences, this nonetheless contributes to the growing evidence supporting the Constructive Episodic Simulation Hypothesis and that overlap exists in how spontaneous future and past events are formed.

**Figure 4**

*Event sequences for future and past events*




*Note.* Chained-event sequences describe when two or more events are consecutively produced and are related. Non-chained event sequences refer to when two or more events are consecutively produced and are not related. Each response was categorized as either a chained or non-chained event for each cue type for future and past events. Future events were simulated in significantly more chained than non-chained sequences only when prompted by event cues. Past events occurred in significantly more chained than non-chained sequences for both event and location cues.

Contrary to our prediction, future events were not simulated in significantly more chained than non-chained sequences for both event and location cues. However, this provides further evidence of how the cues encountered influence the spontaneous events reported. In this case, what information is provided by the cue will determine if the future event is formed in a chained-event sequence. From this, we continue to hypothesize that event cues provide a scaffold for future and past event simulation and this scaffold facilitates chaining in both future and past event simulations. Location cues provide a specific context that better supports the generation of past events in chained-event sequences.

For a chain to form, regardless of the temporality, it requires multiple, associated elements among events. Arguably, events with greater associations may be more likely to form a chained sequence compared to events with fewer associations. Brown (2005) and Sheldon and Chu (2017) have discussed how events and their related themes connect many distinct memories that share overlapping content (e.g., different memories of previous vacations). Because these memories and event knowledge are used to facilitate the simulation of future events (Irish et al., 2012; Irish & Piguet, 2013; Schacter et al., 2012) if more associations between events are available, a future chain could form. The individual can draw on these multiple, related events to simulate various future events. For example, *go shopping* could prompt one to think of going grocery shopping, visiting the mall, and online shopping for clothes. These events would likely involve various locations, people, and objects, although the activity of shopping remains constant across the events. Unlike location cues, the individual is not restricted to what events could occur in a specific location.

Location cues prompted significantly more past events in chains but not significantly more future events in chains. This indicates that location cues provide information that can be effective for past chaining but not future chaining. Location cues provide specific information about a location by reinstating a context (Sheldon & Chu, 2017). For a chain to emerge from a location cue, it would require that the location is associated with multiple events that overlap sufficiently to be prompted consecutively. For future chains, it must also be predicted that multiple events could occur in that location, or at least multiple events that are related to that location (e.g., involving the same person and/or same activity). Past chains, however, have an advantage considering they have already occurred. It is likely that in any given location, an individual has multiple experiences in that shared location, from visiting different museums, visiting the same friend's house growing up, or frequenting a favourite restaurant. Furthermore, these repeated experiences in these locations facilitates chaining for past events. For example, the location of a *restaurant* could remind someone of their favourite restaurant and the different experiences they have had there (e.g., the first time they visited the restaurant, remember taking a friend there recently, and remember ordering takeout from there on their birthday). Unlike event – themes that connect multiple memories and events across different time periods, locations, people, or objects (Brown, 2005; Sheldon & Chu, 2017), locations are bound by a specific element (the location). Due to this, future chains are less likely to emerge from location cues because there might be fewer related future events connected to the location cue.

We were also interested to see what the most effective cues were in each cue condition in generating chained-event sequences. We counted the number of times each cue word prompted chained-event sequences for future and past events (see Tables 3 and 4). Overall, the number of cues that were effective for future and past chains reflects our previous argument that event cues provide a scaffold for future and past chained-event sequences and that locations are more effective at facilitating the formation of past chains. Event cues were frequently used as a connection for future and past chains. In contrast, location cues were more often used in past chains, and as presented in Table 4, only three location cues were used that uniquely prompted future chains.

Event cues such as *see family*, *go to the beach*, and *go on vacation* equally prompted future and past chains. Participants have many experiences with these events, but they also predict that these are events likely to occur in the future. Cues such as *have a reunion*, *get engaged*, and *get married* were especially effective for future events. This is likely due to our demographic sample (18-30) because these events may have not yet happened but are predicted to occur in the future. For past chains, the *start of summer, have an interview*, and *give a gift* were the most effective. While these are events that would be expected to occur in the future, they may be related to more distinct past events. For example, the cues of *have an interview* and *give a gift* may prompt specific events of having a stressful job interview or giving a special gift to a loved one.

When looking at the location cues most effective for future chains, it becomes clear that they are frequently repeating locations. For example, the cues *store, hair salon,* and *library* relate to reoccurring locations that involve highly predictable future events of getting groceries every week, booking a hair appointment every few months, and frequently studying in the library. Parallel to our finding that location cued future event

**Table 3**

*Top mentioned event cues*

| Future and past chains | Future chains | Past chains |
|---|---|---|
| See family | Have a reunion | Start of summer |
| Go to a beach | Get engaged | Have an interview |
| Go on a vacation | Get married | Give a gift |
| Take a flight | Have a celebration | Go to graduation |
| Go to a concert | Make dinner | Rent an apartment |

*Note.* Event cues that were the most effective for future and past chains, future chains only, and past chains only.

simulations were more often planning-oriented, the most effective cues for chains reflect that the best location cues likely prompted already formed, goal-related future events (e.g., planning to book a hair appointment). The less effective cues for future events, albeit highly relevant for past chains, included *cottage, lake,* and *campground*. These specific location cues are especially effective for past events because they may prompt very distinct memories. Furthermore, as discussed by Arnold et al. (2011), highly familiar locations elicit vivid memories. Therefore, using the location cue of *cottage* as an example, this cue might have been particularly effective for chaining past events by eliciting distinct, vivid memories of visiting a family or friend’s cottage.

**Table 4**

*Top mentioned location cues*

| Future and past chains | Future chains | Past chains |
|---|---|---|
| Market | Store | Cottage |
| Airport | Hair salon | Lake |
| Supermarket | Library | Campground |
| Gym | | Park |
| | | School |

*Note.* Location cues that were the most effective for future and past chains, future chains only, and past chains only.

### 2.4.3.2 Chain connections

Our final analysis investigated the connections used in chained-event sequences. Five types of connections were coded: activities, locations, people, objects, and time (see Table 5). These are based on Mace and Clevinger (2019) who identified activities, people, and objects as typical overlapping content. We added location and time to ensure that all types of connections were accounted for. Activities, locations, people, and objects were used when the same activities, locations, people, or objects were involved in both events. Shared time corresponded to two successive events referencing a general time period (e.g., during the summer). The most obvious connection was coded. If there were three or more events in the chain, one connection was coded for each immediately

**Table 5**

*Examples of chain connections*

| Connection type | Example |
|---|---|
| Activity | **Event A:** [I was thinking about my sister's university convocation that just took place a month ago in-person.] |
| | **Event B:** [I also thought about my own, online convocation and how I couldn't attend it in-person.] |
| Location | **Event A:** [Thought about how much time we spent on the beach in Europe recently.] |
| | **Event B:** [And how often that I went to the beach with my mom because it was her favourite place.] |
| People | **Event A:** [I thought about going to the gym with my high school friend] |
| | **Event B:** [and after we finish, going to his place for dinner.] |
| Object | **Event A:** [I chose a gift for an upperyear student from a perfume brand that I really like.] |
| | **Event B:** [Recently I've been into different scents in the form of diffusers and candles.] |
| Time | **Event A:** [Reminded me of swimming in the summertime.] |
| | **Event B:** [And being really tan, which is a great memory, summertime.] |

*Note.* Examples of the five types of the connections that were coded for future and past chained-event sequences.

connecting event. For example, for three events, a connection would be identified for event A and event B and then another connection for event B and event C. This is based on Mace and Clevinger (2019) who found that the third and subsequent memories are not always related to the first memory. Two judges, one naïve to the study's goals, coded the data.

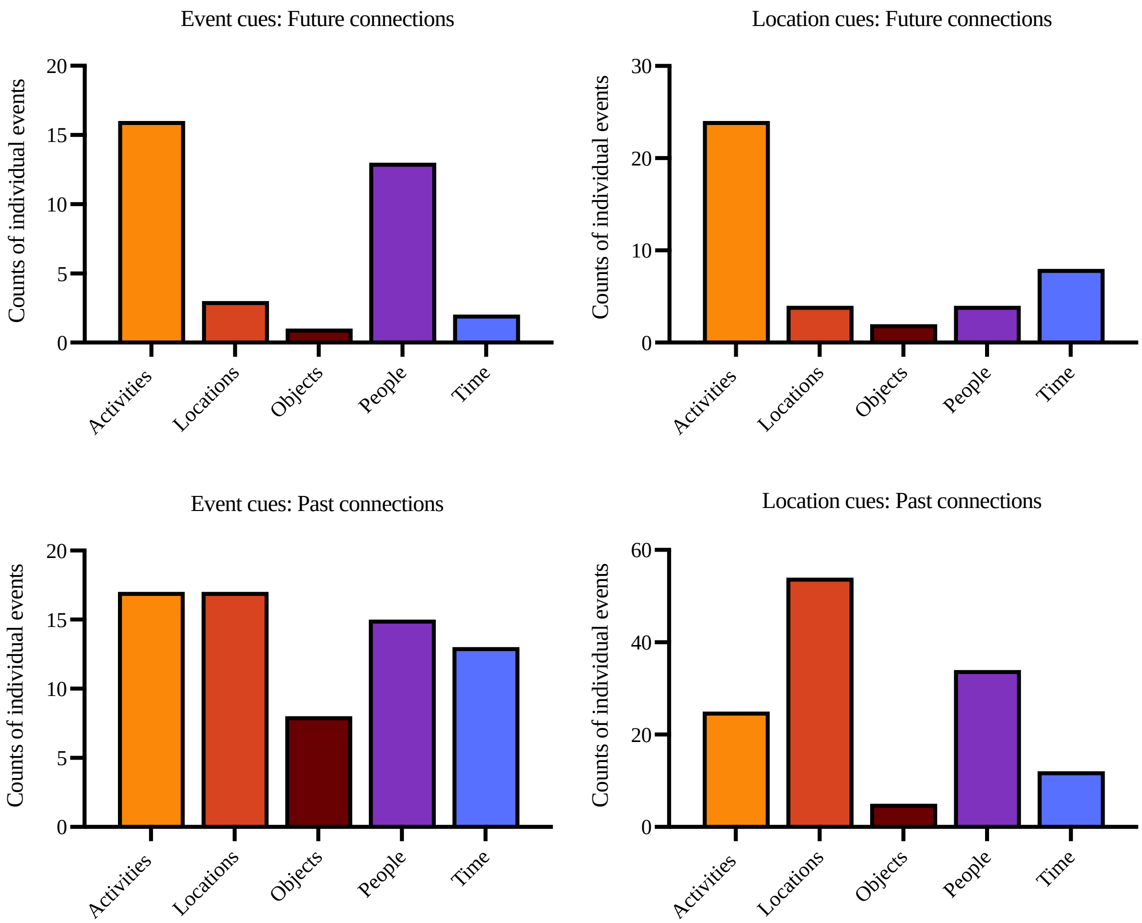
Chi-square tests of independence using the variables of cue type (events vs. locations) and connection type (activities, locations, objects, people, time) revealed a significant relationship. The type of connections used was related to cue type for both future, $\chi^2$ (4) = 9.89, $p$ = 0.042, and past events, $\chi^2$ (4) = 12.68, $p$ = .012. Figure 5 illustrates the distribution of connections for each cue type.

Mace and Clevinger (2019) argued that in chained-event sequences the first memory cues the subsequent, related memory. This raises the question of when multiple related events are generated, how are individuals generating event B from event A? We identified five connections (activities, locations, people, objects, and time) and found that cue type had a significant influence on the type of connections used for future and past chains. These findings add novel insight to the chaining literature that the type of environmental cue encountered influences what will prompt a subsequent event.

It is surprising that future chains, even when given location cues, were highly dependent on activity connections. Unlike past events, where location cues prompted the use of more location connections, future chains infrequently used locations as the connecting factor between event A and event B. This provides further indication that

**Figure 5**

*Connections used in future and past chains for each cue type*




*Note.* This figure shows the number of connections that were produced across the five connection types for future and past chains for each cue condition. A single connection was coded for every future and past chain and described the shared overlap that existed among the chained events. Cue type had a significant influence on the type of connections.

locations are not as effective at eliciting spontaneous future events, compared to other cues. Similar conclusions can also be made with objects and time, as these were relatively infrequent connections for future chains.

Activities were the most common connection for future chains for both event and location cues and this possibly reflects the uncertainty that exists when simulating future events (Atance & O'Niell, 2005). For example, one may know of the activities that they may need or wish to complete, such as chores they need to finish, their weekend plans, or what they would like to do in the summer. On the other hand, they might not know specific details such as the location, people, or objects involved in the event. Thus, when multiple related events are produced, the connection is typically the activity (e.g., schoolwork, shopping, vacation) as opposed to a specific element of the related events. We did find, however, that the people involved in the event were a quite frequent connection for future chains when participants encountered event cues. This might suggest that people could be an element that is more salient for thinking about future events, compared to locations or objects. For example, one might think of their weekend plans with their friends and associated events with those individuals, but other elements such as the location or objects may not yet be well defined (e.g., where they plan to hang out). Potentially, this could also reflect that people might be a more effective cue for spontaneously prompting future events compared to locations.

Turning to the chain connections for past events, event cues elicited a relatively uniform distribution across connection types, with objects being slightly less common. This uniform distribution in connections likely reflects how past events can share similar themes that involve various people, locations, and objects (Brown, 2005; Sheldon & Chu, 2017). Individuals will have multiple experiences in similar locations, that involve the same people, and completing similar activities. For location cue connections, location cued past chains did result in more location connections. This indicates that when prompted by a location, the associated events in the chain are typically related to that location cue. This further reflects that location cues prompt highly specific memories (Sheldon & Chu, 2017) because the cuing of specific episodic details helps prompt other related past events that are in that shared location.

In summary, future events, like past events can be simulated in chained-event sequences. The connection that prompts the subsequent events depends on the environmental cues encountered. Furthermore, the infrequent use of location connections for future chains, but not past chains, further indicates that locations are less effective at prompting future events compared to past events.

# Chapter 3

## 3 General Discussion

The current study investigated how spontaneous future and past events are simulated from cues in the environment. Our results indicated that event cues were more effective at eliciting future event simulations, whereas location cues were more effective for eliciting past event simulations. Event cues resulted in a greater number of hypothetical future events compared to the location cues that prompted a greater number of planning-oriented future events. We also investigated whether future events are simulated in chained-event sequences, as has been found for involuntary autobiographical memories, and how cue type might influence the formation of chains. Past events occurred in chains for event and location cues. Future events resulted in significantly more chained than non-chained event sequences only when prompted by event cues. Cue type also influenced the type of connections that were found in chained-event sequences for future and past events. These interesting findings provide insight into how specific cues influence the spontaneous simulation of future and past events. The remainder of the thesis discusses future directions for research, limitations, and conclusions.

### 3.1 Future directions

This study provides a number of insights into how certain cue types influence spontaneous future and past events. It would be valuable to gather insight into how other cues, for example, people or objects elicit spontaneous events. Previous research has indicated that objects might be especially relevant in eliciting involuntary autobiographical memories (Berntsen & Hall, 2004). Although we did not use object cues to elicit these spontaneous future and past events, we did include objects as a category for the chains connections analysis. Interestingly, we did not find objects to be common connection for future or past chains. In fact, it was the least common connection across both cue conditions. Potentially, this may suggest that objects are effective at eliciting involuntary autobiographical memories (Berntsen & Hall, 2004) but are ineffective at facilitating chained-event sequences. Nonetheless, it would be interesting to use specific elements, such as types of objects and people to prompt off-task thoughts during a vigilance task. Based on our results, we predict that people and object cues would prompt more spontaneous past events than future event simulations. Albeit it could also be predicted that people cues may be more effective at eliciting spontaneous future events and future chains compared to location cues because our results indicated that people often connected future chains. These predictions are based on our hypothesis that like locations, objects and people are elements of an event. Due to this specificity, it may be more challenging for spontaneous future events and future chains to be simulated from these cues compared to event cues. Future research could investigate these specific cue types to gain insight into the role that other environmental information (people, objects) has in spontaneous simulation. Furthermore, investigating these claims would offer support for the current study's conclusions that elements of events (e.g., locations, objects, people) are less effective at eliciting future event simulations, if object and people cues resulted in fewer future events and more past events.

Another avenue of future research would be to assess whether age influences the effects of cue type. Previous work has found that unlike deliberate future thinking, there is an absence of an age-related decline in spontaneous future thinking (Kvavilashvili & Fisher, 2007; Warden et al., 2019). Based on this evidence, we would predict event and location cues to have similar effects on older adults compared to our current age sample. It would be interesting to investigate this explicitly because it could offer further support for an absence of age effects in spontaneous event generation. On the other hand, if age effects were found this would provide evidence that some age-related decline exists in spontaneous simulation.

Finally, it would be important to investigate how event and location cues influence deliberately generated future events. In doing so, a more direct comparison to Sheldon and Chu's (2017) findings would be possible. Directly extending Sheldon and Chu's (2017) event fluency paradigm to future events could provide interesting insights. First, it could address the overlap in how future and past events are deliberately generated. Second, it would provide evidence for how specific cues (events and locations) are used to generate deliberate future events, which has not yet been addressed in the literature. We currently are completing data collection for precisely this study.

## 3.2 Limitations

As is the case for all studies investigating spontaneous thought, researchers are unable to conclude if the events emerging are entirely spontaneous. Regardless, the type of task and instructions contrast greatly with the methods used to study deliberate future and past event generation. In studies that assess deliberate future or past thinking, participants are presented with cues and specifically asked to simulate and describe a related future or past event, typically within a prescribed time limit (Cole & Kvavilashvili, 2019). In comparison, during our study participants were instructed only to locate the left-facing arrow in the vigilance task. Participants were also asked to record off-task thoughts, although they were not instructed to think of anything specific or to stick to a particular temporal period. Participants were given unlimited time to discuss their thoughts and were able to skip an interruption trial if wished. Based on these conditions, we maintain that these events are considered distinct from deliberate future and past event simulations.

## 3.3 Conclusions

Individuals frequently encounter event and location cues every day and sometimes, these cues elicit spontaneous future and past events. This study investigated the degree to which cue type was associated with the type of spontaneous future and past events that were generated. Our findings continue to support that environmental cues are important for eliciting these spontaneous events (Berntsen & Jacobsen, 2008).

Event cues (*hang out with friends*) provide a scaffold for future and past events, including future and past chains. Location cues (*coffee shop*) provide a context (Sheldon & Chu, 2017) that is more effective at prompting past events and past chained-event sequences. Whereas event cues provide the event directly and associated elements of the event, location cues provide one element of the event and then require the individual to generate an event with the element of that location. Together, this study extends previous research (Berntsen & Jacobsen, 2008) and supports that both spontaneous future and past events are simulated from environmental information. The results and conclusions from this study also provide interesting and novel insight into how specific types of cues directly influence the characteristics of spontaneous future and past event simulations. Furthermore, this study replicated findings from Mace et al. (2013) that involuntary autobiographical memories occur in chained-event sequences and even more noteworthy, extended chaining literature to episodic future thinking.

# References

Addis, D. R., Pan, L., Vu, M.-A., Laiser, N., & Schacter, D. L. (2009). Constructive episodic simulation of the future and the past: Distinct subsystems of a core brain network mediate imagining and remembering. *Neuropsychologia*, *47*(11), 2222–2238. https://doi.org/10.1016/j.neuropsychologia.2008.10.026

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, *45*(7), 1363–1377. https://doi.org/10.1016/j.neuropsychologia.2006.10.016

Adlam, A.-L. R., Patterson, K., & Hodges, J. R. (2009). "I remember it as if it were yesterday": Memory for recent events in patients with semantic dementia. *Neuropsychologia*, *47*(5), 1344–1351. https://doi.org/10.1016/j.neuropsychologia.2009.01.029

Arnold, K. M., McDermott, K. B., & Szpunar, K. K. (2011). Imagining the near and far future: The role of location familiarity. *Memory & Cognition*, *39*(6), 954–967. https://doi.org/10.3758/s13421-011-0076-1

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533–539. https://doi.org/10.1016/s1364-6613(00)01804-0

Atance, C. M., & O'Neill, D. K. (2005). The emergence of episodic future thinking in humans. *Learning and Motivation, 36*(2), 126–144. https://doi.org/10.1016/j.lmot.2005.02.003

Benoit, R. G., & Schacter, D. L. (2015). Specifying the core network supporting episodic simulation and episodic memory by activation likelihood estimation. *Neuropsychologia*, *75*, 450–457. https://doi.org/10.1016/j.neuropsychologia.2015.06.034

Berntsen, D. (2019). Spontaneous future cognitions: An integrative review. *Psychological Research*, *83*(4), 651–665. https://doi.org/10.1007/s00426-018-1127-z

Berntsen, D., & Bohn, A. (2010). Remembering and forecasting: The relation. *Memory & Cognition*, *38*(3), 265–278. https://doi.org/10.3758/MC.38.3.265

Berntsen, D., & Hall, N. M. (2004). The episodic nature of involuntary autobiographical memories. *Memory & Cognition*, *32*(5), 789–803. https://doi.org/10.3758/BF03195869

Berntsen, D., & Jacobsen, A. S. (2008). Involuntary (spontaneous) mental time travel into the past and future. *Consciousness and Cognition*, *17*(4), 1093–1104. https://doi.org/10.1016/j.concog.2008.03.001

Binder, J. R., & Desai, R. H. (2011). The Neurobiology of Semantic Memory. *Trends in Cognitive Sciences*, *15*(11), 527–536. https://doi.org/10.1016/j.tics.2011.10.001

Binder, J. R., Desai, R. H., Graves, W. W., & Conant, L. L. (2009). Where Is the Semantic System? A Critical Review and Meta-Analysis of 120 Functional Neuroimaging Studies. *Cerebral Cortex*, *19*(12), 2767–2796. https://doi.org/10.1093/cercor/bhp055

Brown, N. R. (2005). On The Prevalence of Event Clusters in Autobiographical Memory. *Social Cognition*, *23*(1), 35–69. https://doi.org/10.1521/soco.23.1.35.59194

Cole, S. N., & Kvavilashvili, L. (2019). Spontaneous future cognition: The past, present and future of an emerging topic. *Psychological Research*, *83*(4), 631–650. https://doi.org/10.1007/s00426-019-01193-3

Cole, S. N., & Kvavilashvili, L. (2021). Spontaneous and deliberate future thinking: A dual process account. *Psychological Research*, *85*(2), 464–479. https://doi.org/10.1007/s00426-019-01262-7

Cole, S. N., & Berntsen, D. (2016). Do future thoughts reflect personal goals? Current concerns and mental time travel into the past and future. *Quarterly Journal of Experimental Psychology*, *69*(2), 273–284. https://doi.org/10.1080/17470218.2015.1044542

Cole, S. N., Staugaard, S. R., & Berntsen, D. (2016). Inducing involuntary and voluntary mental time travel using a laboratory paradigm. *Memory & Cognition*, *44*(3), 376–389. https://doi.org/10.3758/s13421-015-0564-9

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, *107*(2), 261–288. https://doi.org/10.1037/0033-295X.107.2.261

D’Argembeau, A., & Van der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and Cognition*, *13*(4), 844–858. https://doi.org/10.1016/j.concog.2004.07.007

D'Argembeau, A., & Van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition*, *15*(2), 342–350. https://doi.org/10.1016/j.concog.2005.09.001

Duffy, J., & Cole, S. N. (2021). Functions of spontaneous and voluntary future thinking: Evidence from subjective ratings. *Psychological Research, 85*(4), 1583–1601. https://doi.org/10.1007/s00426-020-01338-9

Ellis, J., & Kvavilashvili, L. (2000). Prospective memory in 2000: Past, present, and future directions. *Applied Cognitive Psychology*, *14*(7), S1–S9. https://doi.org/10.1002/acp.767

Elman, J. L., & McRae, K. (2019). A model of event knowledge. *Psychological Review*, *126*(2), 252–291. https://doi.org/10.1037/rev0000133

Ghosh, V. E., & Gilboa, A. (2014). What is a memory schema? A historical perspective on current neuroscience literature. *Neuropsychologia*, *53*, 104–114. https://doi.org/10.1016/j.neuropsychologia.2013.11.010

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, *11*(7), 299–306. https://doi.org/10.1016/j.tics.2007.05.001

Irish, M., Addis, D. R., Hodges, J. R., & Piguet, O. (2012). Considering the role of semantic memory in episodic future thinking: Evidence from semantic dementia. *Brain*, *135*(7), 2178–2191. https://doi.org/10.1093/brain/aws119

Irish, M., & Piguet, O. (2013). The Pivotal Role of Semantic Memory in Remembering the Past and Imagining the Future. *Frontiers in Behavioral Neuroscience*, *7*. https://www.frontiersin.org/articles/10.3389/fnbeh.2013.00027

Kvavilashvili, L., & Fisher, L. (2007). Is time-based prospective remembering mediated by self-initiated rehearsals? Role of incidental cues, ongoing activity, age, and motivation. *Journal of Experimental Psychology: General*, *136*(1), 112–132. https://doi.org/10.1037/0096-3445.136.1.112

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging*, *17*(4), 677–689. https://doi.org/10.1037/0882-7974.17.4.677

Mace, J. H. (2005). Priming involuntary autobiographical memories. *Memory*, *13*(8), 874–884. https://doi.org/10.1080/09658210444000485

Mace, J. H., & Clevinger, A. M. (2019). The associative nature of episodic memories: The primacy of conceptual associations. In J.H. Mace (Ed.). *The organization and structure of autobiographical memory* (pp.183-200). Oxford University Press. https://doi.org/10.1093/oso/9780198784845.003.0010

Mace, J. H., Clevinger, A. M., & Bernas, R. S. (2013). Involuntary memory chains: What do they tell us about autobiographical memory organisation? *Memory*, *21*(3), 324–335. https://doi.org/10.1080/09658211.2012.726359

Mazzoni, G. (2019). Involuntary memories and involuntary future thinking differently tax cognitive resources. *Psychological Research*, *83*(4), 684–697. https://doi.org/10.1007/s00426-018-1123-3

McRae, K., Brown, K. S., & Elman, J. L. (2021). Prediction-Based Learning and Processing of Event Knowledge. *Topics in Cognitive Science*, *13*(1), 206–223. https://doi.org/10.1111/tops.12482

Mion, M., Patterson, K., Acosta-Cabronero, J., Pengas, G., Izquierdo-Garcia, D., Hong, Y. T., Fryer, T. D., Williams, G. B., Hodges, J. R., & Nestor, P. J. (2010). What the left and right anterior fusiform gyri tell us about semantic memory. *Brain*, *133*(11), 3256–3268. https://doi.org/10.1093/brain/awq272

Newby-Clark, I. R., & Ross, M. (2003). Conceiving the Past and Future. *Personality and Social Psychology Bulletin*, *29*(7), 807–818. https://doi.org/10.1177/0146167203029007001

Plimpton, B., Patel, P., & Kvavilashvili, L. (2015). Role of triggers and dysphoria in mind-wandering about past, present and future: A laboratory study. *Consciousness and Cognition*, *33*, 261–276. https://doi.org/10.1016/j.concog.2015.01.014

Rasmussen, A. S., & Berntsen, D. (2009). The possible functions of involuntary autobiographical memories. *Applied Cognitive Psychology*, *23*(8), 1137–1152. https://doi.org/10.1002/acp.1615

Robin, J., & Moscovitch, M. (2017). Details, gist and schema: Hippocampal–neocortical interactions underlying recent and remote episodic and spatial memory. *Current Opinion in Behavioral Sciences*, *17*, 114–123. https://doi.org/10.1016/j.cobeha.2017.07.016

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *362*(1481), 773–786. https://doi.org/10.1098/rstb.2007.2087

Schacter, D. L., Addis, D. R., Hassabis, D., Martin, V. C., Spreng, R. N., & Szpunar, K. K. (2012). The Future of Memory: Remembering, Imagining, and the Brain. *Neuron*, *76*(4), 677–694. https://doi.org/10.1016/j.neuron.2012.11.001

Schlagman, S., & Kvavilashvili, L. (2008). Involuntary autobiographical memories in and outside the laboratory: How different are they from voluntary autobiographical memories? *Memory & Cognition*, *36*(5), 920–932. https://doi.org/10.3758/MC.36.5.920

Sheldon, S., & Chu, S. (2017). What versus where: Investigating how autobiographical memory retrieval differs when accessed with thematic versus spatial information.

*The Quarterly Journal of Experimental Psychology*, *70*(9), 1909–1921. https://doi.org/10.1080/17470218.2016.1215478

Smallwood, J., & Schooler, J. W. (2015). The Science of Mind Wandering: Empirically Navigating the Stream of Consciousness. *Annual Review of Psychology*, *66*(1), 487–518. https://doi.org/10.1146/annurev-psych-010814-015331

Spreng, R. N., & Levine, B. (2006). *The temporal distribution of past and future autobiographical events across the lifespan | SpringerLink*. https://link.springer.com/article/10.3758/bf03195927

Tulving, E. (2002). Episodic Memory: From Mind to Brain. *Annual Review of Psychology*, *53*(1), 1–25. https://doi.org/10.1146/annurev.psych.53.100901.135114

Vannucci, M., Pelagatti, C., Chiorri, C., & Brugger, P. (2019). Space–time interaction: Visuo-spatial processing affects the temporal focus of mind wandering. *Psychological Research*, *83*(4), 698–709. https://doi.org/10.1007/s00426-018-1080-x

Vannucci, M., Pelagatti, C., Hanczakowski, M., Mazzoni, G., & Paccani, C. R. (2015). Why are we not flooded by involuntary autobiographical memories? Few cues are more effective than many. *Psychological Research*, *79*(6), 1077–1085. https://doi.org/10.1007/s00426-014-0632-y

Warden, E. A., Plimpton, B., & Kvavilashvili, L. (2019). Absence of age effects on spontaneous past and future thinking in daily life. *Psychological Research*, *83*(4), 727–746. https://doi.org/10.1007/s00426-018-1103-7

Wheeler, M. A., Stuss, D. T., & Tulving, E. (1997). Toward a theory of episodic memory: The frontal lobes and autonoetic consciousness. *Psychological Bulletin*, *121*(3), 331–354. https://doi.org/10.1037/0033-2909.121.3.331

# Appendix A

Cues

| Event cues | Location cues |
| --- | --- |
| go to Europe, take a flight | airport |
| go on vacation | cruise ship |
| go to a beach | ocean, lake, island |
| make dinner | kitchen |
| go to a resort | hotel |
| do your taxes, get a mortgage | bank |
| see a lawyer | courtroom |
| take an exam | classroom, library |
| give a speech, attend a ceremony | auditorium |
| go to the office | lobby |
| have an interview, have a career | boardroom |
| get a degree | school |
| go shopping | market |
| give a gift | store |
| make a purchase | supermarket |
| go to a mall | food court |
| go to a bar, go to a party | casino, pub |

| | |
|---|---|
| rent an apartment | bedroom, bathroom |
| move into a new place | dormitory |
| see your nephew, see your niece, see family, have a son, have a daughter | house |
| go to a concert | theatre |
| go to the doctor | hospital, dental office |
| go on adventure | cottage, forest, mountain, river |
| go to a restaurant | bakery |
| start of summer | campground, trailer |
| go on a date, meet your partner, start a relationship | coffee shop |
| have a celebration, achieve something, go to graduation | stage |
| go to a festival | park, highway |
| hang out with friends | arcade, gym |
| make a reservation | gallery, museum |
| have a reunion | backyard |
| * have an anniversary, go to a movie theatre, get engaged, get married, celebrate a holiday | * rink, garage, garden, hair salon, zoo |

*Note.* Event and location cues that were presented during the vigilance task. Event and location cues were similar between cue conditions. * Indicates these cues do not have a specific corresponding cue.

## Appendix B

Phenomenology rating questionnaire*

1. Please write a description of your recently recorded event(s).

2. Please indicate your age(s) during your recently recorded event(s).

Please, rate your overall mental representation according to the following statements. You will rate them from 1 to 7, being 1 "None", 4 “Moderate”, 7 "A lot."

3. Your representation of this event involved visual details.
4. Your representation of this event involved sounds.
5. Your representation of this event involved smells or/and tastes.

Now about the clarity of the context in your simulation, how will you to rate your own mental representation according to the following statements? You must rate them from 1 to 7, being 1 "Vague”, 4 “Moderate”, 7 “Clear."

6. Your representation for the location where the event takes place is:

7. The relative spatial arrangement of objects in your representation for the event is:

8. The relative spatial arrangement of people in your representation for the event is:

9. Your representation for the time of day when the event takes place is:

Now, on a scale from 1 to 7, being 1 "Very negatives", 4 “Neutral”, 7 "Very positives"

10. How clear are the emotions that are involved in this event?

On a scale from 1 to 7, being 1 “Never”, 4 “Moderate”, 7 “A lot”.

11. How much have you thought about this event before?

*Questions 3 through 11 are based on the phenomenology rating questionnaire from D’Argembeau and Van der Linden (2004).

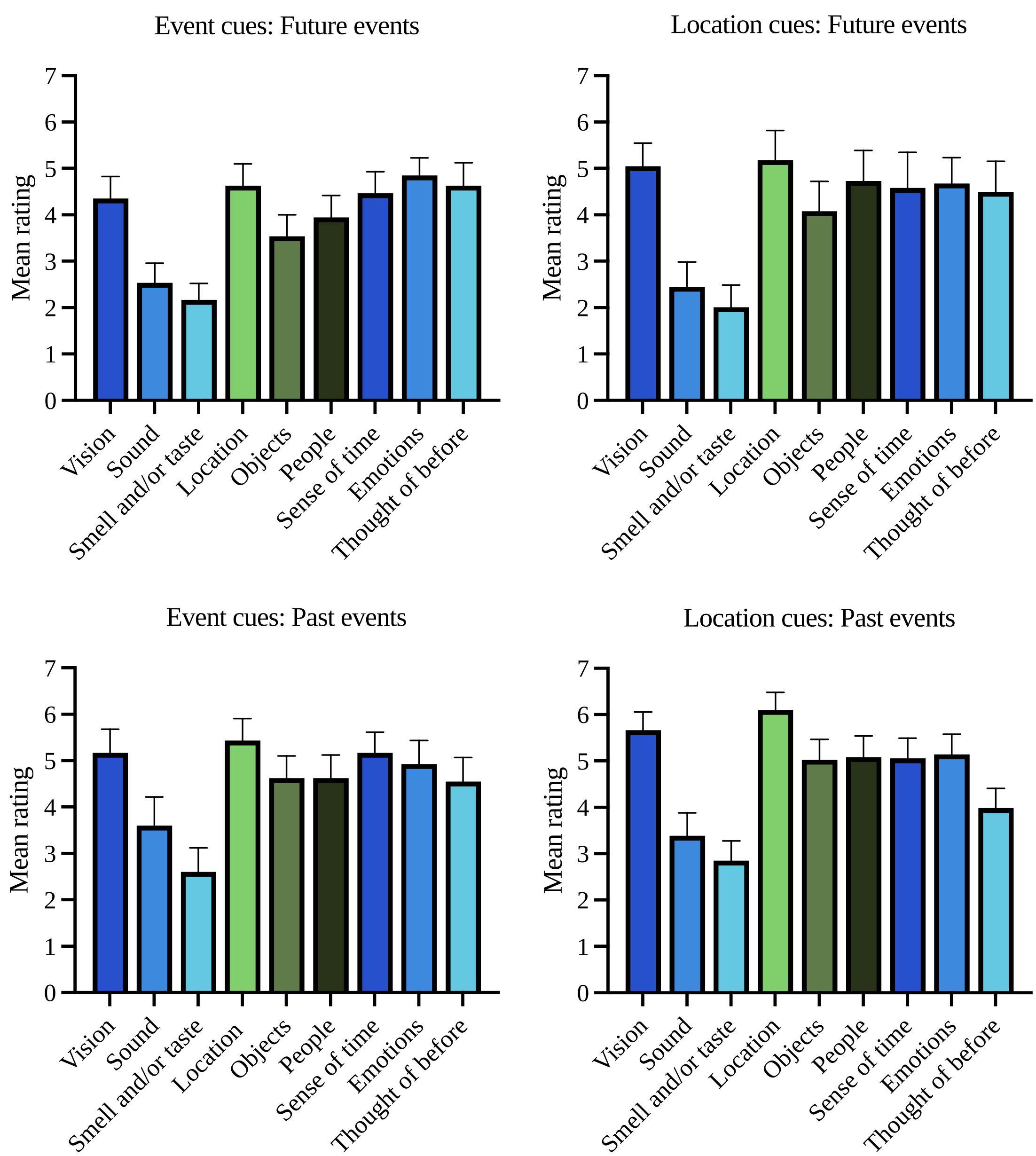
## Appendix C

Demographics

1. Please indicate your age.
2. Please indicate your handedness.
   - *Right*
   - *Left*
   - *Ambidextrous*
3. Please indicate your gender.
   - *Prefer not to say*
   - *Nonbinary/third gender*
   - *Female*
   - *Male*
4. Do you have normal or corrected to normal vision?
   - *No*
   - *Yes*
5. Do you have any neurological impairments?
   - *No*
   - *Yes*

## Appendix D

Phenomenology ratings for future and past events for each cue type




*Note*. Participants completed a phenomenology rating questionnaire immediately after audio recording their off-task thoughts. Because there was an unequal number of future and past events reported, *t*-tests were not conducted to compare future versus past event phenomenology ratings. This figure shows how future and past events follow a similar pattern in their phenomenology ratings for event and location cues. Error bars refer to the 95% confidence interval.

# Appendix E

## Ethics Approval

**Date:** 13 July 2022

**To:** Prof. Kenneth McRae

**Project ID:** 115937

**Study Title:** Simulation of future events

**Application Type:** Continuing Ethics Review (CER) Form

**Review Type:** Delegated

**Meeting Date:** August 5 2022

**Date Approval Issued:** 13/Jul/2022 17:12

**REB Approval Expiry Date:** 28/Jul/2023

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Dear Prof. Kenneth McRae,

The Western University Non-Medical Research Ethics Board has reviewed this application. This study, including all currently approved documents, has been re-approved until the expiry date noted above.

REB members involved in the research project do not participate in the review, discussion or decision.

The Western University NMREB operates in compliance with the Tri-Council Policy Statement Ethical Conduct for Research Involving Humans (TCPS2), the Ontario Personal Health Information Protection Act (PHIPA, 2004), and the applicable laws and regulations of Ontario. Members of the NMREB who are named as Investigators in research studies do not participate in discussions related to, nor vote on such studies when they are presented to the REB. The NMREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000941.

Please do not hesitate to contact us if you have any questions.

Sincerely,

The Office of Human Research Ethics

***Note: This correspondence includes an electronic signature (validation and approval via an online system that is compliant with all regulations).***

# Appendix F

Letter of Information and Consent

Western

*(First screen of the survey)*

Welcome! Thank you for participating in our study. Please, read the information below before you start the survey

Project Title: Simulation of future events

Name of Principal Investigator:

Ken McRae, Ph.D., Psychology

[redacted]

Email: [redacted]

Telephone: [redacted]

Name of Study Contact:

Mackenzie Bain

[redacted]

Email: [redacted]

Invitation to Participate: You are being invited to participate in this research study to help with gaining a greater understanding of how people simulate future events. You are being asked to participate because we are interested in adults' simulation of future events.

Purpose of the Letter: The purpose of this letter is to provide you with the information required for you to make an informed decision regarding participation in this research.

Study Procedures: This study will take 1 hour (60 minutes). The first component is a demographics questionnaire, which will take 10 minutes. The second component, which is the main part of the study in which you will complete a simple reaction time task and survey questions, will take a total of 50 minutes. You will be asked to do the following:

- Respond to a brief questionnaire about demographics.
- Respond to an online questionnaire relating to the simulation of events and memory.
- Complete a computer-based task during which we will audio record responses to questions. You will only be asked to audio record any thoughts/ideas/memories that you feel comfortable with being recorded.

Possible Risks and Harms: There are no known or anticipated risks or discomforts associated with participating in this study.

Possible Benefits: You may not directly benefit from participating in this study, but the knowledge gained may provide benefits to society as a whole. This study aims to obtain knowledge regarding how people simulate future events. The resulting knowledge about people's prospective memory for events is of potential benefit to society. Event knowledge is important to many aspects of cognition, including understanding the world around us, anticipating what might happen next, planning, and understanding language.

Compensation:

You will be compensated for your time with 1 research credit.

Western

**Voluntary Participation**: Your participation is voluntary. You may refuse to participate, refuse to answer any questions, or withdraw from the study at any time, for any reason, without loss of research credit. If you decide to withdraw from the study, you have the right to request (e.g., by phone, in writing, etc.) withdrawal of information collected about you. If you wish to have your information removed please let the researcher know and your information will be destroyed from our records. Once the study has been published we will not be able to withdraw your information.

**Confidentiality**: All data will be labeled with SONA generated codes and will in no way be linked with your name or any other identification that could be associated with you, guaranteeing that your participation remains anonymous and confidential. If the results are published, your name will not be used. In published reports, data will typically be reported in aggregate (i.e., by averaging across multiple participants). However, some data may be published at the individual participant level (e.g., to provide examples or demonstrated individual differences). In all cases, data will be de-identified prior to publication. Your responses will be collected anonymously through two secure online platforms, Pavlovia, which is an online experiment hosting platform, and Qualtrics, which is a survey platform. Pavlovia uses encryption technology and restricted access authorizations to protect all data collected. In addition, Pavlovia's server is in the United Kingdom, where privacy standards are maintained by Open Science Tools Ltd., which falls under UK jurisdiction. Qualtrics uses encryption technology and restricted access authorizations to protect all data collected. In addition, Western's Qualtrics server is in Ireland, where privacy standards are maintained under the European Union safe harbor framework. The data will then be exported from Pavlovia and Qualtrics and will be securely stored on Western University's server. Study records will be kept for 7 years, and then will be securely deleted electronically. Representatives of The University of Western Ontario Non-Medical Research Ethics Board may require access to your study-related records to monitor the conduct of the research.

Western

**Contacts for Further Information:** Once your participation is complete, you will be debriefed, and you may ask any questions of the researcher. If you have any concerns regarding your participation or are interested in learning more about this research study, feel free to contact the principal investigator of this study, Dr. Ken McRae [redacted] If you have any questions about the conduct of the study or your rights as a research participant, please contact the Office of Human Research Ethics at the University of Western Ontario [redacted]. This office oversees the ethical conduct of research studies and is not part of the study team. Everything that you discuss will be kept confidential.

**Publication:** The results of this study may be published as a Master's thesis, conference presentations, and/or a published article.

**Consent**: Your consent will be directly asked.

◯ I have read and understood the information above

*(Second screen of the survey)*

If you agree to participate in the study, please indicate it below by click in YES answer option. You will then receive specific instructions for the study. You do not waive any legal right by agreeing

◯ YES

◯ NO

*(If the participants select NO or do not select an option, then they will not be able to continue with the survey because of validation options applied)*

# Curriculum Vitae

Mackenzie Bain

## Education

2022 – Present **M.Sc. Candidate, Psychology (Cognitive, Developmental, and Brain Sciences)**

University of Western Ontario, London, ON.

Thesis: Spontaneous simulation of future and past events

Supervisor: Dr. Ken McRae

2016 – 2021 **B.A. Honours, Psychology**

University of Guelph, Guelph, ON.

Thesis: Individual differences in devaluation-by-inhibition effect: Behavioural Inhibition

Supervisor: Dr. Mark Fenske

## Conferences

Talks

1. Bain, M. & McRae, K. (2023, September). *Chained-event sequences: Evaluating the chain of thought in spontaneous episodic future thinking and involuntary autobiographical memory.* European Society for Cognitive Science (ESCOP), Porto, Portugal.
2. Bain, M. & McRae, K. (2023, July). *Take a flight or be at the airport? The influence of event versus location cues on chained-event sequences when spontaneously thinking about your future and past.* Canadian Society for Brain, Behaviour, and Cognitive Science (CSBBCS), Guelph, ON.

Poster Presentations

1. Bain, M., & McRae, K. (2023, February). *Are spontaneous episodic future thoughts simulated in chained event sequences? A novel comparison to involuntary autobiographical memory chains.* Lake Ontario Visionary Establishment Conference (LOVE), Niagara, ON.
2. Pardy, B., Clancy, E. M., Bain, M., Mahood, R., Fenske, M. J. (2022, November). *Searching for individual-difference factors in distractor devaluation and no-go devaluation effects: Inhibitory control, emotional reactivity, and visual working memory.* Psychonomic Society, Boston, MA.

3. Clancy, E. M., Bain, M., Pardy, B., & Fenske, M. J. (2021, May). *Exploring the consistency of the affective consequences of cognitive control for visual stimuli across tasks and individuals.* Vision Sciences Society Conference, Virtual.
4. Bain, M., Clancy, E. M., & Fenske, M. J. (2021, May). *Exploring individual-difference factors in the devaluation-by-inhibition effect.* Neuroscience Day, Guelph, ON.
5. Bain, M., Clancy, E. M., & Fenske, M. J. (2021, July). *Exploring individual-difference factors in the devaluation-by-inhibition effect*. Canadian Society of Brain, Behavioural, and Cognitive Sciences (CSBBCS), Virtual.

**Research Experience**

| | |
|---|---|
| 2022 – Present | **Graduate Student** |
| | University of Western Ontario |
| | McRae Cognitive Science Lab |
| | Supervisor: Dr. Ken McRae |
| 2020 – 2021 | **Honours Thesis Student** |
| | University of Guelph |
| | Cognitive Affective Neuroscience Lab |
| | Supervisor: Dr. Mark Fenske |
| 2019 | **Undergraduate Research Assistant** |
| | University of Guelph |
| | Computing and Communication Services |
| | Supervisor: Jon Spencely |

**Awards**

| | |
|---|---|
| 2023 | Graduate Research Awards Fund ($550) |
| 2022 | SSHRC Canada's Graduate Scholarship Master's Award, Social Sciences and Humanities Research Council ($17,500) |
| 2016 – 2021 | Deans Honour List, University of Guelph |

**Related Experience**

| | |
|---|---|
| 2023 | **Member of the Society of Graduate Students Sustainability Committee** |
| | University of Western Ontario |
| 2022 – Current | **Graduate Teaching Assistant** |
| | University of Western Ontario |
| 2022 – Current | **Member of the Psychology Graduate Student Association** |
| | University of Western Ontario |
| 2022 – Current | **Reviewer for Western's Psychology Undergraduate Journal** |
| | University of Western Ontario |