



Involuntary “what if” moments

Improbable simulations across the sleep-wake cycle and their relationship with anxiety

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Abstract

Improbable simulations, or spontaneous thoughts that consist of events that are unlikely to occur in waking life, are presumably common experiences during both periods of waking and dreaming. Yet, despite anecdotes of involuntarily simulating experiences like driving off the road, throwing your cellphone off a bridge, or screaming in a crowded room, the empirical work on this topic has been quite limited. Here we attempt to shed some foundational light on such improbable simulations by exploring their perceived occurrence and relation to sense of agency and intolerance of uncertainty throughout the sleep/wake cycle. Participants ($N=100$) indicated their perceived frequency and affective valence of improbable simulations related to certain themes (personal, social, and nature) across waking and dreaming states. Although participants perceived experiencing improbable simulations more often while awake, the common themes and valence of improbable simulations did not differ across periods of waking and dreaming - that is, participants were most likely to simulate personal events in both states, and social simulations were the most positive theme in both states. Critically, all themes in waking were positively correlated with intolerance of uncertainty, a characteristic of various anxiety disorders, while this relationship was only observed for personal simulations in dreaming states. However, no such relation was observed for sense of agency for any theme across waking and dreaming states. Our findings thus provide insights on the general nature of improbable simulations across both wake and sleep, as well as their relation to anxiety characteristics.

Keywords

Anxiety · Dreaming · Phenomenology · Simulation · Spontaneous cognition

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Our minds have a tendency to suddenly and involuntarily simulate events that will almost certainly not occur; yelling in a crowded room, driving off the road, getting struck by lightning, or falling/jumping from a high place. *Improbable simulations* – defined here as spontaneous thoughts of events that are unlikely to take place in real life – represent an interesting form of spontaneous thoughts; they are not simply unintentional and “out of the blue” – they give us a glimpse into a reality that will likely never exist. However, aside from a small body of work on the “high place phenomenon” which specifically refers to simulating jumping from a high place (Hames et al., 2012; Teismann et al., 2020), not much is known about improbable simulations, including their common themes, phenomenology, and potential relationship to intolerance of uncertainty and sense of agency in our daily lives.

Another curious aspect of improbable simulations is that they may not be relegated to our waking conscious experience alone. Although the improbable nature of such simulations has not been a focus of traditional dream research, a recent study made this connection more explicit; dream content frequently contained simulations of future events that were unlikely to truly happen (Wamsley, 2022). Functional theories of dreams, too, suggest that simulations while we dream are widespread (Lafrenière et al., 2018; Valli & Revonsuo, 2009). The evidence from waking cognition, albeit limited, combined with the empirical evidence from dreams suggests that improbable simulations are likely to occur throughout the sleep-wake cycle – but is this actually the case, and if so, are these experiences similar across states? Here we attempt to gain initial insight into these questions by exploring their thematic content and subjective valence across the sleep-wake cycle – specifically, are our simulations (that we are aware of) similar in content and valence when we are awake vs. when we are asleep? Similarly, how might one’s potential intolerance of uncertainty and sense of agency (characteristics commonly associated with anxiety disorders such as obsessive-compulsive disorder; OCD) be related to the propensity to experience improbable simulations?

Below, we provide an overview of the literature regarding both waking and dreaming improbable simulations, as well as their potential relationship to intolerance of uncertainty and sense of agency. We then outline the current study which attempts to compare improbable simulations across the sleep/wake cycle, with a focus on comparing the common themes, emotional valence, and relation to intolerance of uncertainty and sense of agency across states of consciousness.

1 Phenomenology of improbable simulations

We view improbable simulations as a form of spontaneous thought, or thoughts that arise and unfold in the absence of strong intentions (Christoff et al., 2016; Girn et al., 2020; Mills et al., 2021). This conceptualization is in line with perspectives from The Dynamic Framework of Thought (Christoff et al., 2016), which posits that spontaneous thoughts exist on a 2-dimensional continuum, where thoughts are more likely to be “spontaneous” if both sources of automatic constraints (i.e.,

through affective and sensory salience) and deliberate constraints (i.e., cognitive control) are low. Improbable simulations themselves are likely to have extremely low deliberate constraints, in that they do not arise as a result of our own volition; however, they may arise due to automatic constraints, such as cues in our environment or our current affective state. At the same time, we extend the framework offered by Christoff et al. (2016) and Girn et al. (2020), as we view improbable simulations similarly to how Mills et al. (2020) characterized the phenomenology of spontaneous thoughts as being “surprising” in nature. That is, one cannot determine why a certain thought came “out of the blue” at that exact time (referred to as an abrupt transition), or even why the thought was about a particular set of contents (referred to as a wayward transition).

Before going further, it is also worth pointing out that previous work has indeed focused on other types of thoughts that may involve related phenomena, including intentional and unintentional task-unrelated thought (Seli et al., 2015, 2016) and future episodic simulations (Atance & O’Neill, 2001; Schacter et al., 2008; Schacter et al., 2017). Both unintentional task-unrelated thought and future episodic simulations, in theory, *could* involve improbable simulations. However, evidence to date seems to suggest they are not typically rife with the same phenomenological element of “surprise” or “out of the blue”-ness that we believe marks episodes of improbable simulations. Put simply, improbable simulations can certainly be task-unrelated or an episodic future simulation, but the reverse is not inherently true given that many task-unrelated thoughts involve autobiographical planning (Baird et al., 2011), and many episodic future simulations involve simulating the immediate future instead of a hypothetical scenario (Kvavilashvili & Rummel, 2020). The same may also be said of intrusive thoughts, which overlap with improbable simulations; intrusive thoughts may indeed be surprising, but they need not be improbable, and if they are recurrent, they may be less surprising over time.

Finally, it is also important to distinguish improbable simulations from the idea of “daydreaming” and maladaptive daydreaming (Bigelsen & Schupak, 2011; Salomon-Small et al., 2021; Somer, 2002). Daydreaming is often thought to be more fantastical in nature and often occurs by choice (Dorsch, 2015). For example, someone may have an ongoing narrative in their head about magical dragons chasing them as they pass by cars while driving. This may last for hours with an extensive and vivid narrative that people eventually choose to engage in over other activities, specifically in the case of maladaptive daydreaming (see, e.g., reddit/maladaptivedaydreaming). Improbable simulations, in contrast, evoke possible, yet improbable thoughts about events that, notably, arise unintentionally and unexpectedly (e.g., what if I throw my phone off this bridge?). In sum, as pointed out by Seli et al. (2018), there is often overlap between some of the features involved in various forms of involuntary thoughts and simulations; here, we are specifically and narrowly interested in thoughts that arise in the form of improbable simulations.

2 Improbable simulations in waking

The most closely related work on this topic has been mostly relegated to examining the “high place phenomenon” or “the call of the void” (in French, “l’appel du vide”) (Hames et al., 2012; Teismann et al., 2020) in which one experiences an involuntary urge to jump from a high place. One of the only known existing studies on the high place phenomenon compared the frequency of the phenomenon between individuals who identified as lifetime or non-lifetime suicidal ideators (Hames et al., 2012). The results of the study suggested that the experience is common amongst the general population, with the authors concluding that such experiences are functional as they force you to value your life (Hames et al., 2012). Indeed, these findings were replicated in another study conducted by Teismann et al. (2020) using the same demographic criterion. To our knowledge, however, these are the only two studies that have examined simulative waking thoughts that are inherently improbable in nature.

While the high place phenomenon is specific to simulations of jumping from a high place, this is only one type of improbable simulation as we have defined them in the current paper. Indeed, authors from the “high place” papers have suggested that other improbable events may be simulated as well, such as driving into oncoming traffic (Teismann et al., 2020). Thus, one question concerns what themes are most common for waking improbable simulations. For example, jumping from a high place or driving into oncoming traffic is ultimately a personally related simulation (i.e., death). It is also likely, however, that individuals simulate other types of events, such as social- (e.g., running into a celebrity while shopping in a market) or nature-related events (e.g., picturing a tsunami while visiting a beach). Notably, a recent set of studies by Puig et al. (2025) found that simulations of approximal or near future events involved simulating harmful events (e.g., getting in a car accident or getting hurt) more so than simulations of distal future events, but the improbable nature of such simulations was not a focus here. Although other themes than the three we mention here (personal, social, nature) could exist, we focus on these because they were the most prevalent in data that was previously collected and thematically coded in a separate set of studies where people were asked to describe instances of unexpected thoughts (Poulos et al., 2023). As such, it is unclear if there is a difference in frequencies of each of these themes.

Although some of the intuitive examples of improbable simulations may seem intensely negative in nature, their corresponding affective valence (positive/negative feelings) is not yet understood – as well as how valence may vary across different simulation themes. For example, suddenly thinking about skydiving while working in an office might have a positive valence, whereas thoughts involving a potential earthquake are more likely to be negative. As such, valence may be worth considering, especially given its previously established differential links to the various forms of spontaneous and task-unrelated thoughts mentioned above. For example, Killingsworth & Gilbert (2010) found

that individuals were more likely to report more negative valence when they were mind wandering compared to when they were not mind wandering, although the general findings suggested that mind wandering itself was not negative. Furthermore, task-unrelated thoughts have also been shown to be associated with negative valence, whereas freely-moving thoughts that are thought to arise with lower constraints are positively valenced (Mills et al., 2021; Thiemann et al., 2023). Of note, however, are the findings that the valence of spontaneous thoughts depends on the content of such thoughts (Poerio et al., 2013; Rice & Fredrickson, 2017), highlighting the importance of examining various themes of improbable simulations.

3 Improbable simulations in dreaming

Dreams and the dreaming state have been a topic of philosophical inquiry for centuries. Dreams are spontaneous mental simulations in sleep, and these experiences can be perceptually rich (Revonsuo, 2000). Dreams occur throughout the sleep cycle but are more vivid and intense during rapid-eye movement (REM) sleep (Hobson et al., 2000). Notably, dreams can include a broad range of simulations, with themes ranging from religion (Bulkeley, 2009) to nature (Schredl & Hofmann, 2003). Simulations themselves are a centerpiece of dream content, such that many theories on the function of dreams are based on simulations in preparation for future action (Revonsuo, 2000; Revonsuo et al., 2015; Valli & Revonsuo, 2009). For example, the Threat Simulation Theory (Revonsuo, 2000; Valli & Revonsuo, 2009) posits that dreams may contain threatening simulative content in an effort to “prepare” one for real-world threats such as simulating being chased by a wild animal. Similarly, the Social Simulation Theory posits that dreams may entail friendly social interactions involving familiar and even unfamiliar individuals (Revonsuo et al., 2015). While these theories do not focus on the improbable nature of such simulations in dreaming, it is clear that these experiences may be either positive or negative in nature, similar to waking improbable simulations.

Notably, recent proposals suggest that spontaneous thoughts in waking and dreaming are highly overlapping and have the same neural basis. Kirberg (2022), in line with similar findings (Domhoff, 2018; Domhoff & Fox, 2015; Fox et al., 2013; Nielsen, 2011; Wamsley, 2013; Windt, 2020), recently proposed that dreams may be thought of as “spontaneous offline simulations”, such that dreams are analogous to experiences of mind wandering or spontaneous thought in waking life. With this in mind, there is reason to expect that improbable simulations occur in dreams similarly to waking experiences. For example, a recent study examined the incorporation rates of waking experiences into dreams and incidentally found that dreaming experiences often contained simulations of future events which were unrealistic in nature (Wamsley, 2022). Although this study did not directly investigate the improbable nature of dreams, this suggests that improbable simulations occur often whilst dreaming, similar to waking experiences.

However, numerous other studies reveal differences in content frequency between waking spontaneous thoughts and dreaming. For example, spontaneous thoughts of future episodic events are more frequent in waking than in dreaming from both REM and N2 sleep (Baird et al., 2022). However, less attention has been paid to the improbable nature of future episodic thoughts and how these experiences may differ across the sleep/wake cycle. Perhaps the closest link is the idea of bizarreness in dreams, which often refers to statistically improbable events that may occur whilst dreaming (Colace, 2003). Bizarreness, then, is in line with our conceptualization of improbable simulations, but it has been noted that bizarreness in dreams may also refer to events that are *impossible* such as one flying (rather than only improbable events). Further, bizarreness in dreams is not specific to events themselves. It may arise due to a number of factors, such as discontinuity between dreaming events or incongruity between dreaming events and waking life (Colace, 2003). Notably, bizarreness has been investigated in waking life, with findings suggesting it is at least as frequent in wake as it is during dreaming (Reinsel et al., 1993). Here, however, we predict that improbable simulations might be reported in higher frequency during waking states compared to sleep due to memory saliency effects.

The valence of improbable simulations across the sleep-wake cycle is also interesting to consider, given past work which examined the phenomenological differences across these states. A number of studies have placed spontaneous cognition on a continuous spectrum across the sleep-wake cycle (Fox et al., 2013; Wamsley, 2013; Windt, 2020). Despite this continuum, dreams have more emotional content (Fox et al., 2018) and are more negatively valenced compared to mind wandering and wakefulness (Gross et al., 2020; Sikka et al., 2021). If true, we would expect to see a similar trend in terms of valence for improbable simulations. How this valence might change depending on the theme, however, is an open question.

4 Improbable simulations and intolerance to uncertainty

The two existing studies on the high place phenomenon found a positive correlation between individuals' reported frequency of the phenomenon and anxiety sensitivity (Hames et al., 2012; Teismann et al., 2020), or the trait tendency to be afraid of symptoms of anxiety. This suggests that experiencing improbable simulations very frequently may itself be a characteristic of anxiety. This idea gets additional credence considering that spontaneous thought has been shown to be positively correlated with trait anxiety (Fell et al., 2023; Figueiredo et al., 2020; Seli et al., 2019). However, the two existing studies examining improbable simulations were specifically targeting the high place phenomenon (i.e., simulating falling from a high place). It thus remains unclear whether the general tendency to experience improbable simulations is related to characteristics commonly asso-

ciated with anxiety, or whether this relationship is relegated to certain simulation themes (e.g., personal, social). We focus on two particular constructs related to anxiety due to their theoretical relationship to improbable simulations: intolerance of uncertainty (Nicholas Carleton et al., 2007; Tolin et al., 2003) and a reduced sense of agency (Oren et al., 2019; Tapal et al., 2017).

Intolerance of uncertainty can be conceptualized as a discomfort with the unknown that can lead an individual to have negative emotional, cognitive, and behavioral reactions (Freeston et al., 1994). Intolerance of uncertainty has been recognized as a transdiagnostic factor for many anxiety disorders, including OCD, generalized anxiety disorder, and panic disorder (Dugas et al., 1998; McEvoy et al., 2019). Further, Wahlund et al. (2020) found that an intolerance of uncertainty-based intervention significantly decreased reports of worry and anxiety in adolescents who were experiencing excessive worry.

The general idea is that those who have an intolerance of uncertainty may be more likely to simulate (or be aware of their simulation of) improbable events. This simulation is often an effort to “prepare” for threatening scenarios, thereby reducing potential uncertainty and risks. Improbable simulations may be particularly common for people with an OCD diagnosis, as they commonly experience intrusive imagery and unwanted self-actions that are often fleeting in nature (Rachman, 2007). This may be due to having hyperactive, salient imagery in OCD (Salomon-Small et al., 2021; Soffer-Dudek, 2023), perhaps generating more frequent simulations. Of course, a person who does not have an OCD diagnosis could also experience the same simulation; however, they may be more easily able to distinguish this as an event unlikely to happen. OCD patients are often unable to reject unlikely scenarios because of *inferential confusion*, which refers to the inability to distinguish between probable and improbable events (Aardema et al., 2006). This could occur because OCD patients may sometimes distrust their own senses (O’Connor & Robillard, 1995). For example, someone suffering from OCD could think that there might be a gas leak; even though they do not smell gas, their distrust in their own senses could lead them to consider that far-fetched scenario to be just as likely. Inferential confusion and OCD are thus closely linked to intolerance of uncertainty (Gentes & Ruscio, 2011). Further, trait anxiety has been previously linked to phenomena related to improbable simulations (Fell et al., 2023), such as maladaptive daydreaming (Soffer-Dudek & Somer, 2018) and task-unrelated thought (Arch et al., 2021; Seli et al., 2019). For these reasons, we expect to see a positive relationship between intolerance of uncertainty and the reported frequency of improbable simulations.

One’s sense of agency may also be related to improbable simulations given that it too shares links with anxiety disorders such as OCD. Sense of agency is conceptualized as the belief that one is in control of or responsible for the actions that they perform (Tapal et al., 2017). Previous studies have led to a conflicting narrative in terms of the relationship between OCD and sense of agency (Bregman-Hai et al., 2020; Oren et al., 2016, 2019), which is likely due to differences in measurement

(Oren et al., 2019; Soffer-Dudek, 2023). “Direct” measures of sense of agency (e.g., asking participants to rate statements like “I am in full control of what I do”) are associated negatively with OCD (Tapal et al., 2017), likely because people might attribute their actions to their intrusive thoughts or imagery. However, OCD patients might also feel responsible for the outcomes associated with these actions due to an elevated sense of responsibility (Salkovskis et al., 1999). Hence, OCD is often *positively* correlated with sense of agency when measured indirectly such as when examining language production (Oren et al., 2016).

Considering the methodological design of this study, we have employed “direct” measures to assess sense of agency. Specifically, we used the Sense of Agency Scale (Tapal et al., 2017). As improbable simulations arise without deliberate intention, it is possible that individuals who identify as being low in agency may experience improbable simulations more frequently given that they are likely to appraise their thoughts as out of their control. Under this line of reasoning, we predict that there will be a negative relationship between one’s sense of agency and the frequency with which they experience improbable simulations. We may also be likely to observe differential relationships between improbable simulations and sense of agency across the sleep-wake cycle, as people may have a greater sense of control during waking states. We test this possibility in the current study.

5 The current study

Here we introduce the topic of improbable simulations as an important yet understudied form of spontaneous cognition. We build a foundation for future work by investigating their content, affective valence, and relation to intolerance of uncertainty and sense of agency across both waking and dreaming states. We note up front that we use a self-reported recall method and thus intentionally avoid making claims about raw frequencies of improbable simulations that may be driven by saliency and memory effects. We also note that such recall measures are not tapping into the phenomenon itself, but rather one’s perceptions and beliefs regarding their own thoughts. Given these two caveats, we are especially focused on whether the reported themes and emotional valence are similar across both waking and dream states. For example, are certain themes more or less common in *both* waking and dreaming?

In what follows, we address the following two aims: (a) identify and compare the common themes and corresponding emotional valence of improbable simulations across waking and dreaming, and (b) identify and compare the extent to which intolerance of uncertainty and sense of agency relate to the various themes of improbable simulations across waking and dreaming. To do so, participants in the current study were shown examples of improbable simulations spanning three themes (personal, social, nature) which were adapted from our previous datasets on spontaneous thought reports. They were asked to indicate how frequently they experience similar content in both waking and dreaming states as well as the emo-

tional valence of such experiences. Participants also completed the Intolerance of Uncertainty Scale (Freeston et al., 1994) and the Sense of Agency Scale (Tapal et al., 2017) to examine how characteristics of anxiety relate to various simulative themes across the circadian cycle. By looking at a unique type of spontaneous thought – improbable simulations – the ultimate goal of our paper will be to shed light on the phenomenon of improbable simulations in our everyday lives by incorporating perspectives on spontaneous cognition, the functionality of dreams, and mental health disorders.

6 Method

All methods and procedures were approved by the Institutional Review Board at the University of New Hampshire.

6.1 Participants

Based on a power analysis in G*Power (Faul et al., 2007, 2009), we determined we would need a sample of at least 90 participants to have sufficient power (80%) to detect an effect size of $d = .30$ at $\alpha = .05$ (two-tailed). We thus recruited 101 participants to account for Prolific attrition rates (55.45% men, 43.56% women, 0.99% non-binary), with participants aged 19-71 years old ($M = 36.52$, $SD = 11.91$) who completed the study through Prolific for monetary reward. One participant did not provide a response for the frequency of social simulations in dreaming, so this participant was not included in any of the analyses.

6.2 Materials

6.2.1 Thought prompts for theme frequency and valence.

Our thought prompts were derived based on data from a previous study, where we examined thoughts that appeared to come “out of the blue” by having participants recall prior unexpected thoughts they have experienced (Poulos et al., 2023). We qualitatively noticed a pattern of “what if...[some improbable event occurred]” statements in the data, which sparked our interest in the current phenomenon. To better understand the themes, we randomly extracted 100 thoughts, and the first author identified that roughly 35% of these thoughts contained simulative content. The first author identified the general themes of these extracted simulative thoughts, and it was found that 49% of the simulative thoughts were personally-related, 23% were socially-related, and 11% were nature/environment-related. We thus used these three themes in the current study to understand improbable simulations: personal, social, nature/environment.

Content Theme	Waking Frequency ^a	Waking Valence ^b	Dreaming Frequency ^a	Dreaming Valence ^b
Personal	Do you ever experience simulative or imaginative thoughts about personal matters, or yourself , that are unlikely to happen? For example, imagining moving across the country, or imagining driving off the road.	You indicated that you sometimes simulate or imagine experiences about personal matters or yourself (e.g., moving, dying) that are unlikely to happen. When this occurs, what are your emotions surrounding the thought?	Do you ever experience dreams about personal matters, or yourself , that are unlikely to happen in real life? For example, dreaming about moving across the country, or dreaming about driving off the road.	You indicated that you sometimes dream about experiences regarding personal matters or yourself (e.g., moving, dying) that are unlikely to happen in real life. When this occurs, what are your emotions surrounding the dream?
Social	Do you ever experience simulative or imaginative thoughts about society or social relationships that are unlikely to happen? For example, imagining becoming friends with your favorite celebrity, or imagining another pandemic occurring.	You indicated that you sometimes simulate or imagine experiences about society or social relationships (e.g., celebrities, pandemic) that are unlikely to happen. When this occurs, what are your emotions surrounding the thought?	Do you ever experience dreams about society or social relationships that are unlikely to happen in real life? For example, dreaming about becoming friends with your favorite celebrity, or dreaming about another pandemic occurring.	You indicated that you sometimes dream about experiences regarding society or social relationships (e.g., celebrities, pandemic) that are unlikely to happen in real life. When this occurs, what are your emotions surrounding the dream?
Nature	Do you ever experience simulative or imaginative thoughts about nature or the environment that are unlikely to happen? For example, imagining that the buildings around you are covered in flowers, or imagining a tornado suddenly sweeping through.	You indicated that you sometimes simulate or imagine experiences about nature or the environment (e.g., flower buildings, tornado) that are unlikely to happen. When this occurs, what are your emotions surrounding the thought?	Do you ever experience dreams about nature or the environment that are unlikely to happen in real life? For example, dreaming that the buildings around you are covered in flowers, or dreaming that a tornado suddenly sweeps through.	You indicated that you sometimes dream about experiences regarding nature or the environment (e.g., flower buildings, tornado) that are unlikely to happen in real life. When this occurs, what are your emotions surrounding the dream?

Table 1: Questions and scales. ^aAll items were answered using the following scale: 0 (a few times a year/never); 1 (once a month); 2 (a few times a month); 3 (once/twice a week); 4 (daily). ^bAll items were answered using a scale from 1 (extremely negative) to 7 (extremely positive).

In the current study, participants were asked to rate how frequently they experience simulative thoughts related to these three themes in both waking and dreaming states. See Table 1 for exact prompts and examples. They were also shown both positively and negatively valenced examples of each to avoid an affective bias. Participants also rated the emotional valence of each theme in waking and dreaming states (the examples were restated here). All questions and scales used can be viewed in Table 1.

Note that one cannot easily induce and manipulate improbable simulations or other forms of spontaneous thought; as such, methods for studying them will be inherently limiting, as are the ones used here, especially during the nascent phase of the field. In the current study, we attempt to strike a balance between advancing knowledge on this topic while acknowledging some of the drawbacks of our method by tempering the types of analyses and claims we can make. Specifically, we focus on comparing the themes, emotional valence, and relation to two characteristics of anxiety (intolerance of uncertainty and sense of agency) of these experiences across the sleep/wake cycle.

6.2.2 Measures of OCD correlates.

Participants completed the Intolerance of Uncertainty Scale (Freeston et al., 1994), a measure of worry that consists of 27 items answered using a 1-5 scale (1 = totally disagree; 5 = totally agree). In our data, we achieved an internal consistency measure of 0.95. Participants also completed the Sense of Agency Scale (Tapal et al., 2017) which was developed to measure one’s sense of agency and consists of 13 items that are answered using a 1-7 scale (1 = strongly disagree; 7 = strongly agree). The Sense of Agency Scale has been validated using both exploratory and confirmatory factor analyses in which a two-factor structure that consists of (1) positive agency and (2) negative agency has been identified (Tapal et al., 2017). Positive agency refers to the idea that one is in control of their thoughts and actions; in contrast, negative agency refers to a feeling that your actions are being controlled by external factors which are out of your influence. Synofzik et al. (2013) proposed that a sense of agency arises through both sensorimotor and cognitive cues (e.g., priors) that lead to both predictive and postdictive (i.e., after the event) assessments of agency. Within the data we collected, the Cronbach’s alpha value was 0.86 for the negative factor and 0.80 for the positive factor.

6.3 Procedure

After providing consent, participants were shown various themes of simulative content and were asked to rate how frequently they experience similar simulative content across both waking and dreaming states. Participants also rated the emotional valence of each theme across states. The presentation of thought probes was randomized such that participants completed either the sleep or wake block first. A block consisted of rating the frequency of three content themes followed by rating the corresponding emotional valence of each theme. Theme was then randomized within each block. Next, participants completed the Intolerance to Uncertainty Scale (Freeston et al., 1994) and Sense of Agency Scale (Tapal et al., 2017). Finally, participants completed a demographics questionnaire and were thoroughly debriefed on the purpose of the study.

6.4 Analytical approach

This study used a within-subjects design: sleep/wake and content theme (personal, social, natural) were within-subjects variables. Given the ordinal nature of our dependent variables, we used cumulative link models using the *ordinal* package (Christensen, 2024) in R to test our main effects. We used the *clmm2* function, with our predictors being Theme (Nature, Personal, Social), Time (Sleep, Wake), or the interaction (Theme x Time). Participant ID was included as a random intercept in all models. We thus ran 3 models for each outcome variable (frequency and valence). This also allowed us to do pairwise comparisons between different

conditions. Finally, Spearman's correlations were used to examine the relationship between simulation frequency and intolerance of uncertainty and sense of agency.

7 Results

Table 2 contains the means and standard deviations for both the frequency and valence of each theme of improbable simulations across waking and dreaming states. Please refer to the Appendix for full model results.

Variable	Dream			Wake		
	Personal M (SD)	Nature M (SD)	Social M (SD)	Personal M (SD)	Nature M (SD)	Social M (SD)
Frequency <i>N</i> = 100	2.92 (1.29)	1.92 (1.13)	2.46 (1.23)	3.38 (1.29)	2.12 (1.27)	2.88 (1.39)
Valence <i>N</i> = 100	3.72 (1.46)	3.74 (1.48)	4.55 (1.27)	3.97 (1.60)	3.91 (1.36)	4.47 (1.31)

Table 2: Means and standard deviations by dream/wake and content theme

7.1 Main effect of theme

Our first research question concerned whether certain themes were more commonly reported in improbable simulations, regardless of time of day. We observed a significant main effect of *theme* (personal, social, nature/environment) on the frequency of improbable simulations, suggesting that some themes may be more commonly experienced (or at least remembered) than others. Specifically, people reported experiencing higher frequencies of personal simulations compared to nature ($b = 2.24$, $SE = 0.218$, $p < 0.001$, $d = 1.23$, 95% CI [1.81, 2.67]). The frequency for social simulations was also higher than nature ($b = 1.32$, $SE = 0.206$, $p < 0.001$, $d = 0.729$, 95% CI [0.919, 1.73]), but still lower than personal. The overall pattern was: Personal > Social > Nature/Environment.

We were also interested in the corresponding phenomenological experiences (in this case, emotional valence) of improbable simulations. To this end, we observed a main effect of theme on the subjective emotional valence of improbable simulations. Social simulations were significantly more positive compared to nature simulations ($b = 1.05$, $SE = 0.185$, $p < 0.001$, $d = 0.578$, 95% CI [0.686, 1.41]). No difference was observed in the valence of nature and personal themes ($b = 0.027$, $SE = 0.183$, $p = 0.885$, $d = 0.015$, 95% CI [-0.332, 0.386]); Social > Personal = Nature. Thus, while personal improbable simulations were the most common theme, social improbable simulations were the most positive theme – although it's worth noting that even social simulations were somewhat neutral.

7.2 Main effect of sleep/wake

In addition to the general themes, we also examined the frequency and phenomenological differences across the sleep/wake cycle. We expected there to be higher frequencies of improbable simulations reported during wakefulness than dreaming, due to the additional complications inherent to recalling a dream (e.g., neurochemical transition from wake to sleep) (Demšar & Windt, 2024; Horton & Conway, 2009; Nemeth, 2023). Indeed, in line with those expectations, there was a significant main effect of sleep/wake on the frequency of improbable simulations, such that participants were less likely to recall simulating improbable events during sleep compared to waking state ($b = -0.670$, $SE = 0.158$, $p < 0.001$, $d = -0.369$, 95% CI [-0.980, -0.361]). We do not interpret this as a true “difference” but, at the very least, confirms that improbable simulations during wake are more salient during recall (see more on Interaction below).

Interestingly, there was no significant main effect of sleep/wake on the valence of improbable simulations ($b = -0.161$, $SE = 0.148$, $p = 0.276$, $d = -0.089$, 95% CI [-0.450, 0.128]) – perhaps suggesting that despite the reported frequencies of improbable simulations being variable across the sleep/wake cycle, the emotional experiences of such events are remembered as being quite similar.

7.3 Interaction

Our main research question concerned whether the common themes and emotional valence of improbable simulations were similar across periods of waking and dreaming. The sleep/wake \times theme interaction on frequency was not significant (p 's > 0.138), meaning that the patterns of the themes within wake and dreams were similar (i.e., personal was highest in both, nature/environment lowest).

Additionally, there was no significant interaction of sleep/wake and theme on emotional valence (p 's > 0.210). These results tend to suggest that the thematic and subjective valence of improbable simulations does not differ across the sleep/wake cycle. This lack of interaction is particularly interesting, perhaps speaking to an element of consistency across the sleep-wake cycle.

7.4 Relationship between improbable simulations and intolerance of uncertainty and sense of agency

Previous research suggests that the high place phenomenon is associated with anxiety (Hames et al., 2012); here we extend these findings by examining whether improbable simulations of various themes were correlated with the Intolerance of Certainty and Sense of Agency Scales. We first averaged across all three themes (by participant) to get an *average simulation score* in waking and dreaming, respectively. These scores were correlated with the Intolerance of Uncertainty Scale and Sense of Agency Scale to assess the general relationship between improbable simulations and characteristics of anxiety across the waking and dreaming states. We

then correlated *each* theme within waking and dreaming separately to examine if certain themes (or at certain times) were more closely related to intolerance of uncertainty and sense of agency.

7.4.1 Intolerance of uncertainty scale.

For waking states, the general tendency to simulate improbable events was significantly positively correlated with intolerance of uncertainty (see Table 3) in line with a small effect size. Further examination revealed that all themes (personal, nature, social) in waking were significantly positively correlated to intolerance to uncertainty (Table 3), suggesting that individuals with a higher intolerance to uncertainty are more likely to simulate improbable events in general – at least whilst awake.

In contrast, the tendency to simulate improbable events whilst dreaming was significantly positively correlated to intolerance of uncertainty for only personal events. These differences across the sleep/wake cycle perhaps highlight some of the nuances with respect to the function of improbable simulations.

7.4.2 Sense of agency scale.

We also examined the extent to which sense of agency was related to the frequency of improbable simulations based on the idea that improbable simulations are unintentional in nature and may thus decrease one's sense of agency. We found no support for this idea; there were no significant correlations with the Sense of Agency Scale and the frequency of improbable simulations in waking or dreaming (Table 3). This was true for both overall frequencies of improbable simulations and specific themes in waking and dreaming states.

	Intolerance of Uncertainty Scale		Sense of Agency Factor (Positive Agency)		Sense of Agency Factor (Negative Agency)	
	Wake	Dream	Wake	Dream	Wake	Dream
<i>N</i> = 100						
Theme	Spearman Correlation <i>r</i> (<i>p</i> value)	Spearman Correlation <i>r</i> (<i>p</i> value)	Spearman Correlation <i>r</i> (<i>p</i> value)	Spearman Correlation <i>r</i> (<i>p</i> value)	Spearman Correlation <i>r</i> (<i>p</i> value)	Spearman Correlation <i>r</i> (<i>p</i> value)
Overall	0.281 (<i>p</i> =0.005)*	0.272 (<i>p</i> =0.006)*	-0.127 (<i>p</i> =0.207)	0.098 (<i>p</i> =0.334)	0.069 (<i>p</i> =0.498)	0.033 (<i>p</i> =0.743)
Nature	0.221 (<i>p</i> =0.027)*	0.187 (<i>p</i> =0.062)	-0.178 (<i>p</i> =0.076)	0.160 (<i>p</i> =0.112)	0.126 (<i>p</i> =0.212)	0.038 (<i>p</i> =0.708)
Personal	0.209 (<i>p</i> =0.037)*	0.254 (<i>p</i> =0.011)*	0.007 (<i>p</i> =0.946)	0.010 (<i>p</i> =0.921)	-0.055 (<i>p</i> =0.585)	-0.016 (<i>p</i> =0.872)
Social	0.262 (<i>p</i> =0.009)*	0.191 (<i>p</i> =0.056)	-0.142 (<i>p</i> =0.159)	0.069 (<i>p</i> =0.495)	0.097 (<i>p</i> =0.336)	0.059 (<i>p</i> =0.558)

Table 3: Correlations between simulation frequencies and intolerance of uncertainty and sense of agency.

8 Discussion

Humans have clearly evolved with the tendency of experiencing fleeting simulations of our lives that are almost certainly not going to become reality. Previous research, although quite limited, suggests that improbable simulations are likely to occur in both waking (Hames et al., 2012; Teismann et al., 2020) and dreaming periods (Wamsley, 2022) – however, less research has been dedicated to examining whether these experiences are similar across the sleep/wake cycle. In the current study, we attempted to address this gap by examining the occurrence of various themes (personal, nature/environment, and social) of improbable simulations, their emotional valence, and their relation to intolerance of uncertainty and sense of agency across both waking and dreaming periods.

We found that the common themes of improbable simulations did not differ across periods of waking and dreaming – that is, individuals were most likely to simulate personal events and least likely to simulate nature events across both periods of waking and dreaming. Additionally, the emotional valence of such experiences was also similar across states, with social simulations being the most

affectively positive and personal and nature simulations exhibiting no difference in waking and dreaming states. These results provide novel evidence that improbable simulations may have some similarities across the circadian cycle, as well as provides support for prior research which suggests that improbable simulations occur in both waking and dreaming periods (Hames et al., 2012; Teismann et al., 2020; Wamsley, 2022). Further, the finding that social simulation is more affectively positive than the rest fits in line with the theory of maladaptive daydreaming (Chefet et al., 2023; Wen et al., 2024), where people might voluntarily disengage to simulate unlikely scenarios. This is because individuals may choose to think about scenarios which are positive in nature in an effort to distract themselves from other negative thoughts, feelings, or memories (Bigelsen et al., 2016; Wen et al., 2024). However, it is important to note that maladaptive daydreaming and improbable simulations are phenomenologically distinct, as the former is often voluntary and can last for much longer periods (Dorsch, 2015), while the latter are involuntary in nature and are likely fleeting experiences.

More theoretical and empirical work will need to be done to truly uncover the thematic frequency and phenomenology of improbable thoughts. This study speaks – at least initially – to the idea proposed by Teismann et al. (2020) that simulations in waking are widespread and may refer to a number of simulative behaviors (rather than only jumping from a high place). Critically, our data suggest that these possible “what if” experiences are something that we unintentionally generate throughout the day, regardless of whether we are awake or asleep. Although we are a long way from truly understanding the function of these thoughts, it is interesting to consider that they seem to be a relatively normative experience across our sample – suggesting we have likely evolved to experience them because of some purpose. Some speculative functions may involve opportunities to “learn” without having to engage in dangerous or threatening situations – thereby “affirming your will to live” (Hames et al., 2012). Along these lines, future work may focus on explaining other aspects of improbable simulations, such as when they are most likely to occur (e.g., is it during moments of danger or during moments of low cognitive load?) and if our behaviors are likely to change as a result of the simulations.

We also found that intolerance of uncertainty was related to participants’ reports of improbable simulations. This finding replicates prior work on the high place phenomenon (Hames et al., 2012; Teismann et al., 2020), though with an important extension: it is not selectively the high place theme, and it is not only during wake. Previous work has suggested that these simulations may reveal sensitivity to threatening situations (like being on a bridge or balcony). Our findings extend this work by suggesting that an additional factor may be a general intolerance of uncertainty. When people feel uncomfortable with the unknown, they may be more likely to simulate improbable events so that the outcomes feel less unknown and threatening to them.

Interestingly, however, the relationship with intolerance to uncertainty was not uniform across themes and time. Whereas all *waking* themes were significantly positively correlated with intolerance of uncertainty, only personal simulations were significantly positively correlated to intolerance of uncertainty in *dreaming*. One possible reason for this may be that non-personal simulations (nature and social) are less realistic, or less related to our actual experiences, during dreams. People who are less tolerant of uncertainty may simply have more “triggers” that lead to simulations of social and nature events when they are awake, while this explanation may not apply to dreams, where the focus may be on more personally relevant situations, similar to proposals about personal content made in Wamsley (2022).

Notably, the frequency of improbable simulations was selectively correlated with intolerance of uncertainty but not sense of agency, perhaps suggesting that one’s sense of agency does not play a large role in the experience of improbable simulations. We believe this may reflect the general assumption that improbable simulations are ephemeral in nature – they are likely to be experienced as quick, automatic reactions to potential threats in our environment. In this case, one’s feeling of being in control of their actions might not be related to improbable simulations because of how fleeting they are, perhaps having little impact on whether someone views themselves as an actor in the world.

The concept of improbable simulations represents an interesting form of spontaneous cognition that spans both waking and sleep states – they provide insight into possible “other worlds” or events which likely will not happen in waking reality. In line with evidence from previous research on spontaneous thoughts (Christoff et al., 2016; Girn et al., 2020; Irving, 2016), our results suggest that there is quite an overlap across the sleep-wake cycle in terms of improbable simulations, which are a form of spontaneous cognition given that they arise without intention and feel “surprising” in nature (Mills et al., 2021). This idea of continuity across the sleep-wake cycle aligns with past work as well, suggesting that our thoughts across these states of consciousness may be more likely to exist on a graded continuum, rather than being distinct kinds of mental states (Kirberg, 2022; Wamsley, 2013; Windt, 2020). An interesting difference between them was not necessarily the common themes or corresponding experiences of affective valence, but rather their relationships with intolerance of uncertainty and sense of agency, two characteristics that are commonly associated with several anxiety disorders, which is worth probing further in future research.

There are a number of limitations to the current study that need to be addressed. First, individuals were prompted to recall prior waking and dreaming experiences from memory. Self-reports of introspective experiences have been criticized widely throughout the literature (Baumeister et al., 2007; Schwarz, 1999) – for example, individuals may find it difficult to recall these experiences, and if they are able to recall them, they may not adequately describe such experiences. This is especially true for dreams, as prior research indicates that individuals often are unable to

recall their dreams (Horton & Conway, 2009). Because of this, we were primarily interested in the common themes and emotional valence of improbable simulations across the sleep-wake cycle rather than their relative frequencies in waking and dreaming. As such, this paper serves as a proof of concept by understanding individuals' perceptions of their improbable simulations, and not necessarily their veridical occurrence.

Additionally, participants likely recalled improbable simulations that were the most salient in memory – this could have affected the resulting emotional valence and anxiety findings, such that these experiences were exaggerated. Further, we did not include a clinical group in our study, and instead focused only on two characteristics that are commonly associated with anxiety disorders (intolerance of uncertainty and a reduced sense of agency). While future research should probe this relationship further, we believe that the current study represents a fruitful attempt at identifying the extent to which improbable simulations are related to emotional valence and common characteristics of anxiety disorders.

With this in mind, future research may also examine specific actions of simulative experiences – for example, simulating death seems to be the central consequence of jumping from a high building or bridge. Specificity of action may thus provide additional nuance into the nature of improbable simulations such as the occurrence, phenomenology, and relation to measures of anxiety. This could include incorporating content analyses to better identify the common themes of improbable simulations across the sleep/wake cycle. Future research may also incorporate methodologies that are less subject to biases in memory recall such as experience sampling (also known as ecological momentary assessment) paradigms. Experience sampling has been a common method for investigating the occurrence and phenomenology of spontaneous thoughts (Beaty et al., 2019; Gross et al., 2020; Smith et al., 2018) as this method entails identifying and describing such experiences in an externally-valid context (i.e., in everyday life rather than in the lab). Such experience sampling techniques also allow for temporal analyses of data, which is not possible with retrospective reports.

References

- Aardema, F., O'Connor, & Emmelkamp, P. M. G. and. (2006). Inferential confusion and obsessive beliefs in obsessive-compulsive disorder. *Cognitive Behaviour Therapy*, 35(3), 138–147. <https://doi.org/10.1080/16506070600621922>
- Arch, J. J., Wilcox, Ives, Sroloff, & Andrews-Hanna, J. R. and. (2021). Off-task thinking among adults with and without social anxiety disorder: An ecological momentary assessment study. *Cognition and Emotion*, 35(2), 269–281. <https://doi.org/10.1080/02699931.2020.1830751>
- 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](https://doi.org/10.1016/S1364-6613(00)01804-0)
- Baird, B., Aparicio, M. K., Alauddin, T., Riedner, B., Boly, M., & Tononi, G. (2022). Episodic thought distinguishes spontaneous cognition in waking from REM and NREM sleep. *Consciousness and Cognition*, 97, 103247. <https://doi.org/10.1016/j.concog.2021.103247>
- Baird, B., Smallwood, J., & Schooler, J. W. (2011). Back to the future: Autobiographical planning and the functionality of mind-wandering. *Consciousness and Cognition*, 20(4), 1604–1611. <https://doi.org/10.1016/j.concog.2011.08.007>
- Baumeister, R. F., Vohs, K. D., & Funder, D. C. (2007). Psychology as the science of self-reports and finger movements: Whatever happened to actual behavior? *Perspectives on Psychological Science*, 2(4), 396–403. <https://doi.org/10.1111/j.1745-6916.2007.00051.x>

Poulos, M. C., Kuvar, V., Mallett, R., & Mills, C. (2025). Involuntary “what if” moments: Improbable simulations across the sleep-wake cycle and their relationship with anxiety. *Philosophy and the Mind Sciences*, 6. <https://doi.org/10.33735/phimisci.2025.9966>



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- Beatty, R. E., Seli, P., & Schacter, D. L. (2019). Thinking about the past and future in daily life: An experience sampling study of individual differences in mental time travel. *Psychological Research*, 83(4), 805–816. <https://doi.org/10.1007/s00426-018-1075-7>
- Bigelsen, J., Lehrfeld, J. M., Jopp, D. S., & Somer, E. (2016). Maladaptive daydreaming: Evidence for an under-researched mental health disorder. *Consciousness and Cognition*, 42, 254–266. <https://doi.org/10.1016/j.concog.2016.03.017>
- Bigelsen, J., & Schupak, C. (2011). Compulsive fantasy: Proposed evidence of an under-reported syndrome through a systematic study of 90 self-identified non-normative fantasizers. *Consciousness and Cognition*, 20(4), 1634–1648. <https://doi.org/10.1016/j.concog.2011.08.013>
- Bregman-Hai, N., Kessler, Y., & Soffer-Dudek, N. (2020). Who wrote that? Automaticity and reduced sense of agency in individuals prone to dissociative absorption. *Consciousness and Cognition*, 78, 102861. <https://doi.org/10.1016/j.concog.2019.102861>
- Bulkeley, K. (2009). The religious content of dreams: A new scientific foundation. *Pastoral Psychology*, 58(2), 93–106. <https://doi.org/10.1007/s11089-008-0180-8>
- Chefetz, R. A., Soffer-Dudek, & Somer, E. and. (2023). When daydreaming becomes maladaptive: Phenomenological and psychoanalytic perspectives. *Psychoanalytic Psychotherapy*, 37(4), 319–338. <https://doi.org/10.1080/02668734.2023.2246058>
- Christensen, R. H. B. (2024). *Ordinal: Regression models for ordinal data*. <https://cran.r-project.org/web/packages/ordinal/index.html>
- Christoff, K., Irving, Z. C., Fox, K. C. R., Spreng, R. N., & Andrews-Hanna, J. R. (2016). Mind-wandering as spontaneous thought: A dynamic framework. *Nature Reviews Neuroscience*, 17(11), 718–731. <https://doi.org/10.1038/nrn.2016.113>
- Colace, C. (2003). Dream bizarreness reconsidered. *Sleep and Hypnosis*, 5(3), 105–128. <https://psycnet.apa.org/record/2003-07525-001>
- Demšar, E., & Windt, J. (2024). Studying dream experience through dream reports: Points of contact between dream research and first-person methods in consciousness science. In D. Gregory & K. Michaelian (Eds.), *Dreaming and Memory: Philosophical Issues* (pp. 85–117). Springer International Publishing. https://doi.org/10.1007/978-3-031-68204-9_5
- Domhoff, G. W. (2018). Dreaming is an intensified form of mind-wandering, based in an augmented portion of the default network. In K. Christoff & K. C. R. Fox (Eds.), *The Oxford Handbook of Spontaneous Thought: Mind-Wandering, Creativity, and Dreaming* (pp. 355–370). Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780190464745.013.7>
- Domhoff, G. W., & Fox, K. C. R. (2015). Dreaming and the default network: A review, synthesis, and counterintuitive research proposal. *Consciousness and Cognition*, 33, 342–353. <https://doi.org/10.1016/j.concog.2015.01.019>
- Dorsch, F. (2015). Focused daydreaming and mind-wandering. *Review of Philosophy and Psychology*, 6(4), 791–813. <https://doi.org/10.1007/s13164-014-0221-4>
- Dugas, M. J., Gagnon, F., Ladouceur, R., & Freeston, M. H. (1998). Generalized anxiety disorder: A preliminary test of a conceptual model. *Behaviour Research and Therapy*, 36(2), 215–226. [https://doi.org/10.1016/S0005-7967\(97\)00070-3](https://doi.org/10.1016/S0005-7967(97)00070-3)
- Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, 41(4), 1149–1160. <https://doi.org/10.3758/BRM.41.4.1149>
- Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175–191. <https://doi.org/10.3758/BF03193146>
- Fell, J., Chaieb, L., & Hoppe, C. (2023). Mind wandering in anxiety disorders: A status report. *Neuroscience & Biobehavioral Reviews*, 155, 105432. <https://doi.org/10.1016/j.neubiorev.2023.105432>
- Figueiredo, T., Lima, G., Erthal, P., Martins, R., Corção, P., Leonel, M., Ayrão, V., Fortes, D., & Mattos, P. (2020). Mind-wandering, depression, anxiety and ADHD: Disentangling the relationship. *Psychiatry Research*, 285, 112798. <https://doi.org/10.1016/j.psychres.2020.112798>
- Fox, K. C. R., Andrews-Hanna, J. R., Mills, C., Dixon, M. L., Markovic, J., Thompson, E., & Christoff, K. (2018). Affective neuroscience of self-generated thought. *Annals of the New York Academy of Sciences*, 1426(1), 25–51. <https://doi.org/10.1111/nyas.13740>
- Fox, K. C. R., Nijeboer, S., Solomonova, E., Domhoff, G. W., & Christoff, K. (2013). Dreaming as mind wandering: Evidence from functional neuroimaging and first-person content reports. *Frontiers in Human Neuroscience*, 7. <https://doi.org/10.3389/fnhum.2013.00412>
- Freeston, M. H., Rhéaume, J., Letarte, H., Dugas, M. J., & Ladouceur, R. (1994). Why do people worry? *Personality and Individual Differences*, 17(6), 791–802. [https://doi.org/10.1016/0191-8869\(94\)90048-5](https://doi.org/10.1016/0191-8869(94)90048-5)
- Gentes, E. L., & Ruscio, A. M. (2011). A meta-analysis of the relation of intolerance of uncertainty to symptoms of generalized anxiety disorder, major depressive disorder, and obsessive-compulsive disorder. *Clinical Psychology Review*, 31(6), 923–933. <https://doi.org/10.1016/j.cpr.2011.05.001>
- Girn, M., Mills, C., Roseman, L., Carhart-Harris, R. L., & Christoff, K. (2020). Updating the dynamic framework of thought: Creativity and psychedelics. *NeuroImage*, 213, 116726. <https://doi.org/10.1016/j.neuroimage.2020.116726>
- Gross, M. E., Smith, A. P., Graveline, Y. M., Beatty, R. E., Schooler, J. W., & Seli, P. (2020). Comparing the phenomenological qualities of stimulus-independent thought, stimulus-dependent thought and dreams using experience sampling. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 376(1817), 20190694. <https://doi.org/10.1098/rstb.2019.0694>
- Hames, J. L., Ribeiro, J. D., Smith, A. R., & Joiner, T. E. (2012). An urge to jump affirms the urge to live: An empirical examination of the high place phenomenon. *Journal of Affective Disorders*, 136(3), 1114–1120. <https://doi.org/10.1016/j.jad.2011.10.035>
- Hobson, J. A., Pace-Schott, E. F., & Stickgold, R. (2000). Dreaming and the brain: Toward a cognitive neuroscience of conscious states. *Behavioral and Brain Sciences*, 23(6), 793–842. <https://doi.org/10.1017/S0140525X00003976>

Poulos, M. C., Kuvar, V., Mallett, R., & Mills, C. (2025). Involuntary “what if” moments: Improbable simulations across the sleep-wake cycle and their relationship with anxiety. *Philosophy and the Mind Sciences*, 6. <https://doi.org/10.33735/phimisci.2025.9966>



- Horton, C. L., & Conway, M. A. (2009). The memory experiences and dreams questionnaire (MED-Q): A validated measure of dream remembering. *Imagination, Cognition and Personality, 29*(1), 3–29. <https://doi.org/10.2190/IC.29.1.b>
- Irving, Z. C. (2016). Mind-wandering is unguided attention: Accounting for the “purposeful” wanderer. *Philosophical Studies, 173*(2), 547–571. <https://doi.org/10.1007/s11098-015-0506-1>
- Killingsworth, M. A., & Gilbert, D. T. (2010). A wandering mind is an unhappy mind. *Science, 330*(6006), 932–932. <https://doi.org/10.1126/science.1192439>
- Kirberg, M. (2022). Neurocognitive dynamics of spontaneous offline simulations: Re-conceptualizing (dream)bizarreness. *Philosophical Psychology, 35*(7), 1072–1101. <https://doi.org/10.1080/09515089.2022.2042231>
- Kvavilashvili, L., & Rummel, J. (2020). On the nature of everyday prospection: A review and theoretical integration of research on mind-wandering, future thinking, and prospective memory. *Review of General Psychology, 24*(3), 210–237. <https://doi.org/10.1177/1089268020918843>
- Lafrenière, A., Lortie-Lussier, M., Dale, A., Robidoux, R., & De Koninck, J. (2018). Autobiographical memory sources of threats in dreams. *Consciousness and Cognition, 58*, 124–135. <https://doi.org/10.1016/j.concog.2017.10.017>
- McEvoy, P. M., Hyett, M. P., Shihata, S., Price, J. E., & Strachan, L. (2019). The impact of methodological and measurement factors on transdiagnostic associations with intolerance of uncertainty: A meta-analysis. *Clinical Psychology Review, 73*, 101778. <https://doi.org/10.1016/j.cpr.2019.101778>
- Mills, C., Porter, A. R., Andrews-Hanna, J. R., Christoff, K., & Colby, A. (2021). How task-unrelated and freely moving thought relate to affect: Evidence for dissociable patterns in everyday life. *Emotion, 21*(5), 1029–1040. <https://doi.org/10.1037/emo0000849>
- Mills, C., Zamani, A., White, R., & Christoff, K. (2020). Out of the blue: Understanding abrupt and wayward transitions in thought using probability and predictive processing. *Philosophical Transactions of the Royal Society B: Biological Sciences, 376*(1817), 20190692. <https://doi.org/10.1098/rstb.2019.0692>
- Nemeth, G. (2023). The route to recall a dream: Theoretical considerations and methodological implications. *Psychological Research, 87*(4), 964–987. <https://doi.org/10.1007/s00426-022-01722-7>
- Nicholas Carleton, R., Sharpe, D., & Asmundson, G. J. G. (2007). Anxiety sensitivity and intolerance of uncertainty: Requisites of the fundamental fears? *Behaviour Research and Therapy, 45*(10), 2307–2316. <https://doi.org/10.1016/j.brat.2007.04.006>
- Nielsen, T. (2011). Dream analysis and classification: The reality simulation perspective. *Principles and Practice of Sleep Medicine: Fifth Edition*, 595–603. <https://doi.org/10.1016/B978-1-4160-6645-3.00051-7>
- O'Connor, K., & Robillard, S. (1995). Inference processes in obsessive-compulsive disorder: Some clinical observations. *Behaviour Research and Therapy, 33*(8), 887–896. [https://doi.org/10.1016/0005-7967\(95\)00042-V](https://doi.org/10.1016/0005-7967(95)00042-V)
- Oren, E., Eitam, B., & Dar, R. (2019). Intentional binding and obsessive-compulsive tendencies: A dissociation between indirect and direct measures of the sense of agency. *Journal of Obsessive-Compulsive and Related Disorders, 20*, 59–65. <https://doi.org/10.1016/j.jocrd.2017.11.002>
- Oren, E., Friedmann, N., & Dar, R. (2016). Things happen: Individuals with high obsessive-compulsive tendencies omit agency in their spoken language. *Consciousness and Cognition, 42*, 125–134. <https://doi.org/10.1016/j.concog.2016.03.012>
- Poerio, G. L., Totterdell, P., & Miles, E. (2013). Mind-wandering and negative mood: Does one thing really lead to another? *Consciousness and Cognition, 22*(4), 1412–1421. <https://doi.org/10.1016/j.concog.2013.09.012>
- Poulos, C., Zamani, A., Pillemer, D., Leichtman, M., Christoff, K., & Mills, C. (2023). Investigating the appraisal structure of spontaneous thoughts: Evidence for differences among unexpected thought, involuntary autobiographical memories, and ruminative thought. *Psychological Research, 87*(8), 2345–2364. <https://doi.org/10.1007/s00426-023-01814-y>
- Puig, V. A., Poizner, R., Read, K., & Szpunar, K. K. (2025). Mental simulation of the approximal future: Imagining what might happen next. *Journal of Experimental Psychology: General, 154*(2), 405–419. <https://doi.org/10.1037/xge0001667>
- Rachman, S. (2007). Unwanted intrusive images in obsessive compulsive disorders. *Journal of Behavior Therapy and Experimental Psychiatry, 38*(4), 402–410. <https://doi.org/10.1016/j.jbtep.2007.10.008>
- Reinsel, Ruth, Antrobus, John, & Wollman, M. (1993). Bizarreness in dreams and waking fantasy. In J. S. Antrobus & M. Bertini (Eds.), *The Neuropsychology of Sleep and Dreaming* (pp. 157–183). Psychology Press.
- Revonsuo, A. (2000). Did ancestral humans dream for their lives? *Behavioral and Brain Sciences, 23*(6), 1063–1082. <https://doi.org/10.1017/S0140525X00994020>
- Revonsuo, A., Tuominen, J., & Valli, K. (2015). The avatars in the machine: Dreaming as a simulation of social reality. In T. Metzinger & J. M. Windt (Eds.), *Open MIND*. Open MIND. Frankfurt am Main: MIND Group. <https://doi.org/10.15502/9783958570375>
- Rice, E. L., & Fredrickson, B. L. (2017). Of passions and positive spontaneous thoughts. *Cognitive Therapy and Research, 41*(3), 350–361. <https://doi.org/10.1007/s10608-016-9755-3>
- Salkovskis, P., Shafran, R., Rachman, S., & Freeston, M. H. (1999). Multiple pathways to inflated responsibility beliefs in obsessional problems: Possible origins and implications for therapy and research. *Behaviour Research and Therapy, 37*(11), 1055–1072. [https://doi.org/10.1016/S0005-7967\(99\)00063-7](https://doi.org/10.1016/S0005-7967(99)00063-7)
- Salomon-Small, G., Somer, E., Harel-Schwarzmann, M., & Soffer-Dudek, N. (2021). Maladaptive daydreaming and obsessive-compulsive symptoms: A confirmatory and exploratory investigation of shared mechanisms. *Journal of Psychiatric Research, 136*, 343–350. <https://doi.org/10.1016/j.jpsychires.2021.02.017>
- Schacter, D. L., Addis, D. R., & Buckner, R. L. (2008). Episodic simulation of future events. *Annals of the New York Academy of Sciences, 1124*(1), 39–60. <https://doi.org/10.1196/annals.1440.001>
- Schacter, D. L., Benoit, R. G., & Szpunar, K. K. (2017). Episodic future thinking: Mechanisms and functions. *Current Opinion in Behavioral Sciences, 17*, 41–50. <https://doi.org/10.1016/j.cobeha.2017.06.002>
- Schredl, M., & Hofmann, F. (2003). Continuity between waking activities and dream activities. *Consciousness and Cognition, 12*(2), 298–308. [https://doi.org/10.1016/S1053-8100\(02\)00072-7](https://doi.org/10.1016/S1053-8100(02)00072-7)

Poulos, M. C., Kuvar, V., Mallett, R., & Mills, C. (2025). Involuntary “what if” moments: Improbable simulations across the sleep-wake cycle and their relationship with anxiety. *Philosophy and the Mind Sciences, 6*. <https://doi.org/10.33735/phimisci.2025.9966>



- Schwarz, N. (1999). Self-reports: How the questions shape the answers. *American Psychologist*, *54*(2), 93–105. <https://doi.org/10.1037/0003-066X.54.2.93>
- Seli, P., Beaty, R. E., Marty-Dugas, J., & Smilek, D. (2019). Depression, anxiety, and stress and the distinction between intentional and unintentional mind wandering. *Psychology of Consciousness: Theory, Research, and Practice*, *6*(2), 163–170. <https://doi.org/10.1037/cns0000182>
- Seli, P., Cheyne, J. A., Xu, M., Purdon, C., & Smilek, D. (2015). Motivation, intentionality, and mind wandering: Implications for assessments of task-unrelated thought. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(5), 1417–1425. <https://doi.org/10.1037/xlm0000116>
- Seli, P., Kane, M. J., Smallwood, J., Schacter, D. L., Maillet, D., Schooler, J. W., & Smilek, D. (2018). Mind-wandering as a natural kind: A family-resemblances view. *Trends in Cognitive Sciences*, *22*(6), 479–490. <https://doi.org/10.1016/j.tics.2018.03.010>
- Seli, P., Risko, E. F., Smilek, D., & Schacter, D. L. (2016). Mind-wandering with and without intention. *Trends in Cognitive Sciences*, *20*(8), 605–617. <https://doi.org/10.1016/j.tics.2016.05.010>
- Sikka, P., Valli, K., Revonsuo, A., & Tuominen, J. (2021). The dynamics of affect across the wake-sleep cycle: From waking mind-wandering to night-time dreaming. *Consciousness and Cognition*, *94*, 103189. <https://doi.org/10.1016/j.concog.2021.103189>
- Smith, G. K., Mills, C., Paxton, A., & Christoff, K. (2018). Mind-wandering rates fluctuate across the day: Evidence from an experience-sampling study. *Cognitive Research: Principles and Implications*, *3*(1), 54. <https://doi.org/10.1186/s41235-018-0141-4>
- Soffer-Dudek, N. (2023). Obsessive-compulsive symptoms and dissociative experiences: Suggested underlying mechanisms and implications for science and practice. *Frontiers in Psychology*, *14*. <https://doi.org/10.3389/fpsyg.2023.1132800>
- Soffer-Dudek, N., & Somer, E. (2018). Trapped in a daydream: Daily elevations in maladaptive daydreaming are associated with daily psychopathological symptoms. *Frontiers in Psychiatry*, *9*. <https://doi.org/10.3389/fpsyg.2018.00194>
- Somer, E. (2002). Maladaptive daydreaming: A qualitative inquiry. *Journal of Contemporary Psychotherapy*, *32*(2), 197–212. <https://doi.org/10.1023/A:1020597026919>
- Synofzik, M., Vosgerau, G., & Voss, M. (2013). The experience of agency: An interplay between prediction and postdiction. *Frontiers in Psychology*, *4*. <https://doi.org/10.3389/fpsyg.2013.00127>
- Tapal, A., Oren, E., Dar, R., & Eitam, B. (2017). The sense of agency scale: A measure of consciously perceived control over one's mind, body, and the immediate environment. *Frontiers in Psychology*, *8*. <https://doi.org/10.3389/fpsyg.2017.01552>
- Teismann, T., Brailovskaia, J., Schaumburg, S., & Wannemüller, A. (2020). High place phenomenon: Prevalence and clinical correlates in two German samples. *BMC Psychiatry*, *20*(1), 478. <https://doi.org/10.1186/s12888-020-02875-8>
- Thiemann, R. F., Mills, C., & Kam, J. W. Y. (2023). Differential relationships between thought dimensions and momentary affect in daily life. *Psychological Research*, *87*(5), 1632–1643. <https://doi.org/10.1007/s00426-022-01766-9>
- Tolin, D. F., Abramowitz, J. S., Brigidi, B. D., & Foa, E. B. (2003). Intolerance of uncertainty in obsessive-compulsive disorder. *Journal of Anxiety Disorders*, *17*(2), 233–242. [https://doi.org/10.1016/S0887-6185\(02\)00182-2](https://doi.org/10.1016/S0887-6185(02)00182-2)
- Valli, K., & Revonsuo, A. (2009). The threat simulation theory in light of recent empirical evidence: A review. *The American Journal of Psychology*, *122*(1), 17–38. <https://doi.org/10.2307/27784372>
- Wahlund, T., Jolstedt, M., Andersson, E., Vigerland, S., Perrin, S., Öst, L.-G., Högström, J., & Serlachius, E. (2020). Online cognitive behavior therapy for adolescents with excessive worry: A multiple baseline design feasibility study. *mHealth*, *6*, 5. <https://doi.org/10.21037/mhealth.2019.09.10>
- Wamsley, E. J. (2013). Dreaming, waking conscious experience, and the resting brain: Report of subjective experience as a tool in the cognitive neurosciences. *Frontiers in Psychology*, *4*. <https://doi.org/10.3389/fpsyg.2013.00637>
- Wamsley, E. J. (2022). Constructive episodic simulation in dreams. *PLOS ONE*, *17*(3), e0264574. <https://doi.org/10.1371/journal.pone.0264574>
- Wen, H., Soffer-Dudek, N., & Somer, E. (2024). Daily feelings and the affective valence of daydreams in maladaptive daydreaming: A longitudinal analysis. *Psychology of Consciousness: Theory, Research, and Practice*, *11*(4), 447–460. <https://doi.org/10.1037/cns0000293>
- Windt, J. M. (2020). How deep is the rift between conscious states in sleep and wakefulness? Spontaneous experience over the sleep-wake cycle. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *376*(1817), 20190696. <https://doi.org/10.1098/rstb.2019.0696>

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