Perceptions and Persistence: A Multifaceted Exploration of the Hypnagogic State and Unfinished Intentions

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This cumulative dissertation includes an umbrella paper and the following studies:

Part 1: The hypnagogic state

Study 1:

Ghibellini, R., & Meier, B. (2023). The hypnagogic state: A brief update. *Journal of Sleep Research*, *32*(1), e13719. https://doi.org/10.1111/jsr.13719

Study 2:

Ghibellini, R., & Meier, B. (2023). Hypnagogic states are quite common: Self-reported Prevalence, modalities, and gender differences. *Consciousness and Cognition,*115. https://doi.org/10.1016/j.concog.2023.103582.

Part 2: Intention memory

Study 3:

Ghibellini, R., & Meier, B. (manuscript in preparation). Interruption, recall and resumption: Revisiting the Zeigarnik and Ovsiankina effect.

Study 4:

Ghibellini, R., & Meier, B. (in revision). Hope of success increases memory for unfinished tasks. *Submitted to the Quarterly Journal of Experimental Psychology.*

Umbrella Paper

Perceptions and Persistence: A Multifaceted Exploration of the Hypnagogic State and Unfinished Intentions

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Abstract

The present dissertation explores two research topics: The perceptions during the hypnagogic state and the persistence of incompleted intentions. The hypnagogic state refers to the transition between wakefulness and sleep, in which vivid perceptions can occur across all modalities. A literature review identified a lack of consensus on their definition, prevalence and characteristics. A subsequent questionnaire study assessed their prevalence, modality, and characteristics compared to other phenomena. Hypnagogic states occurred quite frequently in the population, characterized by a predominant emergence in the kinaesthetic modality. Regarding the persistence of unfinished intentions, the focus was put on the memory advantage of interrupted tasks, called the Zeigarnik effect, and the tendency to resume interrupted tasks, called the Ovsiankina effect. To investigate both effects, a meta-analytical approach was employed, with a subsequent experimental replication attempt using videogames. Results showed a general resumption tendency of unfinished intentions, but no memory advantage. Following these results, the memory advantage was investigated using anagrams. Here, a memory advantage of interrupted tasks could be observed but could not be related to the Zeigarnik effect, questioning the effect's validity. Finally, research into the phenomenology and function of the hypnagogic state seems particularly promising. Regarding unfinished intentions, research should focus on their underlying neurological mechanisms, as their resumption tendency seems apparent and their memory advantage unreplicable.

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1 Preface

Conducting research is like eating at an all-you-can-eat buffet. With a plethora of methodological approaches at one's disposal, the question of how one's hunger for knowledge can be satisfied becomes difficult. In research, for instance, someone might be interested in gathering profound knowledge on a topic by conducting a literature review and synthesizing the many results into one numerical value through a meta-analytical approach. Alternatively, another might study how a phenomenon manifests in a population in relation to other self-reported measures with questionnaire studies. Yet another may find interest in the influence of a particular independent variable on a dependent variable by manipulating it in an experimental design. In a broader sense, one might want to advance research by raising and investigating new and more refined research questions. In contrast, another might prefer to revisit old established findings and research whether they stand the test of time through replications. For me, in my dissertation, I did all that.

It is futile to attribute particular importance to one of these approaches. If anything, they equally share the importance of advancing research and eventually answer scientific questions. Aware of this fact, I was delighted to be able to investigate two phenomena with a broad range of scientific approaches: The hypnagogic state and unfinished intentions. I encountered both phenomena with considerable phenomenological uncertainties. For instance, research on the hypnagogic state had become obscure, with ambiguous reports of the phenomenon's prevalence, phenomenology, and inconsistent use of terminology. Here, integrating contemporary literature through a systematic review was long overdue. This allowed us to conduct a more in-depth analysis of their phenomenology with a questionnaire study, answering previous research questions while proposing new ones.

Regarding unfinished intentions, the utility of better memory performance and a resumption tendency for unfinished intentions seemed undoubtedly plausible. However, looking back on a century of research on the subject matter revealed a remarkably difficult-to-replicate memory advantage and

numerous methodological flaws. In this case, a meta-analytical synthesis of the magnitude of these effects was long overdue, as it had never been undertaken. Further, we tried to replicate these findings through standardized and controlled means with short videogames and anagrams while relating the effects to renowned individual differences.

Consequently, the present dissertation addresses two distinct phenomena discussed in the chronological order I encountered them. For each research topic, I looked back into the past, synthesizing and, wherever possible, attempting to replicate previous findings and addressing unanswered research questions. I begin by presenting and discussing our research on *perceptions* during the hypnagogic state. Then, I delve into our research on the *persistence* of unfinished intentions in memory and the tendency for their resumption. Finally, I provide a general discussion reflecting on both phenomena and presenting a future outlook for both research fields.

«From past to future the river of knowledge flows.

Be part of its nourishing waters."

Final Fantasy XIV

2 Topic 1: Perceptions - The hypnagogic state

Perceptions of beautiful landscapes and complex geometric shapes weaving into each other, the familiar voice of a friend accompanied by sweet melodies, or a free fall into the depths of slumber. These experiences can occur in the hypnagogic state, which is the transitional state between wakefulness and sleep (Maury, 1848). In this state, individuals often encounter vivid perceptions in all modalities (Sherwood, 2012). It is, therefore, unsurprising that this ominous state of drowsiness has been used as a creative sweet spot, is presumed to be a source of superstitions and folklore, and is sometimes deemed a state highly conductive for paranormal phenomena (McKellar & Simpson, 1954). Nevertheless, there is a lack of consensus on how to define hypnagogic states, how frequently they occur in the general population, and what function these ominous states assume.

The most comprehensive review of the research conducted on the hypnagogic state was compiled by Schacter (1976) at the end of the 20th century. In his seminal review, he concluded that hypnagogic states were quite common, and evidence suggested a decrease in these states with age. Their most defining characteristics included their spontaneous emergence into consciousness and passive experience, similar to watching a movie. Hypnagogic states were perceived as distinct from dreams, being generally shorter and emotionally flat, though often related to daily activities. Schacter thus defined hypnagogic states as "spontaneously appearing visual, auditory and kinaesthetic images; qualitatively unusual thought processes and verbal constructions; tendencies towards extreme suggestibility; symbolic representations of ongoing mental and physiological processes; and so on" (Schacter, 1976, pp. 452–453). Today, the American Academy of sleep medicine (American Academy of Sleep Medicine, 2014) classifies hypnagogic experiences as *sleep-related hallucinations*, an unsuitable term discussed in the following section. It encompasses three diagnostic criteria: First, recurrent experiences occur before falling asleep or upon waking during the night or in the morning (criterion A). Second, the experiences are predominantly visual (criterion B). Third, the disturbance cannot be

attributed to another sleep disorder (particularly narcolepsy), mental disorder, medical condition, medication, or substance use (criterion C). However, this classification overall provides poor guidance as to what the hypnagogic state is.

2.1 Terminology

The term *hypnagogic*, from the Greek words *ὑπνος* ("*hypnos*"), meaning "sleep", and *αγωγός* ("*agōgos*"), meaning "conductor" or "leader", was first coined by Maury (1848) and refers to the transition from wakefulness to sleep. Later, Myers (1904) conceived the term *hypnopompic*, with the word-ending originating from the word *πομπός* ("*pompos*"), meaning "sender", referring to the same phenomena when transitioning from sleep to wakefulness. However, it quickly became apparent that both terms have been used interchangeably in research, leading to the recommendation for a uniform classification as hypnagogic states. Notably, experiences in the hypnagogic state have often wrongfully been labelled as *hallucinations*. However, hypnagogic experiences need to be delimited from hallucinations for two reasons: First, the terminology used does not suit the properties of hypnagogic experiences. Whereas hallucinations are reflected upon, responded to, and integrated with internal representations, hypnagogic experiences are not, and hypnagogic experiences do not affect an individual's sense of self, beliefs, or personal narrative (Waters et al., 2016). Second, the stigma surrounding hallucinations could be projected upon hypnagogic experiences, which have explicitly been classified as non-pathological phenomena (American Psychiatric Association, 2013; Sacks, 2012).

At best, hypnagogic states could be classified as *pseudo-hallucinations*. Since characteristics of pseudo-hallucinations have been debated, two types of pseudo-hallucinations were proposed (Taylor, 1981): Pseudo-hallucinations describing self-recognized hallucinations (Hare, 1973), in which insight into the origin of those hallucinations is acquired, and pseudo-hallucinations as appearing in the introspected imaginal space, which are of great spontaneity and vividness (Heidelberg, 1911). Recently, both proposed characteristics of pseudo-hallucinations, the location (internal vs. external space), and the

level of insight into the nature of those hallucinations, have been criticized as providing poor guidance in the determination of hallucinations (Sanati, 2012). Due to the ambiguity of the term "pseudo-hallucination", classifying hypnagogic states as such should be refrained from.

Hypnagogic states are primarily benign but can be perceived as bothersome in rare instances (Hinton et al., 2019; Schacter, 1976). Therefore, a distinction between hypnagogic states and hypnagogic hallucinations is necessary, with the latter being characterized by the distress caused in affected individuals (American Academy of Sleep Medicine, 2014). Consequently, we proposed our definition of hypnagogic states as "the experiences of perception in the different modalities at sleep-onset and -offset, which may also, although less frequently, occur during wakefulness. However, these experiences can become clinically relevant, that is, when a complaint is issued or when they result in discomfort in the affected individual" (Ghibellini & Meier, 2023, pp. 2 – 3). We included their occurrence during the day in our definition, as suggested by more recent evidence (Gurstelle & de Oliveira, 2004; Steen, 2017).

2.2 Localization of the hypnagogic state

Hypnagogic states can also be defined based on their temporal occurrence during sleep onset. The American Association of Sleep Medicine's scoring manual (Iber et al., 2007) no longer defines sleep in terms of five stages (stage 1, stage 2, stage 3, stage 4, and REM) but rather as four distinct sleep phases: N1, N2, N3 (slow wave sleep), and R (formerly known as the REM stage). Throughout the sleep cycle, we progress through the three NREM stages (N1 – N3): We begin with the lightest and shortest stage of sleep (N1) and transition into a more extended period of deeper sleep (N2), eventually entering the third and deepest stage of sleep (N3), which is notoriously difficult to awaken from (Patel et al., 2020). The last stage of sleep, R, is typically when, although not exclusively, full-fledged dreams occur (Nir & Tononi, 2010). As hypnagogic stages occur during the transition from wakefulness to sleep, they are typically assigned to the first stage of sleep by definition (Vaitl et al., 2005).

The transition from wakefulness to sleep can further be divided into nine distinct sleep onset phases to localize hypnagogic states more precisely (Hori et al., 1994): Sleep onset stages 1 and 2 both occur during wakefulness when alpha activity slowly diminishes. Afterwards, sleep onset stages 3 to 8 all occur during N1 sleep: During these later stages, alpha activity decreases to less than 50% (stage 3), EEG flattening (stage 4) and ripples (stage 5) occur, before hump solitary (stage 6), hump trains (stage 7), and humps with incomplete spindles (stage 8) emerge. Finally, the sleep onset stages end in N2, with the appearance of spindles (stage 9). Hypnagogic experiences were demonstrated to occur in the sleep onset stages 4, stage 5, and stage 6, with kinaesthetic experiences occurring earlier than visual and auditory experiences and experiences becoming increasingly dream-like throughout sleep onset (Germain & Nielsen, 2001; Hayashi et al., 1999; Hori et al., 1994).

2.3 Differentiation

Evidently, hypnagogic states may be mistaken for other phenomena due to their resemblance. Most prominently, hypnagogic states have been compared to dreams, which are the subjective experiences that occur during sleep (Schredl, 2018). Hypnagogic states are generally shorter, more thought-like, and contain more episodic memories than dreams (Baylor & Cavallero, 2001; Zadra & Domhoff, 2017). Moreover, a distinction between both phenomena based on their temporal occurrence is relatively evident, as dreams occur during sleep, whereas hypnagogic states occur at sleep onset and offset (Schredl, 2018; Waters et al., 2016). Additionally, hypnagogic states have been characterized as more vivid than dreams, with dreams being significantly more common than hypnagogic states (Chokroverty, 2017; McKellar & Simpson, 1954; Pagel, 2003). However, little is known about the consistency of hypnagogic experiences, whereas dream content can occur repetitively and consistently (Domhoff, 1996; Van de Castel, 1995).

Similarly, the differentiation of hypnagogic states from sleep paralysis-related experiences has proven difficult, and both phenomena have often been classified as the same phenomenon. Episodes of

sleep paralysis, that is, the inability to move while maintaining the ability to breath at sleep-onset or -offset, are often accompanied by vivid hallucinations (Schiappa et al., 2018). Both hypnagogic states and sleep paralysis are features commonly associated with narcolepsy, and appropriately, these sleep paralysis-related experiences have been labelled as hypnagogic (Cheyne et al., 1999; D'Agostino & Limosani, 2010). However, both phenomena are distinct in their emotional quality: Whereas sleep paralysis-related experiences are often perceived as terrifying (Cheyne, 2003; Sharpless & Kliková, 2019), hypnagogic states are usually described as emotionally flat (Foulkes & Vogel, 1965).

Hypnagogic states need to be further delimited from imagination, given their occurrence at sleep onset when a degree of consciousness is maintained. Imagination can be defined as the ability to form internal images of objects and situations which are not present to the senses (Abraham, 2020). By this definition alone, hypnagogic states can hardly be delimited from imagination. Their differentiation becomes more apparent, however, when highlighting the degree of agency involved in these experiences: Whereas imagination is usually autogenic and occurs in a state of clear sensorium, hypnagogic states occur spontaneously and in a state of drowsiness (Schacter, 1976). Hence, the definition of imagination encompasses aspects of the hypnagogic states, but the phenomena can be differentiated considering the differences in agency.

2.4 Prevalence

Reports on the prevalence of hypnagogic states have been ambiguous. Some sources claim these states occur frequently in the general population, while others consider them to be rare. Early assessments reported an average prevalence of around 72% to 77% (Buck & Geers, 1967; McKellar, 1957, 1972; McKellar & Simpson, 1954; Owens, 1963). Later, large-scale assessments of the prevalence of hypnagogic states resulted in a lower estimate, with hypnagogic states at sleep onset occurring in 24.8% to 37% and hypnagogic states at sleep offset in 6.6% to 12.5% of participants and being more frequent in women than men (Ohayon, 2000; Ohayon et al., 1996). This discrepancy is further

highlighted in questionnaire validation studies, where 85% and 6.2% prevalence estimates were reported (Fulda et al., 2008; Jones et al., 2009). This variability in prevalence estimates is most likely due to differences in how hypnagogic states were defined. Whereas some studies have focused on specific experiences, such as hearing one's name (e.g., Jones et al., 2009), others have looked at broader experiences, such as hearing something others cannot hear (e.g., Ohayon, 2000). Additionally, some studies examined experiences with strong emotional quality, such as feeling set ablaze (e.g., Ohayon et al., 1996), while others investigated non-emotional experiences, such as the feeling of falling (e.g., Ohayon, 2000). Definitions of hypnagogic states have notoriously been confounded with the specificity of the experience in question and their emotional quality, which might explain the wide range of reported prevalences.

2.5 Study 1

After almost fifty years since Schacter's (1976) extensive review, we took it upon ourselves to review the recent literature on the hypnagogic state. We systematically reviewed empirical research published in the last twenty years to identify relevant literature on the subject matter. As our review followed up on Schacter's (1976) work, we structured our review by starting where he originally left off: With his proposed future directions. We began by outlining the main findings of Schacter (1976) before reviewing the six future directions established in Schacter's review.

While the approaches used to investigate the hypnagogic state remained relatively the same, such as self-observation (Steen, 2017), surveys (Larøi et al., 2019; Ohayon, 2000; Ohayon et al., 1996; Ohayon & Shapiro, 2000; Sherwood, 2012), and electroencephalography (Nielsen et al., 2005; Siclari et al., 2013; C. Speth & Speth, 2016; J. Speth et al., 2013, 2016, 2017; Wackermann et al., 2002), two new approaches emerged: The serial awakening paradigm (Siclari et al., 2013, 2017) and the linguistic analysis (C. Speth & Speth, 2016; J. Speth et al., 2013, 2016, 2017). Both allow the assessment of

hypnagogic experiences at close temporal proximity. Linguistic analysis further allows the investigation of reports without interfering with participants' recollections of their experiences.

Regarding the phenomenology of hypnagogic states, previous literature has stated that hypnagogic states occur most frequently in the visual modality, followed by the auditory and tactile-kinaesthetic modality (Schacter, 1976). Our review presented a contrasting viewpoint: Kinaesthetic experiences, such as the sensation of a presence in the room and the feeling of falling, along with visual experiences, were the most common, followed by experiences in the auditory modality (Jones et al., 2009; Ohayon, 2000; Sherwood, 2012). When comparing hypnagogic states to dreams, several distinct characteristics set them apart. Notably, individuals engaged in less active participation during hypnagogic states than in dreams (J. Speth et al., 2013, 2017).

Both the stimuli prior to and during the hypnagogic state have the potential to impact an individual's experiences. Research has shown that external stimuli can influence one's responses during the hypnagogic state, indicating that these stimuli may play a role in shaping the content of our experiences in this state (Dang-Vu et al., 2011; Michida et al., 2005; Waters et al., 2016). It is plausible that self-generated and environmental external stimuli can have an influence on the content of hypnagogic states (Nielsen, 2017). In terms of experiences preceding the hypnagogic state, a number of studies have successfully demonstrated that engaging in activities like playing games or observing someone else playing a game prior to falling asleep can determine the content of hypnagogic experiences, suggesting that activities before bedtime can affect the content of the experiences we have during the hypnagogic state (Kussé et al., 2012; Stickgold et al., 2000; Wamsley et al., 2010).

Several differences in both clinical and individual differences were associated with the occurrence of hypnagogic states. For instance, the frequency of hypnagogic states was linked to sleep quality (Nielsen et al., 2005; Ohayon et al., 1996; Soffer-Dudek & Shahar, 2011) and narcolepsy (Bosch et al., 2012; Fortuyn et al., 2009; Schiappa et al., 2018), dissociation and schizophrenia traits (Bosch et al.,

2012; Fortuyn et al., 2009; Soffer-Dudek & Shahar, 2011), intrusive thoughts and PTSD (Hinton et al., 2019; Jones et al., 2009; McCarthy-Jones et al., 2011; Ohayon & Shapiro, 2000), as well as depression and anxiety (Bosch et al., 2012; Larøi et al., 2019; Szklo-Coxe et al., 2007). Moreover, it has been found that suppressing a thought during the day can lead to its re-emergence during the hypnagogic state, similar to what is observed in dreams (Schmidt & Gendolla, 2008; Wegner et al., 1987, 2004).

Lastly, hypnagogic states can be induced using the Ganzfeld technique, the induction of visual and auditory sensory deprivation, and hypnosis, and their content can be brought about through targeted dream incubation procedures. Reports of hypnagogic experiences did not show any significant differences between those induced by the Ganzfeld method and those occurring naturally (Wackermann et al., 2002). As EEG signals measured during the Ganzfeld procedure correlate more strongly with wakefulness than sleep onset, we still proposed that the Ganzfeld procedure could be a valuable tool for assessing daytime hypnagogia. While hypnosis has barely been used for investigating hypnagogic states, it appears to be a promising approach for inducing such experiences and potentially manipulating their content. Conversely, techniques like *Dormio*, a protocol for dream incubation, can be employed to elicit specific experiences during the hypnagogic state (Haar Horowitz et al., 2020).

These findings left us with several unanswered questions, which constituted our future directions. First off, the emotional quality of hypnagogic states had been assumed as negative or emotionally flat. Yet, no attempt had been made to assess the emotional quality of hypnagogic states systematically. Second, the question emerged as to why hypnagogic states were predominantly experienced in the kinaesthetic modality. We suspected that these perceptions reflected adaptational processes of the vestibular system at sleep onset due to a lack of vestibular input. Last but certainly not least, the question regarding their functionality persisted. Given the demonstrated rebound of thoughts suppressed during the day in the hypnagogic state, we hypothesized that the hypnagogic state may

represent a state suitable to process and consolidate prior experiences. The second study followed up on our first two proposed future directions.

2.6 Study 2

After reviewing the contemporary literature on the hypnagogic state, we were left with several uncertainties regarding its phenomenology: Vast differences in reports of the prevalence of hypnagogic states became apparent, their emotional quality was propagated as being negative or neutral in the absence of any systematic investigation, and the question arose as to whether the primarily kinaesthetic phenomenology was a characteristic unique to hypnagogic states. Considering the discrepancies in preceding research, a reassessment of the hypnagogic state was needed.

Therefore, we conducted an online questionnaire study to investigate the self-reported prevalence of hypnagogic states in a large sample. Moreover, we assessed the frequency of modality these experiences occurred in and assessed their emotional quality, vividness, and degree of irritation they caused in experiencing individuals separately. We aimed to disentangle the specificity and emotional quality of hypnagogic experiences commonly confounded in previous research. We achieved this by assessing each aspect with separate items and using a broad and emotionally neutral definition. Subsequently, we compared hypnagogic states to other phenomena to identify unique characteristics of hypnagogic states and similarities with other phenomena, such as dreams, sleep paralysis, imagination, and extrasensory perception.

Participants reported experiencing hypnagogic states quite frequently, with 80.2% of participants reporting previous experiences and being more prevalent in women than men. We suspect that women exhibit more engagement and talk more openly about their experiences, thus encoding these experiences better. Such differences in how actively women engage in and discuss their experiences have been shown to influence dream recall and can explain why dream reporting is more common among women than men (Schredl, 2018; Schredl & Piel, 2003; Schredl & Reinhard, 2008;

Schredl & Schawinski, 2010). Hypnagogic states occurred most often at sleep onset, less often at sleep offset, and during the day when some degree of "zoning out" was involved. In accordance with previous literature, hypnagogic states emerged in the kinaesthetic modality most prominently, slightly less in the visual and auditory modality, and the least often in the tactile, olfactory, and gustatory modality (Jones et al., 2009; Ohayon, 2000; Schacter, 1976). This modality profile was unique to hypnagogic states and likely related to the prevalent feeling of falling when transitioning from wakefulness to sleep. Moreover, hypnagogic states were rated as predominantly neutral in their emotional quality, similar to dreams, but were perceived as less vivid and irritating.

2.7 Discussion

A systematic review is a fundamental scientific activity (Mulrow, 1994). Systematically reviewing the literature allowed us to identify considerable progress and vast inconsistencies in the definitions and approaches used in researching hypnagogic states. The absence of a unified working definition was particularly striking, leading to disagreement among researchers on their phenomenology. Fortunately, the literature synthesis enabled us to propose our definition of hypnagogic states in an emotionally neutral and broad way. Moreover, it allowed us to identify research gaps and propose future directions, guiding the research on the phenomenology of hypnagogic states. This led us to propose a further investigation of their emotional quality, their predominant occurrence in the kinaesthetic modality, and their functionality.

Using our working definition, we set out to investigate the hypnagogic states' phenomenology in greater detail. In particular, study 2 was the first to contrast hypnagogic states with similar phenomena. We found hypnagogic states to occur quite frequently. Moreover, we found that hypnagogic states were reported more frequently in women than men. Regarding our first proposed future direction, a systematic assessment of their emotional quality revealed that hypnagogic states did not differ from similar phenomena, such as dreams in their emotional quality. Hypnagogic states were, therefore, not

characterized by a negative emotional quality, as previous research suggested (e.g., Bosch et al., 2012; Fulda et al., 2008; Jones et al., 2009, 2010; Ohayon et al., 1996). Consequently, the frequent conflation of emotional quality and specificity in assessing hypnagogic states was inappropriate and a likely contributor to the reported low prevalence rates.

Exploring our second future direction, we confirmed that hypnagogic states occurred most frequently in the kinaesthetic modality. This unique characteristic became particularly evident when our study contrasted modality profiles among other assessed phenomena. Other phenomena like dreams, sleep paralysis-related experiences, imagination, and extrasensory perception exhibited more multimodal modality profiles. These frequent kinaesthetic experiences, such as the prevalent feeling of falling, are suspected to relate to adaptational processes of the vestibular system at sleep onset. Moreover, they may be more memorable due to their arousing nature and potential to disrupt sleep-onset, leading to better memory encoding (Hamann, 2001; Payne & Kensinger, 2010). These adaptive vestibular processes remain elusive and require further research.

If we assume the predominant occurrence of hypnagogic states in the kinaesthetic modality to be a byproduct of vestibular adaptation processes, our third future direction concerning their functionality persists. Here, two options present themselves. Hypnagogic experiences could reflect multimodal intrusions at the transition from wakefulness to sleep through a deficient inhibition from frontal brain regions (Kjaer et al., 2002; Marzano et al., 2013; Siclari et al., 2014). This does not explain why these experiences can relate to previous activities (Kussé et al., 2012; Schmidt & Gendolla, 2008; Stenstrom et al., 2012; Stickgold et al., 2000; Wamsley et al., 2010). Hence, a second option presents itself: Hypnagogic experiences most likely contain memory replay and reflect some degree of memory consolidation (Wamsley & Stickgold, 2011). Consequently, the role of the hypnagogic state would be to process and consolidate previous daytime activities, such as listening to music, playing videogames, or simply going grocery shopping.

3 Topic 2: Persistence – Unfinished Intentions

Intentions are an integral part of everyday life. When planning everyday activities, such as grocery shopping, we form intentions. Forming intentions helps us achieve respective outcomes and perform relevant behaviours (Gollwitzer, 1993). Intentions must often be postponed until an opportunity emerges for their execution (Goschke & Kuhl, 1993). For instance, a postponement can occur when an intention is interrupted. Nevertheless, we find ourselves resuming intentions after an interruption. Therefore, intentions must possess distinct properties that remind us of their resumption. That is, they involve the ability to plan ahead and anticipate future goal states, and they allow us to schedule, establish, and maintain (sub)goals over extended periods of time (Möschl et al., 2020). Without these reminders, intentions would be forgotten when interrupted or delayed. When an intention is successfully executed, it must be deactivated since a reminder of a completed intention would be redundant.

Mentions of the nature of intentions can be found as early as in Aristotles' introductory line to his famous work on *nicomachean ethics*: "Every craft (*technē*) and every line of inquiry (*methodos*), and likewise every action (*praxis*) and decision (*prohairesis*) seems to seek some good (*agathon*)" (Aristotle, ca. 350 B.C.E/1999, p. 1). In this sentence, Aristotle refers to a "good" as the goal of an action (Wolf, 2002). Therefore, every action is, at its core, intentional and attempts to reach a particular goal. The question arises as to how intentions remind us of their execution when they have to be postponed. Sigmund Freud noted that the "intention slumbers in the person concerned until the time for its execution approaches. Then it awakes and excites the action" (Freud, 1909/1989, p. 194). Still, this explanation is too abstract and calls for more concrete mechanisms to explain the persistence of intentions.

Ach (1910) was one of the first researchers to conceptualize the representation of intentions. It is worth noting that Ach (1910) built his theory on Ebbinghaus' (1885) classical experiment, which

demonstrated that the strength of consolidating learned material was a direct function of its number of repetitions. Ach (1910), therefore, concluded that the driving force behind the urge to complete intentions was the subconsciously created association between the intention and the objective, which he called *Determination* or *Determining Tendencies*. The intensity of the determination was thought to play a crucial role in the likelihood of successfully carrying out the intention. Once fulfilled, the intention would bring about a sense of relief.

3.1 Lewin's theory of tension

In his renowned field theory on tension, Kurt Lewin (1926) presented an alternative perspective to the prevailing association theory of his time. Ach's (1910) association theory posited that the link between intention and its objective served as a causal factor driving the urge to complete an intention. Contrarily, Lewin (1926) pointed out a fundamental flaw in the association theory. He argued that, if it were accurate, the connection between intention and objective should persist even after the intention had been fulfilled and should strengthen further. This, however, was not the observed reality. Lewin noted that successfully executing an intention, like mailing a letter, did not rekindle the intention when encountering a mailbox after its successful completion. Consequently, he suspected the involvement of other mechanisms that could explain the drive to fulfil intentions while allowing the intention to dissipate once completed. As the name suggests, Kurt Lewin's (1926) field theory of tension proposes that implementing an intention generates tension by attributing a sense of importance (*Aufforderungscharakter*) to specific objects and situations. This inner tension resembles a quasi-need, persisting until the intention is successfully realized. In interrupted activities, this tension persists, leading to a noticeable inclination to resume unfinished tasks. This mechanism proves to be highly advantageous, as it ensures the successful completion of interrupted actions and tasks. Hence, Lewin (1926) hypothesized that this persistent tension should translate to a better recall of unfinished

activities than completed ones. Subsequently, this theory was adopted by two of Lewin's doctoral students and subjected to empirical testing in a series of experiments.

3.2 The Zeigarnik effect

One of Lewin's doctoral students, Bluma Zeigarnik (1927), explored the memory advantage associated with unfinished tasks in comparison to completed ones attributed to persistent tension. She conducted a series of experiments involving 164 participants, including students, teachers, and children. Participants were presented with sequences of 18 to 22 tasks, with half of them being interrupted at the point of peak engagement. The individual tasks varied in completion time from 1 to 5 minutes, depending on their complexity. Immediately after completing all tasks, participants recalled, on average, twice as many interrupted tasks as completed ones, clearly illustrating the memory advantage of unfinished tasks. Interestingly, these interrupted tasks tended to cluster at the beginning of the retrieval process. Zeigarnik (1927) thus concluded that interrupted tasks benefited from a memory advantage due to their persistent activation, leading to the establishment of what is known as the "Zeigarnik effect."

It became apparent that the Zeigarnik effect was not a universally reliable phenomenon but somewhat limited to specific conditions, and researchers began investigating the effect in light of individual differences. Atkinson (1953) investigated the impact of achievement motivation on the Zeigarnik effect and found that individuals with a strong desire for achievement were more likely to recall unfinished tasks rather than completed ones under competitive circumstances. In contrast, the opposite was true for individuals with low achievement motivation. Later studies also linked the Zeigarnik effect to various other individual differences, such as task involvement (Green, 1963), dominance (Sinha & Sharan, 1976), and personality traits such as neuroticism and introversion (Claeys, 1969), as well as repression-sensitization (Hofstaetter, 1985). Furthermore, researchers explored the influence of anxiety and ego involvement on task recall, suggesting that individuals who suppress

threatening stimuli tend to exhibit a reversal of the Zeigarnik effect (Farley & Mealiea, 1971; Glixman, 1949; Rosenzweig, 1943; Weiner et al., 1968).

Situational factors also emerged as significant influences on the Zeigarnik effect. Marrow's early studies (1938b, 1938a) highlighted the role of different instructions in shaping recall patterns, and subsequent research expanded on this by manipulating experimental conditions such as task-focused, achievement-oriented, and relaxed settings (Alper, 1946; Atkinson, 1953; Caron & Wallach, 1957; Claeys, 1969; Green, 1963; Hays, 1952). Competitive situations, as investigated by Weiner (1966), provoked diverse recall patterns based on gender, with men and women exhibiting varying degrees of the Zeigarnik effect depending on their competitors. Finally, the presence and characteristics of subsequent tasks (or interpolated tasks) following the primary task also influenced the recall of interrupted and completed tasks. Simple subsequent tasks intensified the Zeigarnik effect, whereas complex tasks appeared to reverse it, possibly due to retroactive inhibition depleting cognitive resources (Hays, 1952; Prentice, 1944). The heterogeneous approaches and various associated factors overall painted a complex and diffuse picture of the Zeigarnik effect.

3.3 The Ovsiankina effect

Taking a similar investigative approach, Maria Rickers-Ovsiankina (1928) examined the tendency to resume unfinished tasks through several experiments involving 124 participants, primarily students and adults, along with children. They were presented with sets of 8 to 12 tasks, some of which were intentionally interrupted. Interruptions occurred through various means, including disruptive actions (e.g., the experimenter introducing another task), prohibition of task completion, random interruptions (e.g., the experimenter dropping something and requesting assistance), sudden probing of introspection regarding the preceding task, or casual conversation distractions. Remarkably, participants independently resumed the interrupted task in 100% of cases when interruptions were random and in

79% of cases when disrupted by a disruptive action. These findings successfully demonstrated the innate drive to resume interrupted actions, nowadays known as the "Ovsiankina effect."

The Ovsiankina effect has been found to be more consistent than the Zeigarnik effect. Various studies showed that both adults and children, including those with intellectual disabilities, reliably returned to their unfinished tasks when presented with an opportunity, even when alternative tasks were provided (Birk et al., 2020; Katz, 1938; Mahler, 1933; Nowlis, 1941; Rethlingshafer, 1941; Rösler, 1955). However, this tendency for resumption is influenced by how similar the alternative task is to the interrupted one (Lissner, 1933). Intriguingly, introducing extrinsic rewards, such as monetary incentives, reduced this tendency, suggesting that the Ovsiankina effect is intrinsically motivated (McGraw & Fiala, 1982). As Reeve et al. (1986) demonstrated, the Ovsiankina effect and intrinsic motivation are related but represent distinct phenomena. Later studies examined how framing tasks in terms of gains or losses impacted the resumption of tasks, concluding that individuals focusing on prevention are more likely to resume unfinished tasks to avoid losses (Liberman et al., 1999).

3.4 Modern intention memory research

Nowadays, unfinished intentions are examined predominantly from the perspective of prospective memory, where the need for a mechanism to maintain an intention is particularly evident. Prospective memory is the ability to remember to perform an action in the future (Einstein & McDaniel, 1990). It entails retaining an intention while engaging in other activities and retrieving the intention at the appropriate time before deactivating it after completion (Meier & Cottini, 2023; Rummel & Kvavilashvili, 2023). Generally, prospective memory comprises a prospective component, that is, knowing when to perform the intended action, and a retrospective component, that is, knowing what the intended action entails (Cohen et al., 2001; Meier & Zimmermann, 2015). Modern research on memory for intentions almost exclusively focuses on the prospective component of prospective memory (Goschke & Kuhl, 1996).

Contemporary perspectives on intentions have shifted from the abstract notion of tension to a theory of activation (Goschke & Kuhl, 1993). The representation of an intention remains in an elevated state of subthreshold activation (Goschke & Kuhl, 1996). This activation guarantees the intention's persistence, prompting us to act upon it when the opportunity arises. Nevertheless, we can observe the effects of this persistent activation. For instance, faster reaction times to intention-related stimuli can be observed (Goschke & Kuhl, 1993). In particular, when an intention has been terminated without the opportunity to act upon it, encountering those previously intention-related stimuli leads to commission errors, wherein individuals respond with intention-related behaviour despite being instructed otherwise (Bugg & Scullin, 2013). In addition, encountering those intention-related stimuli leads to slower performance (Walser et al., 2012), which is also observable in subsequent trials (Meier & Cottini, 2023). To this date, these effects are best explained by the memory advantage of unfinished intentions (Bugg & Streeper, 2019; Möschl et al., 2020).

3.5 Study 3

We began investigating the memory advantage and resumption tendency of interrupted intentions by revisiting past research. Many studies investigated the Zeigarnik and Ovsiankina effects using varying approaches while reporting manifold findings. In particular, the Zeigarnik effect was notoriously difficult to replicate (Butterfield, 1964; MacLeod, 2020; Van Bergen, 1968). Here, a synthesis of previous research was also needed on which further research could be based. Therefore, we decided to conduct the first meta-analysis on the Zeigarnik and Ovsiankina effect. Conducting a systematic literature search resulted in a first sample of 1263 publications, of which we included a final sample of 42 publications after title, abstract, and full-text screening. Subsequently, we investigated the first aim of our study to compute a weighted average Zeigarnik and Ovsiankina effect. Our meta-analysis indicated that interrupted tasks were recalled slightly more often than finished tasks, but to a negligible amount. In fact, the exclusion of Zeigarnik's (1927) original study yielded the opposite result, with

finished tasks being recalled more frequently. The strongest Zeigarnik effect was observed when evaluating situational influences in experimental conditions where no alterations to the experimental environment had been made. In addition, the inspection of achievement motivation, the most prominent individual difference assessed concerning the Zeigarnik effect, did not yield precise results. Instead, the findings suggested that the Zeigarnik effect may, at best, be a product of situational and personality variables. In contrast, the Ovsiankina effect reliably manifested across studies.

These sobering findings made us question whether the Zeigarnik effect would replicate under standardized circumstances. In particular, we also wanted to use the same task material to investigate the Ovsiankina effect. In their original studies, Zeigarnik (1927) and Ovsiankina (1928) used various tasks resembling small games. Videogames, known for their rule-based gameplay and objectives, aligned well with the concept of intentions. Moreover, a computerized approach allowed for precise environmental control (Booth-Kewley et al., 2007; Drasgow & Olson-Buchanan, 1999). Therefore, videogames proved ideal for investigating the Zeigarnik and Ovsiankina effects while ensuring standardized instructions, minimizing situational influences, and mitigating social desirability effects.

We created 16 short videogames using the Unity Engine (Unity®, 2021) with comparable controls. Participants played all 16 videogames in sequence, of which half were interrupted before they were prompted to either recall the videogames or select eight videogames for replay to measure resumption tendencies. In the first step, we piloted our study with a large sample to test our approach using videogames. This first iteration also included conditions with additional prospective memory tasks unique to each game, which we omitted for the experiment. The pilot study's findings on the Zeigarnik effect were inconclusive, whereas the Ovsiankina effect successfully emerged. Following these results, we made necessary changes to the videogames to minimize confounding variables and precisely control the time spent on each task. As participants typically work half as long on interrupted tasks than finished tasks, we included a condition in which we held the duration of interrupted and finished tasks constant

at two minutes. As the videogames lacked a clear endpoint, progress was displayed to participants using a progress bar. Across both conditions, we could not detect a Zeigarnik effect, while an Ovsiankina effect occurred, which reversed when the time of the video games was kept constant.

We suspected that the use of videogames as interruptible tasks may have created a more relaxing environment, reducing task involvement and subsequent memory effects. Moreover, our videogames did not have a clear endpoint, which might have affected the Zeigarnik effect's occurrence. Regarding the Ovsiankina effect, we assumed that unfinished videogames urged participants to select these videogames for replay. When the time of interrupted and finished task was held constant, participants could have noticed the slow progress, causing frustration, which likely deterred participants from resuming interrupted games, resulting in a reverse Ovsiankina effect.

3.6 Study 4

After our unsuccessful attempt at replicating the *Zeigarnik* using videogames, we were left with uncertainties regarding the effect's replicability. Of the publications reviewed in Study 3, the study by Baddeley (1963) yielded the most substantial memory advantage for interrupted tasks. Therefore, we decided to adopt Baddley's (1963) approach. Participants were presented with a total of twelve five-letter anagrams of common German words sequentially. They were allotted 60 seconds to solve the anagram, or else they were given its solution. Subsequently, recall of the anagram solutions was assessed. The novelty of this study was our separate assessment of the two facets of achievement motivation: Hope of success and fear of failure.

According to Kuhl (1996), the expectation of reward, commonly known as hope of success, and the anticipation of punishment, referred to as fear of failure, would play a pivotal role in shaping how intentions are stored and maintained in memory. Intentions rooted in hope of success should increase the likelihood of performing the intention correctly when the time comes through better representation and, consequently, through higher activation. These intentions should profit from a memory advantage,

particularly if they remain incomplete. In contrast, those intentions associated with fear of failure should differ less based on their completion status due to generally lower activation of these intentions. Strikingly, this differing representation of intentions had never been investigated before.

In our study, participants recalled significantly more unsolved anagrams on average than solved anagrams. Interestingly, the recall of unsolved anagrams significantly increased linearly with higher scores in hope of success. Meanwhile, the recall of solved anagrams was not associated with hope of success. These results imply that, as participants' anagram recall increases with higher hope of success, this increase predominantly relates to a recall of unsolved anagrams. No association was found between fear of failure and the recall of unsolved anagrams or the recall of solved anagrams. Therefore, differing recall preferences for unsolved and solved anagrams were solely determined by the expectation of success and the tendency to strive for excellence.

3.7 Discussion

Our results from study 4 may seem promising in demonstrating a Zeigarnik effect, but they must be interpreted with caution. The paradigm we used in study 4, adopted from Baddeley (1963), differs from Zeigarnik's (1927) approach in two ways: On the one hand, task duration was longer on interrupted tasks than on finished tasks, contrary to Zeigarnik's (1927) study. The longer time spent on the task could have contributed to a better memory recall of these interrupted tasks (Pachauri, 1935; Walsh, 1940, 1942).[1] On the other hand, the expectation of completion differed in both paradigms. In Zeigarnik's (1927) original study, the subjects were interrupted in their execution of the task, while the expectation of being able to finish the task if given the opportunity remained. In study 4, participants

[1] Although there could be a correlation between task duration and retrieval in study 4, this analysis is confounded by the interruption and completion of the task. Interrupted tasks always lasted 60 seconds, whereas the duration of completed tasks varied. Thus, the effect of task duration cannot be disentangled from the effect of task completion.

were interrupted and presented with the anagram's solution, negating the expectation of solving the anagram. There is no reason to assume any expectation of completion in study 4.

Consequently, while participants were interrupted during the anagram-solving process, the tasks were not deemed unfinished in study 4, given that participants were presented with the anagrams' solutions. In contrast, tasks were both interrupted and unfinished in study 3, as participants were denied from reaching the end goal in interrupted videogames. Therefore, the result of study 4 could not be attributed to the Zeigarnik effect. Given the puzzle-like nature of the anagrams, it is likely that these findings represent some form of the "Aha!" effect, in which initially ambiguous stimuli which are later resolved benefit from a memory advantage (Auble et al., 1979; Auble & Franks, 1978; Ludmer et al., 2011; Wills et al., 2000). This "Aha!" effect also holds when the solution to a problem is not self-generated but presented (Auble et al., 1979; Kizilirmak et al., 2016; Ludmer et al., 2011). In this case, unsolved anagrams would have benefitted from such an "Aha!" effect once the experimenter presented the anagram's solution to the participant after they failed to solve it. The more pronounced and longer emotional and cognitive engagement in trying to solve the anagram and finally encountering its solution would lead to deeper processing (Craik & Lockhart, 1972; Lockhart et al., 1976).

The existence of the Zeigarnik effect cannot be denied, as it was observed in some studies. However, its universal validity must clearly be rejected (Butterfield, 1964; MacLeod, 2020; Van Bergen, 1968). Instead, the Zeigarnik effect could rather be a product of particular situational influences and individual differences. Experimental settings emphasizing task importance may lay the foundation for individual differences-dependent recall patterns. Some might recall interrupted tasks more frequently, seeing their completion as crucial and a chance to excel (Atkinson, 1953, 1957). Meanwhile, others who consider incompletion a threat to their ego might remember finished tasks more prominently (Farley & Mealiea, 1971; Glixman, 1949; Rosenzweig, 1943). Then again, relaxed and neutral settings, such as in our replication attempt with videogames, might fail to provoke personality-dependent recall patterns

due to insufficient emphasis on task-importance (Alper, 1946; Marrow, 1938a, 1938b). As MacLeod puts it: "At best, it would appear to hinge on certain individual difference characteristics; at worst, it is simply not replicable" (MacLeod, 2020, p. 1081).

Zeigarnik's (1927) result must also be put into historical perspective. As Zeigarnik (1927) stated, participants' task involvement was driven by a sense of duty, ambition, or the tasks themselves. This heightened involvement could be attributed to the authority and prestige associated with academic institutions and their affiliates in the early 20th century (McCain, 1960). Therefore, participants, primarily students, may have naturally been task-involved and driven to excel. Today, the perceived authority of experimenters has diminished, making manipulating the experimental atmosphere necessary to elicit the Zeigarnik effect. Further, modern distractions, such as mobile notifications and multitasking, are omnipresent and could interfere with task involvement (Kushlev & Dunn, 2015; Ophir et al., 2009; Stothart et al., 2015). These factors may explain why later studies reporting a Zeigarnik effect exhibited effects of smaller magnitude.

Results from the meta-analysis and the replication using videogames in study 3 demonstrated a resumption tendency of unfinished tasks. A tendency to resume unfinished tasks is necessary to navigate life successfully and can prominently be observed in prospective memory. Here, too, the retrieval of intentions can, amongst others, occur relatively automatically through environmental cues associated with our intention (McDaniel & Einstein, 2001). This tendency is not always reliable, as we tend to fail to remember our prospective intentions when tasks are perceived as less important, if retrieval cues are insufficiently salient, or when attentional resources are limited (Einstein & McDaniel, 1990; Kvavilashvili & Ellis, 1996; McDaniel & Einstein, 2000). Similarly, task resumption decreases when tasks are perceived as unenjoyable or less important and with increased similarity to the substitute task, thus making the interrupted task less salient (Brazzolotto & Michael, 2021; Lissner, 1933). Further,

depleting cognitive resources through an interrupting task can lead to increased time needed for task resumption (Monk et al., 2008).

Contemporary findings on the persistence of unperformed prospective intentions were attributed to the Zeigarnik effect (Bugg & Streeper, 2019; Möschl et al., 2020). However, modern prospective memory research mainly focuses on the prospective component of intentions, that is, remembering when to perform the intention (Goschke & Kuhl, 1996). In contrast, the Zeigarnik effect relates to the retrospective component, that is, what the intention entails. Moreover, tasks are typically interrupted during their execution in a typical interrupted task paradigm (Pachauri, 1935). In contrast, participants are typically denied even beginning to execute their prospective memory task (Bugg et al., 2016; Bugg & Scullin, 2013; Meier & Cottini, 2023; Streeper & Bugg, 2021). In addition, both paradigms significantly differ in the amount of unfinished or interrupted tasks. Contemporary approaches to investigate prospective memory performance are more closely aligned with Ovsiankina's (1928) approach, in which a single task is interrupted – or, in this context, unfeasible – before resumable after an interpolated task.

In conclusion, unfinished intentions persist until their execution. Their representation seems to be maintained in a heightened state of subthreshold activation, prompting us to resume the task once the opportunity emerges (Goschke & Kuhl, 1996). This activation does not seem to translate into a conscious memory advantage for interrupted intentions in the presence of multiple intentions. Here, situational influences and individual differences may be required to dictate the importance of the interrupted intentions for future recall and a Zeigarnik effect to emerge. To what extent and in what constellation both factors are sufficient to provoke such a memory advantage consistently seems questionable. As van Bergen (1968) puts it, "one wonders how many thousand more of experimental subjects will yet be needed before the problem, which is essentially a non-problem, is discarded" (p. 267).

4 General discussion

The first research topic involved the *perceptions* during the hypnagogic state. In study 1, we reviewed the literature on the hypnagogic state. In study 2, we investigated the hypnagogic states' prevalence, modality, and characteristics and how they relate to other phenomena. Revisiting and synthesizing previous literature helped us identify unanswered research questions we addressed in our second study. The results demonstrated that hypnagogic states occur frequently in the general population and are distinguished from similar phenomena by their most frequent occurrence in the kinaesthetic modality. Here, it was imperative not to label these phenomena as hallucinations since classifying them as such makes no sense phenomenologically, epistemologically, or ontologically.

The second research was concerned with the *persistence* of unfinished intentions. In study 3, we synthesized previous literature on the Zeigarnik and Ovsiankina effect to assess their replicability before undertaking our replication attempt using videogames. In study 4, we set out to investigate the Zeigarnik effect in relation to achievement motivation using another approach with anagrams. Neither the synthesis of previous literature nor the replication attempt favoured the Zeigarnik effect, but both supported the Ovsiankina effect. While the results of study 4 demonstrated a memory advantage of interrupted intentions, the effect observed did not relate to the Zeigarnik effect. As such, unfinished intentions persist but may not manifest in an explicit memory advantage when multiple tasks are recalled, thus contributing to the growing body of literature questioning the Zeigarnik effect.

Both research topics involved an initial review and synthesis of the literature to get an idea of the current state of research and identify gaps. These reviews informed the subsequent approach used to investigate prevailing research questions. For the hypnagogic state, conducting a questionnaire study to reassess its prevalence while disentangling the phenomenon from its specificity and characteristics in comparison to other phenomena was a necessary novelty. For unfinished intentions, using an experimental approach to replicate previous effects under increased standardization and further

investigating the memory advantage for interrupted tasks, while considering individual differences, was called for. Nevertheless, open research questions prevail.

4.1 Outlook

Current research on the hypnagogic state is eagerly investigating the neural mechanisms underlying the hypnagogic state. By now, a relatively precise localization of the hypnagogic state throughout sleep onset has been achieved, and the activity of specific brain regions has already been assigned to the emergence of hypnagogic experiences (Hayashi et al., 1999; Hori et al., 1994; Horikawa et al., 2013; Noreika et al., 2015; Siclari et al., 2017). It is only a matter of time before the neural mechanisms underlying the hypnagogic state will be fully understood. Therefore, I focus on the phenomenology of hypnagogic states, specifically on how consistently hypnagogic states occur. We know that dream content appears somewhat consistent over time and can occur repetitively (Domhoff, 1996; Van de Castel, 1995). However, little is known about the consistency of hypnagogic states and whether this consistency is limited to phenomena occurring at later sleep stages. Further, what purpose do hypnagogic states serve? I have discussed the function of hypnagogic states in the context of memory consolidation already. Possibly, the hypnagogic state also serves to process what we were unable to process during the day, as a resurgence of thoughts suppressed throughout the day in the hypnagogic state has already been demonstrated (Schmidt & Gendolla, 2008).

Regarding unfinished intentions, I have discussed the replicability of the Zeigarnik and Ovsiankina effects. Questions about the function and emergence of these effects seem to have been well explored over the years. In contrast to the hypnagogic state, I would centre on the underlying mechanisms for the maintenance and resumption of unfinished intentions. If we accept the notion of intentions being maintained in a heightened state of subthreshold activation, the question arises about what this activation exactly entails. Where are intentions maintained? And does this activation manifest itself neurologically? Several studies have highlighted the role of the prefrontal cortex in encoding future

intentions (Gilbert, 2011; Haynes et al., 2007; Momennejad & Haynes, 2012, 2013). In addition, a recent meta-analysis emphasized the role of a "Salience Network" being involved in encoding, monitoring, and detecting cues related to the intended action while maintaining attention when the intended action cannot be performed (Cona et al., 2023). In contrast to investigating the Zeigarnik effect, this endeavour seems more promising and purposeful and would help advance related research fields, such as prospective memory research.

In addition, little is known to what extent the Ovsiankina effect relies on memory processes or reflects automatic and unconscious processes. Investigating this phenomenon in patients with anterograde amnesia could offer valuable clarity. If these patients lack a resumption tendency, cognitive processes responsible for the tendency would depend on conventional memory structures. In contrast, if these patients exhibit a resumption tendency, the results might imply that the tendency or inclination to return to unfinished tasks operates independently of the systems governing the formation of new memories. In particular, task complexity and interruption duration should be varied to more precisely identify the involvement of memory processes. While these patients may likely forget the details of their intention, it is uncertain whether they still feel compelled to resume that intention.

4.2 Conclusion

The present dissertation addressed two research topics: The *perceptions* during the hypnagogic state and the *persistence* of unfinished intentions. From the preceding literature summary and the subsequent questionnaire study, it can be summarised that hypnagogic states occur very frequently. Moreover, they can be differentiated from other phenomena by their frequent occurrence in the kinaesthetic modality. The meta-analysis and the experimental study of the Zeigarnik and Ovsiankina effect suggest a tendency to resume unfinished intentions. However, it does not translate into a memory advantage for interrupted intentions when multiple tasks are to be recalled, which calls into question the existence of a Zeigarnik effect.

5 References

Abraham, A. (2020). Surveying the Imagination Landscape. In A. Abraham (Ed.), *The Cambridge Handbook of the Imagination* (pp. 1–10). Cambridge University Press. https://doi.org/10.1017/9781108580298.001

Ach, N. (1910). *Über den Willensakt und das Temperament: Eine experimentelle Untersuchung*. Quelle & Meyer.

Alper, T. G. (1946). Memory for completed and incompleted tasks as a function of personality: An analysis of group data. *The Journal of Abnormal and Social Psychology*, *41*(4), 403–420. https://doi.org/10.1037/h0060011

American Academy of Sleep Medicine. (2014). International classification of sleep disorders—Third edition (ICSD-3) Online Version. *Westchester, IL: American Academy of Sleep Medicine*.

American Psychiatric Association (Ed.). (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed). American Psychiatric Association.

Aristotle. (1999). *Nicomachean ethics* (T. Irwin, Trans.; Second edition). Hackett Publishing. (Original work published 350 B.C.E.)

Atkinson, J. W. (1953). The achievement motive and recall of interrupted and completed tasks. *Journal of Experimental Psychology*, *46*(6), 381–390. https://doi.org/10.1037/h0057286

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review*, *64*(6, Pt.1), 359–372. https://doi.org/10.1037/h0043445

Auble, P. M., & Franks, J. J. (1978). The effects of effort toward comprehension on recall. *Memory & Cognition*, *6*(1), 20–25. https://doi.org/10.3758/BF03197424

Auble, P. M., Franks, J. J., & Soraci, S. A. (1979). Effort toward comprehension: Elaboration or “aha”? *Memory & Cognition*, *7*(6), 426–434. https://doi.org/10.3758/BF03198259

Baddeley, A. D. (1963). A Zeigarnik-like effect in the recall of anagram solutions. *Quarterly Journal of Experimental Psychology*, *15*(1), 63–64. https://doi.org/10.1080/17470216308416553

Baylor, G. W., & Cavallero, C. (2001). Memory sources associated with REM and NREM dream reports throughout the night: A new look at the data. *Sleep*, *24*(2), 165–170.

Birk, M. V., Mandryk, R. L., & Baumann, N. (2020). Just a click away: Action–state orientation moderates the impact of task interruptions on initiative. *Journal of Personality*, *88*(2), 373–390. https://doi.org/10.1111/jopy.12498

Booth-Kewley, S., Larson, G. E., & Miyoshi, D. K. (2007). Social desirability effects on computerized and paper-and-pencil questionnaires. *Computers in Human Behavior*, *23*(1), 463–477. https://doi.org/10.1016/j.chb.2004.10.020

Bosch, P., van Luijtelaar, G., Groetelaers, L., van den Noort, M., Lim, S., Egger, J., & Coenen, A. (2012). The Munich Parasomnia Screening in psychiatry. *Somnologie - Schlafforschung Und Schlafmedizin*, *16*(4), 257–262. https://doi.org/10.1007/s11818-012-0587-4

Brazzolotto, P., & Michael, G. A. (2021). Do not interrupt me if it makes me feel something – Study of the effect of the pleasantness of interruptions on performance. *European Review of Applied Psychology*, *71*(1), 100623. https://doi.org/10.1016/j.erap.2021.100623

Buck, L. A., & Geers, M. B. (1967). Varieties of consciousness: I. Intercorrelations. *Journal of Clinical Psychology*, *23*(2), 151–152. https://doi.org/10.1002/1097-4679(196704)23:2<151::AID-JCLP2270230207>3.0.CO;2-T

Bugg, J. M., & Scullin, M. K. (2013). Controlling intentions: The surprising ease of stopping after going relative to stopping after never having gone. *Psychological Science*, *24*(12), 2463–2471. https://doi.org/10.1177/0956797613494850

Bugg, J. M., Scullin, M. K., & Rauvola, R. S. (2016). Forgetting no-longer-relevant prospective memory intentions is (sometimes) harder with age but easier with forgetting practice. *Psychology and Aging*, *31*(4), 358–369. https://doi.org/10.1037/pag0000087

Bugg, J. M., & Streeper, E. (2019). Fate of suspended and completed prospective memory intentions. In J. Rummel & M. A. McDaniel (Eds.), *Prospective Memory* (1st ed., pp. 44–59). Routledge. https://doi.org/10.4324/9781351000154-4

Butterfield, E. C. (1964). The interruption of tasks: Methodological, factual, and theoretical issues. *Psychological Bulletin*, *62*(5), 309–322. https://doi.org/10.1037/h0039873

Caron, A. J., & Wallach, M. A. (1957). Recall of interrupted tasks under stress: A phenomenon of memory or of learning? *The Journal of Abnormal and Social Psychology*, *55*(3), 372. https://doi.org/10.1037/h0042808

Cheyne, J. A. (2003). Sleep paralysis and the structure of waking-nightmare hallucinations. *Dreaming*, *13*(3), 163–179. https://doi.org/10.1037/1053-0797.13.3.163

Cheyne, J. A., Rueffer, S. D., & Newby-Clark, I. R. (1999). Hypnagogic and hypnopompic hallucinations during sleep paralysis: Neurological and cultural construction of the night-mare. *Consciousness and Cognition*, *8*(3), 319–337. https://doi.org/10.1006/ccog.1999.0404

Chokroverty, S. (Ed.). (2017). *Sleep Disorders Medicine: Basic Science, Technical Considerations and Clinical Aspects*. Springer New York. https://doi.org/10.1007/978-1-4939-6578-6

Claeys, W. (1969). Zeigarnik effect, 'reversed Zeigarnik effect,' and personality. *Journal of Personality and Social Psychology*, *12*(4), 320–327. https://doi.org/10.1037/h0027765

Cohen, A.-L., West, R., & Craik, F. I. M. (2001). Modulation of the prospective and retrospective components of memory for intentions in younger and older adults. *Aging, Neuropsychology, and Cognition*, *8*(1), 1–13. https://doi.org/10.1076/anec.8.1.1.845

Cona, G., Santacesaria, P., & Scarpazza, C. (2023). Envisioning the future: An ALE meta-analysis on neural correlates of future thinking, prospective memory and delay discounting. *Neuroscience & Biobehavioral Reviews*, *153*, 105355. https://doi.org/10.1016/j.neubiorev.2023.105355

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, *11*(6), 671–684. https://doi.org/10.1016/S0022-5371(72)80001-X

D'Agostino, A., & Limosani, I. (2010). Hypnagogic hallucinations and sleep paralysis. In M. Goswami, S. R. Pandi-Perumal, & M. J. Thorpy (Eds.), *Narcolepsy* (pp. 87–97). Springer New York. https://doi.org/10.1007/978-1-4419-0854-4_8

Dang-Vu, T. T., Bonjean, M., Schabus, M., Boly, M., Darsaud, A., Desseilles, M., Degueldre, C., Balteau, E., Phillips, C., Luxen, A., Sejnowski, T. J., & Maquet, P. (2011). Interplay between spontaneous and induced brain activity during human non-rapid eye movement sleep. *Proceedings of the National Academy of Sciences*, *108*(37), 15438–15443. https://doi.org/10.1073/pnas.1112503108

Domhoff, G. W. (1996). *Finding meaning in dreams: A quantitative approach*. Plenum Press. https://doi.org/10.1007/978-1-4899-0298-6

Drasgow, F., & Olson-Buchanan, J. B. (1999). *Innovations in computerized assessment*. Psychology Press.

Ebbinghaus, H. (1885). *Über das gedächtnis: Untersuchungen zur experimentellen psychologie*. Duncker & Humblot.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*(4), 717–726. https://doi.org/10.1037/0278-7393.16.4.717

Farley, F. H., & Mealiea, W. L. (1971). Individual differences in the Zeigarnik effect. *Proceedings of the Annual Convention of the American Psychological Association*.

Fortuyn, H. A. D., Lappenschaar, G. A., Nienhuis, F. J., Furer, J. W., Hodiamont, P. P., Rijnders, C. A., Lammers, G. J., Renier, W. O., Buitelaar, J. K., & Overeem, S. (2009). Psychotic symptoms in narcolepsy: Phenomenology and a comparison with schizophrenia. *General Hospital Psychiatry*, *31*(2), 146–154. https://doi.org/10.1016/j.genhosppsych.2008.12.002

Foulkes, D., & Vogel, G. (1965). Mental activity at sleep onset. *Journal of Abnormal Psychology*, *70*(4), 231. https://doi.org/10.1037/h0022217

Freud, S. (1989). *Psychopathology of everyday life*. WW Norton & Company. (Original work published 1909)

Fulda, S., Hornyak, M., Müller, K., Cerny, L., Beitinger, P. A., & Wetter, T. C. (2008). Development and validation of the Munich Parasomnia Screening (MUPS): A questionnaire for parasomnias and nocturnal behaviors. *Somnologie - Schlafforschung Und Schlafmedizin*, *12*(1), 56–65. https://doi.org/10.1007/s11818-008-0336-x

Germain, A., & Nielsen, T. A. (2001). EEG power associated with early sleep onset images differing in sensory content. *Sleep Research Online*, *4*(3), 83–90.

Ghibellini, R., & Meier, B. (2023). The hypnagogic state: A brief update. *Journal of Sleep Research*, *32*(1), e13719. https://doi.org/10.1111/jsr.13719

Gilbert, S. J. (2011). Decoding the content of delayed intentions. *The Journal of Neuroscience:*, *31*(8), 2888–2894. https://doi.org/10.1523/JNEUROSCI.5336-10.2011

Glixman, A. F. (1949). Recall of completed and incompleted activities under varying degrees of stress. *Journal of Experimental Psychology*, *39*(3), 281–295. https://doi.org/10.1037/h0054442

Gollwitzer, P. M. (1993). Goal achievement: The role of intentions. *European Review of Social Psychology*, *4*(1), 141–185. https://doi.org/10.1080/14792779343000059

Goschke, T., & Kuhl, J. (1993). Representation of intentions: Persisting activation in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(5), 1211–1226. https://doi.org/10.1037/0278-7393.19.5.1211

Goschke, T., & Kuhl, J. (1996). Remembering what to do: Explicit and implicit memory for intentions. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), *Prospective memory: Theory and applications* (pp. 53–91). Lawrence Erlbaum Associates Publishers.

Green, D. R. (1963). Volunteering and the recall of interrupted tasks. *The Journal of Abnormal and Social Psychology*, *66*(4), 397–401. https://doi.org/10.1037/h0042167

Gurstelle, E. B., & de Oliveira, J. L. (2004). Daytime parahypnagogia: A state of consciousness that occurs when we almost fall asleep. *Medical Hypotheses*, *62*(2), 166–168. https://doi.org/10.1016/S0306-9877(03)00306-2

Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Sciences*, *5*(9), 394–400. https://doi.org/10.1016/S1364-6613(00)01707-1

Hare, E. H. (1973). A short note on pseudo-hallucinations. *The British Journal of Psychiatry*, *122*(569), 469–476. https://doi.org/10.1192/bjp.122.4.469

Hayashi, M., Katoh, K., & Hori, T. (1999). Hypnagogic Imagery and Eeg Activity. *Perceptual and Motor Skills*, *88*(2), 676–678. https://doi.org/10.2466/pms.1999.88.2.676

Haynes, J.-D., Sakai, K., Rees, G., Gilbert, S., Frith, C., & Passingham, R. E. (2007). Reading hidden intentions in the human brain. *Current Biology: CB*, *17*(4), 323–328. https://doi.org/10.1016/j.cub.2006.11.072

Hays, D. G. (1952). Situational instructions and task order in recall for completed and interrupted tasks. *Journal of Experimental Psychology*, *44*(6), 434–437. https://doi.org/10.1037/h0061774

Heidelberg, K. J. (1911). Zur Analyse der Trugwahrnehmungen (Leibhaftigkeit und Realitätsurteil). *Zeitschrift Für Die Gesamte Neurologie Und Psychiatrie*, *6*(1), 460. https://doi.org/10.1007/bf02863948

Hinton, D. E., Reis, R., & de Jong, J. (2019). Ghost encounters among traumatized cambodian refugees: Severity, relationship to PTSD, and phenomenology. *Culture, Medicine, and Psychiatry*, *44*(3), 333–359. https://doi.org/10.1007/s11013-019-09661-6

Hofstaetter, A. (1985). *Retention of completed and interrupted tasks as a function of the personality construct of repression-sensitization*. Universitaet Graz (Austria).

Hori, T., Hayashi, M., & Morikawa, T. (1994). Topographical EEG changes and the hypnagogic experience. In R. D. Ogilvie & J. R. Harsh (Eds.), *Sleep onset: Normal and abnormal processes* (pp. 237–253). American Psychological Association. https://doi.org/10.1037/10166-014

Horikawa, T., Tamaki, M., Miyawaki, Y., & Kamitani, Y. (2013). Neural decoding of visual imagery during sleep. *Science*, *340*(6132), 639–642. https://doi.org/10.1126/science.1234330

Iber, C., Ancoli-Israel, S., Chesson, A. L., & Quan, S. F. (2007). *The AASM manual for the scoring of sleep and associated events: Rules, terminology and technical specifications* (Vol. 1). American academy of sleep medicine Westchester, IL.

Jones, S. R., Fernyhough, C., & Larøi, F. (2010). A phenomenological survey of auditory verbal hallucinations in the hypnagogic and hypnopompic states. *Phenomenology and the Cognitive Sciences*, *9*(2), 213–224. https://doi.org/10.1007/s11097-010-9158-y

Jones, S. R., Fernyhough, C., & Meads, D. (2009). In a dark time: Development, validation, and correlates of the Durham hypnagogic and hypnopompic hallucinations questionnaire. *Personality and Individual Differences*, *46*(1), 30–34. https://doi.org/10.1016/j.paid.2008.08.021

Katz, E. (1938). *Some factors affecting resumption of interrupted activities by preschool children*. University of Minnesota Press.

Kizilirmak, J. M., Galvao Gomes da Silva, J., Imamoglu, F., & Richardson-Klavehn, A. (2016). Generation and the subjective feeling of “aha!” are independently related to learning from insight. *Psychological Research*, *80*(6), 1059–1074. https://doi.org/10.1007/s00426-015-0697-2

Kjaer, T. W., Law, I., Wiltschiøtz, G., Paulson, O. B., & Madsen, P. L. (2002). Regional cerebral blood flow during light sleep—A H215O-PET study. *Journal of Sleep Research*, *11*(3), 201–207. https://doi.org/10.1046/j.1365-2869.2002.00303.x

Kuhl, J. (1996). Wille und Freiheitserleben: Formen der Selbststeuerung. In J. Kuhl & H. Heckhausen (Eds.), *Motivation, Volition und Handeln* (Vol. 4). Göttingen, Hogrefe.

Kushlev, K., & Dunn, E. W. (2015). Checking email less frequently reduces stress. *Computers in Human Behavior*, *43*, 220–228. https://doi.org/10.1016/j.chb.2014.11.005

Kussé, C., Shaffii-Le Bourdiec, A., Schrouff, J., Matarazzo, L., & Maquet, P. (2012). Experience-dependent induction of hypnagogic images during daytime naps: A combined behavioural and EEG study. *Journal of Sleep Research*, *21*(1), 10–20. https://doi.org/10.1111/j.1365-2869.2011.00939.x

Kvavilashvili, L., & Ellis, J. (1996). Varieties of intention: Some distinctions and classifications. In *Prospective memory: Theory and applications* (pp. 23–51). Lawrence Erlbaum Associates Publishers.

Larøi, F., Bless, J. J., Laloyaux, J., Kråkvik, B., Vedul-Kjelsås, E., Kalhovde, A. M., Hirnstein, M., & Hugdahl, K. (2019). An epidemiological study on the prevalence of hallucinations in a general-population sample: Effects of age and sensory modality. *Psychiatry Research*, *272*, 707–714. https://doi.org/10.1016/j.psychres.2019.01.003

Liberman, N., Idson, L. C., Camacho, C. J., & Higgins, E. T. (1999). Promotion and prevention choices between stability and change. *Journal of Personality and Social Psychology*, *77*(6), 1135–1145. https://doi.org/10.1037/0022-3514.77.6.1135

Lissner, K. (1933). Die Entspannung von Bedürfnissen durch Ersatzhandlungen. *Psychologische Forschung*, *18*(1), 218–250. https://doi.org/10.1007/bf02409632

Lockhart, R. S., Craik, F. I., & Jacoby, L. (1976). Depth of processing, recognition and recall. In J. Brown (Ed.), *Recall and recognition*. John Wiley & Sons.

Ludmer, R., Dudai, Y., & Rubin, N. (2011). Uncovering camouflage: Amygdala activation predicts long-term memory of induced perceptual insight. *Neuron*, *69*(5), 1002–1014. https://doi.org/10.1016/j.neuron.2011.02.013

MacLeod, C. M. (2020). Zeigarnik and von Restorff: The memory effects and the stories behind them. *Memory & Cognition*, *48*(6), 1073–1088. https://doi.org/10.3758/s13421-020-01033-5

Mahler, W. (1933). Ersatzhandlungen verschiedenen Realitätsgrades. *Psychologische Forschung*, *18*(1), 27–89. https://doi.org/10.1007/BF02409627

Marrow, A. J. (1938a). Goal tensions and recall: I. *The Journal of General Psychology*, *19*(1), 3–35. https://doi.org/10.1080/00221309.1938.9711185

Marrow, A. J. (1938b). Goal tensions and recall: II. *The Journal of General Psychology*, *19*(1), 37–64. https://doi.org/10.1080/00221309.1938.9711186

Marzano, C., Moroni, F., Gorgoni, M., Nobili, L., Ferrara, M., & De Gennaro, L. (2013). How we fall asleep: Regional and temporal differences in electroencephalographic synchronization at sleep onset. *Sleep Medicine*, *14*(11), 1112–1122. https://doi.org/10.1016/j.sleep.2013.05.021

Maury, A. (1848). *Des hallucinations hypnagogiques, ou des erreurs des sens dans l'état intermédiaire entre la veille et le sommeil*. L. Martinet.

McCain, J. A. (1960). Professors and students in european universities: Observations of an american college president. *The Journal of Higher Education*, *31*(4), 200–207. https://doi.org/10.2307/1977404

McCarthy-Jones, S., Barnes, L. J., Hill, G. E., Marwood, L., Moseley, P., & Fernyhough, C. (2011). When words and pictures come alive: Relating the modality of intrusive thoughts to modalities of hypnagogic/hypnopompic hallucinations. *Personality and Individual Differences*, *51*(6), 787–790. https://doi.org/10.1016/j.paid.2011.07.003

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology*, *14*(7), S127–S144. https://doi.org/10.1002/acp.775

McDaniel, M. A., & Einstein, G. O. (2001). Prospective memory, psychology of. In N. J. Smelser & P. B. Baltes (Eds.), *International Encyclopedia of the Social & Behavioral Sciences* (pp. 12241–12244). Pergamon. https://doi.org/10.1016/B0-08-043076-7/01519-9

McGraw, K. O., & Fiala, J. (1982). Undermining the Zeigarnik effect: Another hidden cost of reward. *Journal of Personality*, *50*(1), 58–66. https://doi.org/10.1111/j.1467-6494.1982.tb00745.x

McKellar, P. (1957). *Imagination and thinking; a psychological analysis*. New York, Basic Books.

McKellar, P. (1972). Imagery from the standpoint of introspection. In P. W. Sheehan (Ed.), *The function and nature of imagery* (pp. 35–61). New York.

McKellar, P., & Simpson, L. (1954). Between wakefulness and sleep: Hypnagogic imagery. *British Journal of Psychology*, *45*(4), 266–276. https://doi.org/10.1111/j.2044-8295.1954.tb01254.x

Meier, B., & Cottini, M. (2023). After-effects of responding to activated and deactivated prospective memory target events differ depending on processing overlaps. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *49*(3), 389–406. https://doi.org/10.1037/xlm0001154

Meier, B., & Zimmermann, T. D. (2015). Loads and loads and loads: The influence of prospective load, retrospective load, and ongoing task load in prospective memory. *Frontiers in Human Neuroscience*, *9*. https://doi.org/10.3389/fnhum.2015.00322

Michida, N., Hayashi, M., & Hori, T. (2005). Effects of hypnagogic imagery on the event-related potential to external tone stimuli. *Sleep*, *28*(7), 813–818. https://doi.org/10.1093/sleep/28.7.813

Momennejad, I., & Haynes, J.-D. (2012). Human anterior prefrontal cortex encodes the 'what' and 'when' of future intentions. *NeuroImage*, *61*(1), 139–148. https://doi.org/10.1016/j.neuroimage.2012.02.079

Momennejad, I., & Haynes, J.-D. (2013). Encoding of prospective tasks in the human prefrontal cortex under varying task loads. *The Journal of Neuroscience*, *33*(44), 17342–17349. https://doi.org/10.1523/JNEUROSCI.0492-13.2013

Monk, C. A., Trafton, J. G., & Boehm-Davis, D. A. (2008). The effect of interruption duration and demand on resuming suspended goals. *Journal of Experimental Psychology: Applied*, *14*(4), 299–313. https://doi.org/10.1037/a0014402

Möschl, M., Fischer, R., Bugg, J. M., Scullin, M. K., Goschke, T., & Walser, M. (2020). Aftereffects and deactivation of completed prospective memory intentions: A systematic review. *Psychological Bulletin*, *146*(3), 245–278. https://doi.org/10.1037/bul0000221

Mulrow, C. D. (1994). Systematic Reviews: Rationale for systematic reviews. *BMJ*, *309*(6954), 597–599. https://doi.org/10.1136/bmj.309.6954.597

Myers, F. W. H. (1904). *Human personality and its survival of bodily death* (Vol. 2). Longmans, Green.

Nielsen, T. A. (2017). Microdream neurophenomenology. *Neuroscience of Consciousness*, *2017*(1). https://doi.org/10.1093/nc/nix001

Nielsen, T. A., Stenstrom, P., Takeuchi, T., Saucier, S., Lara-Carrasco, J., Solomonova, E., & Martel, E. (2005). Partial REM-sleep deprivation increases the dream-like quality of mentation from REM sleep and sleep onset. *Sleep*, *28*(9), 1083–1089. https://doi.org/10.1093/sleep/28.9.1083

Nir, Y., & Tononi, G. (2010). Dreaming and the brain: From phenomenology to neurophysiology. *Trends in Cognitive Sciences*, *14*(2), 88–100. https://doi.org/10.1016/j.tics.2009.12.001

Noreika, V., Canales-Johnson, A., Koh, J., Taylor, M., Massey, I., & Bekinschtein, T. A. (2015). Intrusions of a drowsy mind: Neural markers of phenomenological unpredictability. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.00202

Nowlis, H. H. (1941). The influence of success and failure on the resumption of an interrupted task. *Journal of Experimental Psychology*, *28*(4), 304–325. https://doi.org/10.1037/h0055389

Ohayon, M. M. (2000). Prevalence of hallucinations and their pathological associations in the general population. *Psychiatry Research*, *97*(2–3), 153–164. https://doi.org/10.1016/S0165-1781(00)00227-4

Ohayon, M. M., Priest, R. G., Caulet, M., & Guilleminault, C. (1996). Hypnagogic and hypnopompic hallucinations: Pathological phenomena? *British Journal of Psychiatry*, *169*(4), 459–467. https://doi.org/10.1192/bjp.169.4.459

Ohayon, M. M., & Shapiro, C. M. (2000). Sleep disturbances and psychiatric disorders associated with posttraumatic stress disorder in the general population. *Comprehensive Psychiatry*, *41*(6), 469–478. https://doi.org/10.1053/comp.2000.16568

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, *106*(37), 15583–15587. https://doi.org/10.1073/pnas.0903620106

Owens, C. A. (1963). *A study of mental imagery* [Unpublished doctoral dissertation, University of Liverpool].

Pachauri, A. R. (1935). A study of gestalt problems in completed and interrupted tasks. *British Journal of Psychology. General Section*, *25*(3), 365–381. https://doi.org/10.1111/j.2044-8295.1935.tb00748.x

Pagel, J. F. (2003). Non-dreamers. *Sleep Medicine*, *4*(3), 235–241. https://doi.org/10.1016/S1389-9457(02)00255-1

Patel, A. K., Reddy, V., & Araujo, J. F. (2020). Physiology, sleep stages. In *StatPearls*. StatPearls Publishing.

Payne, J. D., & Kensinger, E. A. (2010). Sleep's role in the consolidation of emotional episodic memories. *Current Directions in Psychological Science*, *19*(5), 290–295. https://doi.org/10.1177/0963721410383978

Prentice, W. C. H. (1944). The interruption of tasks. *Psychological Review*, *51*(6), 329–340. https://doi.org/10.1037/h0059614

Reeve, J., Cole, S. G., & Olson, B. C. (1986). The Zeigarnik effect and intrinsic motivation: Are they the same? *Motivation and Emotion*, *10*(3), 233–245. https://doi.org/10.1007/BF00992318

Rethlingshafer, D. (1941). Comparison of normal and feebleminded children with college adults in their tendency-to-continue interrupted activities. *Journal of Comparative Psychology*, *32*(2), 205–2016. https://doi.org/10.1037/h0055539

Rosenzweig, S. (1943). An experimental study of 'repression' with special reference to need-persistive and ego-defensive reactions to frustration. *Journal of Experimental Psychology*, *32*(1), 64–74. https://doi.org/10.1037/h0062000

Rösler, H.-D. (1955). *Über das Behalten von Handlungen schwachsinniger und normaler Kinder*. Johann Ambrosius Barth.

Rummel, J., & Kvavilashvili, L. (2023). Current theories of prospective memory and new directions for theory development. *Nature Reviews Psychology*, *2*(1), 40–54. https://doi.org/10.1038/s44159-022-00121-4

Sacks, O. (2012). *Hallucinations*. Pan Macmillan.

Sanati, A. (2012). Pseudohallucinations: A critical review. *Dialogues in Philosophy, Mental and Neuro Sciences*, *5*(2), 42–47.

Schacter, D. L. (1976). The hypnagogic state: Acritical review of the literature. *Psychological Bulletin*, *83*(3), 452–481. https://doi.org/10.1037/0033-2909.83.3.452

Schiappa, C., Scarpelli, S., D'Atri, A., Gorgoni, M., & De Gennaro, L. (2018). Narcolepsy and emotional experience: A review of the literature. *Behavioral and Brain Functions*, *14*(1). https://doi.org/10.1186/s12993-018-0151-x

Schmidt, R. E., & Gendolla, G. H. E. (2008). Dreaming of white bears: The return of the suppressed at sleep onset. *Consciousness and Cognition*, *17*(3), 714–724. https://doi.org/10.1016/j.concog.2007.09.002

Schredl, M. (2018). *Researching dreams: The fundamentals*. Springer.

Schredl, M., & Piel, E. (2003). Gender differences in dream recall: Data from four representative German samples. *Personality and Individual Differences*, *35*(5), 1185–1189. https://doi.org/10.1016/S0191-8869(02)00327-6

Schredl, M., & Reinhard, I. (2008). Gender differences in dream recall: A meta-analysis. *Journal of Sleep Research*, *17*(2), 125–131. https://doi.org/10.1111/j.1365-2869.2008.00626.x

Schredl, M., & Schawinski, J. A. (2010). Frequency of dream sharing: The effects of gender and personality. *The American Journal of Psychology*, *123*(1), 93–101. https://doi.org/10.5406/amerjpsyc.123.1.0093

Sharpless, B. A., & Kliková, M. (2019). Clinical features of isolated sleep paralysis. *Sleep Medicine*, *58*, 102–106. https://doi.org/10.1016/j.sleep.2019.03.007

Sherwood, S. J. (2012). A web survey of the content, sensory modalities, and interpretation of hypnagogic and hypnopompic experiences. *Journal of Parapsychology*, *76*(1), 27.

Siclari, F., Baird, B., Perogamvros, L., Bernardi, G., LaRocque, J. J., Riedner, B., Boly, M., Postle, B. R., & Tononi, G. (2017). The neural correlates of dreaming. *Nature Neuroscience*, *20*(6), 872–878. https://doi.org/10.1038/nn.4545

Siclari, F., Bernardi, G., Riedner, B. A., LaRocque, J. J., Benca, R. M., & Tononi, G. (2014). Two distinct synchronization processes in the transition to sleep: A high-density electroencephalographic study. *Sleep*, *37*(10), 1621–1637. https://doi.org/10.5665/sleep.4070

Siclari, F., LaRocque, J. J., Postle, B. R., & Tononi, G. (2013). Assessing sleep consciousness within subjects using a serial awakening paradigm. *Frontiers in Psychology*, *4*. https://doi.org/10.3389/fpsyg.2013.00542

Sinha, A. K., & Sharan, M. B. (1976). Zeigarnik-phenomenon as a function of the trait of dominance. *Psychologia*, *19*, 114–117.

Soffer-Dudek, N., & Shahar, G. (2011). Daily stress interacts with trait dissociation to predict sleep-related experiences in young adults. *Journal of Abnormal Psychology*, *120*(3), 719–729. https://doi.org/10.1037/a0022941

Speth, C., & Speth, J. (2016). The borderlands of waking: Quantifying the transition from reflective thought to hallucination in sleep onset. *Consciousness and Cognition*, *41*, 57–63. https://doi.org/10.1016/j.concog.2016.01.009

Speth, J., Frenzel, C., & Voss, U. (2013). A differentiating empirical linguistic analysis of dreamer activity in reports of EEG-controlled REM-dreams and hypnagogic hallucinations. *Consciousness and Cognition*, *22*(3), 1013–1021. https://doi.org/10.1016/j.concog.2013.07.003

Speth, J., Harley, T. A., & Speth, C. (2017). Auditory verbal experience and agency in waking, sleep onset, REM, and non-REM Sleep. *Cognitive Science*, *41*(3), 723–743. https://doi.org/10.1111/cogs.12363

Speth, J., Schloerscheidt, A. M., & Speth, C. (2016). As we fall asleep we forget about the future: A quantitative linguistic analysis of mentation reports from hypnagogia. *Consciousness and Cognition*, *45*, 235–244. https://doi.org/10.1016/j.concog.2016.08.014

Steen, C. (2017). Synesthetic photisms and hypnagogic visions: A comparison. *Multisensory Research*, *30*(3–5), 199–205. https://doi.org/10.1163/22134808-00002557

Stenstrom, P., Fox, K., Solomonova, E., & Nielsen, T. (2012). Mentation during sleep onset theta bursts in a trained participant: A role for NREM stage 1 sleep in memory processing? *International Journal of Dream Research*, *5*(1), 37–46. https://doi.org/10.11588/ijodr.2012.1.9135

Stickgold, R., Malia, A., Maguire, D., Roddenberry, D., & O'Connor, M. (2000). Replaying the game: Hypnagogic images in normals and amnesics. *Science*, *290*(5490), 350–353. https://doi.org/10.1126/science.290.5490.350

Stothart, C., Mitchum, A., & Yehnert, C. (2015). The attentional cost of receiving a cell phone notification. *Journal of Experimental Psychology: Human Perception and Performance*, *41*(4), 893–897. https://doi.org/10.1037/xhp0000100

Streeper, E., & Bugg, J. M. (2021). Deactivation of prospective memory intentions: Examining the role of the stimulus–response link. *Memory & Cognition*, *49*(2), 364–379. https://doi.org/10.3758/s13421-020-01091-9

Szklo-Coxe, M., Young, T., Finn, L., & Mignot, E. (2007). Depression: Relationships to sleep paralysis and other sleep disturbances in a community sample. *Journal of Sleep Research*, *16*(3), 297–312. https://doi.org/10.1111/j.1365-2869.2007.00600.x

Taylor, F. K. (1981). On pseudo-hallucinations. *Psychological Medicine*, *11*(2), 265–271. https://doi.org/10.1017/S0033291700052089

Unity® (2021.1.12f1). (2021). [Computer software]. 2023 Unity Technologies. https://unity.com/

Vaitl, D., Birbaumer, N., Gruzelier, J., Jamieson, G. A., Kotchoubey, B., Kübler, A., Lehmann, D., Miltner, W. H. R., Ott, U., Pütz, P., Sammer, G., Strauch, I., Strehl, U., Wackermann, J., & Weiss, T. (2005). Psychobiology of altered states of consciousness. *Psychological Bulletin*, *131*(1), 98–127. https://doi.org/10.1037/0033-2909.131.1.98

Van Bergen, A. (1968). *Task interruption* [Doctoral dissertation, Universiteit van Amsterdam]. North-Holland Publishing Company.

Van de Castel, R. L. (1995). *Our Dreaming Mind*. New York: Ballantine Books.

Wackermann, J., Pütz, P., Büchi, S., Strauch, I., & Lehmann, D. (2002). Brain electrical activity and subjective experience during altered states of consciousness: Ganzfeld and hypnagogic states. *International Journal of Psychophysiology*, *46*(2), 123–146. https://doi.org/10.1016/S0167-8760(02)00070-3

Walser, M., Fischer, R., & Goschke, T. (2012). The failure of deactivating intentions: Aftereffects of completed intentions in the repeated prospective memory cue paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(4), 1030–1044. https://doi.org/10.1037/a0027000

Walsh, T. (1940). *On the Memory of Completed and Uncompleted Tasks: A Study of Volitional Frustration* [Doctoral dissertation, University of London (King's College)].

Walsh, T. (1942). *A Further Study of Volitional Frustration in Respect of Uncompleted Tasks* [Doctoral dissertation, University of London (King's College)].

Wamsley, E. J., Perry, K., Djonlagic, I., Reaven, L. B., & Stickgold, R. (2010). Cognitive replay of visuomotor learning at sleep onset: Temporal dynamics and relationship to task performance. *Sleep*, *33*(1), 59–68. https://doi.org/10.1093/sleep/33.1.59

Wamsley, E. J., & Stickgold, R. (2011). Memory, Sleep and Dreaming: Experiencing Consolidation. *Sleep Medicine Clinics*, *6*(1), 97–108. https://doi.org/10.1016/j.jsmc.2010.12.008

Waters, F., Blom, J. D., Dang-Vu, T. T., Cheyne, A. J., Alderson-Day, B., Woodruff, P., & Collerton, D. (2016). What is the link between hallucinations, dreams, and hypnagogic–hypnopompic experiences? *Schizophrenia Bulletin*, *42*(5), 1098–1109. https://doi.org/10.1093/schbul/sbw076

Wegner, D. M., Schneider, D. J., Carter, S. R., & White, T. L. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology*, *53*(1), 5–13. https://doi.org/10.1037/0022-3514.53.1.5

Wegner, D. M., Wenzlaff, R. M., & Kozak, M. (2004). Dream rebound: The return of suppressed thoughts in dreams. *Psychological Science*, *15*(4), 232–236. https://doi.org/10.1111/j.0963-7214.2004.00657.x

Weiner, B. (1966). Achievement motivation and task recall in competitive situations. *Journal of Personality and Social Psychology*, *3*(6), 693–696. https://doi.org/10.1037/h0023206

Weiner, B., Johnson, P. B., & Mehrabian, A. (1968). Achievement motivation and the recall of incomplete and completed exam questions. *Journal of Educational Psychology*, *59*(3), 181–185. https://doi.org/10.1037/h0025789

Wills, T. W., Soraci, S. A., Chechile, R. A., & Taylor, A. H. A. (2000). “Aha” effects in the generation of pictures. *Memory & Cognition*, *28*(6), 939–948. https://doi.org/10.3758/BF03209341

Wolf, U. (2002). *Aristoteles'" Nikomachische Ethik"*. Wissenschaftliche Buchgesellschaft Darmstadt.

Zadra, A., & Domhoff, G. W. (2017). Dream content. In M. Kryger, T. Roth, & W. C. Cement (Eds.), *Principles and Practice of Sleep Medicine* (pp. 515-522.e4). Elsevier. https://doi.org/10.1016/B978-0-323-24288-2.00049-0

Zeigarnik, B. (1927). Das Behalten erledigter und unerledigter Handlungen. *Psychologische Forschung*, *9*, 1–85.

6 Appendix

The following pages contain the four studies references in this thesis.

Part 1: The hypnagogic state

Study 1:

Ghibellini, R., & Meier, B. (2023). The hypnagogic state: A brief update. *Journal of Sleep Research*, *32*(1), e13719. https://doi.org/10.1111/jsr.13719

Study 2:

Ghibellini, R., & Meier, B. (2023). Hypnagogic states are quite common: Self-reported prevalence, modalities, and gender differences. *Consciousness and Cognition,*115. https://doi.org/10.1016/j.concog.2023.103582.

Part 2: Intention memory

Study 3:

Ghibellini, R., & Meier, B. (manuscript in preparation). Interruption, recall and resumption: Revisiting the Zeigarnik and Ovsiankina effect.

Study 4:

Ghibellini, R., & Meier, B. (in revision). Hope of success increases memory for unfinished tasks. *Submitted to the Quarterly Journal of Experimental Psychology.*

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REVIEW ARTICLE

The hypnagogic state: A brief update

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Summary

The hypnagogic state refers to a transitional stage between wakefulness and sleep, in which sensory perceptions can be experienced. In this review, we compile and discuss the recent scientific literature on hypnagogia research regarding the future directions proposed by Schacter (1976; *Psychological Bulletin*, **83**, 452). After a short introduction discussing the terminology used in hypnagogia research and the differentiation of hypnagogic states with other related phenomena, we review the reported prevalence of hypnagogic states. Then, we evaluate the six future directions suggested by Schacter and we propose three further future directions. First, a better understanding of the emotional quality of hypnagogic states is needed. Second, a better understanding of why hypnagogic states occur so frequently in the visual and kinaesthetic modalities is needed. Lastly, a better understanding of the purpose of hypnagogic states is needed. In conclusion, research has made great progress in recent years, and we are one step closer to demystifying the hypnagogic state.

KEYWORDS
hypnagogia, hypnagogic hallucinations, hypnagogic states, hypnopompic hallucinations

1 | THE HYPNAGOGIC STATE: AN UPDATE

Over four decades have elapsed since Schacter (1976) reviewed the literature on the hypnagogic state. The hypnagogic state can be defined as "spontaneously appearing visual, auditory and kinaesthetic images; qualitatively unusual thought processes and verbal constructions; tendencies towards extreme suggestibility; symbolic representations of ongoing mental and physiological processes; and so on" (Schacter, 1976, 452–453). Schacter noted that the most common factor of these phenomena was their occurrence in the drowsy interval between the waking state and sleeping. This factor is still one of the critical characteristics defining hypnagogic experiences. Schacter provided valuable and coherent insight into the hypnagogic state, which is briefly summarized first. Next, we follow up on Schacter's review and present an update on the state of the field.

2 | MAIN FINDINGS OF SCHACTER (1976)

Earlier research focused on the prevalence of hypnagogic states. Surveys quickly suggested that the hypnagogic state was relatively common, with prevalences ranging from 72% up to 77%. Particular reference was made to a possible age effect, according to which age was negatively related to the occurrence of hypnagogic states. Research in children between the age of 3 and 15 years resulted in ambiguous findings. Differences in hypnagogic states between childhood and adulthood, however, were not investigated. Thus, a decline in hypnagogic states over the course of life had yet to be examined. In addition, a cultural influence was suspected but remained unassessed. Overall, the phenomenology of hypnagogic state was described extensively, but little emphasis was put on factors that influence the likelihood of hypnagogic states.

One of the most indicative characteristics of hypnagogic states is their spontaneous emergence into consciousness. Several authors noted the lack of active involvement in the hypnagogic state, as the experience resembled the act of passively spectating a play or a movie. Hypnagogic states were reported to occur most frequently in the visual modality, followed by the auditory and tactile-kinaesthetic modality. There were attempts to differentiate hypnagogic states from dreams: compared with dreams, hypnagogic states were described as being mostly emotionally flat. Moreover, hypnagogic states were described as disconnected snapshots, whereas dreams were described as usually longer and better organized. Regarding the content of hypnagogic states, some researchers noted that the content could be traced back to activities pursued during the day.

Data on the hypnagogic state were acquired through multiple approaches. First and foremost, researchers conducted either spontaneous or systematic self-observation or trained subjects to do so. To gather a larger amount of data, researchers used questionnaire sampling. Other researchers attempted to induce and prolong the hypnagogic state, such as by using biofeedback or the ganzfeld approach (an approach that will be explained in detail later on in this review). Lastly, researchers investigated the physiological correlates of the hypnagogic state using electroencephalography (EEG) and electrooculography (EOG). The neurological origin of hypnagogic states, however, was not determined.

Schacter (1976) indicated several directions for future research. First and foremost, the need for further developed experimental techniques, which permit a systematic exploration of the phenomenology of hypnagogic experiences. Second, a more precise description of the phenomenology of hypnagogic imagery and auditory experiences. Can hypnagogic imagery be successfully categorized, to what extent is it consistent over time, and can it be differentiated from other imagery? Third, a more detailed understanding of the individual's capacity to process the environment in the hypnagogic state. To what extent does sensory stimulation experienced before the hypnagogic state influence hypnagogic imagery? Fourth, a better understanding of the influence of cognitive, perceptual and personality variables on the content hypnagogic states. How do these factors influence the likelihood of hypnagogic states and their content? Fifth, the need for fuller development of a psychophysiological approach. What are the physiological correlates of hypnagogic states and how do they vary? And lastly, a better understanding of the necessary conditions to enter the hypnagogic state. Can hypnagogic states be successfully induced? And, further, how do naturally induced hypnagogic states differ from artificially induced ones? Besides reviewing the more recent literature, we also evaluate the progress made regarding the future directions proposed by Schacter (1976).

3 | METHODOLOGICAL NOTE

The search for literature began on 5 March 2020. We searched for scientific articles and chapters published in the last 20 years using the keywords "hypnagogia", "hypnagogic state", "hypnagogic hallucinations", "hypnagogic imagery" and "sleep onset imagery" in PSYINDEX and PsycINFO. We included articles focusing on hypnagogic states themselves, and we excluded those articles in which hypnagogic states were a byproduct of another topic of interest (e.g. an article focusing on narcolepsy with a brief mention of hypnagogic states). Further, we focused on experimental and quasi-experimental studies, and included English publications only. Reference lists of consulted articles and chapters were then searched for additional literature, which resulted in a total of 40 publications we reviewed. Further additional literature was searched independently in favour of supplementary information using Google Scholar.

4 | TERMINOLOGY ISSUES

Before summarizing the scientific findings on the hypnagogic state in recent years, we must clarify the terminology used when discussing hypnagogia. The term *hypnagogic*, from the words ὑπνος ("*hypnos*"), meaning "sleep", and αγωγός ("*agōgos*"), meaning "conductor" or "leader", was first coined by Maury (1848). *Hypnagogic* refers to the phenomena occurring in the transition from wakefulness to sleep. The term *hypnopompic*, with the word-ending originating from the word πομπός ("*pompos*"), meaning "sender", was later coined by Myers (1904). *Hypnopompic*, on the other hand, refers to the very same phenomena occurring at sleep-offset. However, these states seem not to be limited to the transitional phases between wakefulness and sleep, but may also occur during the day (Gurstelle & de Oliveira, 2004; Steen, 2017). In this review, we use the term *hypnagogic states* to refer to the hypnagogic states at sleep-onset and hypnopompic states at sleep-offset (Figure 1).

Hypnagogic states have sometimes been labelled as *hypnagogic hallucinations*. However, as there is great stigma surrounding hallucinations (Sacks, 2012), we believe that this stigma bound to the term *hallucinations* could be projected onto the commonly occurring hypnagogic state. In fact, the term *hallucination*, which describes a pathological phenomenon, is misleading because hypnagogic experiences occur in the normal range of perception. While hallucinations are described as a defining feature of schizophrenia according to the *Diagnostic and Statistical Manual of Mental Disorders* (5th edn; DSM-5), those "hallucinations" occurring at sleep-onset or -offset are not, and are mentioned explicitly as normal experiences (American Psychiatric Association, 2013).

Other important differences between hallucinations and hypnagogic states have been proposed: while hallucinations are reflected upon, reacted to and incorporated with internal representations, hypnagogic experiences are not; an individual's sense of self, its beliefs or personal narrative are not affected by hypnagogic experiences in comparison to hallucinations (Waters et al., 2016). At best, hypnagogic states could be classified as *pseudo-hallucinations*, although the ambiguous nature of this term, as two different meanings of the term pseudo-hallucinations have been proposed (Taylor, 1981).

Based on those arguments, we propose a distinction between hypnagogic *states* and hypnagogic *hallucinations*. The term *hypnagogic states* refers to the experiences of perception in the different modalities at sleep-onset and -offset, which may also, although less frequently,

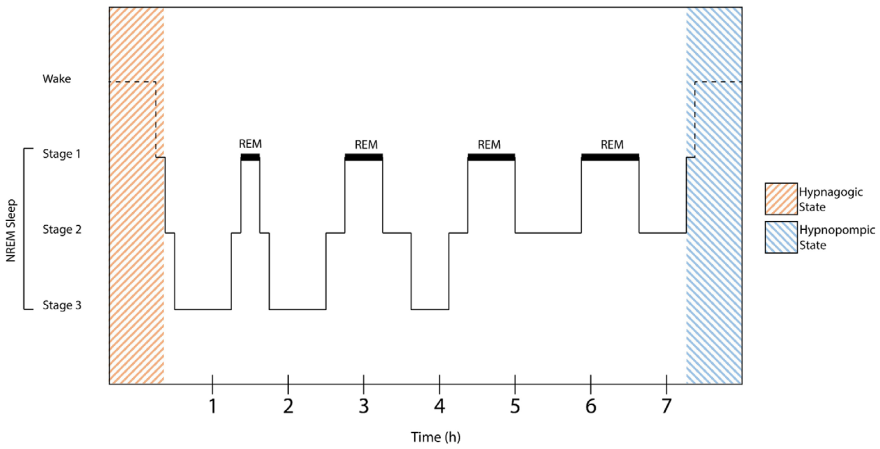

FIGURE 1 Localization of hypnagogic stages over the course of sleep

occur during wakefulness. However, these experiences can become clinically relevant, that is, when a complaint is issued or when they result in discomfort in the affected individual. In accordance with the criteria defined in the third edition of the *International Classification of Sleep Disorders* (*ICSD-3*; American Academy of Sleep Medicine, 2014), we then classify these phenomena as *hypnagogic hallucinations*. Consequently, we would expect hypnagogic states to be more prevalent in the general population than hypnagogic hallucinations.

5 | DIFFERENTIATION

Several sleep-related phenomena share similarities with hypnagogic states. The most difficult differentiation might be the one from *dreams*, especially at sleep-offset. Whereas both can be differentiated on the level of electrophysiological signatures, their phenomenological differentiation appears more complex. Some differentiating characteristics, however, include dreams generally being longer and less thought-like (Zadra & Domhoff, 2017), as well as containing fewer episodic memories (Baylor & Cavallero, 2001). Moreover, dream content appears to be rather consistent over time (Domhoff, 1996) and can occur repetitively (Van de Castel, 1995), whereas little is known about the consistency of hypnagogic experiences. Lastly, whereas dreams occur during sleep (Schredl, 2018), hypnagogic experiences at sleep-offset are usually a continuation of dreams after waking up (Waters et al., 2016).

Another closely related phenomenon is the inability to move while maintaining the ability to breathe at sleep-onset or -offset called *sleep paralysis*, a phenomenon often associated with hallucinations (Schiappa et al., 2018). Both sleep paralysis and hypnagogic states are features commonly associated with narcolepsy (D'Agostino & Limosani, 2010). Appropriately, the anomalous experiences during sleep paralysis have been labelled as hypnagogic and hypnopompic (Cheyne et al., 1999).

Another sleep-related phenomenon sharing similarities with hypnagogic states is the *explosive head syndrome* (EHS). EHS describes the experience of a loud explosive noise at sleep-onset or -offset, awakening the affected individual, with some reports of such an occurrence during the day (Green, 2001). This usually benign and infrequent experience, which can cause fear, confusion and distress, can manifest itself in a more chronic form (Sharpless, 2014). EHS generally has a lower prevalence than hypnagogic states (Fulda et al., 2008). However, one could argue that EHS-related experiences are but amplified auditory hypnagogic experiences.

While synaesthesia and hypnagogic states seem to share similarities at first glance, they are distinguishable by clear characteristics. Synaesthesia, the automatic activation of a concurrent sensation induced by a specific stimulus, is amongst other things defined by its consistent association between the inducing stimulus and the synaesthetic experience (Meier et al., 2014; Ward, 2013). In contrast, in hypnagogic experiences there is no comparably consistent inducing stimulus. Nevertheless, it is an open question whether hypnagogic experiences may occur more frequently in synaesthetes (Steen, 2017).

The ICSD-3 further suggests other phenomena that must be differentiated from hypnagogic states, such as *epileptic seizures*, *visual loss* (*Charles Bonnet hallucinations*), and *midbrain and diencephalic pathology* (*peduncular hallucinosis*). Since these phenomena have an organic cause, however, the differentiation, therefore, appears to be clearer and more convenient. We will thus not further elaborate on the differences between these phenomena and hypnagogic states, but acknowledge that they must be properly differentiated. In this section, we refrained from discussing all sleep-related phenomena that are potentially associated with the hypnagogic state. Rather, we decided to focus on phenomena associated with evoked imagery. Conclusively, both sleep-paralysis-related experiences and the EHS can be classified as hypnagogic phenomena, while synaesthesia can clearly be delimited from such. However, sleep paralysis and the EHS are not the focus of this review.

6 | PREVALENCE

Several studies have investigated the prevalence of hypnagogic experiences; however, the results differed markedly. In Table 1 we present an overview of the reported prevalences and definitions. Most notably, there has been great variability in the definitions of hypnagogic

TABLE 1 Summary of prevalences and definitions of hypnagogic states

Author	Year	Mean age	Sample size	Prevalence	Definition of hypnogogic states
Bosch et al.	2012	39.7 years	29	8%	Auditory or visual illusions that accompany falling asleep or waking in a distressing or threatening manner (e.g. hearing sounds or voices, or seeing people or things that are not in the room)
Fulda et al.	2008	35.0 years	65	6%	
Jones et al.	2009	21.1 years	365	85%	Feeling an evil presence in the room; hearing one's name being called; seeing a blurry human figure in the room; hearing the voice of a familiar person; seeing things or figures floating in the room; [...]
Jones et al.	2010	22.5 years	325	33%[a]	
Ohayon	1996	N/A	4972	37%/12%[b]	The realistic feeling that someone or something is present in the room; a vivid experience of being caught in a fire; a vivid experience that one is about to be attacked; the feeling that one will soon fall into an abyss; [...] over the last year
Ohayon	2000	N/A	13,057	25%/7%[b]	Seeing things, objects or persons other people cannot see; feeling something is under or on one's skin; having the feeling of being outside one's body watching oneself; hearing sounds, music or voices; [...]
Ohayon & Shapiro	2000	N/A	1832	22%/6%[b]	Questionnaire item according to Sleep-EVAL (Ohayon et al., 1999)
Schacter	1976			72%–77%	Individual definitions reviewed
Sherwood	2012	27.0 years	492	9%–82%[c]	Visual imagery, auditory sensations, smell or taste when falling asleep; the feeling of falling; the sensation of seeming to touch, or be touched by, someone or something. The feeling of a presence in the room; [...]

Note: Prevalence estimates are reported for healthy (non-psychiatric) samples and the numbers were rounded to the nearest integer.
[a]Reported prevalence for the auditory modality only.
[b]Hypnagogic states at sleep-onset/hypnagogic states at sleep-offset.
[c]Prevalences were reported for different modalities only, the most frequent being visual perceptions (82%), the lowest being perceptions of taste (9%).

states used when assessing their prevalence. Thus, we describe the studies in greater detail, beginning with large-scale prevalence studies, followed by smaller studies in favour of questionnaire validation, and proceed to discuss their differences.

Ohayon et al. (1996) assessed the prevalence of hypnagogic and hypnopompic states in a general population study based in the UK. Questionnaire items asked for specific experiences with a primarily negative emotional quality. Some examples include a vivid experience of being caught in a fire, a realistic feeling of someone or something being present, or a vivid experience of being attacked, limited to the auditory, the visual and the kinetic modality. From a total of 4972 participants, 37% reported experiencing hypnagogic states at least twice a week over the recent year, and 12.5% reported hypnopompic states at least twice a week over the recent year. Hypnagogic states were reported to be more common in participants who experienced sleep problems or insomnia (Ohayon et al., 1996).

In a later study with a general population sample based in the UK, Germany and Italy, lower prevalences of hypnagogic experiences were reported (Ohayon, 2000). In this study, however, hypnagogic experiences were assessed in a broader and emotionally neutral way. Participants were asked about hypnagogic experiences for each of the different modalities, including out-of-body experiences. For example, participants were asked whether they had smelled something other people could not smell or seen something others could not see when waking up or falling asleep. From a total of 13,057 participants, only 24.8% reported experiencing hypnagogic states, and 6.6% reported experiencing hypnopompic states. Moreover, a higher prevalence for women and younger adults was reported (Ohayon, 2000). Another survey conducted in the same year reported prevalences of hypnagogic states of 21.6% and hypnopompic states of 6% in healthy participants (Ohayon & Shapiro, 2000).

A study with the main aim of validating the Munich Parasomnia Screening (MUPS) reported a lifetime prevalence of hypnagogic states of only 6.2% in a general-population-based sample of 65 healthy participants from Germany (Fulda et al., 2008). The prevalence for hypnagogic states in this study was higher both in a sample of not nearer defined psychiatric patients (21.5%) and another sample of sleep-disordered patients (20%). Hypnagogic states were assessed with one item only, and they were defined as "auditory or visual illusions that accompany falling asleep or waking in a distressing or threatening manner (e.g. hearing sounds or voices, or seeing people or things that are not in the room)", thus rather targeting disturbing hypnagogic hallucinations than hypnagogic states per se.

In contrast, a validation study for the Durham Hypnagogic and Hypnopompic Hallucinations Questionnaire (DHQ) in 365 university students from the UK reported a much higher combined prevalence for both sleep-onset and -offset hypnagogia of 85% (Jones et al., 2009). In this study, hypnagogic states were assessed with 14 different items, each asking for a specific hypnagogic experience in a mostly emotionally neutral way, such as seeing the image of a face or hearing the voice of a familiar person.

The reported studies differed in two key characteristics when assessing the prevalence of hypnagogic states: the emotional valence and the specificity of questionnaire items. Whereas some studies phrased questionnaire items in an emotionally negative way (Fulda et al., 2008; Ohayon et al., 1996), others included more emotionally neutral phrased items (Jones et al., 2009; Ohayon, 2000). Further, some studies used more broadly worded questionnaire items (Fulda et al., 2008; Ohayon, 2000), whereas others asked for more specific experiences (Jones et al., 2009; Ohayon et al., 1996). Finding common ground in assessing prevalences would be beneficial. We would argue for an emotionally neutral and broader definition of hypnagogic states while assessing their emotional nature and specific experiences separately.

Reported prevalences were generally high in Schacter's (1976) review, ranging from 72% to 77%. He noted that "figures representing the percentage of people who have experienced at least one hypnagogic image are likely to be misleading" (Schacter, 1976, p. 454), as individuals are less likely to admit experienced visions or hallucinations due to their negative connotation through societal views (Galton, 1883). This further supports our argument for a broader and emotionally neutral definition of hypnagogic states, and for the differentiation between both hypnagogic states and hypnagogic hallucinations.

Two studies reported a gender effect, with hypnagogic states occurring more frequently in women than men (Ohayon et al., 1996; Ohayon, 2000). However, no newer study has reported such a gender effect, as only one study reported insignificant findings (Larøi et al., 2019). Few studies reported an association between age and the prevalence of hypnagogic states: of those studies, only one reported a significant decrease in hypnagogic experiences with age (Larøi et al., 2019), in accordance with previous studies illustrating an age effect (Ohayon et al., 1996; Ohayon, 2000), and as described in Schacter's review. Overall, it is unclear whether studies did not investigate gender and age effects or whether they did not report them due to insignificant findings. We encourage future studies assessing the prevalence of hypnagogic states to investigate and report gender and age effects. Lastly, it remains yet to be further elaborated to what extent culture might account for differences in the prevalence of hypnagogic states, as no newer study has assessed cultural differences.

7 | DIRECTION 1: THE DEVELOPMENT OF EXPERIMENTAL TECHNIQUES

As a future direction, Schacter (1976) proposed the further development of experimental techniques. While the methodological approach has not changed by a lot since Schacter's review, the newly acquired insight into the hypnagogic state is remarkable. In Table 2 we present a summary of these findings. In this section, we first discuss methods used for broad data collection, followed by methods used to assess the quality of hypnagogic states in recent times. Lastly, we discuss the linguistic analysis and its advantages over methodological approaches.

First and foremost, studies aiming at investigating the prevalence and presence of hypnagogic states in the general population were most commonly conducted as telephone surveys (Ohayon et al., 1996; Ohayon, 2000; Ohayon & Shapiro, 2000), used questionnaires sent by mail (Larøi et al., 2019) or were conducted online (Sherwood, 2012). These methods allow researchers to gather a much larger quantity of reports than before, provide a broad overview about the occurrence of hypnagogic states, and invoke new theories and future research directions.

When assessing the qualitative content of hypnagogic experiences, researchers either applied the method of self-observation (Steen, 2017) or collected data through questionnaires (Sherwood, 2012). More prominently, however, researchers relied on subject's reports at sleep-onset combined with EEG measures to determine and assign sleep phases to the respective reports (Nielsen et al., 2005; Siclari et al., 2013; C. Speth & Speth, 2016; J. Speth et al., 2013, 2016, 2017; Wackermann et al., 2002). In "serial awakening paradigms", participants are woken up at certain intervals during the night, and are asked about the presence or characteristics of specific experiences (Siclari et al., 2013; J. Speth et al., 2013, 2017). The reports are then contrasted among the sleep stages. Other studies focusing on the period of sleep-onset specifically recorded measures closer in time to wakefulness, generally from a few seconds after sleep-onset to a couple of minutes (Germain & Nielsen, 2001; Michida et al., 2005; Nielsen et al., 2005; Noreika et al., 2015; Schmidt & Gendolla, 2008; C. Speth & Speth, 2016; J. Speth et al., 2016; Stenstrom et al., 2012). In some instances, these measures were combined with an approach of systematic self-observation (Germain & Nielsen, 2001; Nielsen, 1995; Noreika et al., 2015).

Recently, a new and more refined method of quantifying verbal reports has re-emerged. The "linguistic analysis" allows the classification of report content to predefined categories. The number of classified elements during sleep-onset is then statistically contrasted with those from rapid eye movement (REM) dreams reports. This method is particularly interesting as it allows a systematic comparison of hypnagogic experiences: different phenomenological characteristics of hypnagogic states and REM sleep can thus be investigated and distinguished (J. Speth et al., 2013, 2017). This procedure can further be applied to sleep-onset by analysing reports during wakefulness and a couple of seconds to a couple of minutes after sleep-onset (C. Speth & Speth, 2016; J. Speth et al., 2016). Linguistic analysis possesses one major advantage over the other mentioned research methods: participants are free to report their experiences and are not limited by being asked about specific experiences, as the classification occurs after reports are collected. Thus, the provided report of hypnagogic experiences remains unbiased but can still be examined and contrasted systematically. An example of this procedure is provided in the following section.

8 | DIRECTION 2: THE PHENOMENOLOGY OF HYPNAGOGIC STATES

Schacter (1976) suggested that a more precise phenomenology of imagery and verbal experiences in the hypnagogic state is needed. First, we investigate the modalities in which hypnagogic states occur.

TABLE 2 Summary of publications, their methods used and their main findings regarding this review

Author	Year	Method	Findings
Bódizs et al.	2005	ECoG	1.5–3.0 Hz activity in the parahippocampus increases at sleep-onset, thought to be REM-sleep specific
Bódizs et al.	2008	EEG	EEG activity at sleep-onset resembles REM sleep activity more closely than stage 2 sleep activity
Bosch et al.	2012	Questionnaire-Study	Patients with depression experience hypnagogic states more often than healthy controls
Cancelli et al.	2004	Review	Tricyclic antidepressants are linked with increased hypnagogic states
Del Prete & Tressoldi	2005	Experimental Study	Hypnosis can induce hypnagogic states successfully
Fortuyn et al.	2009	Questionnaire-Study	Patients with narcolepsy experience hypnagogic states and daytime hypnagogia more often than healthy controls
Fulda et al.	2008	Questionnaire-Study	The prevalence for hypnagogic states was higher both in a sample of not nearer defined psychiatric patients and another sample of sleep-disordered patients, compared with healthy controls
Germain & Nielsen	2001	Systematic Self-Observation, EEG	Kinaesthetic images were accompanied by prefrontal and frontal delta activation, visual images were accompanied by activation in left-central and temporal regions at sleep-onset
Haar Horowitz et al.	2020	Serial Awakening, Dormio	The content of hypnagogic experiences can successfully be induced through instruction to think about a specific target before going to sleep
Hayashi et al.	1999	EEG	Hypnagogic experiences of landscapes occur earlier during sleep-onset, followed by dream-like images, whereas static objects and colour patterns occur later during sleep-onset
Hinton et al.	2019	Questionnaire-Study	Individuals with PTSD report being bothered more by hypnagogic states ("ghost attacks") than healthy controls
Horikawa et al.	2013	Machine Learning (fMRI data)	Brain areas that process specific stimuli show activation during the perception of corresponding stimuli in the hypnagogic state
Jones et al.	2009	Questionnaire-Study	Intrusive thoughts and undertaking thought suppression are associated with hypnagogic experiences
Jones et al.	2010	Questionnaire-Study	Compared with REM dreams, verbal hypnagogic experiences are less likely to be commanding, but more likely to contain a single clear word rather than sentences, sound more like familiar voices than unknown persons, and talk directly to the individual
Kjaer et al.	2002	PET	In stage 1 sleep, relative blood flow increases in visual association cortices, while relative blood flow decreases in the frontal and parietal cortex, the cerebellum and the thalamus
Kussé et al.	2012	Serial Awakening, EEG	Playing TETRIS results in hypnagogic images related to the game Anticipating to play the game after sleep results in fewer reports related to the game
Larøi et al.	2019	Questionnaire-Study	Age is associated with a decrease in hypnagogic experiences. Depression and anxiety are associated with an increase in hypnagogic experiences over the lifespan
Lewis-Hanna et al.	2011	fMRI	fMRI measures indicate that individuals with a history of auditory hypnagogic experiences exhibit a significantly greater speech-evoked activation during wakefulness in the left posterior temporoparietal cortex
McCarthy-Jones et al.	2011	Questionnaire-Study	Auditory hypnagogic experiences are more prevalent in individuals who report a higher susceptibility to intrusive thoughts
Nielsen et al.	2005	Serial Awakening, EEG	The dream-like quality of hypnagogic states increases after preceding REM sleep deprivation
Nielsen	2017	Sleep-Onset Observations	The content of hypnagogic states may be influenced by self-generated external stimuli (autosensory imagery) and non-generated external stimuli (exosensory imagery)
Noreika et al.	2015	Systematic Self-Observation, EEG	Linguistic intrusions are associated with higher alpha and gamma power in the left hemisphere, whereas visual images are associated with higher beta power in the right hemisphere

TABLE 2 (Continued)

Author	Year	Method	Findings
Ohayon et al.	1996	Questionnaire-Study	Hypnagogic states are much more common than expected
Ohayon	2000	Questionnaire-Study	The most frequent hypnagogic experienced mentioned is the feeling of falling down an abyss, followed by felt-presence experiences
Ohayon & Shapiro	2000	Questionnaire-Study	Individuals with PTSD classify the emotional quality of their hypnagogic experiences as more terrifying than healthy controls
Pizzagalli et al.	2000	Questionnaire-Study EEG	Individuals with strong beliefs in paranormal phenomena report having hypnagogic experiences more often
Schacter	1976	Review	An extensive review on the hypnagogic state
Schmidt & Gendolla	2008	Serial Awakening, EEG	Suppressed thoughts during the day are likely to rebound into the hypnagogic state
Sherwood	2012	Questionnaire-Study	Visual experiences, the feeling of falling and feeling a presence in the room are the most frequent hypnagogic experiences, followed by auditory, tactile, bodily and movement sensations. The rarest experiences are olfactory and gustatory
Siclari et al.	2017	Serial Awakening, EEG	A bilateral parieto-occipital "hot zone" correlates with the likelihood of individuals reporting hypnagogic experiences. High activity in this area is associated with dream-like experiences
Siclari et al.	2013	Serial Awakening, EEG	Hypnagogic experiences are less rich and complex, and have less continuity than REM dreams
Soffer-Dudek & Shahar	2011	Questionnaire-Study	Stress is associated with increased hypnagogic states when sleep quality is poor
Speth et al.	2013	Linguistic Analysis, Serial Awakening, EEG	Compared with REM dreams, hypnagogic states are experienced less from a first, second or third perspective. Moreover, there were fewer instances in which the individual or others were involved in the act of speaking
Speth et al.	2016	Linguistic Analysis, Serial Awakening, EEG	Memories of the past and thoughts about the present remain fairly constant, while memories of future events decrease throughout sleep-onset
Speth et al.	2017	Linguistic Analysis, Serial Awakening, EEG	Hypnagogic experiences involve fewer acts of speaking and of hearing speech compared with REM dreams
Speth & Speth	2016	Linguistic Analysis, Serial Awakening, EEG	Cognitive agencies decrease throughout sleep-onset, while motor agencies increase
Stenstrom et al.	2012	Serial Awakening, EEG	The content of hypnagogic experiences can relate to previous episodic memories
Stickgold et al.	2000	Serial Awakening (Nightcap), EEG	Playing TETRIS results in hypnagogic images related to the game. This effect also occurs in patients suffering from dense amnesia
Szklo-Coxe et al.	2007	Questionnaire-Study	Depression and anxiety are both associated with increased reports of hypnagogic states
Wackermann et al.	2002	Ganzfeld Method, EEG, EOG, EMG	Experiences in the ganzfeld and hypnagogic states do not differ in their phenomenology. Vigilance, however, does not decrease in the ganzfeld compared with the hypnagogic state
Wamsley et al.	2010	Serial Awakening (Nightcap), EEG	Playing a highly engaging visuomotor video game or observing someone else play results in hypnagogic images related to the game

Abbreviations: ECoG, electrocorticography; EEG, electroencephalogram; EMG, electromyography; EOG, electrooculography; fMRI, functional magnetic resonance imaging; PET, positron emission tomography; PTSD, post-traumatic stress disorder; REM, rapid eye movement.

Next, we report how hypnagogic states are experienced in comparison to REM dreams, how their phenomenology changes over the course of falling asleep, and end up discussing the emotional quality of hypnagogic states.

Subjectively, hypnagogic experiences have been described as crisp, detailed, non-transparent, as well as changing unexpectedly and rapidly (Steen, 2017), and can consist of multiple elements integrated in a coherent three-dimensional scene (Stenstrom et al., 2012). Questionnaire studies reported different findings regarding the frequency of the modality in which hypnagogic states are experienced. In the survey conducted by Ohayon (2000), hypnagogic experiences in the haptic modality were by far the most prominent, such as the feeling of falling, followed by the feeling of someone or something being present in the room, while visual and auditory experiences were the least

reported. Similarly, in the study of Jones et al. (2009), the feeling of a presence in the room was the most frequently reported hypnagogic experience, followed by auditory experiences such as participants hearing their names or familiar voices. However, a more recent survey conducted by Sherwood (2012) suggested hypnagogic experiences in the visual modality to be the most prominent, followed by the feeling of falling, the sense of a presence and auditory experiences, with the perception of taste and smell being the rarest.

Generally, hypnagogic experiences occurring at sleep-onset have been described as more vivid and hallucinatory than dreams (Chokroverty, 2017). On the other hand, they have been described as less rich and complex, and to have less continuity than REM dreams (Siclari et al., 2013). More unique characteristics of hypnagogic experiences at sleep-onset and -offset emerge with the application of the linguistic analysis, particularly when contrasting these experiences with REM dreams. Compared with REM dreams, participants reported experiencing the hypnagogic state significantly less from a first (e.g. I ran; We ran), second or third (e.g. You/She/They ran) perspective, with less reported instances in which the individuals themselves (e.g. I said: "Run!") or others (e.g. You said: "Run!") were involved in the act of speaking (J. Speth et al., 2013). We would thus expect individuals to experience the hypnagogic state less from a specific perspective as an involved participant in an ongoing narrative but much more so as a passive spectator of internal events. In REM dreams, however, the individual acts as a direct participant (Waters et al., 2016), contrary to hypnagogic states.

When auditory experiences are further differentiated into an auditory–verbal agency, meaning the act of speaking, and auditory–verbal experiences, describing the act of hearing speech, both are reported to be significantly less frequent in hypnagogic states than REM dreams (J. Speth et al., 2017). Verbal experiences were described as less likely to be commanding, more likely to contain single clear words than clear sentences, sound more like familiar voices than unknown persons, and talk directly to the individual (Jones et al., 2010). In summary, speech seems less present in hypnagogic states than REM dreams, independent of the speaker's perspective. However, if speech is present, it is more likely to sound like single words from a familiar voice addressing the individual directly in a non-commanding way.

When inspecting sleep-onset, the linguistic analysis further provides insight into the phenomenology of hypnagogic states: while memories of the past and thoughts about the present remain fairly constant, it seems that memories of events that will occur in the future decrease while falling asleep (J. Speth et al., 2016). This suggests a decrease in prospective hypnagogic content to a focus on present and past events. Over the process of falling asleep, hypnagogic experiences decrease in their reported cognitive agencies (e.g. thoughts or thinking about performing an action), while reported motor agencies (e.g. imagery of performing an action) increase (C. Speth & Speth, 2016). These results indicate a transition from a predominantly thought-filled wake state to a higher presence of motor imagery in the hypnagogic state. Conclusively, phenomenological differences in the hypnagogic state can already be observed as early as a few seconds up to a few minutes after sleep-onset.

Rarely, the emotional valence of hypnagogic experiences has been reported in studies assessing the phenomenology of the hypnagogic states. However, one study questioned Cambodian refugees with post-traumatic stress disorder (PTSD) about their experiences with so-called "ghost attacks", as it had been noted that Cambodians often attribute their auditory and visual hallucinations during wakefulness and experiences in states of partial wakefulness to spirits (Hinton et al., 2019): during the hypnagogic state, individuals most prominently reported seeing a human-shaped shadow at the foot of their bed, heard someone calling out to them and beckoning them. Regarding the emotional nature of such an experience, individuals with PTSD reported being bothered more by these encounters on average than individuals without PTSD. Thus, hypnagogic states can very much be experienced negatively and as bothersome, which supports our differentiation of hypnagogic states and hypnagogic hallucinations.

In conclusion, there are differences between hypnagogic imagery and dreams. Individuals are much less actively involved in their hypnagogic experiences than in their dreams, both in physical actions and verbal interaction. Over the course of sleep-onset, hypnagogic experiences regarding future events decrease, and a shift away from a thought-filled state towards motor imagery occurs. Lastly, regarding the emotional quality of hypnagogic states, these experiences appear more bothersome in individuals with PTSD.

9 | DIRECTION 3: THE INDIVIDUAL'S CAPACITY TO PROCESS THE ENVIRONMENT

Schacter (1976) proposed the need for a better understanding of the individual's capacity to process environmental stimuli in the hypnagogic state. Does the stimulation experienced prior to the hypnagogic state influence hypnagogic imagery?

Throughout sleep, humans cycle through the three non-REM (NREM) stages (N1–N3) of increasing sleep depth, and end up in the last stage of sleep named REM sleep (Patel et al., 2020). As hypnagogic stages occur during the transition from wakefulness to sleep, they are by definition assigned to the first stage of sleep (Vaitl et al., 2005), as seen in Figure 1. During this same cycle of sleep, the processing of external stimuli (in the different modalities of perception) is still present in NREM sleep but vanishes during REM sleep (Waters et al., 2016). While perceptions of sounds during wakefulness elicit a response in the thalamus and the primary auditory cortex, these responses persist in NREM sleep and show cortically enhanced activation when sounds induce K-complexes, suggesting a continued response of the brain to auditory stimuli during NREM sleep (Dang-Vu et al., 2011). This cortical responsivity was proposed to be enhanced in individuals commonly experiencing hypnagogic states (Waters et al., 2016).

The capacity of an individual to process environmental information in the hypnagogic state seems to have been investigated in the auditory modality only: the ability of an individual to process auditory stimuli from the environment persists in early phases of sleep. Further, the likelihood of hypnagogic experience might be linked to an increased cortical responsivity. Interestingly, however, there is evidence that the

processing of hypnagogic experiences might impair the simultaneous processing of external stimuli at sleep-onset (Michida et al., 1998, 2005). Nonetheless, the individual's ability to process stimuli during the hypnagogic state is maintained, albeit less pronounced. Thus, the content of hypnagogic states could be influenced by external stimuli. These findings provide significant directions towards identifying the neural correlates of hypnagogic states and, consequently, determining individuals' proneness to experience them.

Recently, Nielsen (2017) proposed two distinct processes on how external stimuli might shape the content of hypnagogic experiences, expanding on Silberer's (1951) study of autosymbolic images: autosensory imagery and exosensory imagery. Autosensory imagery arises through self-generated stimuli, such as muscle twitches or jerks, or snoring. Such self-generated stimuli may be caused by a previous image and merge with a subsequent one. On the other hand, exosensory imagery is caused by environmental stimuli, such as turbulations on an airplane or noise from the nearby tennis court. Although based on anecdotal evidence, this distinction provides a valuable perspective on the possible interplay between internal and external stimuli and the content of hypnagogic states.

The second element of this future direction proposed by Schacter (1976), that is, to advance the capacity to process the environment in the hypnagogic state, revolves around how sensory stimulation experienced before entering the hypnagogic state influences its occurrence and content. Several activities before sleep have been reported to influence the likelihood of hypnagogic experiences: for instance, activities such as reading in bed, the engagement in intellectual activities, and the consumption of alcohol in bed were associated with more frequently occurring hypnagogic experiences (Ohayon et al., 1996). However, these findings do not disclose to what extent the activities performed before the hypnagogic state influence its content.

In a study by Stickgold et al. (2000), participants who played the game *TETRIS* before going to sleep reported hypnagogic images related to the game. Interestingly, this effect also occurred in patients suffering from dense amnesia. These findings suggest independence of hypnagogic states from declarative memory, as the patients had no recollection of playing the game (Stickgold et al., 2000). In a similar study by Kussé et al. (2012), playing *TETRIS* before sleep resulted in hypnagogic images being related to the game (10% of total reports), while anticipating to play the game after sleep resulted in fewer reports related to the game (3% of total reports). Thus, the sole anticipation of playing the game was less reliable to produce related hypnagogic images compared with the actual exposure to visual input from the game. Moreover, Wamsley et al. (2010) had their participants play a highly engaging visuomotor video game named *Alpine Racer™ II*, and collected subsequent reports at sleep-onset and wakefulness. Reports related to the task were present, independently of whether participants were actively engaged in the task or passively observed another person playing the video game. A recent study, however, questioned the independence of hypnagogic imagery from declarative memory, and suggested that the hippocampus was involved when perceiving more complex scenes (Stenstrom et al., 2012).

These studies demonstrate that the consumption of video games or visual media before going to sleep can influence the content of hypnagogic states. As the study of Wamsley et al. (2010) demonstrated that passively observing a task is enough to influence the content of hypnagogic states, the consumption of visual media (such as TV) before bed may already be sufficient to influence hypnagogic imagery. Conclusively, it seems that stimulation experienced before going to bed is likely to find its way into our hypnagogic states.

10 | DIRECTION 4: INDIVIDUAL AND CLINICAL DIFFERENCES

In his fourth future direction, Schacter (1976) emphasized the need for a better understanding of the influence of cognitive, perceptual and personality variables on the content hypnagogic states. Thus, this section revolves around the multiple individual and clinical differences associated with hypnagogic states. We discuss individual differences, followed by their associated clinical diagnosis, respectively. How are these differences associated with an increased likelihood of hypnagogic states, and can these differences determine the content of these experiences?

Indicators of insomnia, such as difficulties falling asleep, maintaining sleep, early awakening, difficulties maintaining sleep and an overall non-restorative sleep, as well as daytime sleepiness, were reported to be associated with a higher likelihood of reporting hypnagogic states (Ohayon et al., 1996). This influence of sleep quality further appears to be moderated by stress, with more hypnagogic states occurring in stressed individuals when their overall sleep quality is poor (Soffer-Dudek & Shahar, 2011). Moreover, the quality of hypnagogic states was reported to increase in dream-like qualities when individuals were deprived from REM sleep prior to entering the hypnagogic state (Nielsen et al., 2005). As such, we would emphasize the role of sleep in the emergence and quality of hypnagogic states.

In a clinical context, hypnagogic states might be most known to be associated with narcolepsy, a chronic sleep disorder characterized by excessive daytime sleepiness (Schiappa et al., 2018). Hypnagogic states are not only an associated feature of narcolepsy, but they also are favourable for a diagnosis. Accordingly, the prevalence of hypnagogic states was higher in patients with narcolepsy than controls (Bosch et al., 2012; Fortuyn et al., 2009). Moreover, patients with narcolepsy are also more prone to experience daytime hypnagogia (Fortuyn et al., 2009), most likely due to excessive daytime sleepiness.

The DSM-5 further suggests that vivid hypnagogic hallucinations, mistaken as real experiences, might indicate schizophrenia. Thus, one would expect a higher prevalence of hypnagogic states in individuals at risk of schizophrenia. Accordingly, hypnagogic states were more frequent in individuals who experienced dissociations (both clinical and non-clinical), such as absorption, amnesia and derealization/depersonalization (Soffer-Dudek & Shahar, 2011). Moreover, individuals who exhibited strong beliefs in paranormal phenomena reported having more hypnagogic experiences than those who did not (Pizzagalli et al., 2000). Interestingly, individuals with schizophrenia reported hypnagogic states more often than healthy controls (Bosch et al., 2012; Fortuyn et al., 2009), but this difference did not yield

significance (Bosch et al., 2012). This insignificance, however, might be caused by a lack of statistical power due to small sample sizes of 29 participants in each group.

Further, the suppression of thoughts and the susceptibility to intrusive thoughts seem to be associated with hypnagogic states. When instructed to suppress a specific thought content during the day, subjects reported more target thoughts when falling asleep than controls, an effect that has been demonstrated in dreams previously (Schmidt & Gendolla, 2008; Wegner et al., 1987). Similarly, auditory hypnagogic experiences were associated with the tendency to undertake thought suppression and the self-reported susceptibility to intrusive thoughts (Jones et al., 2009; McCarthy-Jones et al., 2011).

Accordingly, hypnagogic experiences are more likely to occur in individuals with PTSD (Hinton et al., 2019; Ohayon & Shapiro, 2000), as intrusive thoughts are a hallmark of PTSD and are more likely following traumatic events (Shipherd & Salters-Pedneault, 2008). In fact, hypnagogic experiences are intrusive as they occur unwillingly. Individuals with PTSD judge the emotional quality of their hypnagogic states as more terrifying than healthy controls (Ohayon & Shapiro, 2000). Moreover, the severity of being bothered by these experiences is highly correlated with the severity of the diagnosis (Hinton et al., 2019).

Two further clinical diagnoses associated with the frequency of hypnagogic states are depression and anxiety. The prevalence of hypnagogic states was significantly higher in patients diagnosed with depression (Bosch et al., 2012), although medication was not controlled for. A control for medication would be especially crucial, as, for example, tricyclic antidepressants have been linked with an increase in hypnagogic states (Cancelli et al., 2004). Further, both depression and anxiety were associated with increased reports of hypnagogic states both overall (Szklo-Coxe et al., 2007) and over the lifespan (Larøi et al., 2019).

In conclusion, multiple factors can influence the occurrence of hypnagogic states, such as narcolepsy, PTSD, anxiety and depression, as well as other factors, such as sleep, stress and strong beliefs in paranormal phenomena. Regarding hypnagogic imagery, certain individual differences, such as the suppression of specific thoughts that rebound into hypnagogic states and the consumption of video games, were shown to influence the content of hypnagogic states.

11 | DIRECTION 5: THE PSYCHOPHYSIOLOGICAL APPROACH

Schacter (1976) requested a fuller development of the psychophysiological approach. This approach has made great strides in recent years and was complemented by newer methodological approaches. Thus, we discuss the different attempts made to identify the neural correlates of hypnagogic states.

Horikawa et al. (2013) used machine learning to predict the neural correlates of visual images during the hypnagogic state. Words describing visual content from participant reports were added into a lexical database, which grouped semantically similar words. Then, every functional magnetic resonance imaging (fMRI) dataset recorded before participants' awakenings was labelled with information about the presence or absence of each of the semantically similar word groups. Next, the content of visual experiences in the hypnagogic state based on the brain activity at sleep-onset was predicted using machine learning. Results indicated that higher visual areas such as the fusiform face area performed better with human-associated word groups. In contrast, the parahippocampal place area performed better with word groups associated with scenes. The authors concluded that brain areas processing specific stimuli show activation during the perception of corresponding stimuli in the hypnagogic state.

Extending these findings, Siclari et al. (2017) used a serial awakening paradigm to investigate the neural correlates of dreaming in REM and NREM sleep. Participants were awoken repeatedly during the night and questioned about their experiences: if participants reported having experienced something, they were asked to describe the most recent content of their experience. Further, they were asked to rate their experience from exclusively thought-like to exclusively perceptive. EEG measures indicated a bilateral parieto-occipital "hot zone" correlating with the likelihood of participants reporting dream experiences both in REM and NREM sleep: When EEG activity was high in this area, subjects reported having dream-like experiences. When EEG activity was low, however, subjects reported no experiences. The authors suggested that, as slow waves relatively spare sensory parieto-occipital regions in the early part of the sleep-onset process (Siclari et al., 2014), this circumstance may account for hypnagogic experiences at sleep-onset (Siclari & Tononi, 2017). Hypnagogic states could thus be associated with higher activity in this very parietal-occipital "hot zone".

Kjaer et al. (2002) investigated the cerebral blood flow during light sleep. Specifically, they used positron emission tomography (PET) to identify changes in regional cerebral blood flow during subjectively reported hypnagogic experiences at sleep-onset. In stage 1 sleep, a relative blood flow increase in visual association cortices compared with the state of wakefulness was found. Interestingly, this did not apply to the primary visual cortex. Concurrently, a relative blood flow decrease in the frontal and parietal cortex, the cerebellum, and the thalamus was measured. According to the authors, the relative blood flow increase in visual association cortices accounts for the visual imagery experienced at sleep-onset.

Lewis-Hanna et al. (2011) investigated differences in cortical activation in individuals who had experienced auditory hypnagogic states compared with individuals who did not. The fMRI measures indicated that individuals with a history of auditory hypnagogic experiences exhibited a significantly greater speech-evoked activation in the left posterior temporoparietal cortex during wakefulness, which peaked in the left supramarginal gyrus. The authors suggested that the hypersensitivity of the left supramarginal gyrus might play a role in whether individuals experience auditory hypnagogic states or not. Although these results must be interpreted with caution due to their small sample size, they further indicate differences in cortical activation that might be accountable for a disposition towards hypnagogic experiences.

Several studies assessed the electrophysiological correlates of specific content of hypnagogic experiences at sleep-onset. This line of

research was guided by the distinction between different stages during sleep-onset by Hori et al. (1994). They defined nine distinct stages of sleep-onset, which were distinct in their electrophysiological characteristics (Table 3). Hori et al. (1994) found that most hypnagogic experiences were recalled when awoken from sleep-onset stage 5. Moreover, kinaesthetic imagery decreased over the course of the sleep-onset stages, whereas visual and auditory imagery increased. This subdivision of sleep-onset into different stages marks a major improvement since Schacter's (1976) review, as it allows the investigation of hypnagogic states on a smaller and more precise scale.

Hayashi et al. (1999) also awakened participants during different sleep-onset stages (Hori et al., 1994) and asked them to report the content of their experiences. The results suggested that different contents coincided with specific EEG signatures: landscapes were most prevalent early over sleep-onset during the presence of alpha waves (sleep-onset stage 3), whereas dream-like images and images of people occurred later when EEG flattening (sleep-onset stage 5) and vertex sharp waves (sleep-onset stage 6) occurred. On the other hand, static objects and colour patterns occurred the latest over the course of sleep-onset when sleep spindles were present. Thus, the content of hypnagogic states was associated with different electrophysiological characteristics and was temporally distributed over the course of sleep-onset.

Germain and Nielsen (2001) compared EEG signals over the course of sleep-onset for both reported unimodal visual and kinaesthetic hypnagogic experiences. Most hypnagogic experiences were reported during Hori stages 4 and 5 of sleep-onset. Changes in topographical power were different for visual and kinaesthetic reports. Overall, visual and kinaesthetic reports were preceded by a decrease in alpha and theta power. Kinaesthetic experiences coincided with increased frontal delta power, while visual experiences coincided with increased power in left central and temporal regions. Germain and Nielsen concluded that kinaesthetic experiences occur earlier than visual experiences over the course of sleep-onset, consistent with Hori et al. (1994).

Noreika et al. (2015) were interested in how linguistic intrusions differed from the more common hypnagogic experiences in a single case study. Linguistic intrusions, which could be classified as auditory hypnagogic experiences, were described as words or phrases that occasionally occurred and were unrelated to imagery perceived at sleep-onset. In accordance with Germain and Nielsen (2001), the authors found a decrease in alpha and theta power right before reports of visual hypnagogic experiences. However, these so-called linguistic intrusions differed from reports of visual experiences in that they were preceded by a significant increase in theta power. Moreover, linguistic intrusions were associated with higher alpha and gamma power in the left hemisphere, whereas visual hypnagogic experiences were associated with higher beta power in the right hemisphere.

Lastly, two studies assessed similarities between REM sleep and sleep-onset activity. According to the covert-REM sleep hypothesis of dreaming, elements of REM sleep that emerge during sleep-onset are suspected to be causal for hypnagogic experiences (Nielsen, 2000). To examine this hypothesis, Bódizs et al. (2005) used electrocorticography (ECoG) to measure parahippocampal activity. The authors reported an increase in 1.5–3.0 Hz activity in the parahippocampus at sleep-onset, which was reported to be specific to REM sleep. In a second study, Bódizs et al. (2008) used EEG measures to compare sleep-onset-activity with stage 2 and REM sleep. EEG activity during sleep-onset shared more similarities with REM sleep activity than with stage 2 sleep activity. Further, REM-like EEG activity increased during alpha dropout at sleep-onset. The authors concluded their results to be in favour of the covert-REM sleep hypothesis. The interplay between REM-like activity and hypnagogic states, however, remains to be further inspected.

Since Schacter (1976) proposed a fuller development of the psychophysiological approach to assessing hypnagogic states, research has progressed. While EEG measures still represent an integral part of hypnagogia research, they were complemented with other imaging techniques. Attempts at understanding the neural correlates of specific contents during hypnagogic experiences are heading in a promising direction.

TABLE 3 Sleep-onset stages defined by Hori et al. (1994)

Sleep stage	EEG stage	Characteristics
Wake	1	Alpha wave train
	2	Alpha wave intermittent (> 50% alpha activity)
Stage 1	3	Alpha wave intermittent (< 50% alpha activity)
	4	EEG flattening
	5	Ripples
	6	Hump solitary
	7	Humps train
	8	Humps with incomplete spindles
Stage 2	9	Spindles

Abbreviation: EEG, electroencephalogram.

12 | DIRECTION 6: THE INDUCTION OF HYPNAGOGIC STATES

The last proposed future direction suggested by Schacter (1976) revolves around the necessary conditions to enter the hypnagogic state. Two questions are of interest in this section, namely, whether hypnagogic states can successfully be induced, and whether these artificially induced hypnagogic states differ from naturally occurring ones.

One study tried to induce hypnagogic states using the *multi-modal ganzfeld* technique (Wackermann et al., 2002), an approach generally used to induce altered states of consciousness (Wackermann et al., 2008). Participants sitting in a reddish illuminated room were instructed to sit with their eyes open while having their eyes covered with anatomically shaped halves of ping-pong balls. Concurrently, the sound of a waterfall was projected onto headphones as white noise, and reports were acquired on-demand, as initiated by the experimenter. A qualitative analysis of reports did not yield a difference

between hypnagogic experiences and experiences in the ganzfeld. However, the EEG signal indicated that a decrease in vigilance was absent in ganzfeld-induced states, unlike when falling asleep. The authors concluded that, although different from the waking state, the ganzfeld-induced state was more comparable to the waking state than the hypnagogic state, deeming this approach imprecise. However, even if different from sleep-onset hypnagogia, this method may be useful to investigate daytime hypnagogia.

Another method to induce the hypnagogic state is hypnosis. So far, only one study attempted to induce hypnagogic experiences through hypnosis (Del Prete & Tressoldi, 2005). In this study, a hypnotist induced the hypnagogic state through a modified Jacobson technique. The individual is instructed on how to relax the principal muscle groups of the body (Jacobson, 1925) for about 20–30 min. Then, the participant was induced into hypnosis through indirect flight suggestion for 15–20 min. Different indices, such as "deep muscular relaxation, slow and regular breath, reports of spontaneous images, slow ocular movements, and a sensation of hand paralysis" (Del Prete & Tressoldi, 2005, p. 332), were interpreted as the attainment of the hypnagogic state.

Thus, hypnosis seems to be promising. In fact, it has been stated that the induction of drowsiness during hypnosis can increase the vividness of imagery through a reduction of internal and external distractors (Robazza & Bortoli, 1995). The increasing internal awareness associated with hypnosis (Demertzi et al., 2015) could thus facilitate the occurrence of hypnagogic experiences during this state of drowsiness, and improve the ability to monitor and report these experiences in greater detail. Interestingly, hypnosis has not only been used to induce hypnagogic states, but also to treat hypnagogic hallucinations (Gathercole, 2008).

Recently, Haar Horowitz et al. (2020) proposed a new approach to intentionally induce the content of hypnagogic states, a targeted dream incubation procedure called *Dormio*. Before sleep-onset, participants were prompted with a target stimulus to be induced, for example, "remember to think of a tree". Heart rate, finger flexion and electrodermal activity were then tracked to identify sleep-onset. Once asleep, participants were woken up and asked about the content of their thoughts and whether they were asleep. After collecting reports, participants were reminded to think of the target stimulus. This procedure was then repeated for a total of 45 min. The procedure successfully induced the target stimulus into the content of hypnagogic experiences, in contrast to a control condition where no target stimulus was presented. However, as admitted by the authors, it remains questionable whether reports from subjects can be trusted due to influence from demand characteristics. Nevertheless, the results demonstrate the malleability of hypnagogic experiences through external stimuli and/or demands.

In summary, the artificial induction of hypnagogic states has not been sufficiently tested, but hypnosis seems to be a promising method to induce hypnagogic states at sleep-onset. The ganzfeld method, on the other hand, could be used to assess daytime hypnagogia. Hypnagogia has generally been investigated when naturally occurring, such as by using self-observation or sleep-onset measures. Importantly, these artificially induced hypnagogic states do not seem to differ from naturally occurring ones.

13 | CONCLUSIONS

The purpose of this review was to provide an update on hypnagogic states since the review of Schacter (1976). We evaluated the proposed future directions suggested by Schacter (1976) based on the more recent literature.

Multiple methods were used to assess both the prevalence and quality of hypnagogic states. Two approaches emerged as the most promising to examine hypnagogic states: the serial awakening paradigm (Siclari et al., 2013, 2017); and the linguistic analysis (C. Speth & Speth, 2016; J. Speth et al., 2013, 2016, 2017). Both approaches assess hypnagogic states when they naturally occur in close temporal proximity to the experience. Moreover, both allow hypnagogic states to be contrasted with dreams. The linguistic analysis also allows a systematic exploration of hypnagogic experiences without limiting reports to predefined categories, as the classification occurs after collected reports.

Previously, literature reported hypnagogic states to occur most frequently in the visual modality, followed by the auditory and tactile-kinaesthetic modality (Schacter, 1976). However, our review suggests otherwise: kinaesthetic experiences, such as the feeling of a presence in the room and the feeling of falling, as well as visual experiences were the most frequent, followed by experiences in the auditory modality (Jones et al., 2009; Ohayon, 2000; Sherwood, 2012). When comparing hypnagogic states with dreams, both can be differentiated by clear characteristics. Most notably, individuals experience less active involvement in hypnagogic states than in dreams (J. Speth et al., 2013, 2017).

Both stimuli prior to and during the hypnagogic state can influence an individual's experiences. There is evidence for a continued response of the individuum to external stimuli during the hypnagogic state (Dang-Vu et al., 2011; Michida et al., 2005; Waters et al., 2016) and, thus, these stimuli could shape the content of our hypnagogic experiences. However, it remains to be assessed how stimuli in modalities other than the auditory modality are accessible while falling asleep. An influence on the content of hypnagogic states from self-generated and environmental external stimuli appears plausible (Nielsen, 2017). Regarding experiences prior to the hypnagogic states, three studies successfully demonstrated that playing or watching someone other play a game during wakefulness dictated the content of hypnagogic experiences (Kussé et al., 2012; Stickgold et al., 2000; E. J. Wamsley et al., 2010). Conclusively, visual activities before bedtime, such as watching movies or playing video games, are likely to influence the content we experience during the hypnagogic state.

Likewise, several clinical and individual differences are associated with the occurrence of hypnagogic states. Sleep quality and narcolepsy, traits of dissociation and schizophrenia, intrusive thoughts and PTSD, and depression and anxiety were linked to more frequent hypnagogic states. Most notably, however, suppressing a thought throughout the

day resulted in its re-emergence during the hypnagogic state, as it was previously observed in dreams, in accordance with the theory of dream rebound (Wegner et al., 2004; Wegner et al., 1987).

We have seen further progress in the development of the psychophysiological approach, with results providing insight as to how hypnagogic states may occur. First, three possible correlates of hypnagogic states were identified: a blood flow increase in visual association areas, a decrease in alpha and theta power, and an increased activity in a parieto-occipital zone. Second, the content of hypnagogic experiences coincides with specific patterns of electrophysiological activity and might be determined by activation in the very same cortical areas that process specific stimuli during wakefulness, as machine learning suggests. Third, findings suggest that individuals with higher cortical activity are more likely to experience hypnagogic states.

Lastly, hypnagogic states can be induced with the ganzfeld method and hypnosis, and their content can be induced with procedures through targeted dream incubation. Hypnagogic reports did not differ qualitatively in the ganzfeld from naturally occurring ones. As EEG signals in the ganzfeld relate more to wakefulness than sleep-onset, we would suggest that the ganzfeld procedure may be useful to assess daytime hypnagogia. So far, hypnosis was barely used to investigate hypnagogic states, but seems to be a promising approach to induce hypnagogic experiences and eventually manipulate their content. On the other hand, procedures such as *Dormio* can be used to induce specific experiences in the hypnagogic state (Haar Horowitz et al., 2020).

A barely addressed aspect of hypnagogic experiences is their emotional quality. Previously, researchers assumed hypnagogic experiences to have either a negative emotional quality or be emotionally flat. However, our review states that hypnagogic experiences can be positive and negative or have no emotional quality at all. We thus proposed the differentiation between hypnagogic states and hypnagogic hallucinations, with the latter having a negative emotional quality, being clinically relevant. However, their interplay has yet to be examined. When do hypnagogic states become hypnagogic hallucinations? And what factors determine the emotional quality of these experiences?

Moreover, the question as to why hypnagogic states occur most frequently in the kinaesthetic and visual modality requires further investigation. The hypnagogic state differs from wakefulness in two ways regarding sensory perception. First, there is a lack of visual input due to generally closed eyes at sleep-onset, which might account for the visual experiences in the hypnagogic state. Second, vestibular input differs due to a lying position when going to sleep. This circumstance might account for the often occurring kinaesthetic experiences, such as the feeling of falling. Hypnagogic states could be a byproduct from adaptational processes of the vestibular system, which could explain the frequent kinaesthetic experiences at sleep-onset.

Another, far more central question, is that of their purpose: do hypnagogic states fulfil a specific purpose or are they but a phenomenon without meaning occurring due to the loss of volitional control? We now know that memories of future events significantly decrease during the hypnagogic state, while memories of the past persist (J. Speth et al., 2016). During dreams, however, more than a quarter of dreams relate to future events (Wamsley, 2021). As suppressed thoughts have been shown to rebound both into the hypnagogic state and dreams, it could be that both phenomena help us cope with defining experiences, be it in different ways: hypnagogic states perhaps help us process and consolidate our past experiences, while dreams could allow us to process these experiences and prepare us for future events. This form of prospective coding in dreams has been discussed recently (Llewellyn, 2016). However, future research is needed to understand the purpose of hypnagogic states.

Hypnagogic states occur quite frequently and can occur in all modalities. They are distinguishable from similar phenomena by clear characteristics and are generally benign. They can, however, manifest as hypnagogic hallucinations, where they are perceived as bothersome and have a negative emotional quality. As hypnagogia research progresses, a better understanding of the hypnagogic state will be achieved. Although some uncertainties remain at present, this phenomenon becomes more and more tangible.

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Romain Ghibellini and Beat Meier wrote the manuscript and approved the final manuscript for submission.

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The authors declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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REFERENCES

American Academy of Sleep Medicine. (2014). *International classification of sleep disorders—Third edition (ICSD-3) online version*. American Academy of Sleep Medicine.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (5th ed.). American Psychiatric Association.

Baylor, G. W., & Cavallero, C. (2001). Memory sources associated with REM and NREM dream reports throughout the night: A new look at the data. *Sleep*, *24*(2), 165–170.

Bódizs, R., Sverteczki, M., Lázár, A. S., & Halász, P. (2005). Human parahippocampal activity: Non-REM and REM elements in wake–sleep transition. *Brain Research Bulletin*, *65*(2), 169–176. https://doi.org/10.1016/j.brainresbull.2005.01.002

Bódizs, R., Sverteczki, M., & Mészáros, E. (2008). Wakefulness–sleep transition: Emerging electroencephalographic similarities with the rapid eye movement phase. *Brain Research Bulletin*, *76*(1–2), 85–89. https://doi.org/10.1016/j.brainresbull.2007.11.013

Bosch, P., van Luijtelaar, G., Groetelaers, L., van den Noort, M., Lim, S., Egger, J., & Coenen, A. (2012). The Munich parasomnia screening in

psychiatry. *Somnologie - Schlafforschung und Schlafmedizin*, *16*(4), 257–262. https://doi.org/10.1007/s11818-012-0587-4

Cancelli, I., Marcon, G., & Balestrieri, M. (2004). Factors associated with complex visual hallucinations during antidepressant treatment. *Human Psychopharmacology: Clinical and Experimental*, *19*(8), 577–584. https://doi.org/10.1002/hup.640

Cheyne, J. A., Rueffer, S. D., & Newby-Clark, I. R. (1999). Hypnagogic and hypnopompic hallucinations during sleep paralysis: Neurological and cultural construction of the night-mare. *Consciousness and Cognition*, *8*(3), 319–337. https://doi.org/10.1006/ccog.1999.0404

Chokroverty, S. (2017). Basic science technical considerations and clinical aspects. In *Sleep Disorders Medicine*. Springer. https://doi.org/10.1007/978-1-4939-6578-6

D'Agostino, A., & Limosani, I. (2010). Hypnagogic hallucinations and sleep paralysis. In M. Goswami, S. R. Pandi-Perumal, & M. J. Thorpy (Eds.), *Narcolepsy*. Springer. https://doi.org/10.1007/978-1-4419-0854-4_8

Dang-Vu, T. T., Bonjean, M., Schabus, M., Boly, M., Darsaud, A., Desseilles, M., Degueldre, C., Balteau, E., Phillips, C., Luxen, A., Sejnowski, T. J., & Maquet, P. (2011). Interplay between spontaneous and induced brain activity during human non-rapid eye movement sleep. *Proceedings of the National Academy of Sciences*, *108*(37), 15438–15443. https://doi.org/10.1073/pnas.1112503108

Del Prete, G., & Tressoldi, P. E. (2005). Anomalous cognition in hypnagogic state with OBE induction: An experimental study. *Journal of Parapsychology*, *69*(2), 329.

Demertzi, A., Vanhaudenhuyse, A., Noirhomme, Q., Faymonville, M.-E., & Laureys, S. (2015). Hypnosis modulates behavioural measures and subjective ratings about external and internal awareness. *Journal of Physiology-Paris*, *109*(4–6), 173–179. https://doi.org/10.1016/j.jphysparis.2015.11.002

Domhoff, G. W. (1996). *Finding meaning in dreams: A quantitative approach* (Vol. 14, p. 356). Plenum Press. https://doi.org/10.1007/978-1-4899-0298-6

Fortuyn, H. A. D., Lappenschaar, G. A., Nienhuis, F. J., Furer, J. W., Hodiamont, P. P., Rijnders, C. A., Lammers, G. J., Renier, W. O., Buitelaar, J. K., & Overeem, S. (2009). Psychotic symptoms in narcolepsy: Phenomenology and a comparison with schizophrenia. *General Hospital Psychiatry*, *31*(2), 146–154. https://doi.org/10.1016/j.genhosppsych.2008.12.002

Fulda, S., Hornyak, M., Müller, K., Cerny, L., Beitinger, P. A., & Wetter, T. C. (2008). Development and validation of the Munich parasomnia screening (MUPS): A questionnaire for parasomnias and nocturnal behaviors. *Somnologie - Schlafforschung Und Schlafmedizin*, *12*(1), 56–65. https://doi.org/10.1007/s11818-008-0336-x

Galton, F. (1883). *Inquiries into human faculty and its development*. Macmillan.

Gathercole, M. (2008). The use of hypnosis for the treatment of hypnagogic hallucinations. *Australian Journal of Clinical & Experimental Hypnosis*, *36*(2), 169–175.

Germain, A., & Nielsen, T. A. (2001). EEG power associated with early sleep onset images differing in sensory content. *Sleep Research Online*, *4*(3), 83–90.

Green, M. W. (2001). The exploding head syndrome. *Current Pain and Headache Reports*, *5*(3), 279–280. https://doi.org/10.1007/s11916-001-0043-9

Gurstelle, E. B., & de Oliveira, J. L. (2004). Daytime parahypnagogia: A state of consciousness that occurs when we almost fall asleep. *Medical Hypotheses*, *62*(2), 166–168. https://doi.org/10.1016/S0306-9877(03)00306-2

Haar Horowitz, A., Cunningham, T. J., Maes, P., & Stickgold, R. (2020). Dormio: A targeted dream incubation device. *Consciousness and Cognition*, *83*, 102938. https://doi.org/10.1016/j.concog.2020.102938

Hayashi, M., Katoh, K., & Hori, T. (1999). Hypnagogic imagery and EEG activity. *Perceptual and Motor Skills*, *88*(2), 676–678. https://doi.org/10.2466/pms.1999.88.2.676

Hinton, D. E., Reis, R., & de Jong, J. (2019). Ghost encounters among traumatized cambodian refugees: Severity, relationship to PTSD, and phenomenology. *Culture, Medicine, and Psychiatry.*, *44*, 333–359. https://doi.org/10.1007/s11013-019-09661-6

Hori, T., Hayashi, M., & Morikawa, T. (1994). Topographical EEG changes and the hypnagogic experience. In *Sleep onset: Normal and abnormal processes* (pp. 237–253). American Psychological Association. https://doi.org/10.1037/10166-014

Horikawa, T., Tamaki, M., Miyawaki, Y., & Kamitani, Y. (2013). Neural decoding of visual imagery during sleep. *Science*, *340*(6132), 639–642. https://doi.org/10.1126/science.1234330

Jacobson, E. (1925). Progressive relaxation. *The American Journal of Psychology*, *36*, 73–87.

Jones, S. R., Fernyhough, C., & Larøi, F. (2010). A phenomenological survey of auditory verbal hallucinations in the hypnagogic and hypnopompic states. *Phenomenology and the Cognitive Sciences*, *9*(2), 213–224. https://doi.org/10.1007/s11097-010-9158-y

Jones, S. R., Fernyhough, C., & Meads, D. (2009). In a dark time: Development, validation, and correlates of the Durham hypnagogic and hypnopompic hallucinations questionnaire. *Personality and Individual Differences*, *46*(1), 30–34. https://doi.org/10.1016/j.paid.2008.08.021

Kjaer, T. W., Law, I., Wiltschiotz, G., Paulson, O. B., & Madsen, P. L. (2002). Regional cerebral blood flow during light sleep—A H215O-PET study. *Journal of Sleep Research*, *11*(3), 201–207. https://doi.org/10.1046/j.1365-2869.2002.00303.x

Kussé, C., Shaffii-Le Bourdiec, A., Schrouff, J., Matarazzo, L., & Maquet, P. (2012). Experience-dependent induction of hypnagogic images during daytime naps: A combined behavioural and EEG study. *Journal of Sleep Research*, *21*(1), 10–20.

Larøi, F., Bless, J. J., Laloyaux, J., Kråkvik, B., Vedul-Kjelsås, E., Kalhovde, A. M., Hirnstein, M., & Hugdahl, K. (2019). An epidemiological study on the prevalence of hallucinations in a general-population sample: Effects of age and sensory modality. *Psychiatry Research*, *272*, 707–714. https://doi.org/10.1016/j.psychres.2019.01.003

Lewis-Hanna, L. L., Hunter, M. D., Farrow, T. F. D., Wilkinson, I. D., & Woodruff, P. W. R. (2011). Enhanced cortical effects of auditory stimulation and auditory attention in healthy individuals prone to auditory hallucinations during partial wakefulness. *NeuroImage*, *57*(3), 1154–1161. https://doi.org/10.1016/j.neuroimage.2011.04.058

Llewellyn, S. (2016). Dream to predict? REM dreaming as prospective coding. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.01961

Maury, A. (1848). Des hallucinations hypnagogiques, ou des erreurs des sens dans l'état intermédiaire entre la veille et le sommeil.

McCarthy-Jones, S., Barnes, L. J., Hill, G. E., Marwood, L., Moseley, P., & Fernyhough, C. (2011). When words and pictures come alive: Relating the modality of intrusive thoughts to modalities of hypnagogic/hypnopompic hallucinations. *Personality and Individual Differences*, *51*(6), 787–790. https://doi.org/10.1016/j.paid.2011.07.003

Meier, B., Rothen, N., & Walter, S. (2014). Developmental aspects of synaesthesia across the adult lifespan. *Frontiers in Human Neuroscience*, *8*. https://doi.org/10.3389/fnhum.2014.00129

Michida, N., Hayashi, M., & Hori, T. (1998). Comparison of event related potentials with and without hypnagogic imagery. *Psychiatry and Clinical Neurosciences*, *52*(2), 145–147. https://doi.org/10.1111/j.1440-1819.1998.tb00997.x

Michida, N., Hayashi, M., & Hori, T. (2005). Effects of hypnagogic imagery on the event-related potential to external Tone0Stimuli. *Sleep*, *28*(7), 813–818. https://doi.org/10.1093/sleep/28.7.813

Myers, F. W. H. (1904). *Human personality and its survival of bodily death* (Vol. 2). Longmans.

Nielsen, T. A. (1995). Describing and modeling hypnagogic imagery using a systematic self-observation procedure. *Dreaming*, *5*(2), 75–94. https://doi.org/10.1037/h0094426

Nielsen, T. A. (2000). A review of mentation in REM and NREM sleep: "Covert" REM sleep as a possible reconciliation of two opposing

models. *Behavioral and Brain Sciences*, *23*(6), 851–866. https://doi.org/10.1017/S0140525X0000399X

Nielsen, T. A. (2017). Microdream neurophenomenology. *Neuroscience of Consciousness*, *2017*(1). https://doi.org/10.1093/nc/nix001

Nielsen, T. A., Stenstrom, P., Takeuchi, T., Saucier, S., Lara-Carrasco, J., Solomonova, E., & Martel, E. (2005). Partial REM-sleep deprivation increases the dream-like quality of mentation from REM sleep and sleep onset. *Sleep*, *28*(9), 1083–1089. https://doi.org/10.1093/sleep/28.9.1083

Noreika, V., Canales-Johnson, A., Koh, J., Taylor, M., Massey, I., & Bekinschtein, T. A. (2015). Intrusions of a drowsy mind: Neural markers of phenomenological unpredictability. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/fpsyg.2015.00202

Ohayon, M. M. (2000). Prevalence of hallucinations and their pathological associations in the general population. *Psychiatry Research*, *97*(2–3), 153–164. https://doi.org/10.1016/S0165-1781(00)00227-4

Ohayon, M. M., Guilleminault, C., Zulley, J., Palombini, L., & Raab, H. (1999). Validation of the Sleep-EVAL system against clinical assessments of sleep disorders and polysomnographic data. *Sleep*, *22*(7), 925–930. https://doi.org/10.1093/sleep/22.7.925

Ohayon, M. M., Priest, R. G., Caulet, M., & Guilleminault, C. (1996). Hypnagogic and hypnopompic hallucinations: Pathological phenomena? *British Journal of Psychiatry*, *169*(4), 459–467. https://doi.org/10.1192/bjp.169.4.459

Ohayon, M. M., & Shapiro, C. M. (2000). Sleep disturbances and psychiatric disorders associated with posttraumatic stress disorder in the general population. *Comprehensive Psychiatry*, *41*(6), 469–478. https://doi.org/10.1053/comp.2000.16568

Patel, A. K., Reddy, V., & Araujo, J. F. (2020). *Physiology, sleep stages*. StatPearls Publishing.

Pizzagalli, D., Lehmann, D., Gianotti, L., Koenig, T., Tanaka, H., Wackermann, J., & Brugger, P. (2000). Brain electric correlates of strong belief in paranormal phenomena: Intracerebral EEG source and regional omega complexity analyses. *Psychiatry Research: Neuroimaging*, *100*(3), 139–154. https://doi.org/10.1016/S0925-4927(00)00070-6

Robazza, C., & Bortoli, L. (1995). A case study of improved performance in archery using hypnosis. *Perceptual and Motor Skills*, *81*(3), 1364–1366. https://doi.org/10.2466/pms.1995.81.3f.1364

Sacks, O. (2012). *Hallucinations*. Pan Macmillan.

Schacter, D. L. (1976). The hypnagogic state: A critical review of the literature. *Psychological Bulletin*, *83*(3), 452–481.

Schiappa, C., Scarpelli, S., D'Atri, A., Gorgoni, M., & De Gennaro, L. (2018). Narcolepsy and emotional experience: A review of the literature. *Behavioral and Brain Functions*, *14*(1), 19. https://doi.org/10.1186/s12993-018-0151-x

Schmidt, R. E., & Gendolla, G. H. E. (2008). Dreaming of white bears: The return of the suppressed at sleep onset. *Consciousness and Cognition*, *17*(3), 714–724. https://doi.org/10.1016/j.concog.2007.09.002

Schredl, M. (2018). *Researching dreams: The fundamentals*. Springer.

Sharpless, B. A. (2014). Exploding head syndrome. *Sleep Medicine Reviews*, *18*(6), 489–493.

Sherwood, S. J. (2012). A web survey of the content, sensory modalities, and interpretation of hypnagogic and hypnopompic experiences. *Journal of Parapsychology*, *76*(1), 27.

Shipherd, J. C., & Salters-Pedneault, K. (2008). Attention, memory, intrusive thoughts, and acceptance in PTSD: An update on the empirical literature for clinicians. *Cognitive and Behavioral Practice*, *15*(4), 349–363. https://doi.org/10.1016/j.cbpra.2008.01.003

Siclari, F., Baird, B., Perogamvros, L., Bernardi, G., LaRocque, J. J., Riedner, B., Boly, M., Postle, B. R., & Tononi, G. (2017). The neural correlates of dreaming. *Nature Neuroscience*, *20*(6), 872–878. https://doi.org/10.1038/nn.4545

Siclari, F., Bernardi, G., Riedner, B. A., LaRocque, J. J., Benca, R. M., & Tononi, G. (2014). Two distinct synchronization processes in the transition to sleep: A high-density electroencephalographic study. *Sleep*, *37*(10), 1621–1637. https://doi.org/10.5665/sleep.4070

Siclari, F., LaRocque, J. J., Postle, B. R., & Tononi, G. (2013). Assessing sleep consciousness within subjects using a serial awakening paradigm. *Frontiers in Psychology*, *4*. https://doi.org/10.3389/fpsyg.2013.00542

Siclari, F., & Tononi, G. (2017). Local aspects of sleep and wakefulness. *Current Opinion in Neurobiology*, *44*, 222–227. https://doi.org/10.1016/j.conb.2017.05.008

Silberer, H. (1951). 8. Report on a method of eliciting and observing certain symbolic hallucination-phenomena. In *Report on a method of eliciting and observing certain symbolic hallucination-phenomena. In organization and pathology of thought* (pp. 195–207). Columbia University Press.

Soffer-Dudek, N., & Shahar, G. (2011). Daily stress interacts with trait dissociation to predict sleep-related experiences in young adults. *Journal of Abnormal Psychology*, *120*(3), 719–729. https://doi.org/10.1037/a0022941

Speth, C., & Speth, J. (2016). The borderlands of waking: Quantifying the transition from reflective thought to hallucination in sleep onset. *Consciousness and Cognition*, *41*, 57–63. https://doi.org/10.1016/j.concog.2016.01.009

Speth, J., Frenzel, C., & Voss, U. (2013). A differentiating empirical linguistic analysis of dreamer activity in reports of EEG-controlled REM-dreams and hypnagogic hallucinations. *Consciousness and Cognition*, *22*(3), 1013–1021. https://doi.org/10.1016/j.concog.2013.07.003

Speth, J., Harley, T. A., & Speth, C. (2017). Auditory verbal experience and agency in waking, sleep onset, REM, and non-REM sleep. *Cognitive Science*, *41*(3), 723–743. https://doi.org/10.1111/cogs.12363

Speth, J., Schloerscheidt, A. M., & Speth, C. (2016). As we fall asleep we forget about the future: A quantitative linguistic analysis of mentation reports from hypnagogia. *Consciousness and Cognition*, *45*, 235–244. https://doi.org/10.1016/j.concog.2016.08.014

Steen, C. (2017). Synesthetic photisms and hypnagogic visions: A comparison. *Multisensory Research*, *30*(3–5), 199–205. https://doi.org/10.1163/22134808-00002557

Stenstrom, P., Fox, K., Solomonova, E., & Nielsen, T. (2012). Mentation during sleep onset theta bursts in a trained participant: A role for NREM stage 1 sleep in memory processing? *International Journal of Dream Research*, *5*, 37–46. https://doi.org/10.11588/ijodr.2012.1.9135

Stickgold, R., Malia, A., Maguire, D., Roddenberry, D., & O'Connor, M. (2000). Replaying the game: Hypnagogic images in normals and amnesics. *Science*, *290*(5490), 350–353. https://doi.org/10.1126/science.290.5490.350

Szklo-Coxe, M., Young, T., Finn, L., & Mignot, E. (2007). Depression: Relationships to sleep paralysis and other sleep disturbances in a community sample. *Journal of Sleep Research*, *16*(3), 297–312. https://doi.org/10.1111/j.1365-2869.2007.00600.x

Taylor, F. K. (1981). On pseudo-hallucinations. *Psychological Medicine*, *11*(2), 265–271. https://doi.org/10.1017/S0033291700052089

Vaitl, D., Birbaumer, N., Gruzelier, J., Jamieson, G. A., Kotchoubey, B., Kübler, A., Lehmann, D., Miltner, W. H. R., Ott, U., Pütz, P., Sammer, G., Strauch, I., Strehl, U., Wackermann, J., & Weiss, T. (2005). Psychobiology of altered states of consciousness. *Psychological Bulletin*, *131*(1), 98–127. https://doi.org/10.1037/0033-2909.131.1.98

Van de Castel, R. L. (1995). *Our Dreaming Mind*. Ballantine Books.

Wackermann, J., Putz, P., & Allefeld, C. (2008). Ganzfeld-induced hallucinatory experience, its phenomenology and cerebral electrophysiology. *Cortex*, *44*(10), 1364–1378. https://doi.org/10.1016/j.cortex.2007.05.003

Wackermann, J., Pütz, P., Büchi, S., Strauch, I., & Lehmann, D. (2002). Brain electrical activity and subjective experience during altered states of consciousness: Ganzfeld and hypnagogic states. *International Journal of Psychophysiology*, *46*(2), 123–146. https://doi.org/10.1016/S0167-8760(02)00070-3

Wamsley, E. (2021). Dreaming as constructive episodic future simulation. *Sleep*, *44*(2), A15. https://doi.org/10.1093/sleep/zsab072.033

Wamsley, E. J., Perry, K., Djonlagic, I., Reaven, L. B., & Stickgold, R. (2010). Cognitive replay of visuomotor learning at sleep onset: Temporal dynamics and relationship to task performance. *Sleep*, *33*(1), 59–68. https://doi.org/10.1093/sleep/33.1.59

Ward, J. (2013). Synesthesia. *Annual Review of Psychology*, *64*(1), 49–75. https://doi.org/10.1146/annurev-psych-113011-143840

Waters, F., Blom, J. D., Dang-Vu, T. T., Cheyne, A. J., Alderson-Day, B., Woodruff, P., & Collerton, D. (2016). What is the link between hallucinations, dreams, and hypnagogic–hypnopompic experiences? *Schizophrenia Bulletin*, *42*(5), 1098–1109. https://doi.org/10.1093/schbul/sbw076

Wegner, D. M., & Schneider, D. J. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology*, *53*(1), 5–13.

Wegner, D. M., Wenzlaff, R. M., & Kozak, M. (2004). Dream rebound: The return of suppressed thoughts in dreams. *Psychological Science*, *15*(4), 232–236. https://doi.org/10.1111/j.0963-7214.2004.00657.x

Zadra, A., & Domhoff, G. W. (2017). Dream content. In *Principles and practice of sleep medicine* (pp. 515–522). Elsevier. https://doi.org/10.1016/B978-0-323-24288-2.00049-0

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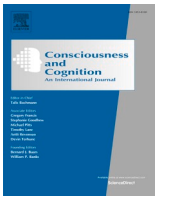

Hypnagogic states are quite common: Self-reported prevalence, modalities, and gender differences

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ABSTRACT

The hypnagogic state refers to the transitional phase between wakefulness and sleep during which vivid experiences occur. In this questionnaire study, we assessed the self-reported prevalence of hypnagogic states considering the frequency of experiences in different modalities. We also assessed the emotional quality and the vividness of the experiences. Moreover, we compared hypnagogic states to other phenomena, such as dreams, sleep paralysis, imagination, and extra-sensory perception in these measures. Hypnagogic states were reported by 80.2 % of 4456 participants and were more prevalent in women than men. Experiences were most often kinaesthetic and visual, and less often auditory, tactile, and olfactory or gustatory. Hypnagogic states were less prevalent than dreams and characterized by different modality profiles. However, they were similar to dreams in their emotional quality, the irritation they caused, and in their vividness. In conclusion, hypnagogic states are quite common.

1. Introduction

The hypnagogic state refers to the transitional phase between wakefulness and sleep, in which vivid experiences occur (Maury, 1848). These experiences can occur in all modalities: Visual, auditory, taste, smell, touch, the feeling of falling, or even out-of-body experiences (Sherwood, 2012). They are mostly benign and generally have either a positive or no specific emotional quality (Schacter, 1976). However, in rare cases, hypnagogic experiences can become bothersome and develop a negative emotional quality (Hinton et al., 2019). Although hypnagogic states have been investigated for more than a century, reports of their prevalence remain ambiguous, probably related to different degrees of specificity of measurement instruments (see Ghibellini & Meier, 2023, for a recent review). The goal of the present study was to assess the self-reported prevalence of hypnagogic states in a large sample of young adults (N = 4456) considering the frequency of experiences in different modalities (visual, auditory, tactile, kinaesthetic, olfactory and gustatory), characteristics and potential gender differences. Moreover, we compared hypnagogic states to other phenomena, such as dreams, sleep-paralysis, imagination, and extra-sensory perception, and assessed individual differences as predictors.

During sleep, humans cycle through three different sleep stages, which increase in sleep depth before ending up in REM sleep, where typically dreams occur (Patel et al., 2023). When we fall asleep, we transition from wakefulness to an increasingly relaxed drowsiness state, which flows into sleep onset. Our eyes are generally closed, our body rests in a laying position, and our mind begins to roam freely. This very transition marks the beginning of the hypnagogic state (Vaitl et al., 2005). In this state, experiences in all modalities can occur: Visual imagery such as the experience of geometrical shapes and faces, hearing sounds or voices, the sensation of

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touch or falling, smell and taste are a few ways one might experience the hypnagogic state (Jones et al., 2009; McKellar, 1957; Ohayon, 2000; Schacter, 1976; Sherwood, 2012). Hypnagogic states appear as disconnected snapshots, are generally narratively less organized and shorter than dreams (Schacter, 1976). When waking up, that is, at sleep offset, these experiences can also occur, labelled hypnopompic states. This term, however, has not been used consistently (Ghibellini & Meier, 2023). Consequently, we use the term hypnagogic states to refer to both sleep onset and offset hypnagogia.

Different definitions of hypnagogic states have been used throughout research on the phenomena. Most prominently, the hypnagogic state has been defined as "spontaneously appearing visual, auditory and kinaesthetic images; qualitatively unusual thought processes and verbal constructions; tendencies towards extreme suggestibility; symbolic representations of ongoing mental and physiological processes; and so on." (Schacter, 1976, pp. 452 – 453). Therefore, the hypnagogic state can be characterized by both perceptual experiences as well as mental activity, with the latter becoming gradually less thought-like and increasing in dream-like qualities (Rowley et al., 1998; C. Speth & Speth, 2016). As we were primarily interested in the perceptual experiences during the hypnagogic state and the modality they occur in, we operationalized hypnagogic experiences as "experiences of perception in the different modalities at sleep-onset and offset, which may also, although less frequently, occur during wakefulness" (Ghibellini & Meier, 2023 – 3).

The term "hypnagogic hallucinations" has frequently been used to refer to hypnagogic states (American Academy of Sleep Medicine, 2014). A hallucination is defined as a perception-like experience that occurs in the absence of an external stimulus and must occur in the state of clear sensorium (American Psychiatric Association, 2013). As a pathological phenomenon, the term "hallucination" is misleading when applied to hypnagogic experiences that fall within the range of normal perception. Researchers have suggested additional differences between hallucinations and hypnagogic states, highlighting that hallucinations are typically integrated with internal representations and can affect an individual's sense of self, beliefs, or personal narrative, whereas hypnagogic experiences do not (Waters et al., 2016).

In addition, hallucinations are typically experienced with open eyes, and the hallucination is superimposed onto veridical perceptions and located externally of the individual's self (Waters et al., 2016; Waters & Fernyhough, 2017). Hypnagogic states, on the other hand, typically occur in the drowsy state of sleep onset when eyes are generally closed. In such cases, a hypnagogic experience could not be labelled as a "hallucination". If these experiences occur during sleep onset with open eyes, however, they could be classified as hallucinations. It is unclear whether these experiences with open and closed eyes differ, as the label "hypnagogic hallucinations" has generally been used for closed-eyes experiences, and a study differentiating the two has remained absent. In this study, we refer to hypnagogic experiences with eyes closed. We deem it important to recognize the differences between pathological hallucinations and normal hypnagogic states and to avoid projecting the stigma associated with the former onto the latter. Therefore, we refrained from labelling hypnagogic experiences as "hypnagogic hallucinations" in this study.

1.1. Prevalence

Reports on the prevalence of hypnagogic states have been quite ambiguous (for a review, see Ghibellini & Meier, 2023). While some sources claimed hypnagogic states to occur quite frequently in the general population, others claimed them to be rare. Early assessments of the hypnagogic state reported an average prevalence of around 72 % to 77 % (Schacter, 1976). McKellar (1972) reported a prevalence of 76 % of hypnagogic states in their investigations conducted with university students (McKellar, 1957; McKellar & Simpson, 1954). Here, hypnagogic states were defined as "Imagery of any sense, frequently of intense, almost hallucinatory vividness, experienced in the drowsy state before sleep" (McKellar & Simpson, 1954, p. 270). In her unpublished doctoral thesis, Owens placed the prevalence of hypnagogic states at 77 % in a group of female participants (Owens, 1963, as cited in McKellar, 1972). Lastly, Buck and Geers (1967) investigated, amongst other things, hypnagogic states in a sample of 91 university students and reported a prevalence of 72 %. Recent studies, however, reported significantly lower prevalences of hypnagogic states.

In a telephone survey by Ohayon et al. (1996), hypnagogic states were assessed in a general population sample from the United Kingdom consisting of 4972 participants. Participants received several examples of hypnagogic experiences, such as being caught in a fire, the feeling of a presence in the room, or the vivid sensation of being attacked. Experiences were limited to the auditory, visual, and kinetic modalities. On average, hypnagogic states at sleep onset occurred in 37 %, while hypnagogic states at sleep offset occurred in 12.5 % of participants at least twice a week within the recent year. Prevalences were slightly higher in women and younger individuals.

In a later study, Ohayon (2000) examined hypnagogic states in a general population sample based in the United Kingdom, Germany, and Italy and reported slightly lower prevalences. In this study, a broader and more neutral approach was taken to assess hypnagogic experiences. Participants were asked about hypnagogic experiences for each modality, including out-of-body experiences. The participants were asked, for instance, whether they had smelled something others could not smell or seen something others could not see. Of 13′057 participants, only 24.8 % reported experiencing these states at sleep onset and 6.6 % at sleep offset, and hypnagogic states were more prevalent in women than men.

Fulda et al. (2008) assessed the hypnagogic state among other parasomnias in a sample of 65 healthy participants , 65 psychiatric patients, and 50 sleep-disordered patients when validating the Munich Parasomnia Screening (MUPS). The questionnaire was completed on paper unsupervised by the researchers. Hypnagogic states were defined as "auditory or visual illusions that accompany falling asleep or waking in a distressing or threatening manner (e.g., hearing sounds or voices, or seeing people or things that are not in the room)" and were assessed with one item only. Of these 65 healthy participants, only 6.2 % reported experiencing the hypnagogic state.

Jones et al. (2009) reported a much higher prevalence of hypnagogic states. The questionnaire was administered to a sample of 365 university student. They assessed hypnagogic experiences online with 14 items related to a specific experience occurring in a specific

modality. In total, 85 % of participants reported hypnagogic experiences.

The variability in prevalence estimates is likely due to differences in how the hypnagogic state was defined. Some studies asked for specific experiences, such as hearing one's name (e.g., Jones et al., 2009), whereas others asked for broader experiences, such as hearing something others cannot hear (e.g., Ohayon, 2000). Further, some studies asked for experiences with strong emotional quality, such as the feeling of being set ablaze (e.g., Ohayon et al., 1996). In contrast, others asked for non-emotional experiences, such as the feeling of falling (e.g., Ohayon, 2000). It is thus unsurprising that reported prevalences varied to such a large extent. A broader and more neutral approach would prove beneficial in assessing the hypnagogic state to disentangle prevalence measures from other influential factors (Ghibellini & Meier, 2023). Hence, we were interested in the resulting self-reported prevalence of hypnagogic experiences, independently of their emotional quality and the specificity of experiences.

The variability in prevalence may also be due to the properties of the particular samples. As suggested by the studies of Ohayon, hypnagogic states seem to be more prevalent in women (Ohayon, 2000; Ohayon et al., 1996). Although this has not been tested systematically, it may influence the variability of prevalence estimates. Moreover, sleep differs between men and women: Women exhibit better sleep quality compared to men (Goel et al., 2005). However, they report more sleep problems, such as inadequate sleep time and insomnia (Bixler et al., 2002; Zhang & Wing, 2006). Thus, we were particularly interested in gender differences in the present study and whether women and men reported experiencing the hypnagogic state differently, providing a more detailed understanding of the phenomenon.

Hypnagogic states can occur both when falling asleep and before waking up. Generally, hypnagogic states at sleep onset appear more prevalent than at sleep offset (Ohayon, 2000; Ohayon et al., 1996; Ohayon & Shapiro, 2000). However, hypnagogic states can also occur during the day (Gurstelle & de Oliveira, 2004). These episodes of daytime hypnagogia are especially prevalent in individuals with narcolepsy (Fortuyn et al., 2009), likely due to excessive daytime sleepiness. They can, however, also occur in individuals without narcolepsy (Steen, 2017), but a prevalence measure of how often daytime hypnagogia occurs in the general population has not been reported yet. It can be expected that daytime hypnagogia is more prevalent in individuals who exhibit greater sleepiness during the day.

1.2. Modality of hypnagogic states

Reports on the frequency of hypnagogic experiences in different modalities have also been ambiguous. Early questionnaire-studies named visual experiences to be the most frequent (Foulkes & Vogel, 1965; Green et al., 1970), with the exception of one study labelling auditory experiences as the most frequent (McKellar & Simpson, 1954). The predominance of visual experiences in the hypnagogic state was further emphasized by electroencephalographic studies probing participants at sleep onset when hypnagogic experiences occurred (Hori et al., 1994; Rowley et al., 1998; Wackermann et al., 2002). It is unclear from the reports of these studies, however, whether researchers recorded the prominent feeling of falling at sleep onset as a kinaesthetic experience (Bertini et al., 1964; Oswald, 1962; Whitney & Weiss, 2018).

More recent questionnaire-studies reported haptic and kinaesthetic experiences, such as the feeling of falling (Ohayon, 2000) or the feeling of a presence in the room (Jones et al., 2009), as the most frequent hypnagogic experiences. An extensive questionnaire study by Sherwood concluded visual experiences to be the most prominent, followed by the feeling of falling and felt presence experiences (Sherwood, 2012). Participants reported auditory experiences less often, and perceptions of taste and smell were the least prevalent hypnagogic experiences.

1.3. Differentiation from other phenomena

Hypnagogic states share similarities with other phenomena, such as dreams, sleep paralysis, imagination, and extra-sensory perception. To provide a more fine-grained characterization of hypnagogic states, we compared their self-reported prevalence and modality profile to these phenomena. This allowed us to identify unique defining characteristics of the hypnagogic state.

1.3.1. Dreams

For example, hypnagogic states resemble dreams, that is, the subjective experiences that occur during sleep (Schredl, 2018). However, while dreams occur during sleep, hypnagogic states precede sleep or occur when waking up (Vaitl et al., 2005). Moreover, dreams involve more agency than hypnagogic experiences (McKellar & Simpson, 1954; J. Speth et al., 2013, 2017). Accordingly, individuals often act as direct participants in their dreams, contrary to passive spectators in hypnagogic states (McKellar & Simpson, 1954; Waters et al., 2016). Dreams are generally longer and less thought-like (Zadra & Domhoff, 2017) and contain fewer episodic memories (Baylor & Cavallero, 2001). In addition, hypnagogic states have been described as more vivid than dreams, and dreams are far more prevalent than hypnagogic states (Chokroverty, 2017; McKellar & Simpson, 1954; Pagel, 2003).

1.3.2. Sleep paralysis

Another phenomenon that bears a resemblance to hypnagogic states are sleep paralysis-related experiences. During sleep paralysis, individuals cannot perform voluntary movements, however, respiration is usually unaffected. Consciousness is preserved while hallucinations can accompany these episodes (American Academy of Sleep Medicine, 2014). Sleep paralysis and hypnagogic states can both occur at sleep onset and offset. As such, sleep paralysis-related experiences can be subordinated to hypnagogic states. However, sleep paralysis occurs less often than hypnagogic states: Sharpless and Kliková systematically reviewed the prevalence of sleep paralysis and reported an average prevalence of 7.6 % in general population samples (Sharpless & Kliková, 2019). More importantly,

however, sleep paralysis-related experiences are often described as terrifying (Cheyne, 2003; Sharpless & Kliková, 2019), whereas typically, hypnagogic states without sleep paralysis are not.

1.3.3. Imagination

At first glance, hypnagogic states might be mistaken for imagination, "the power or capacity to form internal images or ideas of objects and situations not actually present to the senses" (Abraham, 2020, p. 3). However, imagination is usually self-generated and occurs in a state of clear sensorium. Hypnagogic states, however, occur spontaneously (Schacter, 1976), and if they occur during the day, some degree of sleepiness is usually involved. Further, almost everyone engages in imagination, whereas not everyone experiences hypnagogic states. Accordingly, research on aphantasia, the inability to evoke mental imagery, estimates that only 3.9 % of the population cannot engage in visual imagination (Dance et al., 2022). Thus, imagination is more prevalent than hypnagogic states and under higher degree of volitional control.

1.3.4. Extra-sensory perception

Interestingly, the hypnagogic state has been proposed as highly conducive to extra-sensory perception (Del Prete & Tressoldi, 2005). Extra-sensory perception covers a wide range of phenomena, such as "telepathy, thought-transference, mind reading, clairvoyance, telesthesia, and cryptesthesia" (Rhine, 1940, p. 450). Beliefs in extra-sensory perceptions are quite prevalent in the general population: In a representative sample from the USA of $N = 1255$ participants, 60.1 % of participants expressed beliefs in extra-sensory perception. Hypnagogic experiences could be misinterpreted as extra-sensory perceptions, especially if a person has prior beliefs in such phenomena (Sherwood, 2002). Thus, we also assessed the self-reported prevalence of extra-sensory perception.

1.4. Individual differences

Several individual differences factors have been linked to the frequency of occurrence of hypnagogic experiences such as psychiatric disorders, sleep-related characteristics, and personality features (for a review, see Ghibellini & Meier, 2023; Waters, Moretto, & Dang-Vu, 2017). For instance, anxiety and depression were associated with increased hypnagogic occurrences (Bosch et al., 2012; Ohayon, 2000; Szklo-Coxe et al., 2007). Schizophrenia, is also associated with more frequent hypnagogic states (Bosch et al., 2012; Fortuyn et al., 2009) and individuals exhibiting strong beliefs in paranormal phenomena are also more likely to report hypnagogic experiences (Pizzagalli et al., 2000). Previous research has also linked schizotypy with unusual sleep experiences (Koffel & Watson, 2009) and schizotypal personality seems to be more prone to hypnagogic experiences (Parra & Paul, 2009). Low conscientiousness and high neuroticism were associated with poor sleep hygiene, quality and daytime sleepiness, whereas low agreeableness was only associated with poor sleep hygiene and daytime sleepiness (Duggan et al., 2014; Križan & Hisler, 2019; Sutin et al., 2020). Critically, poor sleep-hygiene, poor sleep-quality, and daytime sleepiness have been associated with more frequent hypnagogic experiences (Ohayon et al., 1996). Given the importance of sleep in hypnagogic states, personality might very well be associated with such experiences. Thus, we also assessed the big five personality factors in the present study.

The hypnagogic state has been labelled a state of extreme suggestibility (Schacter, 1976). One could argue that the hypnagogic state resembles a state of trance during hypnosis: During both, individuals are in a drowsy state of increased internal awareness (Demertzi et al., 2015). Moreover, individuals high in suggestibility were shown to enter the hypnotic state more easily (Kirsch & Braffman, 2001). Thus, we were curious to explore whether individuals high in suggestibility would be more susceptible to influence from previous daytime activities. Suggestibility as a personality trait is characterized by a general tendency to accept messages uncritically (Kotov et al., 2004). Since individuals are more suggestible in the hypnagogic state than when awake (Schacter, 1976), increased suggestibility could relate to a higher receptivity towards hypnagogic experiences.

Chronotype refers to the behavioural trait of preference to schedule activities during morning or evening hours (Partonen, 2015). Individuals can be categorized as morning or evening types based on their preferences (Horne & Östberg, 1976). Accordingly, morning types achieve peak mental and physical performance early during the day, whereas evening types do so towards the end of the day (Adan et al., 2012). The chronotype has been associated with numerous health outcomes, sleep quality and duration, and psychiatric disorders (Kivelä et al., 2018; Partonen, 2015). Interestingly, chronotypes have even been associated with parasomnias (Nielsen, 2010; Wei & Praharaj, 2019). However, the relationship between chronotypes and hypnagogic states has not been assessed yet.

1.5. Aims of the current study

To summarize, the main goal of this study was to explore the self-reported prevalence of hypnagogic states and investigate possible gender-differences. We used a broad and emotionally neutral definition to assess the specificity of these experiences and their emotional quality separately, as prevalence measures have previously been confounded with these qualities. Moreover, we were interested in the frequency of hypnagogic experiences in different modalities, their emotional quality, the degree to which they are perceived as irritating, and their vividness, thus providing a profile of hypnagogic states. To differentiate hypnagogic states from other phenomena, we also assessed the self-reported prevalence of dream-recall, sleep paralysis, imagination, and extra-sensory perception. Differences in the modality of occurrence as well as characteristics (emotional quality, irritation caused, and vividness) of hypnagogic states compared with other phenomena provides a more fine-grained understanding of the specific properties of hypnagogic states. To our knowledge, no study has yet been conducted comparing hypnagogic states with similar phenomena systematically. Lastly, we aimed to explore possible factors associated with hypnagogic states.

2. Method

2.1. Participants

We collected data on three different occasions. Reports were collected anonymously, and the ethical committee of the University of Bern approved the study.

The first wave consisted of 687 undergraduate psychology students from the University of Bern (141 male, 544 female, two who did not identify as male or female) between the age of 18 and 39 ($M = 21.88$, $SD = 2.66$) in 2020. The average age for male participants was $M = 22.70$ ($SD = 2.22$) years, ranging from 18 to 29 years of age. The average age for female participants $M = 21.67$ ($SD = 2.72$) years, ranging from 18 to 39 years of age. They signed up through an internal university web system and were rewarded with a credit towards the fulfilment of curriculum requirements. Participants completed the questionnaire-battery online.

The second wave consisted of 2420 participants (967 male, 1453 female) from the general population between the age of 18 and 30 ($M = 22.22$, $SD = 2.61$). The average age for male participants was $M = 22.24$ ($SD = 2.62$) years, ranging from 18 to 30 years of age. The average age for female participants was $M = 22.22$ ($SD = 2.60$) years, ranging from 18 to 30 years of age. They were recruited by undergraduate students as part of a research course at the University of Bern in 2020 and were not compensated for their participation. Participants completed the questionnaire-battery on a computer in the presence of the experimenter.

The third wave consisted of 1349 participants (553 male, 796 female) from the general population between the age of 18 and 30 ($M = 22.28$, $SD = 3.08$). The average age for male participants was $M = 22.75$ ($SD = 3.20$) years, ranging from 18 to 39 years of age. The average age for female participants $M = 21.95$ ($SD = 2.95$) years, ranging from 18 to 33 years of age. They were recruited by undergraduate students as part of a research course at the University of Bern in 2021 and were not compensated for their participation. Participants completed the questionnaire-battery on a computer in the presence of the experimenter.

2.2. Questionnaire-battery

We designed a questionnaire to assess the self-reported prevalence, modalities, and characteristics of hypnagogic states (see Table 1). We assessed the same characteristics of other phenomena such as dreams, sleep paralysis-related experiences, imagination, and extra-sensory perception for comparison (see Appendix B for the translated questionnaire). Moreover, we addressed individual differences, such as schizotypal personality, daytime sleepiness, anxiety and depression, suggestibility, chronotype and personality. The total questionnaire-battery consisted of 201 items and required approximately 30 min for completion.

2.2.1. Prevalence measures

We provided participants with a brief description of the phenomena in question and proceeded to ask whether or how often they had experienced the different phenomena before. We defined them as “vivid subjective visual perceptions that typically appear spontaneously at the transition between waking and sleeping. The shape of these perceptions can vary strongly, as they can also express themselves in other ways: Visual (e.g. pictures, colors, or geometric shapes), auditory (e.g. hearing noises or voices), tactile (e.g. touch or feeling pain), kinaesthetic (e.g. a feeling of leaving the body or falling, or twitches), and smell or taste sensations.” Participants were given the option to respond with “never”, “rarely”, or “regularly”. We then asked participants whether they experienced hypnagogic states at sleep onset, sleep offset or at other times during the day, with the opportunity to describe their experiences and when they occurred.

For the other phenomena, participants were asked to rate the frequency of occurrence on a scale ranging from “never”, less than once a year”, “multiple times a year”, “multiple times a month”, “multiple times a week”, or “every night”.

2.2.2. Modalities

Next, we asked participants to rate how often these phenomena occurred in the different modalities. Participants were asked to rate the visual, auditory, tactile, kinesthetic, olfactory and gustatory modalities. The rating scale ranged from “never” to “rarely”,

Table 1
Questionnaire-battery structure.

Questionnaire	Topic
Hypnagogic states*	Frequency, modality, emotional quality, irritation, vividness
Dreams*	Frequency, modality, emotional quality, irritation, vividness
Sleep paralysis*	Frequency, modality, emotional quality, irritation, vividness
Imagination*	Frequency, modality, emotional quality, irritation, vividness
Extra-sensory perception*	Frequency, modality, emotional quality, irritation, vividness
Schizotypal personality questionnaire (SPQ; Raine, 1991)	Magical thinking, unusual perceptions, eccentric behaviour, suspiciousness
Epworth sleepiness scale (ESS; Müller et al., 2000)	Daytime sleepiness
Hospital anxiety and depression scale (HADS; Herrmann et al., 1995)	Anxiety, depression
Short suggestibility scale (SSS; Kotov et al., 2004)	Suggestibility
Morningness-eveningness-questionnaire (D-MEQ; Griefahn et al., 2001)	Chronotype
NEO five-factor inventory (NEO-FFI; Borkenau & Ostendorf, 2008)	Neuroticism, extraversion, openness to experience, conscientiousness, agreeableness

Note. *These questionnaires were developed by the authors and are presented in Appendix B.

"regularly", and "always".

2.2.3. Characteristics

We assessed three characteristics of the phenomena and related experiences: Their emotional quality, the degree to which participants perceived these experiences as irritating and how vivid or real these experiences seemed to the individual. Participants rated their experiences on a 7-point Likert scale ranging from "negative" to "positive" for emotional quality and "not at all" to "very much" for irritation and vividness.

2.2.4. Schizotypal personality questionnaire (SPQ)

The SPQ consists of nine scales in total, each of which relates to one of the nine diagnostic criteria according to the DSM-III-R (Raine, 1991). We used four scales of the German version of the schizotypal personality questionnaire (Klein et al., 1997), namely "magical thinking" with 7 items, "unusual perceptions" with 9 items, "eccentric behaviour" with 7 items, and "suspiciousness" with 8 items (i.e., a total of 31 items). Participants rate each item on a dichotomous response scale with "yes" or "no".

2.2.5. Epworth sleepiness scale (ESS)

We used the German translation (Müller et al., 2000) of the Epworth sleepiness scale (Johns, 1991) to measure participants' general daytime sleepiness. The scale consists of 8 items, in which participants are asked to rate their likeliness of dozing off in different situations during the day. Participants rate each item on a four-point scale, ranging from "no chance of dozing" to "high chance of dozing".

2.2.6. Hospital anxiety and depression scale (HADS)

The hospital anxiety and depression scale (Zigmond & Snaith, 1983) is a 14 item screening questionnaire with two scales for depression and anxiety, consisting of 7 items each. Participants rate each item on a four-point scale, with individual response categories per item. Here, we used the German translation of the HADS (Herrmann et al., 1995).

2.2.7. Short suggestibility scale (SSS)

The short suggestibility scale is a 21 item scale and a short version of the longer 95 item multidimensional Iowa suggestibility scale (Kotov et al., 2004). Suggestibility is thereby viewed as a personality trait and a general tendency to accept messages. Items are rated on whether the statements apply to the questioned individual on a five-point Likert scale ranging from "not at all or very slightly" to "a lot".

2.2.8. Morningness-eveningness-questionnaire (D-MEQ)

We used the German version of the morningness-eveningness-questionnaire (Griefahn et al., 2001) to assess the chronotype of the participants. Participants are questioned on their preferred time to wake up and go to bed or when they feel the most productive during the day. The questionnaire consists of 19 items, distinguishing between morning types, neither types and evening types.

2.2.9. NEO five-factor inventory (NEO-FFI)

The NEO-FFI (Costa & McCrae, 1992) is a 60 item inventory assessing the big five personality factors neuroticism, extraversion, openness to experience, conscientiousness and agreeableness. In this study, we used the German translation of the NEO-FFI (Borkenau & Ostendorf, 2008). Each of the five personality factors is evaluated with a scale of 12 items, rated on a five-point Likert scale, encompassing a total of 60 items.

2.3. Procedure

The questionnaire battery was always presented in the same order. First, participants answered questions about the frequency of hypnagogic states and were asked about the time of occurrence (sleep onset, sleep offset, or other). We also asked participants to

Table 2
Questionnaires sample size.

	Sample Women	Sample Men	Total Participants
Hypnagogic states	2793	1661	4456
Dreams	2793	1661	4456
Sleep paralysis	2793	1661	4456
Imagination	2793	1661	4456
Extra-sensory perception	2793	1661	4456
Schizotypal personality (SPQ)	2793	1661	4456
Daytime sleepiness (ESS)	2793	1661	4456
Anxiety and depression (HADS)	2793	1661	4456
Suggestibility (SSS)	2793	1661	4456
Morningness-eveningness-questionnaire (D-MEQ)	1827	1017	2846
Big five personality (NEO-FFI)	1285	876	2161

describe when they experienced the hypnagogic state at other times than sleep onset or offset and prompted them to describe their experiences. These reports were not analyzed statistically, but a brief description of the most prominent responses is presented in the discussion. Next, participants were presented with questions about the different modalities, followed by questions about emotional quality, irritation and vividness.

This same structure was then used to assess dreams, sleep paralysis, imagination and extra-sensory perception, except that

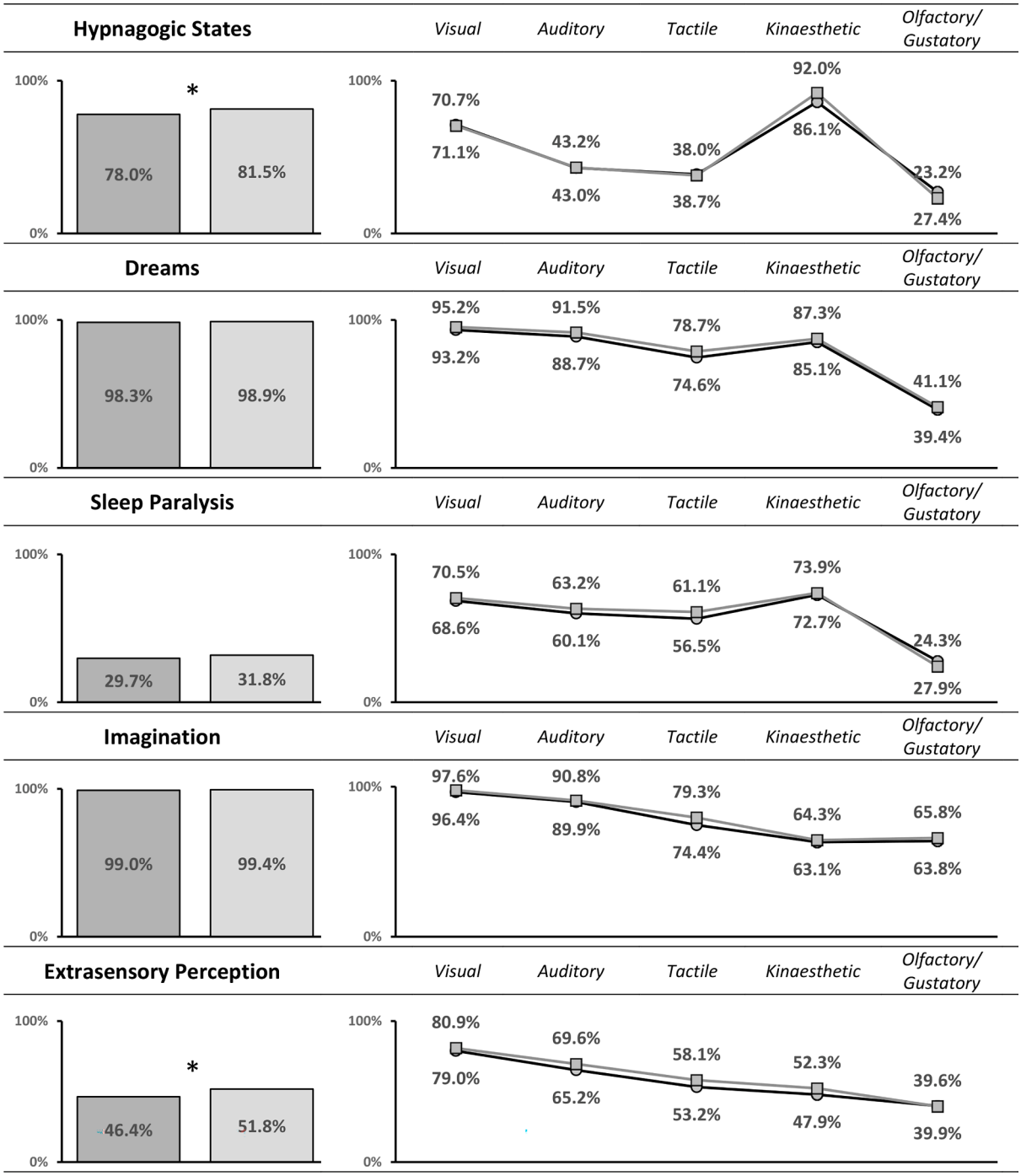

Fig. 1. Prevalences and frequency of modalities for the different phenomena. For prevalences, the left bar corresponds to men, and the right bar to women. For modalities, circles correspond to male and squares to female participants. The modalities were summarized across waves. Percentages are rounded to the first decimal place. Hypnagogic states were reported by N = 3574 participants, dreams by N = 4397 participants, sleep paralysis by N = 1383 participants, imagination by N = 4423 participants, and extra-sensory perception by N = 2218 participants.

questions about the time of occurrence and the respective descriptions were not asked. We implemented a skip logic if participants responded that they had never experienced a phenomenon.

Next, participants filled out the four selected scales of the schizotypal personality questionnaire (SPQ), followed by the Epworth sleepiness scale (ESS) and the two scales of the hospital anxiety and depression scale (HADS). Then, participants filled out the short suggestibility scale (SSS). In the last part, participants filled out the morningness-eveningness-questionnaire (D-MEQ) and the NEO-FFi. Administration of the questionnaire-battery varied slightly amongst waves of data collection. As a result, the D-MEQ and NEO-FFI were not completed by all participants. The sample size for each questionnaire can be found in Table 2.

In the first wave, students had previously completed the D-MEQ as part of their registration for the internal university web system, with the exception of two students. As part of an online questionnaire study, they completed all questionnaires with the exception of the NEO-FFI. Of the initial N = 704 respondents who signed up for the study, 17 (1.85 %) did not complete the whole questionnaire-battery (final $N = 687$, and $N = 685$ for the D-MEQ).

In the second wave, participants were recruited by undergraduate students for an empirical research method course. The questionnaires were used to create retention intervals for a memory study which had to conditions: short interval and long interval. Participants were between 18 and 30 years old. The experimenter was present in case participants needed computer assistance. The short interval condition consisted of all questionnaires up to the short suggestibility scale (SSS), see Table 1. The long interval condition included all the other questionnaires (i.e., D-MEQ and NEO-FFI, in addition). Of the total of $N = 2420$ recruited participants, 1608 only completed the first part and 812 completed the whole questionnaire-battery. Due to a technical error, data on the modality of the hypnagogic state was not recorded in this sample.

In the third wave, participants were also recruited by undergraduate students for an empirical research method course. Again, the questionnaires were used to create a retention interval for a memory study, however, unlike the second wave, there was only one retention interval condition (i.e., long interval.) Participants were between 18 and 40 years old and all of them ($N = 1349$) completed all questionnaires.

2.4. Statistical analyses

First, we evaluated the reported frequency and time of occurrence of hypnagogic states, and explored gender differences. Second, we analyzed the self-reported prevalence of hypnagogic states and the other phenomena, evaluated their modalities, and investigated gender-differences in self-reported prevalences using a chi-squared test. Third, we analyzed the characteristics of hypnagogic states and the other phenomena using repeated-measures ANOVAs. We conducted post hoc analyses and applied Tukey's corrections for pairwise comparisons. Further, we analyzed how the characteristics differed based on the reported frequency of hypnagogic states and gender using independent sample t-tests. Last, we analyzed differences in the frequency of hypnagogic states based on chronotype using a chi-square test and the relationship between the individual differences and the frequency of hypnagogic for women and men separately using logistic regression analysis.

3. Results

3.1. Frequency of hypnagogic states and gender-differences

Of the total of N = 4456 participants, 25.5 % of participants reported experiencing hypnagogic states regularly, 54.7 % reported experiencing them rarely, and 19.8 % reported not experiencing them. For men, 23.1 % reported experiencing hypnagogic states regularly, 54.8 % reported experiencing them rarely, and 22 % reported not experiencing them. For women, 26.9 % reported experiencing hypnagogic states regularly, 54.6 % reported experiencing them rarely, and 18.5 % reported not experiencing them.

Of the N = 3574 participants who reported experiencing hypnagogic states, 85.5 % reported experiencing hypnagogic states at sleep onset, 47.3 % % reported experiencing them at sleep offset, and 34.1 % reported experiencing them at other times. For men, 83.9 % reported experiencing hypnagogic states at sleep onset, 50.6 % reported experiencing them at sleep offset, and 37.5 % reported experiencing them at other times. For women, 86.3 % % reported experiencing hypnagogic states at sleep onset, 45.5 % reported experiencing them at sleep offset, and 32.1 % reported experiencing them at other times.

3.2. Modality profiles and gender-differences

The self-reported prevalence of hypnagogic states compared to other phenomena and profiles based on the prevalences in different modalities and by gender are presented in Fig. 1. In total, 80.2 % of participants reported experiencing hypnagogic states. Hypnagogic states were most frequent in the kinaesthetic (90.3 %) modality, followed by the visual (70.9 %) and auditory (43.1 %) modalities. Hypnagogic experiences were the least often tactile (38.3 %) and olfactory or gustatory (24.6 %). Overall, women reported hypnagogic states more often than men, with 81.5 % of women reporting hypnagogic states and 78 % of men reporting hypnagogic states. A chi-square test of association further confirmed a significant gender-effect, $\chi^2(1, N = 4454) = 8.31$, $p = .004$, $d = 0.09$.

Dream recall was more prevalent than reported hypnagogic states. In total, 98.7 % of participants reported dreaming. Dreams were most often visual (94.4 %) and auditory (90.5 %), followed by kinaesthetic (86.4 %) and tactile (77.2 %) experiences. They occurred the least in the olfactory or gustatory modalities (40.5 %). Overall, the prevalence of dreams was comparable for both men and women, as 98.3 % of men reported dreaming, and 98.9 % of women reported dreaming.

Sleep paralysis, however, was the rarest of the assessed phenomena. In total, 31.1 % of participants reported having experienced

sleep paralysis. Sleep paralysis-related experiences were most often kinaesthetic (73.5 % %), followed by visual (69.9 %), auditory (62.1 %), and tactile (59.4 %) experiences. Sleep paralysis was the least accompanied by olfactory or gustatory experiences (25.7 %). Prevalences for men and women were comparable, as 29.7 % of men reported previous sleep paralysis experiences, and 31.8 % % of women reported previous sleep paralysis experiences.

Imagination was the most prevalent phenomenon. In total, 99.3 % of participants reported having imagination. Imagination was most frequently visual (97.1 %) and auditory (90.4 %). Imagination was the least often tactile (77.5 %), olfactory or gustatory (65 % %), and kinaesthetic (63.9 %). The prevalence of imagination was comparable for men and women, as 99.0 % of men reported imagination, and 99.4 % of women reported imagination.

Lastly, 49.8 % of participants reported previous extra-sensory experiences. Extra-sensory experiences were most often visual (80.2 %) and auditory (68.1 %), followed by experiences in the tactile (56.4 %) and kinaesthetic (50.8 %) modalities. Extra-sensory experiences were the least often olfactory or gustatory (39.7 %). Overall, women reported extra-sensory perception more often than men, as 46.4 % of men reported extra-sensory perception, whereas 51.8 % of women reported extra-sensory perception. A chi-square test of association confirmed a significant gender-effect for the self-reported prevalence of extra-sensory experiences, $\chi^2(1, N = 4454) = 12.54$, $p < .001$, $d = 0.11$.

All other self-reported prevalences between men and women did not differ significantly. The reported prevalence for each assessed phenomenon across the distinct waves of data collection can be found in Table A1.

3.3. Characteristics and gender-differences

Descriptives are presented in Table 3. We performed three separate repeated measures ANOVAs for the three characteristic measures. The perceived emotional quality ($F_{Huynh\text{-}Feldt}(3.63, 2585.45) = 305.68$, $p < .001$, $\eta_p^2 = 0.30$), irritation ($F_{Huynh\text{-}Feldt}(3.76, 2675.19) = 96.03$, $p < .001$, $\eta_P^2 = 0.12$), and vividness ($F_{Huynh\text{-}Feldt}(3.90, 2776.76) = 47.57$, $p < .001$, $\eta_P^2 = 0.06$) all differed significantly across phenomena.

First, hypnagogic states were perceived as more positive than sleep paralysis ($p < .001$) and more negative than imagination ($p < .001$). Sleep paralysis was perceived as more negative (all $p < .001$), and imagination as more positive (all $p < .001$) than the other phenomena. All other phenomena did not differ.

Second, hypnagogic states were perceived as less irritating than dreams, sleep paralysis and extra-sensory perception (all $p < .001$). Sleep paralysis was perceived as more irritating than the other phenomena (all p $< .001$). On the other hand, imagination was perceived as less irritating than the other phenomena (all $p < .001$), except for hypnagogic states. All other phenomena did not differ.

Last, hypnagogic states were perceived as more vivid than extra-sensory perception ($p < .005$) and less vivid than dreams and imagination (both $p < .001$). Dreams were perceived as more vivid than the other phenomena (all $p \leq 0.001$). Imagination was perceived as more vivid than hypnagogic states, sleep paralysis and extra-sensory perception (all $p < .001$). Lastly, sleep paralysis was perceived as more vivid than extra-sensory perception ($p < .001$). All other phenomena did not differ.

Next, we compared the characteristics of hypnagogic states according to the reported frequency of occurrence using independent sample t-tests (see Table 4). Most importantly, participants who reported regular hypnagogic states rated them as more positive, $t(3572) = 5.23$, $p < .001$, $d = 0.19$, and more vivid, $t(3572) = 8.45$, $p < .001$, $d = 0.30$, but not as more irritating, $t(3572) = 0.71$, $p = .475$, $d = 0.03$.

Last, we compared reported characteristics of hypnagogic states between women and men (see Table 5). Women rated their hypnagogic experiences as more negative than men, $t(3570) = 3.16$, $p = .002$, $d = 0.11$, more irritating, $t(3570) = -3.08$, $p = .002$, $d = -0.11$, and more vivid, $t(3570) = -3.17$, $p < .001$, $d = -0.12$.

3.4. Individual differences

Finally, we evaluated individual difference measures (see Table 6). Of a total of $N = 2846$ participants who filled out the D-MEQ, $N = 441$ were classified as evening types (15.5 %), $N = 578$ were classified as morning types (20.3 %), and $N = 1827$ were classified as neither morning type nor evening type (64.2 %). A chi-square test of association was performed to assess possible differences in the frequency of hypnagogic states between morning types and evening types (D-MEQ) did not yield significance, $X^2(1, N = 1019) = 0.84$, $p = .656$.

We conducted separate logistic analyses for male and female participants. The logistic regression model was statistically significant

Table 3
Descriptive statistics of the different phenomena.

		Emotional Quality		Irritation		Vividness	
	N	M	SD	M	SD	M	SD
Hypnagogic states	3574	−0.09	1.13	1.57	1.53	3.16	1.65
Dreams	4397	0.17	1.14	1.97	1.55	3.73	1.53
Sleep paralysis	1383	−1.31	1.33	2.88	1.74	3.31	1.68
Imagination	4423	0.73	1.04	1.64	1.43	3.42	1.42
Extra-sensory perception	2218	0.08	1.13	2.26	1.56	3.00	1.41

Note. Emotional quality ranged from −3 (negative) to +3 (positive). Irritation and vividness ranged from 0 (not at all) to 6 (very much).

Table 4
Characteristics of hypnagogic states in relation to frequency of experienced hypnagogic states.

	Rarely			Frequently				
	N	M	SD	N	M	SD	p	d
Emotional quality	2439	−0.16	1.06	1135	0.05	1.24	<0.001	0.19
Irritation	2439	1.56	1.50	1135	1.60	1.57	0.475	0.03
Vividness	2439	3.00	1.63	1135	3.49	1.65	<0.001	0.30

Note. P-values and effect sizes expressed as Cohen's d for independent samples t-tests testing for differences between individuals who reported rare and frequent experiencing hypnagogic states. Emotional quality ranged from −3 (negative) to +3 (positive). Irritation and vividness ranged from 0 (not at all) to 6 (very much).

Table 5
Characteristics of hypnagogic states by gender.

	Men			Women				
	N	M	SD	N	M	SD	p	d
Emotional quality	1295	−0.01	1.15	2277	−0.14	1.11	0.002	0.11
Irritation	1295	1.47	1.50	2277	1.63	1.54	0.002	−0.11
Vividness	1295	3.03	1.63	2277	3.23	1.66	<0.001	−0.12

Note. P-values and effect sizes expressed as Cohen's d for independent samples t-tests testing for differences between men and women. Emotional quality ranged from −3 (negative) to +3 (positive). Irritation and vividness ranged from 0 (not at all) to 6 (very much).

Table 6
Descriptive statistics of individual differences by gender.

	Men		Women		
	M	SD	M	SD	range
Magical thinking (SPQ)	1.66	1.81	2.02	1.90	0–7
Unusual perceptions (SPQ)	2.48	1.92	2.86	1.97	0–9
Eccentric behaviour (SPQ)	1.32	1.61	1.18	1.59	0–7
Suspiciousness (SPQ)	1.85	1.80	2.01	1.89	0–8
Daytime sleepiness (ESS)	8.17	3.99	8.55	4.06	0–24
Depression (HADS)	4.04	3.13	4.07	3.15	0–21
Anxiety (HADS)	6.54	3.51	7.20	3.74	0–21
Suggestibility (SSS)	1.59	0.49	1.68	0.49	0–4
Neuroticism (NEO-FFI)	1.59	0.63	1.80	0.63	0–4
Extraversion (NEO-FFI)	2.31	0.55	2.34	0.54	0–4
Openness (NEO-FFI)	2.46	0.57	2.50	0.56	0–4
Conscientiousness (NEO-FFI)	2.49	0.54	2.52	0.52	0–4
Agreeableness (NEO-FFI)	2.73	0.45	2.86	0.45	0–4

Note. Sample size for the NEO-FFI personality factors: N = 876 men and N = 1285 women. Sample size for all other measures: N = 1661 men and N = 2793 women.

Table 7
Logistic regression analysis on the frequency of hypnagogic experiences for men.

					95 % CI	
Predictor	β	SE	p	Odds ratio	Lower	Upper
Magical thinking (SPQ)	0.08	0.04	0.077	1.08	0.99	1.17
Unusual perceptions (SPQ)	0.17	0.04	<0.001	1.19	1.10	1.30
Eccentric behaviour (SPQ)	0.01	0.05	0.817	1.01	0.92	1.11
Suspiciousness (SPQ)	0.04	0.05	0.362	1.04	0.95	1.14
Daytime sleepiness (ESS)	0.02	0.02	0.353	1.02	0.98	1.05
Depression (HADS)	−0.02	0.03	0.500	0.98	0.93	1.04
Anxiety (HADS)	0.05	0.03	0.061	1.05	1.00	1.10
Suggestibility (SSS)	−0.01	0.15	0.943	0.99	0.74	1.33
Neuroticism (NEO-FFI)	−0.30	0.15	0.043	0.74	0.55	0.99
Extraversion (NEO-FFI)	0.08	0.15	0.597	1.08	0.81	1.44
Openness (NEO-FFI)	0.09	0.12	0.457	1.09	0.86	1.39
Conscientiousness (NEO-FFI)	−0.11	0.13	0.417	0.90	0.69	1.17
Agreeableness (NEO-FFI)	0.49	0.17	0.003	1.63	1.18	2.26

Note. $R^2 = 0.04$ (McFadden), 0.03 (Cox-Snell), 0.05 (Nagelkerke). Model $\chi^2(13) = 67.77$, $p < .001$, AIC = 1731.24, BIC = 1802.87. The samples were combined for this analysis.

for men, $X^2(13, N = 876) = 67.77, p < .001$ (see Table 7) and for women, $X^2(13, N = 1285) = 119.77, p < .001$ (see Table 8). Each model explained 5–6 % of the variance (Nagelkerke R^2). However, the patterns of the results were somewhat different (for a comparison of odds ratios from both Table 7 and Table 8, see Table A3).

For men, reports of hypnagogic states were positively associated with unusual perceptions ($\beta = 0.17, SE = 0.04, p < .001$, Odds Ratio = 1.19, 95 %*CI*[1.10, 1.30]), negatively associated with neuroticism ($\beta = -0.30, SE = 0.15, p = .043$, Odds Ratio = 0.74, 95 %*CI*[0.55, 0.99]), and positively associated with agreeableness ($\beta = 0.4\,9, SE = 0.17, p = .003$, Odds Ratio = 1.63, 95 %*CI*[1.18, 2.26]).

For women, reports of hypnagogic states were positively associated with magical thinking ($\beta = 0.08, SE = 0.03, p = .012$, Odds Ratio = 1.08, 95 %*CI*[1.02, 1.15]) and unusual perceptions ($\beta = 0.20, SE = 0.03, p < .001$, Odds Ratio = 1.22, 95 %*CI*[1.14, 1.30]). Moreover, reports were positively associated with daytime sleepiness ($\beta = 0.03, SE = 0.01, p = .025$, Odds Ratio = 1.03, 95 %*CI*[1.00, 1.06]), openness to experience ($\beta = 0.30, SE = 0.11, p = .005$, Odds Ratio = 1.35, 95 %*CI*[1.10, 1.67]), and agreeableness ($\beta = 0.35, SE = 0.14, p = .012$, Odds Ratio = 1.42, 95 %*CI*[1.08, 1.87]).

4. Discussion

The goal of the present study was to assess the self-reported prevalence of hypnagogic states in a large sample of young adults considering the frequency of experiences in different modalities (visual, auditory, tactile, kinaesthetic, olfactory and gustatory), characteristics and potential gender differences. Moreover, we compared hypnagogic states to dreams, sleep paralysis, imagination, and extra-sensory perception. The results showed that hypnagogic states occurred quite frequently and were more prevalent in women than in men. They were most often kinaesthetic, visual and auditory, and the least often tactile, olfactory or gustatory. They occurred most often at sleep onset, followed by sleep offset and other times during the day. We expected hypnagogic states to occur most often at sleep onset and less often and sleep offset. Interestingly, hypnagogic states were reported to be experienced at other times quite frequently, such as while meditating, during sex, during hypnosis, during sport or when experiencing stress. Other examples include when experiencing pain, during everyday activities, when relaxing, while taking a shower, staring into space, or sitting on a train. Therefore, self-reported instances of daytime hypnagogia mostly occurred when individuals were in a state of drowsiness or when "zoning out".

These self-reported episodes of daytime hypnagogia resemble mind-wandering, in which awareness drifts toward inner thoughts, fantasies, and feelings (Smallwood & Schooler, 2006). Interestingly, local sleep has been proposed to account for these episodes of mind-wandering (see Andrillon et al., 2019; Wienke et al., 2021). Local sleep refers to the local occurrence of sleep-like slow wave events (delta and/or theta waves), which can occur during wakefulness, especially while sleep-deprived (Andrillon et al., 2019; Vyazovskiy et al., 2011). While falling asleep, researchers have suggested that local sleep may account for the emergence of hypnagogic experiences (Siclari et al., 2014; Siclari & Tononi, 2017). These episodes of local sleep could be associated with hypnagogic experiences during the day, like mind-wandering: Daytime hypnagogia could thereby coincide with local sleep activity, and it remains to be investigated whether daytime hypnagogia and mind-wandering reflect the same or different processes.

The questionnaire survey was conducted in response to the unclear prevalence of hypnagogic states documented in the literature. Moreover, our objective was to evaluate hypnagogic states broadly and emotionally neutrally. Therefore, we developed a questionnaire assessing their modality and emotional quality through distinct items. Notably, the self-reported prevalence was higher than in previous studies (e.g. Fulda et al., 2008; Ohayon, 2000; Ohayon et al., 1996). A broader and emotionally neutral definition can capture a broader spectrum of phenomenological expressions of the hypnagogic states, which is why we assume the high self-reported prevalence resulted. Hence, we would encourage future research to opt for an according definition.

Hypnagogic states exhibited a rather clear modality profile: They were predominantly kinaesthetic and slightly less often visual, and modality profiles were comparable between men and women. Other phenomena were much more multimodal and approximately evenly distributed in the modalities they occurred. That hypnagogic states occurred predominantly in the kinaesthetic modality may

Table 8
Logistic regression analysis on the frequency of hypnagogic experiences for women.

					95 % CI	
Predictor	β	SE	p	Odds ratio	Lower	Upper
Magical thinking (SPQ)	0.08	0.03	0.012	1.08	1.02	1.15
Unusual perceptions (SPQ)	0.20	0.03	<0.001	1.22	1.14	1.30
Eccentric behaviour (SPQ)	0.01	0.04	0.855	1.01	0.93	1.09
Suspiciousness (SPQ)	0.03	0.04	0.367	1.03	0.96	1.11
Daytime sleepiness (ESS)	0.03	0.01	0.025	1.03	1.00	1.06
Depression (HADS)	−0.04	0.02	0.117	0.96	0.92	1.01
Anxiety (HADS)	0.03	0.02	0.175	1.03	0.99	1.08
Suggestibility (SSS)	−0.01	0.12	0.966	0.99	0.78	1.27
Neuroticism (NEO-FFI)	−0.02	0.13	0.865	0.98	0.76	1.25
Extraversion (NEO-FFI)	0.01	0.12	0.967	1.01	0.79	1.27
Openness (NEO-FFI)	0.30	0.11	0.005	1.35	1.10	1.67
Conscientiousness (NEO-FFI)	0.03	0.12	0.805	1.03	0.82	1.29
Agreeableness (NEO-FFI)	0.35	0.14	0.012	1.42	1.08	1.87

Note. $R^2 = 0.05$ (McFadden), 0.03 (Cox-Snell), 0.06 (Nagelkerke). Model $\chi^2(13) = 119.77$, $p < .001$, AIC = 2455.43, BIC = 2532.81. The samples were combined for this analysis.

be related to a prevalent feeling of falling (Ohayon, 2000; Sherwood, 2012). We suspect that adaptational processes of the vestibular system may be causal for such occurrences. The body lacks visual input when falling asleep, as the eyes are generally closed. Furthermore, vestibular input differs in a lying position from when we are awake standing. Thus, these circumstances could lead to the vestibular system adapting during sleep onset, which may relate to these frequent kinaesthetic experiences during the hypnagogic state (Ghibellini & Meier, 2023).

In addition, we suspect kinaesthetic hypnagogic experiences, especially the feeling of falling, to be more memorable than experiences in other modalities, as they could be perceived as irritating and potentially waking the individual up during sleep onset. Therefore, such arousing experiences could lead to better memory encoding (Hamann, 2001; Payne & Kensinger, 2010) and an advantage for recalling kinaesthetic hypnagogic experiences compared to the other modalities. Moreover, hypnagogic experiences in the visual and auditory modality often lack narrative structure and appear as "snapshots" (Schacter, 1976), which could result in worse recall during the questionnaire administration. This could explain the discrepancy between studies which immediately probe experiences after recall, generally reporting visual experiences as the most frequent (Hori et al., 1994; Rowley et al., 1998; Wackermann et al., 2002), whereas questionnaire studies typically report kinaesthetic experiences as the most frequent (Jones et al., 2009; Ohayon, 2000; except for Sherwood, 2002).

Women reported hypnagogic states more frequently than men. These findings are consistent with previous literature (Ohayon, 2000; Ohayon et al., 1996), although previous studies did not discuss possible explanations for these findings. Interestingly, similar gender differences can be observed in dream recall (Schredl, 2018; Schredl & Piel, 2003; Schredl & Reinhard, 2008). Women tend to talk more openly about their dreams (Schredl & Schawinski, 2010) and show more engagement regarding their dreams (Schredl, 2000). In this study, no gender-differences in the frequency of dreams likely resulted due to ceiling-effects. We suspect a comparable mechanism: Women might engage more frequently with their hypnagogic experiences, reflect upon them, and thus encode these experiences better than men. However, no statement can be made about whether women would be more engaged with their hypnagogic experiences because they remember them better or because they are more engaged with them.

On average, participants rated hypnagogic states as predominantly emotionally neutral, similar to dreams. Other phenomena tended to express a more apparent emotional quality, such as sleep paralysis-related experiences as more negative or imagination as more positive, compared to hypnagogic states. Moreover, participants rated hypnagogic experiences as less irritating than dreams. We attribute these findings to the brief duration of hypnagogic states and the higher voluntary control over one's body than while dreaming or during sleep paralysis. For extra-sensory perception, we suspect the potentially overwhelming nature of these experiences as the cause of moderate irritation. Lastly, ratings in the vividness of the different experiences did not differ notably. Hypnagogic states were perceived as only slightly less vivid than dreams, and more vivid than extra-sensory perception. Overall, hypnagogic states bear more resemblance to dreams than to the other phenomena we assessed.

Interestingly, participants who regularly experienced hypnagogic states did not rate them as more irritating or negative. Due to increased familiarity, hypnagogic states probably become more enjoyable as one experiences them regularly. Moreover, individuals who regularly experience hypnagogic states may engage more attention and thus perceive them as more vivid. Interestingly, women rated their hypnagogic experiences as more negative, irritating and vivid than men. However, female participants rated the assessed phenomena as overall more negative, more irritating, and more vivid than male participants and also scored higher on anxiety and neuroticism, which may suggest a more general bias (see Table 6 and Table A2).

Notably, we also found differences in individual differences associated with the frequency of hypnagogic states for men and women. For example, the frequency of hypnagogic states was predominantly associated with perception-related facets of schizotypal personality, with daytime sleepiness, and with certain personality factors. Suggestibility was not related to the frequency of hypnagogic states. Similarly, chronotype was also not associated with the frequency of hypnagogic experiences, that is, morning types and evening types reported hypnagogic states comparably frequently.

4.1. Limitations

Despite the valuable insights that this questionnaire study offers, it is important to acknowledge its limitations. First, the decision to exclude children and older adults may have restricted our understanding of experiences across the lifespan. Second, the study relied solely on self-reported data, which may be susceptible to biases and errors. Specifically, the possibility of recall bias exists as participants may have undergone memory decay due to the time between the occurrence and the survey administration. Additionally, some participants may have been hesitant to disclose sensitive information or may not have remembered certain experiences accurately. Therefore, a validation with an external criterion would prove beneficial. Further, we did not differentiate between experiences that occurred with eyes open or closed: This distinction would be beneficial for distinguishing hypnagogic experiences from hallucinations. Finally, we did not assess sleep onset and offset separately, and cannot make any statement regarding their differences. Conclusively, it is crucial to consider these limitations when interpreting the findings of this questionnaire study.

Another prominent approach used to assess the hypnagogic state is the "serial awakening" approach. In this approach, the sleep activity of participants is measured using EEG. They are awakened at specific intervals during the night or over the course of sleep onset and asked about the presence or characteristics of particular experiences. The fact that the participants are 'awakened' suggests they were already sleeping. However, the hypnagogic state is limited to the transition between wakefulness and sleep (Maury, 1848). Serial awakenings, in which the participant is interrupted during the falling asleep process, capture the phenomenon more accurately. It must be considered, however, that experiences of different modalities appear at different times during sleep onset: For example, studies showed that kinesthetic experiences appear earlier than visual ones (Germain & Nielsen, 2001; Hori et al., 1994). Depending on when the participant is interrupted during the falling asleep process, different descriptions may result, which should be accounted for.

However, the benefit of the serial awakening paradigm lies in the fact that the participants are not subject to memory decay, as the experience is directly probed.

5. Conclusion

Hypnagogic states occur frequently and are reported more often by women compared to men. These states primarily manifest as kinaesthetic, visual, and auditory experiences and are most commonly reported at sleep onset. However, they can also occur during other times of the day, particularly when individuals are in a state of drowsiness or "zoning out". Hypnagogic states exhibit an emotionally neutral quality, distinguishing them from experiences such as dreams, sleep paralysis, and imagination that often have more apparent emotional qualities. The high prevalence of hypnagogic states suggests that studies on their function might be an interesting avenue for future research.

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Author contributions

RG and BM designed the study and wrote the manuscript. RG analyzed the data. Both authors contributed to the article and approved the final version.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data can be accessed through OSF (link in manuscript under data availability statement).

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.concog.2023.103582.

References

Abraham, A. (2020). Surveying the Imagination Landscape. In A. Abraham (Ed.), *The Cambridge Handbook of the Imagination* (pp. 1–10). Cambridge University Press. https://doi.org/10.1017/9781108580298.001.

Adan, A., Archer, S. N., Hidalgo, M. P., Di Milia, L., Natale, V., & Randler, C. (2012). Circadian typology: A comprehensive review. *Chronobiology International, 29*(9), 1153–1175. https://doi.org/10.3109/07420528.2012.719971

American Academy of Sleep Medicine. (2014). *International classification of sleep disorders—Third edition (ICSD-3) Online Version*. Westchester, IL: American Academy of Sleep Medicine.

American Psychiatric Association (Ed.). (2013). *Diagnostic and statistical manual of mental disorders: DSM-5 (5th ed)* (5th ed). American Psychiatric Association.

Andrillon, T., Windt, J., Silk, T., Drummond, S. P. A., Bellgrove, M. A., & Tsuchiya, N. (2019). Does the mind wander when the brain takes a break? Local sleep in wakefulness, attentional lapses and mind-wandering. *Frontiers in Neuroscience, 13*. https://doi.org/10.3389/fnins.2019.00949

Baylor, G. W., & Cavallero, C. (2001). Memory sources associated with REM and NREM dream reports throughout the night: A new look at the data. *Sleep, 24*(2), 165–170.

Bertini, M., Lewis, H. B., & Witkin, H. A. (1964). Some preliminary observations with an experimental procedure for the study of hypnagogic and related phenomena. *Archivio Di Psicologia, Neurologia e Psichiatria, 25*, 493–534.

Bixler, E. O., Vgontzas, A. N., Lin, H.-M., Vela-Bueno, A., & Kales, A. (2002). Insomnia in central pennsylvania. *Journal of Psychosomatic Research, 53*(1), 589–592. https://doi.org/10.1016/S0022-3999(02)00450-6

Borkenau, P., & Ostendorf, F. (2008). *NEO-FFI: NEO-Fünf-Faktoren-Inventar nach Costa und McCrae, Manual*.

Bosch, P., van Luijtelaar, G., Groetelaers, L., van den Noort, M., Lim, S., Egger, J., & Coenen, A. (2012). The Munich Parasomnia Screening in psychiatry. *Somnologie - Schlafforschung und Schlafmedizin, 16*(4), 257–262. https://doi.org/10.1007/s11818-012-0587-4

Buck, L. A., & Geers, M. B. (1967). Varieties of consciousness: I. Intercorrelations. *Journal of Clinical Psychology, 23*, 151–152.

Cheyne, J. A. (2003). Sleep paralysis and the structure of waking-nightmare hallucinations. *Dreaming, 13*(3), 163–179. https://doi.org/10.1037/1053-0797.13.3.163

Chokroverty, S. (Ed.). (2017). *Sleep Disorders Medicine: Basic Science, Technical Considerations and Clinical Aspects*. Springer New York. https://doi.org/10.1007/978-1-4939-6578-6.

Costa, P. T., & McCrae, R. R. (1992). Normal personality assessment in clinical practice: The NEO Personality Inventory. *Psychological Assessment, 4*(1), 5–13. https://doi.org/10.1037/1040-3590.4.1.5

Dance, C. J., Ipser, A., & Simner, J. (2022). The prevalence of aphantasia (imagery weakness) in the general population. *Consciousness and Cognition, 97*, Article 103243. https://doi.org/10.1016/j.concog.2021.103243

Del Prete, G., & Tressoldi, P. E. (2005). Anomalous cognition in hypnagogic state with OBE induction: An experimental study. *Journal of Parapsychology, 69*(2), 329.

Demertzi, A., Vanhaudenhuyse, A., Noirhomme, Q., Faymonville, M.-E., & Laureys, S. (2015). Hypnosis modulates behavioural measures and subjective ratings about external and internal awareness. *Journal of Physiology-Paris, 109*(4–6), 173–179. https://doi.org/10.1016/j.jphysparis.2015.11.002

Duggan, K. A., Friedman, H. S., McDevitt, E. A., & Mednick, S. C. (2014). Personality and healthy sleep: The importance of conscientiousness and neuroticism. *PloS One, 9*(3), e90628.
Fortuyn, H. A. D., Lappenschaar, G. A., Nienhuis, F. J., Furer, J. W., Hodiamont, P. P., Rijnders, C. A., … Overeem, S. (2009). Psychotic symptoms in narcolepsy: Phenomenology and a comparison with schizophrenia. *General Hospital Psychiatry, 31*(2), 146–154. https://doi.org/10.1016/j.genhosppsych.2008.12.002
Foulkes, D., & Vogel, G. (1965). Mental activity at sleep onset. *Journal of Abnormal Psychology, 70*(4), 231.
Fulda, S., Hornyak, M., Müller, K., Cerny, L., Beitinger, P. A., & Wetter, T. C. (2008). Development and validation of the Munich Parasomnia Screening (MUPS): A questionnaire for parasomnias and nocturnal behaviors. *Somnologie - Schlafforschung und Schlafmedizin, 12*(1), 56–65. https://doi.org/10.1007/s11818-008-0336-x
Germain, A., & Nielsen, T. A. (2001). EEG power associated with early sleep onset images differing in sensory content. *Sleep Research Online, 4*(3), 83–90.
Ghibellini, R., & Meier, B. (2023). The hypnagogic state: A brief update. *Journal of Sleep Research, 32*(1), Article e13719. https://doi.org/10.1111/jsr.13719
Goel, N., Kim, H., & Lao, R. P. (2005). Gender differences in polysomnographic sleep in young healthy sleepers. *Chronobiology International, 22*(5), 905–915. https://doi.org/10.1080/07420520500263235
Green, E. E., Green, A. M., & Walters, E. D. (1970). Voluntary control of internal states: Psychological and physiological. *The Journal of Transpersonal Psychology, 2*(1), 1.
Griefahn, B., Künemund, C., Bröde, P., & Mehnert, P. (2001). Zur Validität der deutschen Übersetzung des Morningness-Eveningness-Questionnaires von Horne und Östberg. *Somnologie, 5*(2), 71–80.
Gurstelle, E. B., & de Oliveira, J. L. (2004). Daytime parahypnagogia: A state of consciousness that occurs when we almost fall asleep. *Medical Hypotheses, 62*(2), 166–168. https://doi.org/10.1016/S0306-9877(03)00306-2
Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Sciences, 5*(9), 394–400. https://doi.org/10.1016/S1364-6613(00)01707-1
Herrmann, C., Buss, U., & Snaith, R. P. (1995). *HADS-D hospital anxiety and depression scale–Deutsche version*. Bern: Huber.
Hinton, D. E., Reis, R., & de Jong, J. (2019). Ghost encounters among traumatized cambodian refugees: Severity, relationship to PTSD, and phenomenology. *Culture, Medicine, and Psychiatry*.. https://doi.org/10.1007/s11013-019-09661-6
Hori, T., Hayashi, M., & Morikawa, T. (1994). Topographical EEG changes and the hypnagogic experience. In *Sleep onset: Normal and abnormal processes* (pp. 237–253). American Psychological Association. https://doi.org/10.1037/10166-014.
Horne, J. A., & Östberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of Chronobiology, 4*, 97–110.
Johns, M. W. (1991). A new method for measuring daytime sleepiness: The Epworth sleepiness scale. *Sleep, 14*(6), 540–545. https://doi.org/10.1093/sleep/14.6.540
Jones, S. R., Fernyhough, C., & Meads, D. (2009). In a dark time: Development, validation, and correlates of the Durham hypnagogic and hypnopompic hallucinations questionnaire. *Personality and Individual Differences, 46*(1), 30–34. https://doi.org/10.1016/j.paid.2008.08.021
Kirsch, I., & Braffman, W. (2001). Imaginative suggestibility and hypnotizability. *Current Directions in Psychological Science, 10*(2), 57–61. https://doi.org/10.1111/1467-8721.00115
Kivelä, L., Papadopoulos, M. R., & Antypa, N. (2018). Chronotype and psychiatric disorders. *Current Sleep Medicine Reports, 4*(2), 94–103. https://doi.org/10.1007/s40675-018-0113-8
Klein, C., Andresen, B., & Jahn, T. (1997). Erfassung der schizotypen Persönlichkeit nach DSM-III-R: Psychometrische Eigenschaften einer autorisierten deutschsprachigen Übersetzung des“ Schizotypal Personality Questionnaire”(SPQ) von Raine. *Diagnostica*, 43(4), 347–369.
Koffel, E., & Watson, D. (2009). Unusual sleep experiences, dissociation, and schizotypy: Evidence for a common domain. *Clinical Psychology Review, 29*(6), 548–559. https://doi.org/10.1016/j.cpr.2009.06.004
Kotov, R. I., Bellman, S. B., & Watson, D. B. (2004). Multidimensional Iowa Suggestibility Scale (MISS). *Brief Manual., 16*.
Križan, Z., & Hisler, G. (2019). Personality and sleep: Neuroticism and conscientiousness predict behaviourally recorded sleep years later. *European Journal of Personality, 33*(2), 133–153. https://doi.org/10.1002/per.2191
Maury, A. (1848). Des hallucinations hypnagogiques, ou des erreurs des sens dans l’état intermédiaire entre la veille et le sommeil. L. Martinet.
McKellar, P. (1957). *Imagination and thinking; a psychological analysis*. New York, Basic Books. http://archive.org/details/imaginationthink00mckerich.
McKellar, P. (1972). Imagery from the standpoint of introspection. In P. W. Sheehan (Ed.), *The function and nature of imagery* (pp. 35–61). New York.
McKellar, P., & Simpson, L. (1954). Between wakefulness and sleep: Hypnagogic imagery. *British Journal of Psychology, 45*(4).
Müller, T., Fulda, S., Eger, A., Wehrl, R., Liendl, S., Croenlein, T., Wimmer, S., Hein, H., & Geissler, P. (2000). *Epworth Schläfrigkeitsskala–Deutsche Version*.
Nielsen, T. (2010). Nightmares associated with the eveningness chronotype. *Journal of Biological Rhythms, 25*(1), 53–62. https://doi.org/10.1177/0748730409351677
Ohayon, M. M. (2000). Prevalence of hallucinations and their pathological associations in the general population. *Psychiatry Research, 97*(2–3), 153–164. https://doi.org/10.1016/S0165-1781(00)00227-4
Ohayon, M. M., Priest, R. G., Caulet, M., & Guilleminault, C. (1996). Hypnagogic and hypnopompic hallucinations: Pathological phenomena? *British Journal of Psychiatry, 169*(4), 459–467. https://doi.org/10.1192/bjp.169.4.459
Ohayon, M. M., & Shapiro, C. M. (2000). Sleep disturbances and psychiatric disorders associated with posttraumatic stress disorder in the general population. *Comprehensive Psychiatry, 41*(6), 469–478. https://doi.org/10.1053/comp.2000.16568
Oswald, I. (1962). Sleeping and waking: Physiology and psychology. *Elsevier*. https://doi.org/10.1037/11541-000
Pagel, J. F. (2003). Non-dreamers. *Sleep Medicine, 4*(3), 235–241. https://doi.org/10.1016/S1389-9457(02)00255-1
Parra, A., & Paul, L. E. (2009). Exploring the links between nocturnal hallucinatory experiences and personality characteristics. *European Journal of Parapsychology, 24*(2), 139–154.
Partonen, T. (2015). Chronotype and health outcomes. *Current Sleep Medicine Reports, 1*(4), 205–211. https://doi.org/10.1007/s40675-015-0022-z
Patel, A. K., Reddy, V., Shumway, K. R., & Araujo, J. F. (2023). Physiology, Sleep Stages. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK526132/.
Payne, J. D., & Kensinger, E. A. (2010). Sleep’s role in the consolidation of emotional episodic memories. *Current Directions in Psychological Science, 19*(5), 290–295. https://doi.org/10.1177/0963721410383978
Pizzagalli, D., Lehmann, D., Gianotti, L., Koenig, T., Tanaka, H., Wackermann, J., & Brugger, P. (2000). Brain electric correlates of strong belief in paranormal phenomena: Intracerebral EEG source and regional omega complexity analyses. *Psychiatry Research: Neuroimaging, 100*(3), 139–154. https://doi.org/10.1016/S0925-4927(00)00070-6
Raine, A. (1991). The SPQ: A scale for the assessment of schizotypal personality based on DSM-III-R criteria. *Schizophrenia Bulletin, 17*(4), 555–564. https://doi.org/10.1093/schbul/17.4.555
Rhine, J. B. (1940). Extra-sensory perception: A review. *The Scientific Monthly, 51*(5), 450–459.
Rowley, J. T., Stickgold, R., & Allan Hobson, J. (1998). Eyelid movements and mental activity at sleep onset. *Consciousness and Cognition, 7*(1), 67–84. https://doi.org/10.1006/ccog.1998.0333
Schacter, D. L. (1976). The hypnagogic state: Acritical review of the literature. *Psychological Bulletin, 83*(3), 452.
Schredl, M. (2000). Gender differences in dream recall. *Journal of Mental Imagery, 24*(1–2), 169–176.
Schredl, M. (2018). *Researching dreams: The fundamentals*. Springer.
Schredl, M., & Piel, E. (2003). Gender differences in dream recall: Data from four representative German samples. *Personality and Individual Differences, 35*(5), 1185–1189. https://doi.org/10.1016/S0191-8869(02)00327-6
Schredl, M., & Reinhard, I. (2008). Gender differences in dream recall: A meta-analysis. *Journal of Sleep Research, 17*(2), 125–131. https://doi.org/10.1111/j.1365-2869.2008.00626.x

Schredl, M., & Schawinski, J. A. (2010). Frequency of dream sharing: The effects of gender and personality. *The American Journal of Psychology, 123*(1), 93–101. https://doi.org/10.5406/amerjpsyc.123.1.0093
Sharpless, B. A., & Kliková, M. (2019). Clinical features of isolated sleep paralysis. *Sleep Medicine, 58*, 102–106. https://doi.org/10.1016/j.sleep.2019.03.007
Sherwood, S. J. (2002). Relationship between the hypnagogic/hypnopompic states and reports of anomalous experiences. *The Journal of Parapsychology, 66*(2), 127.
Sherwood, S. J. (2012). A web survey of the content, sensory modalities, and interpretation of hypnagogic and hypnopompic experiences. *Journal of Parapsychology, 76*(1), 27.
Siclari, F., Bernardi, G., Riedner, B. A., LaRocque, J. J., Benca, R. M., & Tononi, G. (2014). Two distinct synchronization processes in the transition to sleep: A high-density electroencephalographic study. *Sleep, 37*(10), 1621–1637. https://doi.org/10.5665/sleep.4070
Siclari, F., & Tononi, G. (2017). Local aspects of sleep and wakefulness. *Current Opinion in Neurobiology, 44*, 222–227. https://doi.org/10.1016/j.conb.2017.05.008
Smallwood, J., & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin, 132*(6), 946. https://doi.org/10.1037/0033-2909.132.6.946
Speth, C., & Speth, J. (2016). The borderlands of waking: Quantifying the transition from reflective thought to hallucination in sleep onset. *Consciousness and Cognition, 41*, 57–63. https://doi.org/10.1016/j.concog.2016.01.009
Speth, J., Frenzel, C., & Voss, U. (2013). A differentiating empirical linguistic analysis of dreamer activity in reports of EEG-controlled REM-dreams and hypnagogic hallucinations. *Consciousness and Cognition, 22*(3), 1013–1021. https://doi.org/10.1016/j.concog.2013.07.003
Speth, J., Harley, T. A., & Speth, C. (2017). Auditory verbal experience and agency in waking, sleep onset, REM, and non-REM Sleep. *Cognitive Science, 41*(3), 723–743. https://doi.org/10.1111/cogs.12363
Steen, C. (2017). Synesthetic photisms and hypnagogic visions: A comparison. *Multisensory Research, 30*(3–5), 199–205. https://doi.org/10.1163/22134808-00002557
Sutin, A. R., Gamaldo, A. A., Stephan, Y., Strickhouser, J. E., & Terracciano, A. (2020). Personality Traits and the Subjective and Objective Experience of Sleep. *International Journal of Behavioral Medicine, 27*(4), 481–485. https://doi.org/10.1007/s12529-019-09828-w
Szklo-Coxe, M., Young, T., Finn, L., & Mignot, E. (2007). Depression: Relationships to sleep paralysis and other sleep disturbances in a community sample. *Journal of Sleep Research, 16*(3), 297–312. https://doi.org/10.1111/j.1365-2869.2007.00600.x
Vaitl, D., Birbaumer, N., Gruzelier, J., Jamieson, G. A., Kotchoubey, B., Kübler, A., … Weiss, T. (2005). Psychobiology of altered states of consciousness. *Psychological Bulletin, 131*(1), 98–127. https://doi.org/10.1037/0033-2909.131.1.98
Vyazovskiy, V. V., Olcese, U., Hanlon, E. C., Nir, Y., Cirelli, C., & Tononi, G. (2011). Local sleep in awake rats. *Nature*, *472*(7344), Article 443-447. https://doi.org/10.1038/nature10009.
Wackermann, J., Pütz, P., Büchi, S., Strauch, I., & Lehmann, D. (2002). Brain electrical activity and subjective experience during altered states of consciousness: Ganzfeld and hypnagogic states. *International Journal of Psychophysiology, 46*(2), 123–146. https://doi.org/10.1016/S0167-8760(02)00070-3
Waters, F., Blom, J. D., Dang-Vu, T. T., Cheyne, A. J., Alderson-Day, B., Woodruff, P., & Collerton, D. (2016). What is the link between hallucinations, dreams, and hypnagogic–hypnopompic experiences? *Schizophrenia Bulletin, 42*(5), 1098–1109. https://doi.org/10.1093/schbul/sbw076
Waters, F., & Fernyhough, C. (2017). Hallucinations: A systematic review of points of similarity and difference across diagnostic classes. *Schizophrenia Bulletin, 43*(1), 32–43. https://doi.org/10.1093/schbul/sbw132
Waters, F., Moretto, U., & Dang-Vu, T. T. (2017). Psychiatric illness and parasomnias: A systematic review. *Current Psychiatry Reports, 19*(7), 37. https://doi.org/10.1007/s11920-017-0789-3
Wei, N. S., & Praharaj, S. K. (2019). Chronotypes and its association with psychological morbidity and childhood parasomnias. *Indian Journal of Psychiatry, 61*(6), 598–604. https://doi.org/10.4103/psychiatry.IndianJPsychiatry_208_19
Whitney, R., & Weiss, S. K. (2018). Sleep-related movement disorders: Hypnic jerks. *Current Sleep Medicine Reports, 4*(1), 19–27. https://doi.org/10.1007/s40675-018-0104-9
Wienke, C., Bartsch, M. V., Vogelgesang, L., Reichert, C., Hinrichs, H., Heinze, H.-J., & Dürschmid, S. (2021). Mind-wandering is accompanied by both local sleep and enhanced processes of spatial attention allocation. *Cerebral Cortex. Communications, 2*(1), tgab001. https://doi.org/10.1093/texcom/tgab001
Zadra, A., & Domhoff, G. W. (2017). Dream content. *In Principles and Practice of Sleep Medicine*, 515–522.e4. https://doi.org/10.1016/B978-0-323-24288-2.00049-0. Elsevier.
Zhang, B., & Wing, Y.-K. (2006). Sex differences in insomnia: A meta-analysis. *Sleep, 29*(1), 85–93. https://doi.org/10.1093/sleep/29.1.85
Zigmond, A. S., & Snaith, R. P. (1983). The hospital anxiety and depression scale. *Acta Psychiatrica Scandinavica, 67*(6), 361–370.

Interruption, recall and resumption: Revisiting the Zeigarnik and Ovsiankina effect.

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Abstract

The memory advantage of unfinished tasks (*Zeigarnik* effect) and their tendency towards resumption (*Ovsiankina* effect) are well-known phenomena that have been subjected to numerous replications. However, this memory advantage proved to be difficult to replicate. We, therefore, explored the question of the extent to which both phenomena can be replicated. In the first step, we conducted a meta-analysis of the literature on the *Zeigarnik* and *Ovsiankina* effect and computed several associated measures. We found a general tendency to resume tasks, whereas the memory advantage of unfinished tasks proved questionable. Therefore, we attempted to replicate both effects under standardized conditions using a series of videogames in a second step. Participants played sixteen videogames, of which half were interrupted. Then, participants were either prompted to recall or instructed to select eight videogames for replay. We were unable to find a *Zeigarnik* effect but found a general preference for unfinished video games for replay. We suspect the Zeigarnik effect to be dependent on situational influences and individual differences, such as the experimenter's authority, situational demands of task performance, and task involvement. These circumstances were more prevalent historically and are rarer today, which could explain the difficulty in replicating the *Zeigarnik* effect. Conclusively, the *Ovsiankina* effect represents a general tendency, whereas the *Zeigarnik* effect lacks universal validity.

Keywords: Zeigarnik effect, Ovsiankina effect, videogames, replication

Interruption, recall and resumption: Revisiting the Zeigarnik and Ovsiankina effect.

An interrupted intention is better remembered than a completed one and urges us towards its completion. This claim resulted from two seminal studies at the beginning of the twentieth century. Zeigarnik (1927), for instance, presented participants with numerous tasks, of which some were interrupted, and noted that participants recalled more interrupted than finished tasks (*Zeigarnik* effect). Ovsiankina (1928), on the other hand, used a similar approach and noted that participants tended to try to resume these interrupted tasks unprovoked (*Ovsiankina* effect). It seems intuitively logical that interrupted intentions must persist somewhere for planned actions to be resumed and completed and would translate to a memory advantage. However, a growing body of research aiming to replicate this memory advantage failed in their attempt. Consequently, the question arises as to what extent this advantage and tendency to resume genuinely occurs.

Kurt Lewin (1926) proposed an opposing view to the then-prevailing association theory in his famous field theory of tension. According to the association theory, the association between the intention and its objective was seen as causal for the urge to complete an intention (Ach, 1910). Lewin (1926), however, emphasized a fundamental theoretical flaw in the association theory: If the association theory were to hold true, the established association between intention and objective should persist after the intention's fulfilment and, in fact, further deepen the association. This, however, is not the case. Successfully performing an intention, such as mailing a letter, does not re-invoke the intention when passing a mailbox after the intention's successful execution, as Lewin noted. Therefore, he suspected other mechanisms at play, which could explain the urge to fulfil intentions, while successfully terminating the intention once concluded.

As the name of his field theory of tension implies, Lewin (1926) proposed that implementing an intention builds up a tension by attaching valence (*Aufforderungscharakter*) to specific objects and situations. This inner tension resembles a quasi-need, and the tension persists until the successful

fulfilment of the intention. In an interrupted activity, this tension cannot be discharged, which becomes particularly evident in the tendency to resume unfinished activities. Such a mechanism is quite beneficial, as otherwise, the successful completion of actions and tasks would fail. Furthermore, Lewin (1926) assumed that persistent tension should also manifest in a better recall of unfinished activities compared to finished ones. In the following years, this theory was adopted by two of his doctoral students and tested empirically in a series of experiments.

One of his doctoral students, Bluma Zeigarnik (1927), investigated the memory advantage of unfinished tasks compared to finished tasks due to persistent tension in a series of experiments with 164 participants, consisting of students, teachers, and children. They were presented with 18 to 22 tasks in sequence, of which half were interrupted when participants were most engaged with the task. The individual tasks took between 1 and 5 minutes to complete, depending on the complexity of the task. When probed immediately after the performance of all tasks, participants recalled, on average, twice as many interrupted tasks as completed tasks, demonstrating a clear memory advantage for unfinished tasks. Interestingly, interrupted tasks seem to accumulate at the beginning of the retrieval. Zeigarnik (1927) concluded that interrupted tasks profited from a memory advantage due to the persistent activation, thereby establishing the eponymous "*Zeigarnik effect*".

Using a similar approach, Maria Rickers-Ovsiankina (1928) investigated the tendency to resume unfinished tasks in several experiments with 124 participants, consisting of adults, most of whom were students and children. They, too, were presented with a series of 8 to 12 tasks, of which some were interrupted. Tasks were either interrupted by a disruptive action (e.g. the experimenter intersperses another task), by the prohibition of completion, by random interruption (e.g. the experimenter drops something and requires help), by sudden probed introspection of the preceding task, or by distraction through a casual conversation. Participants independently resumed the task in 100% of cases when

randomly interrupted and in 79% of cases when interrupted by a disruptive action. She successfully demonstrated the urge to resume interrupted actions, known today as the "*Ovsiankina effect*".

Following these impressive results, research took great interest in both these effects, particularly in the *Zeigarnik effect*. An increased amount of researchers began employing the interrupted task paradigm (e.g., Atkinson, 1953; Cooper, 1983; D. R. Green, 1963; Mahler, 1933; Moot III et al., 1988; Pachauri, 1935; Rösler, 1955; Van Bergen, 1968; Weiner, 1966). In this paradigm, several tasks are presented in sequence, half of which are interrupted, whereas the other half is completed. Then, the recall of tasks or the resumption rate are assessed. The effect of the interrupt is thereby claimed to be independent of the material used if the task duration is maintained somewhat constant (Pachauri, 1935). This claim proved untrue, as attempts at replicating the *Zeigarnik* effect produced remarkably inconsistent results (see MacLeod, 2020 for an overview; see Van Bergen, 1968 for an in-depth replication of the original study).

The Zeigarnik effect

It quickly became evident that the *Zeigarnik* effect was not a universally reliable phenomenon but appeared to be bound to specific terms. Atkinson (1953) was amongst the first to investigate the *Zeigarnik* effect in light of individual differences by measuring achievement motivation (or *n Ach*). A high achievement motive is seen as a stable disposition to strive for achievement or success (Atkinson, 1957). Participants were divided into two groups: A group with a high achievement motivation (high n Ach) and a group with a low expression (low n Ach). Then, the experimental setting was manipulated to create three distinct conditions: A task-oriented condition, in which no attempt at creating an experimental atmosphere was made, a relaxed-orientation condition, in which a relaxed atmosphere was created, and an achievement-orientation condition, in which a competitive atmosphere was created. Highly achievement-motivated individuals recalled remarkably more interrupted tasks than completed tasks in the achievement-oriented condition, whereas individuals low in achievement motivation exhibited the

opposite pattern. These results undermined the importance of individual differences and situational influences and the strength of motivation to achieve, in particular, in relation to the *Zeigarnik* effect. Consequently, achievement motivation gained popularity in this research field (Cooper, 1983; Moot III et al., 1988; Raffini & Rosemier, 1972; Reiss, 1968; Weiner, 1966).

Following these results, a long line of research began investigating the influence of other potential individual differences on the *Zeigarnik* effect. Some authors believed task-involvement to be a critical factor in the occurrence of the effect. Green (1963), for instance, noted that participants in replication studies differed in their requirement to participate: While some studies included volunteers, others tested students who were required to participate as part of their curriculum. He concluded that volunteers should be more task-involved, aiming to complete the task successfully. Accordingly, volunteers exhibited a stronger *Zeigarnik* effect than non-volunteers. Similarly, a heightened task-involvement was propagated in dominant individuals due to their task-oriented attitudes and strong completion-tendencies (Gough et al., 1951; Sinha & Sharan, 1976). When testing both dominant and submissive individuals, dominant individuals exhibited a *Zeigarnik* effect. Submissive individuals, however, exhibited the opposite pattern, an inversion of the *Zeigarnik* effect.

Other authors noted that an inversion of the *Zeigarnik* effect usually occurred in anxiety-inducing situations when the ego was involved (Farley & Mealiea, 1971; Glixman, 1949; Rosenzweig, 1943). It was argued that recall of failure or unfinished tasks would threaten the ego and should, therefore, be repressed (Weiner et al., 1968). Hence, it was hypothesized that individuals with a tendency to avoid threatening stimuli (e.g. repressors) should exhibit this inversion of the *Zeigarnik* effect, whereas individuals with a tendency to approach threatening stimuli (e.g. sensitizers) should not. Of the studies contrasting repressors and sensitizers, however, only one successfully demonstrated differing recall patterns: While, Farley and Mealiea (1973) found an inverse *Zeigarnik* effect in both

repressors and sensitizers, Hofstätter (1985) successfully demonstrated *Zeigarnik* effect in sensitizers and an inverse *Zeigarnik* effect in repressors.

In his study, Claeys (1969) attempted to resolve the indifferent findings on the recall of interrupted and completed tasks by acknowledging the two different mechanisms at play in the recall of interrupted tasks: First, a drive urging towards the completion of unfinished tasks resulting better memory of interrupted tasks (i.e. the *Zeigarnik* effect), and second, a tendency to recall completed task in favour of the ego, which he labelled "success factor". He hypothesized that neurotic individuals would exhibit a stronger *Zeigarnik* effect compared to stable individuals due to their tense and overdriven nature. On the other hand, introverted individuals would spontaneously evaluate their performance on tasks as good or bad compared to extraverted individuals and would therefore be in need of this "success factor", resulting in an inverse *Zeigarnik* effect. Both individuals high in neuroticism and low in introversion recalled more interrupted tasks than individuals low in neuroticism and high in introversion. Since then, however, the relationship of neuroticism and introversion with the *Zeigarnik* effect has not been investigated again.

Besides the influence of individual differences on the *Zeigarnik* effect, one major factor should not be overlooked: the situational influence. Marrow (1938a, 1938b) noted that the instructions given could influence the participant's recall. In a series of experiments, he repeated the same experiment but varied the instructions given to American students: In one experiment, participants were given with neutral and sober description of the experimental procedure. In a second experiment, participants were informed that the purpose of the study was to replicate a previous experiment conducted with a German sample, and a preliminary analysis revealed a superior performance of the American students. In a third experiment, participants were given the same instruction as in the second experiment but were told that a preliminary analysis instead revealed a superior performance of the German students. The minor memory advantage of interrupted tasks observed in the first experiment drastically increased

in the second experiment when participants were encouraged by the instruction but decreased again in the third experiment when discouraged by a demoralizing instruction.

Following Marrow (1938b, 1938a), researchers manipulating the experimental atmosphere followed a threefold distinction of situational conditions: First, a neutral and task-focused condition sometimes used as a baseline measure called *task orientation* condition (Atkinson, 1953; D. R. Green, 1963; Hays, 1952) or *neutral* condition (Caron & Wallach, 1957). Second, a more formal and demanding condition designed to emphasize the importance of the tasks by framing them as a measure of intellect labelled as *achievement orientation* condition (Alper, 1946; Atkinson, 1953; Hays, 1952), *ego orientation* condition (D. R. Green, 1963), *formal* condition (Claeys, 1969), or *stressful* condition (Caron & Wallach, 1957; Glixman, 1949). Last, a more informal condition to minimize the focused on the task, in which the subjects perform the tasks under the pretext of assisting the experimenter in testing the material, either called a *relaxed orientation* condition (Alper, 1946; Atkinson, 1953), or *informal condition* (Claeys, 1969). The influence of these conditions on the *Zeigarnik* effect produced mixed effects, likely due to their interaction with individual differences, as Atkinson (1953) had previously demonstrated.

Inspired by Atkinson's (1953) results, Weiner (1966) caught interest in how the social context could determine achievement-related behaviour. Particularly, he was interested in how participants in competition with another same-sex or opposite-sex competitor would vary in their achievement-related behaviour, manifesting in different recall patterns. Women exhibited a greater *Zeigarnik* effect when competing against other women compared to competing against men, although the result did not yield significance. Conversely, men exhibited a greater *Zeigarnik* effect when competing against women and an inverse Zeigarnik effect when competing against other men. Weiner (1966) concluded that female competitors were more appropriate at enhancing achievement striving than male competitors, as both women and men exhibited a greater *Zeigarnik* effect when competing with another woman.

Lastly, the influence of interpolated and subsequent tasks on the recall of interrupted and finished tasks was assessed. When interpolating tasks with complex or simple tasks, completed tasks were more frequently recalled when followed by a complex task. In contrast, interrupted tasks were more frequently recalled when followed by a simple task (Hays, 1952). When a new activity follows a set of multiple interrupted and completed tasks before recall, individuals recall more completed tasks when presented with a demanding task, such as performing a new set of tasks. In contrast, they recall more interrupted tasks when followed by a less demanding task, such as reading a book (Prentice, 1944). The *Zeigarnik* effect, therefore, manifests in the presence of interpolated or subsequent cognitively undemanding tasks. However, it appears to inverse when cognitive resources are exhausted by complex interpolated and subsequent tasks through retroactive inhibition.

The Ovsiankina effect

Meanwhile, the *Ovsiankina* effect had also received considerable attention, but nowhere to the same extent as the *Zeigarnik* effect. The *Ovsiankina* effect, however, appeared to be more reliable. Several authors demonstrated that, when given the opportunity to resolve a task, participants reliably resumed the task when the opportunity arose (Katz, 1938; Mahler, 1933; Nowlis, 1941; Rethlingshafer, 1941). This effect occurred in adults, children, and individuals with intellectual disabilities (Rethlingshafer, 1941; Rösler, 1955). Even when presenting participants with interesting alternative tasks, participants reliably resumed their interrupted tasks when presented with the choice (Mahler, 1933). This tendency, however, decreases the more the alternative task resembles the interrupted task (Lissner, 1933). A recent computerized study further showed that when participants were interrupted in their activity by a prompt under the pretext of a network problem and instructed to wait for 60 seconds but given the opportunity to resume, they dismissed the prompt and resumed their activity reliably (Birk et al., 2020).

Strikingly, the effect seemed to reflect an intrinsically motivated tendency truly. McGraw and Fiala (1982) were interested in how extrinsically motivating participants through a monetary incentive for participation would affect the resumption rate of interrupted tasks. In one condition, participants were told beforehand about the financial compensation for their participation, whereas in another condition, participants were not informed about the compensation. Interestingly, the monetary incentive noticeably lowered the resumption rate of interrupted tasks. The authors concluded that by introducing an incentive for participation, the participants' intrinsic goal for task-completion was overlapped by an extrinsic goal of participating, which rendered the resumption of a task obsolete.

Reeve et al. (1986) wondered whether the *Ovsiankina* effect was the same as intrinsic motivation and, if not, how both could be delimited. Participants were tasked with solving a series of puzzles in a competitive setting and were either allowed to beat the competitor (*competence* feedback), were prearranged to lose against the competitor (in*competence* feedback) or did not compete (*no* feedback). Participants were interrupted on the tasks by a time limit. The authors used two indices in their study: The resumption rate measuring the *Ovsiankina* effect and the time spent on the task after the resumption as a measure of interest in the task and an intrinsic motivation index. The authors found that *competence* feedback increased both the *Ovsiankina* effect and the intrinsic motivation index, but the effect was greater on intrinsic motivation. Additionally, the study found that participants displayed intrinsically motivated behaviours even after completing tasks, distinguishing intrinsic motivation from the Zeigarnik effect.

Liberman et al. (1999) later reintroduced the idea of manipulating motivation in relation to the resumption or substitution of interrupted tasks. They assigned participants to two conditions: A *promotion* condition, in which tasks were framed as a gain-nongain situation, and a *prevention* condition, in which the task was framed as a loss-nonloss situation. In experiment one, for instance, participants in the *promotion* condition were awarded points when completing a task but no points

when failing to complete a task, whereas in the *prevention* condition, participants where deducted points when failing to complete a task, but not when successfully completing a task. Participants consistently resumed interrupted tasks more frequently than substituting the task in the *prevention* condition compared to the *promotion* condition. Therefore, individuals with a prevention focus may be more inclined to maintain stability and avoid losses by resuming interrupted tasks.

Summary

Originating in Lewin's theory of tension, both the *Zeigarnik* effect and the *Ovsiankina* effect garnered substantial amounts of attention over the years and were put to the test in numerous replication attempts. Whereas the *Ovsiankina* effect has proven to be a reliable phenomenon over the years, the evidence surrounding the *Zeigarnik* effect presents a more complex picture. In particular, the interplay between individual differences and situational influences complicates understanding the *Zeigarnik* effect. Individual differences such as achievement motivation, the voluntary or involuntary nature of participation, the tendency to repress ego-threatening stimuli, and personality all shape the recall of tasks considering situational influence, as the situation itself can induce different recall preferences. The *Ovsiankina* effect, however, does seem to be a universal and intrinsically motivated phenomenon, which occurs even when presented with the opportunity to substitute the interrupted task.

Meta-Analysis

Almost a century after the original publications by Zeigarnik (1927) and Ovsiankina (1928), the question arises as to what the magnitude of these effects truly are. The need for synthesising these studies becomes apparent with many replication attempts using different materials, assessing numerous individual differences, and manipulating the experimental atmosphere in various ways. To what extent do interrupted tasks profit from an average memory advantage compared to completed tasks? And further, how likely is the resumption of a task on average when interrupted?

Method

The present meta-analysis used anonymized data and was therefore exempt from approval by the Ethics Committee from the first author's institution (Faculty of Human Sciences, University of Bern) in accordance with national law.

Literature Search

The goal of our study was to identify the magnitude of both the *Zeigarnik* and *Ovsiankina* effect. Specifically, we were interested in the following: First, the average ratio of recalled interrupted and finished tasks (*Zeigarnik* effect). Second, the percentage of resumed interrupted tasks (*Ovsiankina* effect). Third, if available or computable, the average effect size of the memory advantage for unfinished tasks compared to finished tasks. To search for relevant studies, we conducted our literature search using PsycInfo and PSYINDEX using the search terms *Zeigarnik*, *Zeigarnik-Effect*, *Zeigarnik Effect*, *Ovsiankina*, *Ovsiankina-Effect*, and *Ovsiankina Effect*. This first search resulted in a total of 1263 publications and a total of 1224 publications after removing duplicates (see Figure 1).

These 1224 publications were then screened for title and abstract. Publications were considered for full-text screening if the following criteria were met: (a) The study was empirically-quantitative; (b) The study focused on interrupted and finished tasks; (c) The study measured retrospective recall or resumption of interrupted tasks. All studies were screened by the first author for inclusion of full-text screening. Studies with ambiguous relevance to the inclusion criteria were screened in full text. In addition, a random sample of 60 studies was rated by an independent rater instructed on the important criteria to estimate interrater agreement. The interrater agreement on inclusion or exclusion was high ($\kappa = 1.00$). Screening titles and abstracts resulted in 99 remaining publications considered for inclusion.

The remaining 99 publications were then screened for their definitive inclusion by the first author. Studies were included for data extraction if they met all the following criteria: (a) The study was empirically-quantitative; (b) The study used interrupted and finished tasks and assessed free recall or

the resumption of these tasks; (c) The resumption of tasks in the study was not forced by the experimenter (d) The study provided sufficient information on recall and resumption to compute the ratio of recalled interrupted tasks to recalled finished tasks if not already provided; (e) The study was published in either English, German, or French; (f) The publication was available. Screening full texts resulted in a final sample of 43 publications. Of these publications, 30 investigated the *Zeigarnik* effect, 12 investigated the *Ovsiankina* effect, and 1 investigated both.

Data extraction

We coded the following data: Year of publication, the assessed effect (*Zeigarnik* effect, *Ovsiankina* effect, or both), number of experiments, type of experiment (experimental or quasi-experimental), total sample, sub-sample by conditions, sample type (i.e., students, adults, children), the sample size by gender, the average age and standard deviation of the sample as well as the age range (minimum and maximum age), the country in which the study was conducted, the different experimental conditions, the individual differences assessed, the type of tasks used, the manipulation of the interrupt, whether the task-interruption was manipulated within- or between-subjects, and the recall (immediate vs. delayed).

To compute the magnitude of both effects, we coded the following measures found throughout the literature (Butterfield, 1964): For the *Zeigarnik* effect, we first retrieved the value we label $mean\ ratio\ \frac{IR}{CR}$. This value relates to the averaged ratio of interrupted recalled (IR) and completed recalled (CR) tasks across all participants. Typically, the ratio of IR/CR is first computed for each participant separately and then averaged in a second step. This measure was originally introduced by Zeigarnik (1927) but is massively influenced by single extreme-values and outliers.

A second measure was computed to assess the *Zeigarnik* effect: The value we would label $ratio\ \frac{mean(IR)}{mean(CR)}$. This measure was later introduced and provided the ratio of the average recalled interrupted tasks to the average recalled finished tasks. More specifically, the recall of interrupted and

finished tasks is first averaged across participants before their ratio is computed. This value is substantially less influenced by individual extreme-values and outliers and, therefore, more suitable to represent an unbiased *Zeigarnik effect*, and represents the most commonly used measure.[1]

Lastly, we computed the proportion of interrupted tasks recalled to total tasks recalled for the *Zeigarnik* effect, which we labelled $proportion\,\frac{IR}{TR}$. This measure relates to the average amount of all recalled tasks, which are interrupted tasks. It was first introduced by Marrow (1938a), criticizing Zeigarnik's (1927) approach. The extent of memory superiority of interrupted and completed tasks is reflected differently based on the direction in which the superiority lies. By computing the ratios as mentioned above, the relation of interrupted recalled tasks to completed recalled tasks is distorted in favour of the interrupted ones.[2] On the other hand, the computation of interrupted tasks to total tasks provides an unbiased measure of the memory advantage of unfinished tasks.

For the *Ovsiankina* effect, we calculated the *resumption rate (%)*, which reflects the percentage of individuals who resumed the task after interruption. Ovsiankina (1928) differentiated in her original publication between *resumed* tasks and tasks with a *tendency for resumption*. As subsequent studies combined both types of resumption, we consolidated both values into one value of *resumption*. The

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[1] Consider the following: Two subjects, A and B, both participated in an interrupted task paradigm with sixteen tasks, of which half were interrupted. Subject A recalled 8 interrupted tasks and 4 finished tasks, subject B recalled 4 interrupted tasks and 8 finished tasks. Computing the $mean\ ratio\,\frac{IR}{CR}$ results in a value of 1.25, a clear memory advantage for interrupted tasks ($ratio\,\frac{IR=8}{CR=4}$ = 2 for subject A, $ratio\,\frac{IR=4}{CR=8}$ = 0.5 for subject A, μ = 1.25. Computing the $ratio\,\frac{mean(IR)}{mean(CR)}$, however, results in a value of 1 ($\frac{mean(IR)=6}{mean(CR)=6}$ = 1), demonstrating no differences in the recall of interrupted and finished tasks.

[2] Consider the following: When both interrupted and completed tasks are remembered equally, a value of 1 is calculated ($\frac{IR=1}{CR=1}=1$). If interrupted tasks are recalled twice as frequently as completed tasks, a value of 2 is obtained ($\frac{IR=2}{CR=1}=2$), demonstrating that interrupted tasks are recalled twice as often. Conversely, if completed tasks are remembered twice as often as interrupted tasks, a value of 0.5 is computed ($\frac{IR=1}{CR=2}=0.5$), making the interpretation of results less intuitive.

resumption rate (%), therefore, reflects the percentage of individuals resuming interrupted tasks when the opportunity arises.

Results

In the first step, we calculated the weighted mean by sample size of the outcome measures for each publication across their experimental conditions. We aimed to partial out any manipulations of the experimental atmosphere and individual differences so that the fundamental effects could be calculated. Then, we again computed an overall weighted mean by sample size across all publications to converge the values into one combined value per measure. For the *Zeigarnik* effect we combined the commonly used situational manipulations into three distinct conditions and analyzed the weighted average effect. Moreover, we analyzed the influence of achievement motivation across the different studies. The summary of the included studies and their averaged effect sizes can be found in Table 1. A graphical depiction of the studies and their averaged effect sizes in relation to their year of publication are presented in Figure 2 for the *Zeigarnik* effect and Figure 3 for the *Ovsiankina* effect.

Zeigarnik effect

First, we analyzed the available effects of the $mean\ ratio\ \frac{IR}{CR}$, the measure Zeigarnik (1927) used in her original publication. This value was provided by or could be computed from three additional publications. Including the value provided by Zeigarnik (1927), a weighted $mean\ ratio\ \frac{IR}{CR} = 1.31$ resulted, suggesting that interrupted tasks are recalled 31% better than finished tasks. If the value provided by Zeigarnik (1927) is excluded, a weighted $mean\ ratio\ \frac{IR}{CR} = 1.10$ results, suggesting that interrupted tasks are recalled 10% better than finished tasks.

Next, we analyzed the available effects of the $ratio\ \frac{mean(IR)}{mean(CR)}$, representing the most commonly used measure of the *Zeigarnik* effect. This value was provided or could be computed from 30 additional publications. Including the value calculated in Zeigarnik's (1927) publication, a weighted

$ratio\,\frac{mean(IR)}{mean(CR)} = 1.02$ resulted, suggesting that interrupted tasks are recalled 2% better than finished tasks. If Zeigarnik (1927) is excluded, a weighted $ratio\,\frac{mean(IR)}{mean(CR)} = 0.98$ results, suggesting that interrupted tasks are recalled worse than finished tasks (see Figure 4).

Last, we analyzed the available effects of the $propotion\,\frac{IR}{TR}$. This value was provided or could be computed from five additional publications. Including the value calculated in Zeigarnik's (1927) publication, a weighted $percentage\,\frac{IR}{TR} = 51.10\%$ results, suggesting a minimal memory advantage of interrupted tasks. If Zeigarnik (1927) is excluded, a weighted $percentage\,\frac{IR}{TR} = 49.09\%$ results, suggesting a memory disadvantage for interrupted tasks.

Computing the effect size of the Zeigarnik effect emerged to be more complicated than expected. Most studies did not report any effect size or did not provide sufficient information to compute them. Thankfully, studies such as Zeigarnik (1927), Schlote (1930), Lewis (1944), Alper (1946), and van Bergen (1968) provided detailed information on each subject's recall. This allowed us to compute *Cohen's* d_z for paired sample t-tests by dividing the mean difference by the standard deviation of the mean difference (Lakens, 2013). Weighting the computed effect sizes by the sample size resulted in an overall *Zeigarnik* effect of $d_z = .04$, thus reflecting a small effect (J. Cohen, 2013).

Situational influence

We then investigated how the experimental atmosphere is related to the $ratio\,\frac{mean(IR)}{mean(CR)}$. For this, we grouped experimental conditions into three distinct categories: A *neutral* condition, in which the the experiment focuses on the tasks themselves (e.g. *task orientation* or *neutral* conditions), an *achievement* condition, in which experimental situation and instructions induce a performance atmosphere (e.g. *achievement orientation*, *ego*, *formal*, or *stressful* conditions), and a *relaxed* condition, in which a relaxed atmosphere is deliberately created (e.g. *relaxed* or *informal* conditions). We

calculated the weighted mean $ratio\,\frac{mean(IR)}{mean(CR)}$ for each condition. The weighted average ratio for the *neutral* conditions was $ratio\,\frac{mean(IR)}{mean(CR)} = 1.19$, for the *achievement* conditions $ratio\,\frac{mean(IR)}{mean(CR)} = 1.04$, and for the *relaxed* conditions $ratio\,\frac{mean(IR)}{mean(CR)} = 1.07$.

Achievement motivation

Next, we computed the weighted mean $ratio\,\frac{mean(IR)}{mean(CR)}$ for the most prominent individual difference: Achievement motivation. In the seven studies that assessed achievement motivation, participants have typically been categorized into high, moderate, and low achievement motivation. The weighted average ratio for individuals with *high* achievement motivation was $ratio\,\frac{mean(IR)}{mean(CR)} = 1.00$, for *moderate* achievement motivation $ratio\,\frac{mean(IR)}{mean(CR)} = 0.92$, and for *low* achievement motivation $ratio\,\frac{mean(IR)}{mean(CR)} = 0.96$.

Ovsiankina effect

For the *Ovsiankina* effect, we assessed the sole measure used for the resumption of interrupted tasks, the *resumption rate (%)*. Including the value obtained in Ovsiankina's (1928) publication, a weighted *resumption rate (%)* = 69.25% results, demonstrating that interrupted tasks are frequently resumed. If Ovisankina (1928) is excluded, a weighted *resumption rate (%)* = 68.13% results, exhibiting only a minor difference in the resumption rate. Still, studies reliably demonstrated that interrupted tasks are resumed around 70% of the time (see Figure 5).

Discussion

The present meta-analysis revealed significant inconsistencies in the Zeigarnik effect. The measure applied originally by Zeigarnik (1927), which we labelled $mean\ ratio\,\frac{IR}{CR}$, grossly overestimated the effect and is particularly susceptible to extreme values. If a ratio is to be computed, the measure we labelled $ratio\,\frac{mean(IR)}{mean(CR)}$ is more suitable, although not without its drawbacks. It heavily distorts values in

favour of interrupted tasks. As such, we would recommend the use of the measure introduced by Marrow (1938a) we labelled $proportion\,\frac{IR}{TR}$, that is, the average proportion of interrupted tasks recalled in relation to the total amount of tasks. This measure is more favorable as it does not suffer from the same disadvantages as the other measures and provides information on the recall of finished tasks as well.

Our analysis of the Zeigarnik effect is quite sobering. Without considering the result of Zeigarnik's (1927) original study, a ratio of interrupted to completed tasks of 0.98 is computed. Interrupted tasks account for an average of 49.09% of the recalled tasks. Despite being unable to calculate the effect size for numerous studies, the *Zeigarnik* effect yielded an average effect size of d_z = .04, indicating a small effect. The current findings do not support a memory advantage for interrupted tasks when situational influences and individual differences are not accounted for. Therefore, the *Zeigarnik* effect should relate to situational influences, individual differences, or the interaction of both.

When distinguishing experimental situations into the three distinct conditions, the *Zeigarnik* effect appears to be most prominent in what we labelled a *neutral* condition. In these situations, the experimental atmosphere is not manipulated through instructions or the experimenter's behaviour with a strict focus on the tasks themselves. A slightly lower Zeigarnik effect could be observed in situations we labelled relaxed conditions, suggesting that some degree of focus is necessary to provoke the effect. Surprisingly, the lowest *Zeigarnik* effect occurred in the situations we labelled *achievement* conditions, in which the tasks are framed as some intelligence measure. We suspect that such situations evoke different recall patterns based on individual differences. Success-oriented individuals might find such situations exciting and stimulating, whereas failure-oriented individuals might perceive such situations as threatening to the ego. The former could favour the retrieval of interrupted tasks, whereas the latter might favour the retrieval of completed tasks.

Focusing solely on achievement motivation, no clear pattern in the *Zeigarnik* effect occurs. Highly achievement-motivated individuals recalled a comparable amount of interrupted and finished tasks, whereas moderately achievement-motivated individuals recalled even more finished tasks than slightly achievement-motivated individuals. We assume that achievement motivation is highly dependent on situational influences to evoke specific recall patterns. Unfortunately, only the study by Atkinson (1953) provided us with measures of both the manipulated experimental atmosphere in relation to achievement motivation. In his study, individuals high in achievement motivation exhibited the strongest *Zeigarnik* effect in an *achievement* condition. In contrast, individuals low in achievement motivation exhibited the strongest *Zeigarnik* effect in a *relaxed* condition.

The *Ovsiankina* effect, on the other hand, appears to be a more general tendency. However, we must note here that the *Ovsiankina* effect was addressed more descriptively. Studies investigating the effect assessed the percentage of resumed interrupted tasks. If some degree of experimental manipulation was involved, researchers usually tried to increase or decrease this tendency and evaluated their findings descriptively or in relation to a baseline condition. This, however, does not negate the fact that a general tendency to resume interrupted tasks can be observed reliably. It is, therefore, not surprising that the *Ovsiankina* effect received less attention than the *Zeigarnik* effect since its results can be observed reliably and require less investigation.

It is important to note that this meta-analysis does not encompass all potential publications on the topic due to the specific search terms employed. As such, the computed effects and ratios are limited to the studies included in our meta-analysis. We recognize that employing a more comprehensive set of search terms might have yielded a broader spectrum of studies. However, narrowing our search terms helped us retrieve studies directly related to the effects in question (Liberati et al., 2009). Further, including more lenient search terms could have increased the heterogeneity of research approaches, making it even more challenging to draw cohesive conclusions (Higgins et al.,

2003). The included studies already employed a broad array of approaches to induce the *Zeigarnik* and *Ovsiankina* effect, which already complicated the synthesis of the findings. Moreover, limiting search terminology made the systematic review of studies more feasible due to limited time resources (Shamseer et al., 2015).

Pilot Study

Given the variable findings on the Zeigarnik effect and the few studies investigating the *Ovsiankina* effect, we decided to conduct our investigation in a modern setting. Our meta-analysis revealed that the *Zeigarnik* effect occurred most strongly in a *neutral* condition. Therefore, we aimed to investigate these effects in a neutral environment without manipulating the experimental setting, such as by creating a performance-demanding or relaxed situation. Moreover, we deemed it essential to investigate these effects in a standardized setting, preferably using a computerized approach, thereby minimizing influencing factors such as the experimenter's effects and allowing the control of other variables. Consequently, we aimed to replicate the Zeigarnik and *Ovsiankina* effect in as neutral and standardized an environment as possible.

In their original studies, both Zeigarnik (1927) and Ovsiankina (1928) used a number of heterogenous tasks for interruption. Some tasks were monotonous, others required dexterity, and others represented problem-solving tasks or puzzles. One could argue that these tasks were but small games. Therefore, the logical conclusion for their computerization would be the use of videogames. Videogames are an object of entertainment and provide entertainment by employing rule and objective gameplay and interactive fiction (Tavinor, 2008). Note that videogames share one critical aspect with intentions: The objective. Therefore, video games as computerized tasks appeared as an appropriate choice since they can be used to induce the desire to reach an end state easily.

The use of videogames provides an additional major advantage in controlling the environment due to their computerization. Computerized research allows a more convenient, reliable, standardized,

and affordable administration of tasks and instructions than human administrators (Drasgow & Olson-Buchanan, 1999). Moreover, computerized research is less susceptible to social desirability effects (Booth-Kewley et al., 2007). Hence, using videogames as tasks seems particularly suited to investigate the *Zeigarnik* and *Ovsiankina* effect while allowing the standardization of instructions and task presentation and avoiding social desirability effects and other potential influences from the experimenter. In short, videogames present an optimal approach to investigate the true effects in question.

Besides the interruption of intentions in the process of being fulfilled, we were also interested in how these effects would relate to the inability to execute a prospective intention. In their studies, Zeigarnik (1927) and Ovsiankina (1928) implemented new intentions with each task instruction that was subsequently started, interrupted, or completed. However, we often have to postpone our intentions until an opportunity emerges for their execution while engaging in other activities (Goschke & Kuhl, 1993). This ability to remember to perform an action in the future is called *prospective memory* (Einstein & McDaniel, 1990). It consists of a prospective component, that is, knowing when to perform the intended action, and a retrospective component, that is, knowing what the intended action entails (Cohen et al., 2001; Meier & Zimmermann, 2015).

Similarly to better memory for unfinished tasks (Zeigarnik, 1927) and a tendency to resume unfinished actions unprompted (Rickers-Ovsiankina, 1928), unperformed prospective intentions have demonstrated some form of persistent activation. Persistent activation becomes apparent if individuals cannot perform an instructed intention before it is deemed finished but are then confronted with intention-related stimuli. In such cases, commission errors occur, where people act on the intention even when told not to (Bugg & Scullin, 2013). Moreover, exposure to stimuli that were once relevant to the intention can slow reaction times (Walser et al., 2012). These slower reaction times are also

observed in subsequent trials (Meier & Cottini, 2023). Interestingly, these observations have, amongst others, been attributed to the *Zeigarnik* effect (Bugg & Streeper, 2019; Möschl et al., 2020).

Typically, prospective memory is assessed in the laboratory by having participants work on an ongoing task while also requiring them to perform the prospective memory task at specified future instances (see, for instance, Bugg & Scullin, 2013; Einstein & McDaniel, 1990; Meier & Cottini, 2023; Scullin et al., 2012; Streeper & Bugg, 2021). Luckily, this paradigm can be adapted easily for videogames. By having participants play a videogame as an ongoing task, we can provide additional instructions to react to embedded prospective stimuli during the task. If these prospective stimuli are never presented, the intention persists as unfulfilled. Thus, we can manipulate the interruption of an intention in the execution process (the ongoing task) while also preventing participants from performing their prospective intention altogether (the prospective memory task).

In this pilot study, we tested the suitability of sixteen videogames as interruptible tasks. Eight videogames were interrupted midway, while participants could finish the other eight. The pilot study consisted of three different conditions. In the *Replication* condition, participants played all sixteen videogames and were interrupted in half. In the *ProM-Instruction* condition, participants were instructed with an additional prospective memory task (ProM), which was embedded and differed in each game. This ProM task occurred a few times over the videogames' duration at Constant Time intervals. If, for instance, participants were tasked to fish in a videogame, they were additionally instructed to press enter whenever they encountered a crab. This additional ProM task could always be executed in this condition and served as a control condition to investigate the effect of an additionally present ProM task on both effects. Lastly, in the *ProM-Variation* condition, participants were also instructed with a ProM task but could only execute half of these additional tasks. In the other half of the tasks, the stimuli relating to the ProM task (e.g., the crab in the previous example) never appeared during the videogame.

This initial pilot study aimed to evaluate the application of videogames in measuring both the *Zeigarnik* and *Ovsiankina* effects. We hypothesized that the interruption of a videogame would result in a memory advantage and a tendency for resumption. Further, we hypothesized that the inability to execute a ProM task should result in persisting activation, also resulting in better recall and a higher tendency for resumption. Lastly, we hypothesized that the activation resulting from the inability to finish a game and execute an additional ProM task would accumulate, resulting in an even higher recall of and tendency to resume the task.

Method

Participants

For the Zeigarnik effect, a total of N = 560 participants (267 male, 293 female) were recruited by undergraduate students for a research course at the University of Bern. Participants were, on average, 30.07 (*SD* = 14.48) years old, ranging from 18 to 89 years of age. Of these participants, N = 96 were assigned to the *Replication* condition, N = 96 were assigned to the *Instruction* condition, and N = 364 were assigned to the *ProM* condition.

For the *Ovsiankina* effect, a total of N = 576 participants (235 male, 340 female, and one who did not identify as either gender) were recruited by undergraduate students for the same research course at the University of Bern. Participants were, on average, 30.87 (*SD* = 15.26) years old, ranging from 18 to 89 years of age. Of these participants, N = 96 were assigned to the *Replication* condition, N = 96 were assigned to the *Instruction* condition, and N = 384 were assigned to the *ProM* condition.

Participants were recruited through word of mouth and were not compensated for their participation. Participants were required to be between 18 and 40 years of age, are required to speak German fluently and have normal to corrected vision. Reports were collected anonymously, and the ethical committee of the University of Bern approved the study. We used a one-factorial within-subjects design (interrupted vs. finished) for the Replication and Instruction conditions. For the *ProM* conditions,

we used a 2 (interrupted vs. finished) x 2 (ProM targets present vs. ProM targets absent) within-subjects design. As dependent variables, we measured the recall of interrupted and finished videogames for the *Zeigarnik* effect and the selection of interrupted and finished games for replay for the *Ovsiankina* effect.

Materials

Videogames. We created 16 short videogames, which shared similar controls using Unity Engine version 2021.1.12f (Unity®, 2021). Assets (a term used for the visual elements of videogames) were created or bought from GameDev Market (2021), consisting of two-dimensional images in pixel art. Each game was preceded by an instruction-screen, briefly explaining the games and their controls, followed by an end-screen, instructing participants to proceed to the next game. Approximately half of the videogames were limited by a 120-second timer, requiring participants to achieve the highest score possible in a limited time. In this case, both the timer and the achieved score were displayed to participants on-screen. The other half of the videogames were completable with a clear goal, such as completing a puzzle. In this case, time was not limited, and the game was finished once the required score or end state was achieved.

Recall and resumption. Dependent variables were assessed differently based on the effect of interest. For the Zeigarnik effect, participants were asked to recall both the title and describe the videogames they remembered. This provided us with both stringent and lenient recall measures for the videogames played. After recalling the videogames, participants were further required to recall whether the videogame was interrupted or not and, if present, whether participants had been able to complete the additional prospective memory task. These measures were assessed after the recall of videogames to avoid providing participants with an additional memory cue. For the *Ovsiankina* effect, participants were presented with a 4x4 grid of each game they had played, with both the title and an image of the videogame, to select eight videogames they would like to replay. We required participants to select eight games to avoid some participants selecting too few or too many videogames for replay.

Postquestionnaire. In the postquestionnaire, participants were asked questions about their videogame expertise. First, they were asked to rate how often they play videogames on their computer, consoles, phones or other devises. Response categories ranged from *never*, *less than once a year*, *once or more a year*, *once or more a month*, *once or more a week*, or *daily*. Next, participants were asked when they began playing videogames. Response categories ranged from *I don't play videogames*, *less than 5 years ago*, *more than 5 years but less than 10 years ago*, *more than 10 years but less than 20 years ago*, *more than 20 years but less than 30 years ago*, *or more than 30 years ago*. Then, participants were asked to rate their video expertise on a 5-point Likert scale. Response categories ranged from *1 (beginner)* to *5 (expert)*. Lastly, participants were asked to rate how much they enjoyed playing each videogame on a 5-point Likert scale, ranging from *0 (no fun)* up to *4 (a lot of fun)*.

Procedure

Participants were tested individually in the presence of an experimenter. We employed the following cover story: *The current investigation aims to explore the variations in performance between individuals with different levels of expertise in video games across various age groups*. Each session included eight interrupted and eight uninterrupted games, with a counterbalanced order of games and interruptions. Participants were instructed to play the videogames as quickly and carefully as possible, with the option to end the experiment whenever they chose. Then, demographical variables, such as age, gender, and handedness were recorded.

In the *Replication* condition, participants were interrupted in eight videogames while they were allowed to finish the other eight. Both the order of videogames and interrupts were counterbalanced across participants. In the *Instruction* condition, participants also played all sixteen videogames and were interrupted in half but instructed with an additional ProM task, which they could always execute. In the *ProM* condition, this additional ProM task was also instructed but could only be executed half the time, resulting in a Latin square: Participants played four interrupted games without execution of the

ProM task, four finished games without execution of the ProM task, four interrupted games with execution of the ProM task, and four finished games with the execution of the ProM task.

Before each videogame, participants received written instructions, which they were required to repeat verbally to the experimenter to confirm their understanding of the game. If participants could finish the game, they were congratulated on finishing the game and required to proceed to the next game. However, after an interrupted game, participants were interrupted with a prompt while pausing their videogame, stating that the game could not be resumed and that they should move on to the next one. All video games were presented sequentially.

Once participants finished playing all videogames, dependent variables were immediately assessed based on the condition participants were in. In the Zeigarnik condition, participants were asked to recall the title of each videogame they remembered an describe the game's content. Afterwards, participants were further required to recall whether the game was interrupted and, if present, whether the prospective memory task could be executed. In the Ovsiankina condition, participants were asked to select eight games they would like to play again.

Finally, participants completed the postquestionnaire. They answered questions about the frequency with which they played video games, rated themselves on their expertise, and reported when they had begun playing videogames. Subsequently, participants rated each game on how much they enjoyed the game. Finally, participants were debriefed and dismissed.

Analyses

We conducted different statistical analyses for the *Zeigarnik* and *Ovsiankina* effects. For the *Zeigarnik* effect, we used a one-sided paired sample t-test in both the *Replication* and *Instruction* conditions. For the *Ovsiankina* effect, we employed one-sample t-tests in the same conditions, testing against a value of four, as participants had to choose from eight games. For both effects under the *ProM* conditions, we utilized a 2 x 2 repeated measure ANOVA.

Results

Zeigarnik effect

In the *Replication* condition, participants recalled *M* = 4.96 (*SD* = 1.72) interrupted and *M* = 4.88 (*SD* = 1.61) finished games. A one-sided paired sample t-test did not yield significance, *t*(95) = 0.49, *p* = .314, *d* = .05. In the *Instruction* condition, participants recalled *M* = 5.30 (*SD* = 1.44) interrupted and *M* = 5.31 (*SD* = 1.51) finished games. A one-sided paired sample t-test did also not yield significance, *t*(95) = -0.07, *p* = .527, *d* = -.01. The computed *Zeigarnik* measures for each condition can be found in Figure 6.

In the *ProM* condition, participants recalled *M* = 2.35 (*SD* = 1.13) interrupted games without execution of the ProM task, *M* = 2.44 (*SD* = 1.13) finished games without execution of the ProM task, *M* = 2.50 (*SD* = 1.10) interrupted games with execution of the ProM task, and *M* = 2.59 (SD = 1.09) finished games with execution of the ProM task. A repeated measures ANOVA resulted in a significant main effect of the interrupt, *F*(1, 367) = 4.11, *p* = .043, η^2_p = .01, and a main effect of the execution of the ProM task, *F*(1, 367) = 7.78, *p* = .006, η^2_p = .02. The interaction did not yield significance. Videogames were better recalled when finished and when a ProM task could be executed.

Ovsiankina effect

In the *Replication* condition, participants chose *M* = 4.19 (*SD* = 0.98) interrupted and *M* = 3.81 (*SD* = 0.98) finished games for replay. A one-sided one-sample t-test tested against four was significant, *t*(95) = 1.88, *p* = .032, *d* = .19. In the *Instruction* condition, participants chose *M* = 4.03 (*SD* = 1.01) interrupted and *M* = 3.97 (*SD* = 1.01) finished games for replay. A one-sided one-sample t-test tested against four did not yield significance, *t*(95) = 0.30, *p* = .381, *d* = .03. The computed *Ovsiankina* measure for each condition can be found in Figure 7.

In the *ProM* condition, participants selected *M* = 2.09 (*SD* = 0.90) interrupted games without execution of the ProM task, *M* = 1.96 (*SD* = 0.97) finished games without execution of the ProM task, *M* = 2.03 (*SD* = 0.91) interrupted games with execution of the ProM task, and *M* = 1.92 (*SD* = 1.00) finished

games with execution of the ProM task for recall. A repeated measures ANOVA resulted in a significant main effect of the interrupt, $F(1, 383) = 5.36$, $p = .021$, $\eta^2_p = .01$, but no main effect of the execution of the ProM task, $F(1, 383) = 0.74$, $p = .389$, $\eta^2_p < .01$. The interaction did not yield significance. Videogames were selected for replay more often when they had been interrupted.

Discussion

This pilot study evaluated whether we could replicate the *Zeigarnik* and *Ovsiankina* effect using videogames as computerized tasks in a standardized environment. Moreover, we aimed to investigate whether the activation caused by an interrupted task and the activation caused by the inability to perform a task would accumulate. For the Zeigarnik effect, we were unable to replicate the effect in both the *Replication* and the *Instruction* conditions. In the *ProM* condition, however, the opposite pattern occurred: Not only were finished games better recalled than interrupted ones, but the execution of an additional ProM task also resulted in better recall, contrary to our expectations. For the *Ovsiankina* effect, we replicated the effect in the *Replication* condition but could not do so in the *Instruction* condition when the additional ProM task was present. Finally, in the *ProM* condition, interrupted tasks were selected more frequently for replay than finished tasks, whereas the execution of an additional ProM task did not influence the *Ovsiankina* effect.

While using videogames as computerized tasks still seemed promising, we identified several issues in our pilot study that may explain these inconsistent results. For instance, when manipulated, the additional ProM task unsuccessfully induced both effects and even resulted in the opposite pattern for the Zeigarnik effect. We suspected that, when present, ProM targets provided an additional memory cue. This may have resulted in better recall of games where the ProM task could be executed compared to when the ProM task could not. We realized that implementing an additional ProM task resulted in unnecessary complications with the potential to counteract the effects in question. Therefore, we

decided to simplify the experiment by removing the additional ProM task and limiting the experiment to the *Replication* condition.

Moreover, time on task varied severely, as some games were limited by time, whereas others were limited by clear goals, such as completing a puzzle. Thereby, time on task was better controlled on time-limited videogames, as the duration was set to 120 seconds, and the interrupt always occurred after 60 seconds. For goal-limited videogames, however, the time participants needed to complete the task varied highly, as did the interruption time. For consistency's sake, we decided that time-limited videogames were more suitable, as they allowed for a better standardization of time on task. Further, they allowed to standardize the interruption time, occurring at the halfway mark after precisely 60 seconds. However, this would come at the cost of tasks having a clear end-goal, a trade-off between standardization and external validity, as intentions typically tend to have a clear end-goal.

We further noted that the presence of certain assets in more than one game led to participants confusing games during recall in their descriptions. For instance, a knight was used as a player character for two distinct games. The repeated exposure to assets as stimuli could have resulted in a memory advantage for these games. As such, we ensured that each game consisted of unique assets to rule out memory advantages due to repeated stimuli exposure.

After consulting participants following the experiment, we received feedback that some participants struggled with the difficulty of the videogames. This could also be attributed to the fact that we did not restrict the age of participants, and older individuals might not be as comfortable using computers, let alone playing video games. Therefore, we saw the need to simplify the videogames while providing the option for a more challenging version to cater to both videogame novices and experts. Simultaneously, we decided to limit participants' age to 45 years to increase the likelihood of participants being proficient in using computers while maintaining comparability in cognitive performance.

Lastly, we realized the need to account for individual differences. The inconsistency in successfully replicating these effects has been attributed to individual differences (Atkinson, 1953). In particular, the Zeigarnik effect has been demonstrated to be more pronounced in individuals high in achievement motivation (Atkinson, 1953; Farley & Mealiea, 1973; Mandowsky, 2007; Weiner, 1965). Achievement motivation is seen as a stable disposition to strive for success and achievement (Atkinson, 1957). This relationship, however, has not been investigated in relation to the *Ovsiankina* effect. Hence, we hypothesized that these effects may become more apparent in individuals high in achievement motivation.

Experiment

After identifying these potential issues in our pilot study, we implemented the discussed improvements and re-conducted the experiment. We focused our experiment on the *Replication* condition and removed the additional ProM task. This allowed us to investigate both effects without interference from other mechanisms while allocating more participants to this *Replication* condition, thereby increasing the statistical power of our experiment and allowing us to detect smaller effects. Further, we improved and modified the videogames used in this study. Each of the sixteen videogames now consisted of unique assets, undermining potential memory advantages. In their new iteration, videogames were limited by a 120-second timer, and the interrupt consistently occurred after 60 seconds, thereby controlling for the effects of time on the task. Moreover, we simplified the videogames with the option to opt for a more challenging mode. This allowed us to account for the participants' proficiency in videogames, giving newer players the possibility to successfully play the videogames while providing an appropriate challenge for videogame adepts.

Further, the precise standardization of time on task allowed us to investigate one additional aspect of interrupted tasks. In a typical interrupt task paradigm, tasks are presented sequentially and, if interrupted, generally encompass a shorter time on task than when completed (Pachauri, 1935).

Therefore, the longer time spent on a finished task could subsequently lead to better memory recall (Reiss, 1968), as observed in the *ProM* condition of our pilot study. In fact, other researchers noted that more finished tasks were recalled when the time on task for interrupted tasks was shorter than for finished tasks, but a memory advantage for interrupted tasks emerged when time on task was held constant (Seifert & Patalano, 1991). It can be assumed that the memory advantage for finished tasks from a longer time on task and the memory advantage of interrupted tasks urging for their completion represent opposing forces cancelling each other out, nullifying subsequent memory advantages.

The structure of our experiment allowed us to investigate the Zeigarnik and *Ovsiankina* effect both when participants played interrupted videogames for half the duration of finished videogames, and when they played both interrupted and finished videogames for the same duration. We were eager to investigate whether this effect on time on task would account for the absence of the Zeigarnik effect in our pilot study. Moreover, this aspect had not yet been investigated concerning the *Ovsiankina* effect. However, we did not expect time on task to influence the motivation to resume and finish a task and hence did not expect any changes in the *Ovsiankina* effect.

One prominent individual difference we were interested in was achievement motivation (Atkinson, 1953; Cooper, 1983; Moot III et al., 1988; Raffini & Rosemier, 1972; Reiss, 1968; Weiner, 1966). Achievement motivation refers to a behaviour characterized by competition with a standard of excellence (McClelland et al., 1976). Consequently, a high achievement motive is considered a stable disposition to strive for achievement or success (Atkinson, 1957). Here, we assessed the two distinct aspects of achievement motivation: The anticipation of reward, known as hope of success, and the anticipation of punishment, known as fear of failure (Clark et al., 1956; McClelland et al., 1953). We were interested in whether a neutral experimental atmosphere was sufficient to detect achievement-motivated differences in recall patterns, as our meta-analysis yielded mixed results.

In the final experiment, we similarly presented participants with sixteen videogames in sequence as interruptible tasks. Eight videogames were interrupted midway, while participants could finish the other eight. Participants in the *Varying Time* condition played interrupted videogames for exactly half as long as the finished videogames. Participants in the *Constant Time* condition, however, played interrupted videogames for exactly as long as they finished videogames. Again, we hypothesized that the interruption of a videogame would result in its memory advantage and a tendency for its resumption.

Method

Participants

Given the variable findings on the *Zeigarnik* effect and the small effect computed in our meta-analysis, we conducted an a priori power analysis using G*Power version 3.1.9.7 (Faul et al., 2009) to determine the minimum sample size required to discern a small effect of Cohen's $d_z = 0.2$ for a one-sided paired sample t-test. The analysis yielded that a sample size of N = 272 was sufficient to attain 95% power when detecting a small effect with a significance criterion of $\alpha = 0.05$.

For the Zeigarnik effect, a total of *N* = 576 participants (247 male, 328 female, and one who did not identify as either gender) were recruited by undergraduate students for a research course at the University of Bern. Participants were, on average, 22.70 (*SD* = 4.18) years old, ranging from 18 to 44 years of age. Of these participants, *N* = 288 were assigned to the *Varying Time* condition, and N = 288 were assigned to the *Constant Time* condition.

For the *Ovsiankina* effect, a total of *N* = 576 participants (254 male, 315 female, and seven who did not identify as either gender) were recruited by undergraduate students for the same research course at the University of Bern. Participants were, on average, 23.91 (*SD* = 5.26) years old, ranging from 18 to 45 years of age. Of these participants, *N* = 288 were assigned to the *Varying Time* condition, and *N* = 288 were assigned to the *Constant Time* condition.

Participants were recruited through word of mouth and were not compensated for their participation. Participants were required to be between 18 and 40 years of age, are required to speak German fluently and have normal to corrected vision. Reports were collected anonymously, and the ethical committee of the University of Bern approved the study. We employed a one-factorial within-subjects design (interrupted vs. finished) for all conditions. As dependent variables, we measured the recall of interrupted and finished videogames for the *Zeigarnik* effect and the selection of interrupted and finished games for replay for the *Ovsiankina* effect.

Materials

Videogames. We created 16 short videogames, which shared similar controls using Unity Engine version 2021.1.12f (Unity®, 2021). Assets were either created or bought from GameDev Market (2021) and consisted of two-dimensional images in pixel art (an example of each game can be found in Appendix A). Each asset was used for one game uniquely. Games were played for a maximum of 120 seconds each. Each game was preceded by an instruction-screen, briefly explaining the games and their controls (see Table A1). To accommodate both new videogame players and experts and avoid boredom for the latter, we created each videogame in an easy and hard mode. The easy mode offered a slight challenge to novel video game players, whereas the hard mode offered experts a slightly more challenging experience. Before starting the experiment, participants were informed about both game modes and asked to select the appropriate mode. Subsequently, all games were played in the same difficulty mode.

The progress in each game was displayed to participants at the top of the screen with a progress bar. The colour of the progress bar changed from red to orange and finally to green, representing participants' distance to successfully finishing the game. A filled progress bar represented 120 seconds on the task, and the progress bar was updated in increments whenever participants successfully scored in the respective videogame. Given the frequent updating of the progress bar and the participants' focus

on the videogame, updates appeared authentic and were barely noticeable. As such, a full progress bar always represented 120 seconds on the task while ensuring participants remained unaware of this fact. In the Constant Time condition, participants reached the middle of the progress bar after 120 seconds, and the game was interrupted. This gave participants the impression of having only reached the middle of the game while having played the full 120 seconds of the videogame.

Additionally, participants were given an audio cue based on the videogames status. When a game was interrupted, a sound indicating failure was played when the game was interrupted by the prompt. When the game was finished, participants were noticed about their success with a joyful audio cue.

Recall and resumption. Dependent variables were assessed differently based on the effect of interest, identical to the pilot study. For the Zeigarnik effect, participants were again asked to recall both the title and describe the videogames they remembered. This provided us with both stringent and lenient recall measures for the videogames played. After recalling the videogames, participants were further required to recall whether the videogame was interrupted or not. These measures were assessed after the recall of videogames to avoid providing participants with an additional memory cue. For the *Ovsiankina* effect, participants were again presented with a 4x4 grid of each game they had played, with both the title and an image of the videogame, to select eight videogames they would like to replay. Participants were required to select eight games to avoid some participants selecting too few or too many videogames for replay.

Postquestionnaire. We used the same postquestionnaire as in the pilot study. After playing all sixteen games, participants were asked questions about their videogame expertise. First, they were asked to rate how often they play videogames on their computer, consoles, phones or other devises. Response categories ranged from *never*, *less than once a year*, *once or more a year*, *once or more a month*, *once or more a week*, or *daily*. Next, participants were asked when they began playing

videogames. Response categories ranged from *I don't play videogames*, *less than 5 years ago*, *more than 5 years but less than 10 years ago*, *more than 10 years but less than 20 years ago*, *more than 20 years but less than 30 years ago*, or *more than 30 years ago*. Then, participants were asked to rate their video expertise on a 5-point Likert scale. Response categories ranged from *1 (beginner)* to *5 (expert)*. Lastly, participants were asked to rate how much they enjoyed playing each videogame on a 5-point Likert scale, ranging from *0 (no fun)* up to *4 (a lot of fun)*.

Achievement motivation. We also used the revised 10-item version of the Achievement Motives Scale (AMS-R; Lang & Fries, 2006) to measure achievement motivation. The achievement motives scale measures a general tendency to evaluate and act in situations with a standard of excellence to be met. This achievement motive is split into an approach (hope of success) and avoidance (fear of failure) tendency. We used both the 5-item hope of success scale (Cronbach α = .71 – .80) and the 5-item fear of failure scale (Cronbach α = .76 – .85). Items were rated on a four-point Likert scale (1 = totally disagree, 4 = totally agree). Items reflect an individual's attraction or anxieties when facing challenges, such as, for instance, *I like situations, in which I can find out how capable I am* for hope of success, or *I am afraid of failing in somewhat difficult situations, when a lot depends on me* for fear of failure.

Procedure

Participants were tested individually in the presence of an experimenter. We employed the same cover story as in the pilot study: *The current investigation aims to explore the variations in performance between individuals with different levels of expertise in video games across various age groups*. Each participant underwent individual testing sessions. Participants were given the choice between an easy and difficult mode. Subsequently, all videogames were played in either the easy or difficult mode.

Before each game, participants received written instructions, which they were required to repeat verbally to the experimenter to confirm their understanding of the game. If participants could finish the game, an audio cue was played, indicating their success, they were congratulated on finishing the game and required to proceed to the next game. However, after an interrupted game, an audio cue was played indicating their failure. Participants were interrupted with a prompt pausing their videogame, stating that the game could not be resumed and that they should move on to the next one. All video games were presented sequentially.

In the *Varying Time* condition, participants spent a total of 60 seconds on interrupted videogames and 120 seconds on finished videogames. In the *Constant Time* condition, participants spent 120 seconds on interrupted and finished games. For both conditions, the progress bar reached the middle of the interrupted videogames before being interrupted by a prompt and reached the end of the finished videogames.

Once participants finished playing all videogames, dependent variables were immediately assessed based on the condition participants were in. In the Zeigarnik condition, participants were asked to recall the title of each videogame they remembered and describe the content of the game. Afterwards, participants were further required to recall whether the game was interrupted. In the Ovsiankina condition, participants were asked to select eight games they would like to play again.

Finally, participants completed the postquestionnaire. They answered questions about the frequency with which they played video games, rated themselves on their expertise, and reported when they had been playing videogames. Subsequently, participants rated each game on how much they enjoyed the game and completed the AMS-R. Finally, participants were debriefed and dismissed.

Analyses

We conducted different statistical analyses for the *Zeigarnik* and *Ovsiankina* effects. For the *Zeigarnik* effect, we used a one-sided paired sample t-test in both the *Varying Time* and *Constant Time*

conditions. For the *Ovsiankina* effect, we employed one-sample t-tests in the same conditions, testing against a value of four, as participants had to choose from eight games. We conducted correlation analyses and employed linear regression models to investigate hope of success and fear of failure. Descriptive analyses of the post-questionnaire variables can be found in Appendix B.

Results

Zeigarnik effect

In the *Varying Time* condition, participants recalled M = 5.15 (SD = 1.65) interrupted and M = 5.25 (SD = 1.69) finished games. A one-sided paired sample t-test did not yield significance, $t(287) = -0.64$, $p = .740$, $d = -.04$. In the *Constant Time* condition, participants recalled M = 5.16 (SD = 1.58) interrupted and M = 5.06 (SD = 1.68) finished games. A one-sided paired sample t-test did also not yield significance, $t(287) = 1.01$, $p = .155$, $d = .06$. The computed *Zeigarnik* measures for both conditions can be found in Figure 6.

Ovsiankina effect

In the *Varying Time* condition, participants chose M = 4.12 (SD = 1.25) interrupted and M = 3.88 (SD = 1.25) finished games for replay. A one-sided one-sample t-test tested against four was significant, $t(287) = 1.65$, $p = .049$, $d = .10$. In the *Constant Time* condition, participants chose M = 3.80 (SD = 1.18) interrupted and M = 4.20 (SD = 1.18) finished games for replay. A one-sided one-sample t-test tested against four also yielded significance, $t(287) = -2.91$, $p = .002$, $d = -.17$. The computed *Ovsiankina* measure for both conditions can be found in Figure 7.

Hope of success

For the *Zeigarnik* effect, we conducted a correlation analysis of the hope of success scores with the recall of interrupted and finished videogames. Hope of success was not correlated with the amount of recalled interrupted videogames, $r(574) = .05$, $p = .223$, but significantly correlated with the amount of recalled finished videogames, $r(574) = .36$, $p < .001$. A linear regression analysis confirmed a small

effect of the linear relationship of hope of success with the recall of finished games, R^2 =.02, F(1, 574) = 7.09, p = .008, B = 0.08.

Next, we analyzed whether the correlation analysis differed for the *Varying Time* condition and *Constant Time* condition: In the Varying Time condition, hope of success was neither correlated with the recall of interrupted nor the recall of finished videogames. In the *Constant Time* condition, however, hope of success was significantly correlated with the recall of finished videogames, r(286) = .12, p < .039. A linear regression analysis confirmed a small effect of the linear relationship of hope of success with the recall of finished games, R^2 =.01, F(1, 574) = 4.30, p = .039, B = 0.09.

For the *Ovsiankina* effect, we also conducted a correlation analysis of the hope of success scores and the selection of interrupted and finished videogames for replay. Hope of success was neither correlated with the amount of selected interrupted videogames, r(574) = -.04, p = .291, nor with the amount of selected finished videogames, r(574) = .04, p = .291. Correlation coefficients remained insignificant when the *Varying Time* condition and the *Constant Time* condition were analyzed separately.

Fear of failure

For the *Zeigarnik* effect, we conducted a correlation analysis of the fear of failure scores with the recall of interrupted and finished videogames. Fear of failure was not correlated with the amount of recalled interrupted videogames, r(574) = .04, p = .327, but significantly correlated with the amount of recalled finished videogames, r(574) = .14, p < .001. A linear regression analysis confirmed a small effect of the linear relationship of hope of success with the recall of finished games, R^2 =.02, F(1, 574) = 11.29, p < .001, B = 0.07.

Next, we analyzed whether the correlation analysis differed for the *Varying Time* condition and *Constant Time* condition differed: In the *Varying Time* condition, fear of failure was neither correlated with the recall of interrupted nor with the recall of finished videogames. In the *Constant Time* condition,

however, fear of failure was significantly correlated with the recall of interrupted, $r(286) = .14$, $p = .021$, and finished videogames, $r(286) = .18$, $p < .002$. Linear regression analyses confirmed a small effect of the linear relationship of hope of success with the recall of interrupted, $R^2 = .02$, $F(1, 574) = 5.35$, $p = .021$, B = 0.06, and finished videogames, $R^2 = .03$, $F(1, 574) = 9.45$, $p = .002$, B = 0.08.

For the *Ovsiankina* effect, we also conducted a correlation analysis of the hope of success scores with the selection of interrupted and finished videogames for replay. Hope of success was neither correlated with the amount of selected interrupted videogames, $r(574) = -.05$, $p = .235$, nor with the amount of selected finished videogames, $r(574) = .05$, $p = .235$. Correlation coefficients remained insignificant when the *Varying Time* condition and the *Constant Time* condition were analyzed separately.

Discussion

The goal of the present study was to replicate the *Zeigarnik* and *Ovsiankina* effect using a more modern and standardized approach. We deemed videogames a suitable substitute for the commonly used manual and paper-pencil tasks. A computerized approach allowed us to standardise instructions, stimuli presentation, and time on task. After playing 16 videogames, of which half were interrupted, participants were either tasked with recalling as many videogames as possible or selecting eight games they wished to replay. We did not find a *Zeigarnik* effect in both the *Varying Time* condition and the *Constant Time* condition. Regarding the *Ovsiankina* effect, however, we did find that participants selected more interrupted games for replay in the *Varying Time* condition, with the opposite pattern occurring in the *Constant Time* condition.

Descriptive analyses underscored that the difference between the recall of interrupted and finished videogames was negligible. The effect sizes obtained were comparable to our meta-analysis's computed average effect size. Although the ratio of interrupted and finished recalled videogames differed somewhat in both conditions, we suspect this to be a chance finding. Interestingly, hope of

success and fear of failure were only associated with recall in the *Constant* Time condition. Keeping the time on task constant may have eliminated other potential influences, such as time on task, thus allowing effects from individual differences to shine through. Hope of success was only associated with an increased recall of finished videogames. On the other hand, fear of failure was associated with an increased recall of interrupted and finished videogames. Although these results diverge from prior literature, they might be better understood considering the subsequent explanations.

We assume that videogames may have induced a more relaxed experimental atmosphere than initially considered. Therefore, the urgency to complete the videogames may have been diminished. Individuals high in hope of success may have encoded finished tasks better as a means of self-enhancement, validating their success (J. D. Green et al., 2008; Taylor, 1953). On the other hand, individuals high in fear of failure exhibited better recall independent of whether videogames were interrupted or finished. It is possible that the encoding of both interrupted and finished games profited from different mechanisms. Interrupted games could be encoded better because they are perceived as potential failures and are more memorable due to their negative valence (Hamann, 2001; Payne & Kensinger, 2010). Meanwhile, these individuals may also have preferred recalling finished games to protect the ego (Farley & Mealiea, 1973). This may have resulted in an unspecific subsequent memory advantage.

Interestingly, we did find an *Ovsiankina* effect in the *Varying Time* condition and a reverse *Ovsiankina* effect in the *Constant Time* condition. While we didn't initially hypothesize the impact of time on task on the *Ovsiankina* effect, we suspect that time constancy is the pivotal variable: In the *Varying Time* condition, participants likely realized that they spent less time on interrupted videogames than finished videogames. Thus, replaying the videogame with sufficient time would allow the completion of the game, resulting in a resumption tendency. In the *Constant Time* condition, however, participants spent an identical amount of time on the videogame, only reaching their goal's midway

point. This may have resulted in frustration while playing the interrupted video games, deterring them from choosing them for resumption. Therefore, participants in the Constant Time condition perceived finished games as less frustrating and more pleasant.

Some limitations need to be taken into consideration, however. As we controlled for the duration of the videogames, these videogames did not have a clear endpoint. We attempted to induce the intention of completion by providing participants with a progress bar and auditory cues representing their progress. Due to this fact, we cannot exclude the occurrence of the *Zeigarnik* effect when using videogames. However, this was unavoidable as otherwise, the duration of the videogames would have fluctuated strongly.

Further, the employment of videogames as tasks was a novelty, particularly regarding the *Zeigarnik* effect. Whereas typically, heterogenous manual tasks with a clear endpoint had been used, it could be argued that the videogames were too homogenous: All videogames shared similar controls, were performed on a computer, and used similar stimuli. As a result, the tasks could have been insufficiently distinguishable, resulting in the different videogames being perceived as one big task. However, studies using homogenous tasks, such as paper-pencil tasks, also occasionally demonstrated *Zeigarnik* effects (e.g., Atkinson, 1957; Baddeley, 1963; Hofstaetter, 1985; Mäntylä & Sgaramella, 1997; Reiss, 1968), which is why a demonstration of the *Zeigarnik* effect should be possible with videogames. Hence, we would not deem the use of videogames as tasks inappropriate.

Another issue regarding the *Ovsiankina* effect needs to be acknowledged: Typically, the resumption of tasks was investigated for a few tasks and was assessed promptly after their interruption. In our study, participants were presented with eight interrupted games, and their resumption, measured in their selection for replay, occurred after multiple tasks and a prolonged time interval. The duration of an interruption has been linked directly to its resumption lag, that is, the time needed to resume a task (Monk et al., 2008). The prolonged duration from the moment of interruption up to the

ability to resume the videogame may have impaired participants' tendency to select interrupted videogames for replay, resulting in a lower resumption rate than expected. Given the unfavourable circumstances, the significant *Ovsiankina* effect in the Varying Time condition is surprising.

Last, hope of success and fear of failure were assessed using a self-report measure, which in previous research showed minimal correlation with a more objective measure (Brunstein & Heckhausen, 2018). However, opting for self-report measures allowed us to significantly reduce time needed, thus benefiting test efficiency. Moreover, both measures were typically assessed as one measure of achievement motivation. Therefore, our assumptions about the influence of hope of success and fear of failure were speculative. As our study did not manipulate the experimental setting, likely these personality traits did not provoke the expected recall patterns. However, creating an achievement-oriented atmosphere with videogames is rather difficult unless these videogames are played competitively.

Therefore, We would not exclude using video games to study the *Zeigarnik* and *Ovsiankina* effect. On the contrary, the present findings emphasise that the *Zeigarnik* effect could not be detected under relaxed, even playful circumstances if the influences of the experimenter, the task duration and the stimuli presentation are kept constant. The *Ovsiankina* effect, however, is also present under these standardized circumstances.

General Discussion

The current findings are not in favour of a *Zeigarnik* effect. In fact, it can be concluded from the numerous studies failing to demonstrate the *Zeigarnik* effect that it is not a ubiquitous and universally applicable effect. At least, it seems that its occurrence is dependent on certain conditions. Meanwhile, the *Ovsiankina* effect could generally be observed, indicating that both effects may differ in their nature. The resumption of tasks appears to be more intuitive, without relying on conscious processing. As Ovsiankina (1928) observed, participants appeared to have difficulties shifting from the interrupted task

to the substitute task. However, when performing the substitute task, their tendency for resumption was suppressed, reemerging naturally once the substitute task was complete. Still, it seems that this tendency of resumption does not translate directly to a conscious memory advantage for the interrupted tasks per se.

The favourable recall of interrupted rather than finished tasks seems to be particularly susceptible to situational influences and individual differences. Rather than being generally present, the *Zeigarnik* effect could represent a product of both factors. On the one hand, situational influences could dictate the importance of completing the tasks through instructions or experimenter authority, such as when they are framed as intelligence measures, when participants compete with others, or when emphasis is put on the tasks. The intention to complete the tasks becomes particularly strong in such cases. Here, the situation establishes the basis for different retrieval patterns: Either the perceived task importance results in more recalled interrupted tasks because their completion is perceived as important, or it results in more recalled finished tasks because the failure to complete those tasks represents an ego-threatening failure. In a relaxed situation, however, no particular importance is attributed to the tasks and recall patterns are uninfluenced, as demonstrated in our study.

On the other hand, individual differences could also influence the general tendency for recall, as some traits may be associated with a favourable recall of interrupted or finished tasks. These individual differences may evoke particular recall patterns but often emerge to little extent unless provoked by situational influence. For example, the experimental situation may suggest to participants that the completion of tasks is of particular importance. Based on their individual differences, some participants may now perceive the tasks as an opportunity to excel and, therefore, recall more interrupted tasks. In contrast, others may perceive interrupted tasks as ego-threatening and recall more finished tasks. And yet again, others might be indifferent to the situational demands, recalling a comparable amount of interrupted and finished tasks. Under these circumstances, it becomes clear why replicating the

Zeigarnik effect is tricky since both factors can contribute to the effect, as demonstrated in Atkinson's (1953) study.

The question now arises as to why Zeigarnik (1927) could demonstrate the memory advantage for interrupted tasks without manipulating the situation and considering individual differences. Here, a historical perspective is necessary. Zeigarnik (1927) herself states that participants carried out the tasks conscientiously either out of a sense of duty towards the experimenter, out of ambition, or motivated by the tasks themselves. These observations underline the heightened task involvement of participants during the experiment. If we consider that the experiments were conducted at the beginning of the 20th century, we can assume a high authority of the experimenter, given their association with academic institutions. At the time, professors and universities in Europe enjoyed great respect and prestige, as McCain reports hearing that "… professors are not human beings, they are gods" (McCain, 1960 p. 100). Accordingly, the then-present situation demanded excellence and performance without the need for situational manipulation. If we assume the subjects to be predominantly students, we are presented with a highly achievement-motivated sample privileged to study at a prestigious university.

We assume that, nowadays, experimental atmospheres have lost their performance-demanding qualities due to decreased experimenter-authority. Manipulation of the experimental atmosphere has become mandatory to provoke a *Zeigarnik* effect. Further, individuals capable of sufficient task involvement are needed. Herein lies the problem: Task involvement has become more difficult as we are increasingly faced with interruptions: Mobile phone notifications, e-mails at work, and a tendency for multitasking impede our ability to focus on a task (Kushlev & Dunn, 2015; Ophir et al., 2009; Stothart et al., 2015). We assume, therefore, that the subjects at that time were much more capable of engaging in a task. Finding such task-involved individuals in the present time should prove more difficult, which could contribute to the fact that today's findings on the *Zeigarnik* effect do not reach the same magnitude as in Zeigarnik's (1927) time.

In contemporary research, intentions have mainly been investigated concerning prospective memory. Artefacts of unfulfilled intentions, such as commission errors (e.g., Bugg & Scullin, 2013) and slower reaction times (e.g., Meier & Cottini, 2023; Walser et al., 2012), have typically been explained by the *Zeigarnik* effect (Bugg & Streeper, 2019; Möschl et al., 2020). However, these effects differ from the *Zeigarnik* effect. First, contemporary prospective memory research mainly focused on the prospective component of intentions, that is, knowing when to execute the intention, compared to earlier research that captured the recall of the content of a task (Goschke & Kuhl, 1996). Second, in an interrupted task paradigm, a task is interrupted in the progress of its execution. In prospective memory research, however, targets relevant to the prospective memory task typically don't appear until the task's termination. Only then are targets presented to the participant. Therefore, participants do not get the opportunity to start their intention. The degree of task fulfilment significantly differs between both paradigms.

If we were to revert to Lewin's (1926) theory of tension, the tension caused by implementing an intention could be discharged to some degree during task execution. In a typical zero-target condition, in which a prospective memory task is instructed but task-relevant stimuli remain absent, the tension would persist at its initial level due to an individual's ability to even begin the task. This assumption finds support in a recent prospective memory study by Streeper and Bugg (2021), where the partial completion of a prospective memory task resulted in lower commission errors compared to a zero-target condition but more commission errors than when the prospective memory task was fully completed. The partial completion of an intention subsequently partially satisfied the intention. These findings could explain why intentions are more activated in prospective memory research than in a typical interrupted task paradigm, resulting in more robust effects.

Modern theories of intentions have turned away from the abstract concept of tension towards a theory of activation (Goschke & Kuhl, 1993). The representation of an intention persists in a state of

heightened subthreshold activation (Goschke & Kuhl, 1996). Such activation ensures that the intention persists, prompting us to act upon it when the opportunity arises. Nevertheless, the observation remains that interrupted intentions are not simply forgotten but are reliably resumed and urge us towards their completion. Intentions must, therefore, take on a unique role in our memory. However, they don't always possess a conscious memory advantage compared to finished intentions in the presence of multiple tasks. As MacLeod puts it: "At best, it would appear to hinge on certain individual difference characteristics; at worst, it is simply not replicable" (MacLeod, 2020, S. 1081).

Summary

With Lewin's (1926) field theory of tension, two effects were established concerning unfinished intentions: The better recall of interrupted intentions, labelled the *Zeigarnik* effect, and the tendency to resume them, labelled the *Ovsiankina* effect. Whereas the *Ovisankina* effect replicated more reliably, replicating the *Zeigarnik* effect emerged as a challenging endeavour. The *Zeigarnik* effect appears to depend on particular situational influences and individual differences, such as the experimenter's authority, situational demands of task performance, and task involvement. These circumstances were more prevalent historically and are rarer today. Conclusively, the *Ovsiankina* effect represents a general tendency, while the validity of the *Zeigarnik* effect remains questionable and certainly not universal.

References

Ach, N. (1910). *Über den Willensakt und das Temperament: Eine experimentelle Untersuchung*. Quelle & Meyer.

Alper, T. G. (1946). Memory for completed and incompleted tasks as a function of personality: An analysis of group data. *The Journal of Abnormal and Social Psychology*, *41*(4), 403–420. https://doi.org/10.1037/h0060011

Atkinson, J. W. (1953). The achievement motive and recall of interrupted and completed tasks. *Journal of Experimental Psychology*, *46*(6), 381–390. https://doi.org/10.1037/h0057286

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review*, *64*(6, Pt.1), 359–372. https://doi.org/10.1037/h0043445

Baddeley, A. D. (1963). A Zeigarnik-like effect in the recall of anagram solutions. *Quarterly Journal of Experimental Psychology*, *15*(1), 63–64. https://doi.org/10.1080/17470216308416553

Birk, M. V., Mandryk, R. L., & Baumann, N. (2020). Just a click away: Action–state orientation moderates the impact of task interruptions on initiative. *Journal of Personality*, *88*(2), 373–390. https://doi.org/10.1111/jopy.12498

Booth-Kewley, S., Larson, G. E., & Miyoshi, D. K. (2007). Social desirability effects on computerized and paper-and-pencil questionnaires. *Computers in Human Behavior*, *23*(1), 463–477. https://doi.org/10.1016/j.chb.2004.10.020

Bugg, J. M., & Scullin, M. K. (2013). Controlling intentions: The surprising ease of stopping after going relative to stopping after never having gone. *Psychological Science*, *24*(12), 2463–2471. https://doi.org/10.1177/0956797613494850

Bugg, J. M., & Streeper, E. (2019). Fate of suspended and completed prospective memory intentions. In J. Rummel & M. A. McDaniel (Hrsg.), *Prospective Memory* (1. Aufl., S. 44–59). Routledge. https://doi.org/10.4324/9781351000154-4

Butterfield, E. C. (1964). The interruption of tasks: Methodological, factual, and theoretical issues. *Psychological Bulletin*, *62*(5), 309–322. https://doi.org/10.1037/h0039873

Caron, A. J., & Wallach, M. A. (1957). Recall of interrupted tasks under stress: A phenomenon of memory or of learning? *The Journal of Abnormal and Social Psychology*, *55*(3), 372. https://doi.org/10.1037/h0042808

Claeys, W. (1969). Zeigarnik effect, „reversed Zeigarnik effect," and personality. *Journal of Personality and Social Psychology*, *12*(4), 320–327. https://doi.org/10.1037/h0027765

Cohen, A.-L., West, R., & Craik, F. I. M. (2001). Modulation of the prospective and retrospective components of memory for intentions in younger and older adults. *Aging, Neuropsychology, and Cognition*, *8*(1), 1–13. https://doi.org/10.1076/anec.8.1.1.845

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Academic press.

Cooper, W. H. (1983). An achievement motivation nomological network. *Journal of Personality and Social Psychology*, *44*(4), 841–861. https://doi.org/10.1037/0022-3514.44.4.841

Drasgow, F., & Olson-Buchanan, J. B. (1999). *Innovations in computerized assessment*. Psychology Press.

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, memory, and cognition*, *16*(4), 717–726. https://doi.org/10.1037/0278-7393.16.4.717

Farley, F. H., & Mealiea, W. L. (1973). Motivation and the recall of completed and incompleted achievement items. *The Journal of Educational Research*, *66*(7), 302–306. https://doi.org/10.1080/00220671.1973.10884489

Farley, F. H., & Mealiea, W. L. (1971). Individual differences in the Zeigarnik effect. *Proceedings of the Annual Convention of the American Psychological Association*.

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.

GameDev Market. (2021). [GameDevNetwork Limited]. *GameDevNetwork Limited*. https://www.gamedevmarket.net/

Glixman, A. F. (1949). Recall of completed and incompleted activities under varying degrees of stress. *Journal of Experimental Psychology*, *39*(3), 281–295. https://doi.org/10.1037/h0054442

Goschke, T., & Kuhl, J. (1993). Representation of intentions: Persisting activation in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(5), 1211–1226. https://doi.org/10.1037/0278-7393.19.5.1211

Goschke, T., & Kuhl, J. (1996). Remembering what to do: Explicit and implicit memory for intentions. In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Hrsg.), *Prospective memory: Theory and applications* (S. 53–91). Lawrence Erlbaum Associates Publishers.

Gough, H. G., McClosky, H., & Meehl, P. E. (1951). A personality scale for dominance. *The Journal of Abnormal and Social Psychology*, *46*(3), 360.

Green, D. R. (1963). Volunteering and the recall of interrupted tasks. *The Journal of Abnormal and Social Psychology*, *66*(4), 397–401. https://doi.org/10.1037/h0042167

Green, J. D., Sedikides, C., & Gregg, A. P. (2008). Forgotten but not gone: The recall and recognition of self-threatening memories. *Journal of Experimental Social Psychology*, *44*(3), 547–561. https://doi.org/10.1016/j.jesp.2007.10.006

Hamann, S. (2001). Cognitive and neural mechanisms of emotional memory. *Trends in Cognitive Sciences*, *5*(9), 394–400. https://doi.org/10.1016/S1364-6613(00)01707-1

Hays, D. G. (1952). Situational instructions and task order in recall for completed and interrupted tasks. *Journal of Experimental Psychology*, *44*(6), 434–437. https://doi.org/10.1037/h0061774

Higgins, J. P. T., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ : British Medical Journal*, *327*(7414), 557–560.

Hofstaetter, A. (1985). *Retention of completed and interrupted tasks as a function of the personality construct of repression-sensitization*. Universitaet Graz (Austria).

Katz, E. (1938). *Some factors affecting resumption of interrupted activities by preschool children*. University of Minnesota Press.

Kushlev, K., & Dunn, E. W. (2015). Checking email less frequently reduces stress. *Computers in Human Behavior*, *43*, 220–228. https://doi.org/10.1016/j.chb.2014.11.005

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, *4*, 863. https://doi.org/10.3389/fpsyg.2013.00863

Lang, J. W. B., & Fries, S. (2006). A revised 10-item version of the Achievement Motives Scale. *European Journal of Psychological Assessment*, *22*(3), 216–224. https://doi.org/10.1027/1015-5759.22.3.216

Lewin, K. (1926). Vorsatz, Wille und Bedürfnis. *Psychologische Forschung*, *7*(1), 330–385. https://doi.org/10.1007/bf02424365

Lewis, H. B. (1944). An experimental study of the role of the ego in work. I. The role of the ego in cooperative work. *Journal of Experimental Psychology*, *34*(2), 113.

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J., & Moher, D. (2009). The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: Explanation and elaboration. *BMJ*, *339*, b2700. https://doi.org/10.1136/bmj.b2700

Lissner, K. (1933). Die Entspannung von Bedürfnissen durch Ersatzhandlungen. *Psychologische Forschung*, *18*(1), 218–250. https://doi.org/10.1007/bf02409632

MacLeod, C. M. (2020). Zeigarnik and von Restorff: The memory effects and the stories behind them. *Memory & Cognition*, *48*(6), 1073–1088. https://doi.org/10.3758/s13421-020-01033-5

Mahler, W. (1933). Ersatzhandlungen verschiedenen Realitätsgrades. *Psychologische Forschung*, *18*(1), 27–89. https://doi.org/10.1007/BF02409627

Mandowsky, D. (2007). The effect of achievement motivation on the Zeigarnik effect. *The Huron University College Journal of Learning and Motivation*, *45*(1).

Mäntylä, T., & Sgaramella, T. (1997). Interrupting intentions: Zeigarnik-like effects in prospective memory. *Psychological Research*, *60*(3), 192–199. https://doi.org/10.1007/BF00419767

Marrow, A. J. (1938a). Goal tensions and recall: I. *The Journal of General Psychology*, *19*(1), 3–35. https://doi.org/10.1080/00221309.1938.9711185

Marrow, A. J. (1938b). Goal tensions and recall: II. *The Journal of General Psychology*, *19*(1), 37–64. https://doi.org/10.1080/00221309.1938.9711186

McCain, J. A. (1960). Professors and students in european universities: Observations of an american college president. *The Journal of Higher Education*, *31*(4), 200–207. https://doi.org/10.2307/1977404

McGraw, K. O., & Fiala, J. (1982). Undermining the Zeigarnik effect: Another hidden cost of reward. *Journal of personality*, *50*(1), 58–66. https://doi.org/10.1111/j.1467-6494.1982.tb00745.x

Meier, B., & Cottini, M. (2023). After-effects of responding to activated and deactivated prospective memory target events differ depending on processing overlaps. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *49*(3), 389–406. https://doi.org/10.1037/xlm0001154

Meier, B., & Zimmermann, T. D. (2015). Loads and loads and loads: The influence of prospective load, retrospective load, and ongoing task load in prospective memory. *Frontiers in Human Neuroscience*, *9*. https://doi.org/10.3389/fnhum.2015.00322

Monk, C. A., Trafton, J. G., & Boehm-Davis, D. A. (2008). The effect of interruption duration and demand on resuming suspended goals. *Journal of Experimental Psychology: Applied*, *14*(4), 299–313. https://doi.org/10.1037/a0014402

Moot III, S. A., Teevan, R. C., & Greenfeld, N. (1988). Fear of failure and the Zeigarnik effect. *Psychological Reports*, *63*(2), 459–464.

Möschl, M., Fischer, R., Bugg, J. M., Scullin, M. K., Goschke, T., & Walser, M. (2020). Aftereffects and deactivation of completed prospective memory intentions: A systematic review. *Psychological Bulletin*, *146*(3), 245–278. https://doi.org/10.1037/bul0000221

Nowlis, H. H. (1941). The influence of success and failure on the resumption of an interrupted task. *Journal of Experimental Psychology*, *28*(4), 304–325. https://doi.org/10.1037/h0055389

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, *106*(37), 15583–15587. https://doi.org/10.1073/pnas.0903620106

Pachauri, A. R. (1935). A study of gestalt problems in completed and interrupted tasks. *British Journal of Psychology. General Section*, *25*(3), 365–381. https://doi.org/10.1111/j.2044-8295.1935.tb00748.x

Payne, J. D., & Kensinger, E. A. (2010). Sleep's role in the consolidation of emotional episodic memories. *Current Directions in Psychological Science*, *19*(5), 290–295. https://doi.org/10.1177/0963721410383978

Prentice, W. C. H. (1944). The interruption of tasks. *Psychological Review*, *51*(6), 329–340. https://doi.org/10.1037/h0059614

Raffini, J., & Rosemier, R. A. (1972). Effect of resultant achievement motivation on postexam error-correcting performance. *Journal of Educational Psychology*, *63*(3), 281.

Reeve, J., Cole, S. G., & Olson, B. C. (1986). The Zeigarnik effect and intrinsic motivation: Are they the same? *Motivation and Emotion*, *10*(3), 233–245. https://doi.org/10.1007/BF00992318

Reiss, G. (1968). *Der Einfluss von Erfolge- und Misserfolgsmotivierung auf das Behalten eigener Leistungen*.

Rethlingshafer, D. (1941). Comparison of normal and feebleminded children with college adults in their tendency-to-continue interrupted activities. *Journal of Comparative Psychology*, *32*(2), 205–2016. https://doi.org/10.1037/h0055539

Rickers-Ovsiankina, M. A. (1928). Untersuchungen zur Handlungs- und Affektpsychologie. *Psychologische Forschung*, *11*, 302–379. https://doi.org/10.1007/bf00410261

Rosenzweig, S. (1943). An experimental study of „repression" with special reference to need-persistive and ego-defensive reactions to frustration. *Journal of Experimental Psychology*, *32*(1), 64–74. https://doi.org/10.1037/h0062000

Rösler, H.-D. (1955). *Über das Behalten von Handlungen schwachsinniger und normaler Kinder*. Johann Ambrosius Barth.

Schlote, W. (1930). *Über die Bevorzugung unvollendeter Handlungen*.

Scullin, M. K., Bugg, J. M., & McDaniel, M. A. (2012). Whoops, I did it again: Commission errors in prospective memory. *Psychology and Aging*, *27*(1), 46–53. https://doi.org/10.1037/a0026112

Seifert, C. M., & Patalano, A. L. (1991). Memory for incomplete tasks: A re-examination of the Zeigarnik effect. In *Proceedings of the Thirteenth Annual Conference of the Cognitive Science Society* (S. 114–119). Chicago, IL.

Shamseer, L., Moher, D., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., & Stewart, L. A. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: Elaboration and explanation. *BMJ*, *349*, g7647. https://doi.org/10.1136/bmj.g7647

Sinha, A. K., & Sharan, M. B. (1976). Zeigarnik-phenomenon as a function of the trait of dominance. *Psychologia*, *19*, 114–117.

Stothart, C., Mitchum, A., & Yehnert, C. (2015). The attentional cost of receiving a cell phone notification. *Journal of Experimental Psychology: Human Perception and Performance*, *41*(4), 893–897. https://doi.org/10.1037/xhp0000100

Streeper, E., & Bugg, J. M. (2021). Deactivation of prospective memory intentions: Examining the role of the stimulus–response link. *Memory & Cognition*, *49*(2), 364–379. https://doi.org/10.3758/s13421-020-01091-9

Tavinor, G. (2008). Definition of videogames. *Contemporary Aesthetics (Journal Archive)*, *6*(1), 16.

Taylor, J. W. (1953). An experimental study of repression with special reference to success-failure and completion-incompletion. *Journal of Clinical Psychology*, *9*(4), 352–355.

Unity® (2021.1.12f1). (2021). [Software]. 2023 Unity Technologies. https://unity.com/

Van Bergen, A. (1968). *Task interruption* [Doctoral dissertation, Universiteit van Amsterdam]. North-Holland Publishing Company.

Walser, M., Fischer, R., & Goschke, T. (2012). The failure of deactivating intentions: Aftereffects of completed intentions in the repeated prospective memory cue paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(4), 1030–1044. https://doi.org/10.1037/a0027000

Weiner, B. (1965). Need achievement and the resumption of incompleted tasks. *Journal of Personality and Social Psychology*, *1*(2), 165–168. https://doi.org/10.1037/h0021642

Weiner, B. (1966). Achievement motivation and task recall in competitive situations. *Journal of Personality and Social Psychology*, *3*(6), 693–696. https://doi.org/10.1037/h0023206

Weiner, B., Johnson, P. B., & Mehrabian, A. (1968). Achievement motivation and the recall of incomplete and completed exam questions. *Journal of Educational Psychology*, *59*(3), 181–185. https://doi.org/10.1037/h0025789

Zeigarnik, B. (1927). Das Behalten erledigter und unerledigter Handlungen. *Psychologische Forschung*, *9*, 1–85.

Author Contributions

RG and BM designed the study and wrote the manuscript. RG analyzed the data. Both authors contributed to the article and approved the final version.

Declaration of Conflicting Interests

The authors declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Data availability statement

The data of the present study will be available on OSF.

Figure 1

Flow Chart of Study Selection Process for Meta-Analysis

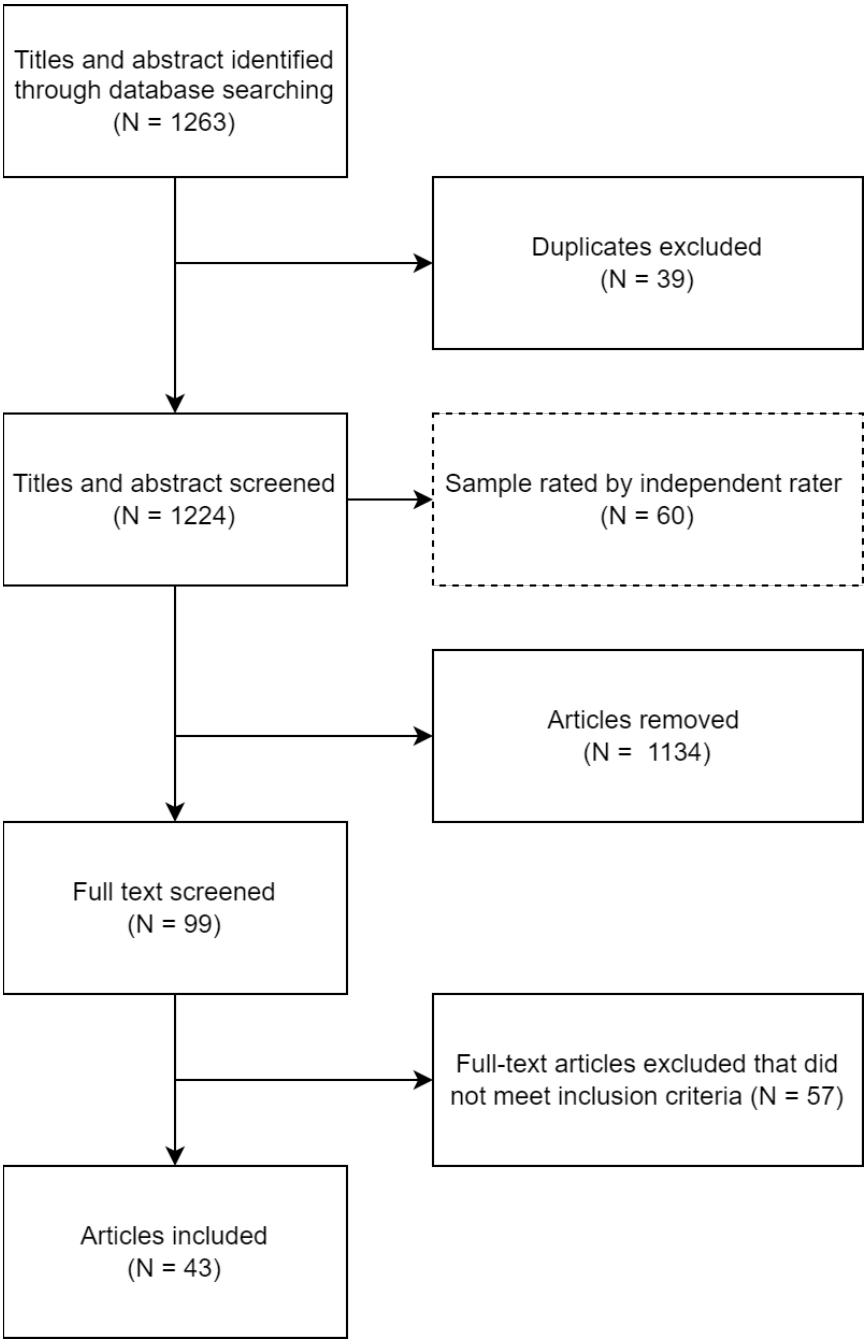
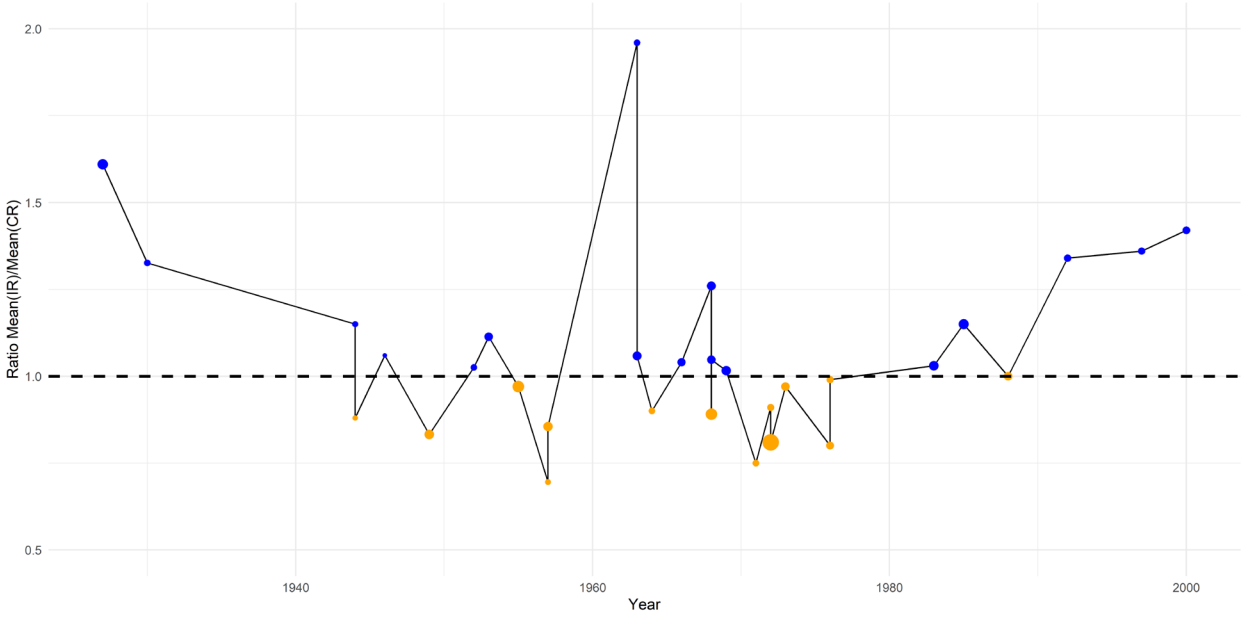


Figure 2

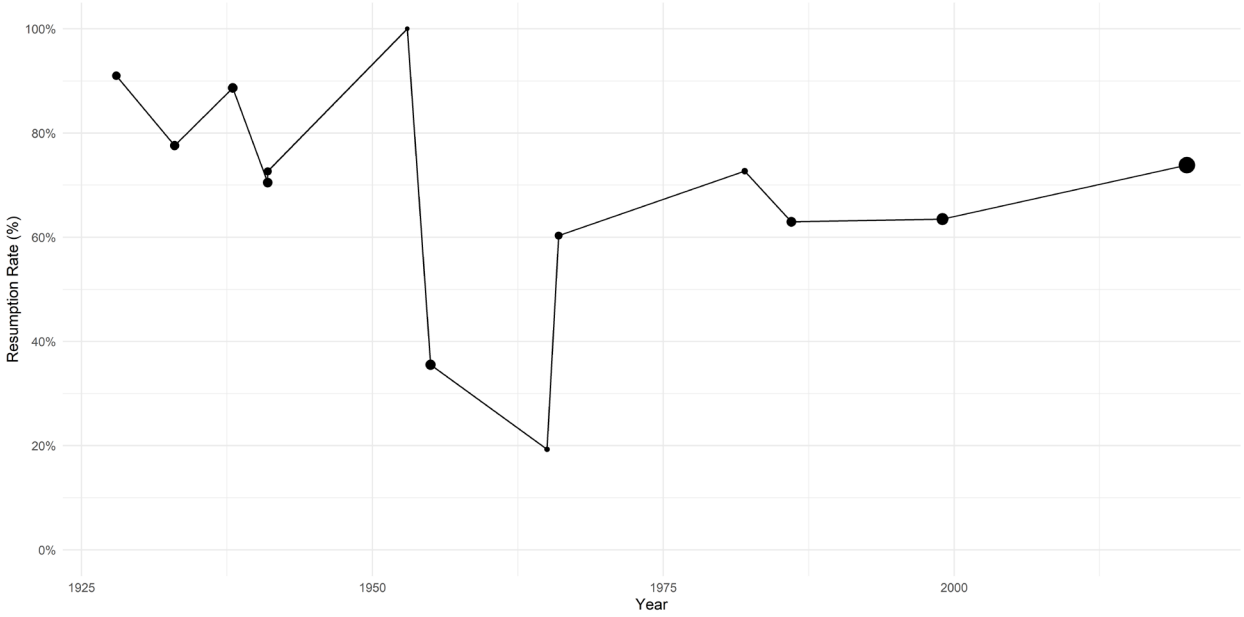
Temporal Evolution of the Results From Studies Assessing the Zeigarnik Effect



Note. Each point represents the ratio of the averaged mean recall of interrupted tasks to completed tasks from individual studies. The size of each point corresponds to the study's sample size. Blue points indicate a higher recall for interrupted tasks, supporting the *Zeigarnik* effect, while orange points suggest a higher recall for completed tasks, reflecting the inverse *Zeigarnik* effect. A dotted line at a value of 1.0 serves as a reference, indicating an equal level of recall between interrupted and completed tasks. Points above this line validate the *Zeigarnik* effect, whereas points below signify its inverse.

Figure 3

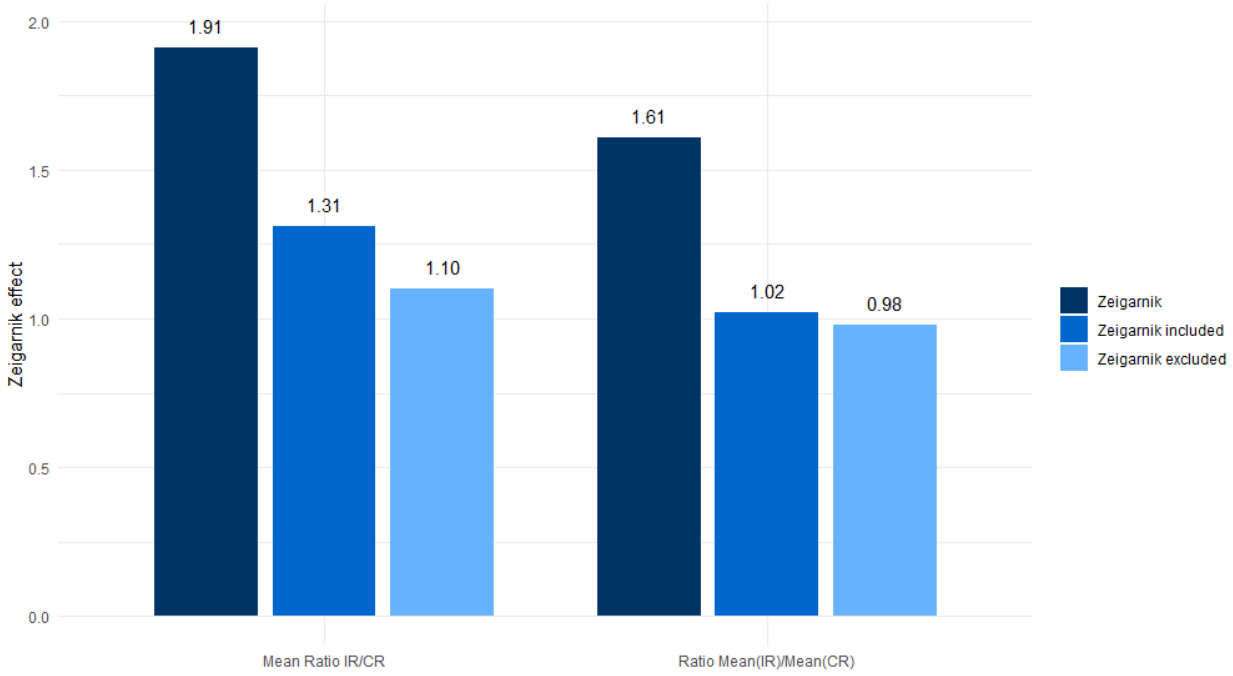
Temporal Evolution of the Results From Studies Assessing the Ovsiankina Effect



Note. Each point represents the percentage of resumed interrupted tasks from individual studies. The size of each point corresponds to the study's sample size.

Figure 4

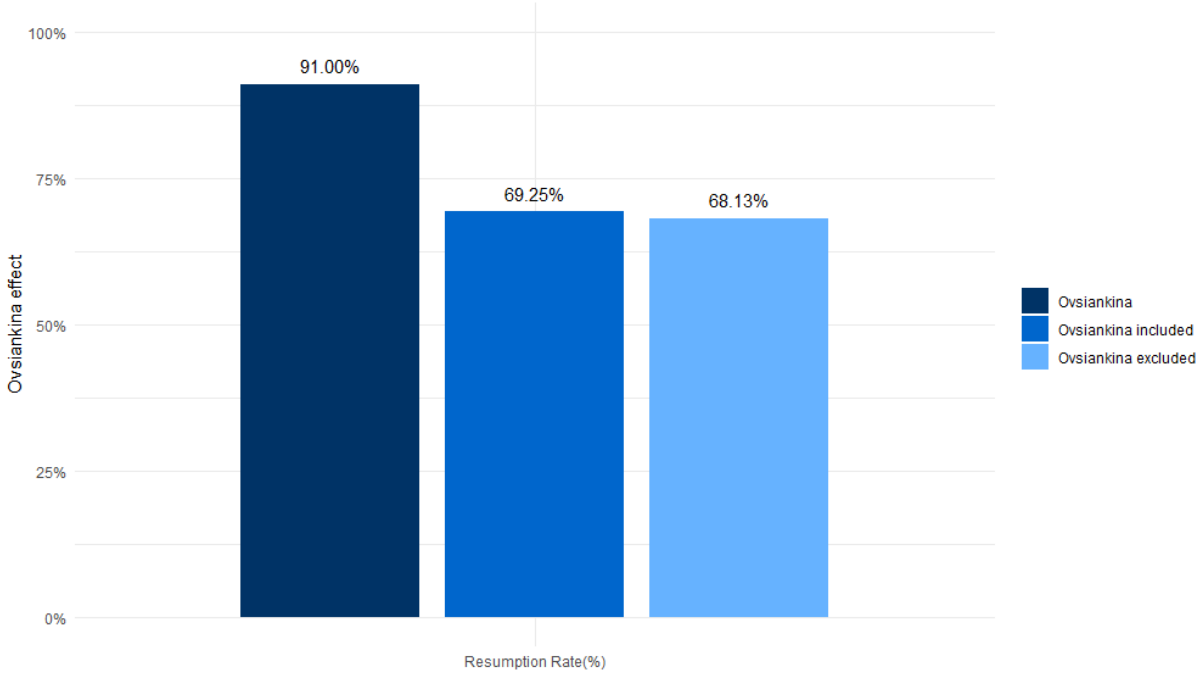
Results From Different Zeigarnik Measures



Note. The Mean Ratio of IR/CR corresponds to the initial measure introduced by Zeigarnik (1927). The Ratio of Mean(IR)/Mean(CR) offers a measure less influenced by outliers. Data showcased include Zeigarnik's original findings from (1927), the weighted mean outcome from our meta-analysis that incorporates Zeigarnik's (1927) study, and the weighted mean outcome excluding Zeigarnik's (1927) original data.

Figure 5

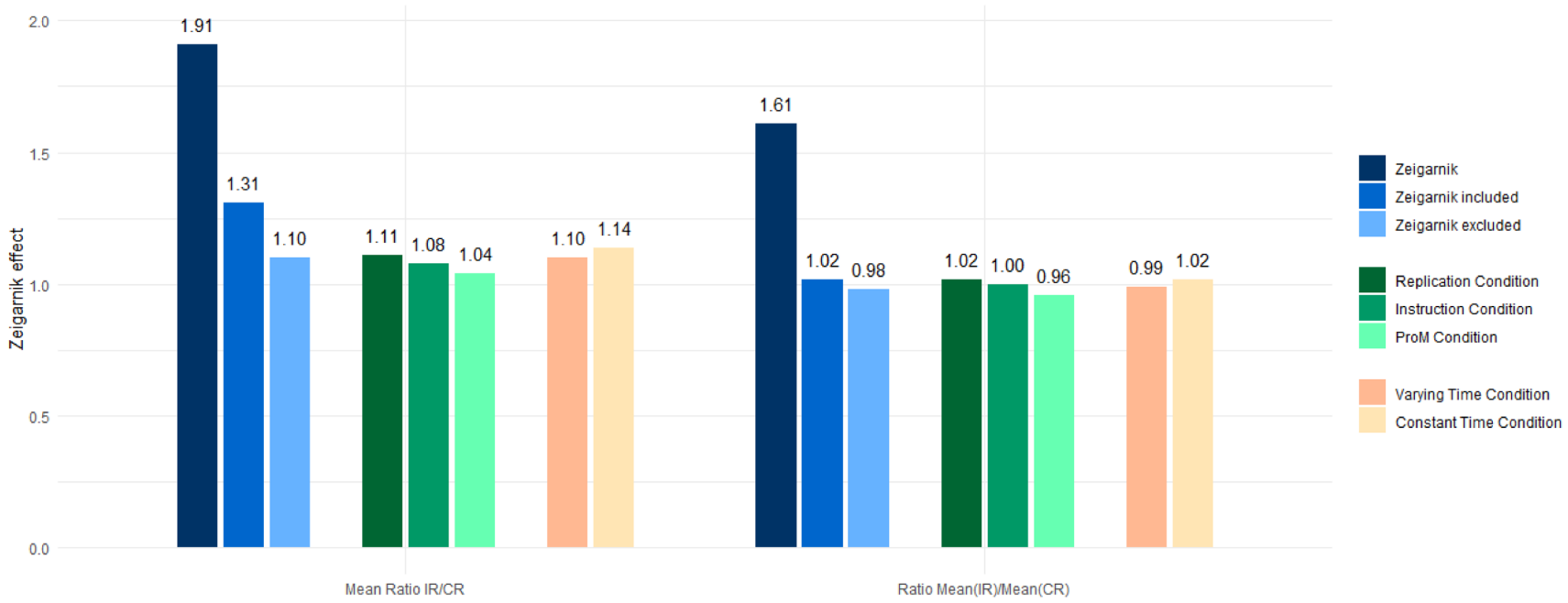
Results From Different Ovsiankina Measures



Note. Data showcased include Ovsiankina's original findings from (1928), the weighted mean outcome from our meta-analysis that incorporates Ovsiankina's (1928) study, and the weighted mean outcome excluding Ovsiankina's (1928) original data.

Figure 6

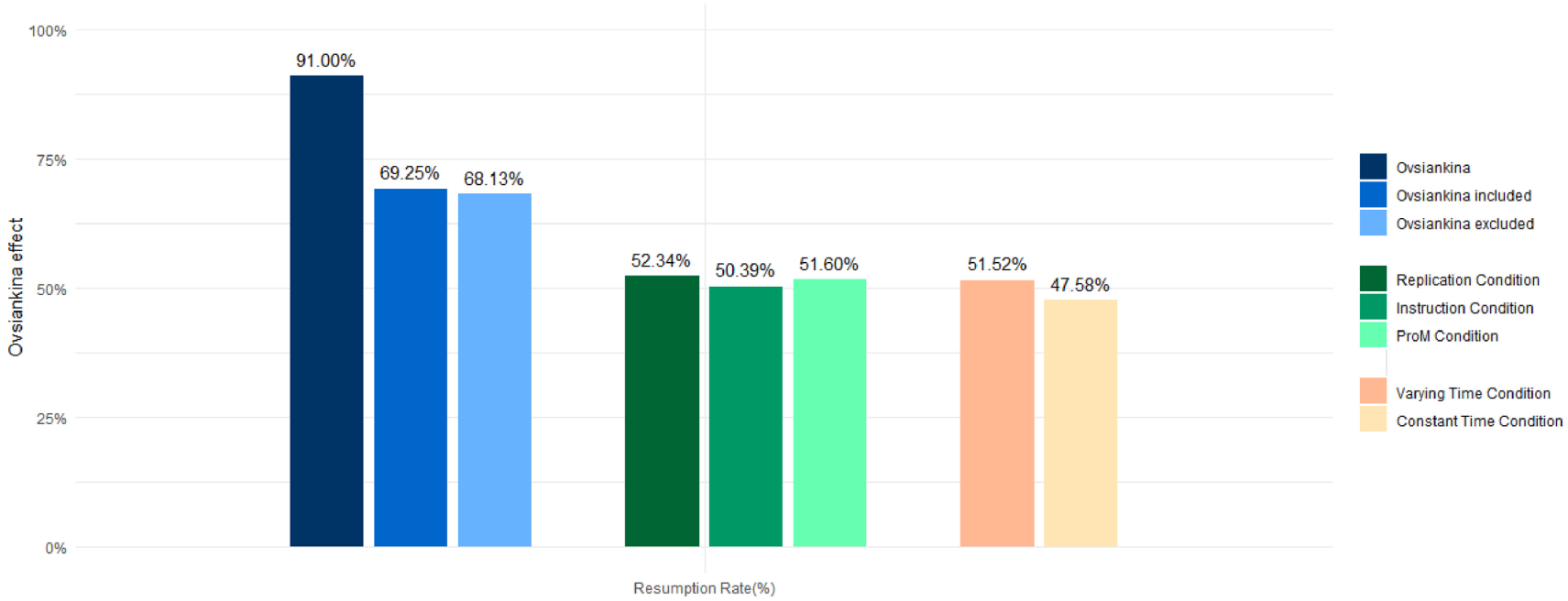
Zeigarnik Measures From Pilot Study and Experiment Contrasted With Meta-Analysis Results



Note. The Mean Ratio of IR/CR corresponds to the initial measure introduced by Zeigarnik (1927). The Ratio of Mean(IR)/Mean(CR) offers a measure less influenced by outliers. Blue bars correspond to our meta-analysis and are identical to Figure 3. Green bars correspond to the different conditions from our pilot study, and the peach-coloured bars to the two conditions from our experiment.

Figure 7

Ovsiankina Measures From Pilot Study and Experiment Contrasted With Meta-Analysis Results



Note. Blue bars correspond to our meta-analysis and are identical to Figure 3. Green bars correspond to the different conditions from our pilot study, and the peach-coloured bars to the two conditions from our experiment.

Table 1

Description of the Included Studies and Averaged Effect Sizes Across Conditions.

Author	Year	Effect	Sample	Sample Description	Nr. Tasks	Task	Recall	Mean Ratios	Ratio Means	IR/TR	Resumption Rate
Birk et al.	2020	O	875	Online-Sample	1	Bejeweld Online Game					73.85%
House and McIntosh	2000	Z	55	Adults with mental disabilities	10	NA	Immediate		1.42		
Liberman et al.	1999	O	351	Students	3	Describing three figures					63.47%
Mäntylä and Sgaramella	1997	Z	44	Students	70	5 Letter Anagrams	Immediate		1.36		
Bhavsar et al.	1992	Z	45	Students	20	Paper-Pencil Tasks	*NA*		1.34		
Moot Ill et al.	1988	Z	81	Students	20	Paper-Pencil Tasks	Delayed (15 min.)		1.00		
Reeve et al.	1986	O	181	Students	5	Puzzles					62.97%
Hofstätter	1985	Z	144	Students	12	Paper-Pencil Tasks	Immediate and Delayed		1.15	52.67%	

Author	Year	Effect	Sample	Sample Description	Nr. Tasks	Task	Recall	Mean Ratios	Ratio Means	IR/TR	Resumption Rate
Cooper	1983	Z	121	Students	20	Problem-Solving Tasks	Immediate		1.03		
McGraw and Fiala	1982	O	40	Students	1	Jiggsaw Puzzle					72.70%
Bottenberg et al.	1976	Z	61	Students	17	Paper-Pencil Tasks	*NA*		0.80		
Sinha and Sharan	1976	Z	40	Students	20	*NA*	*NA*		0.99		
Farley and Mealiea	1973	Z	84	Students	117	Multiple-Choice Test	Immediate		0.97		
Grieser et al.	1972	Z	40	Students	30	Anagrams	*NA*		0.91		
Raffini and Rosemier	1972	Z	624	Students	52	Multiple-Choice Test	Immediate		0.81		
Kruglanski et al.	1971	Z	32	Students	16	Heterogenous Tasks	*NA*		0.75		
Claeys	1969	Z	112	Students	16	Drawing Tasks	*NA*		1.02		
Reiss	1968	Z	96	Students	16	Paper-Pencil Tasks	Delayed (5 min.)		1.26		
Van Bergen	1968	Z	220	Students, Children, Adults	20	Paper-Pencil Tasks	NA	1.10	0.89	47.58%	

Author	Year	Effect	Sample	Sample Description	Nr. Tasks	Task	Recall	Mean Ratios	Ratio Means	IR/TR	Resumption Rate
Weiner et al.	1968	Z	82	Students	58	Fill-in-the-blanks Exam	Immediate		1.05		
Sternlicht and Wanderer	1966	O	90	Students	6	Heterogenous Tasks					60.33%
Weiner	1966	Z	70	Students	20	Paper-Pencil Tasks	Delayed (7 min.)		1.04		
Weiner	1965	O	25	Students	20	Paper-Pencil Tasks					19.32%
Martin and Davidson	1964	Z	29	Students	12	Paper-Pencil Tasks	*NA*		0.90		
Baddeley	1963	Z	28	Military members	12	5 Letter Anagrams	Immediate		1.96		
Green	1963	Z	96	Students	20	Paper-Pencil Tasks	Immediate		1.06	51.00%	
Alper	1957	Z	18	Students	12	Scrambled Sentences	Delayed (10 min.)		0.70		
Caron and Wallach	1957	Z	117	Students	20	Scrambled Sentences	Delayed (15 min.)		0.86	45.68%	
Rösler	1955	Z/O	224	Healthy children,	16 - 22	Heterogenous Tasks	Immediate and Delayed (24h)	1.06	0.97	47.71%	35.54%

Author	Year	Effect	Sample	Sample Description	Nr. Tasks	Task	Recall	Mean Ratios	Ratio Means	IR/TR	Resumption Rate
				children with mental disability							
Henle and Aull	1953	O	20	Students	1	Puzzle					100.00%
Atkinson	1953	Z	83	Students	20	Paper-Pencil Tasks	Delayed		1.11		
Hays	1952	Z	27	Students	4	Object-Location Task	Immediate		1.03		
Glixman	1949	Z	120	Students	20	Paper-Pencil Tasks	Delayed		0.83		
Alper	1946	Z	10	Students	12	Scrambled Sentences	Immediate and Delayed		1.06		
Prentice	1944	Z	20	Students	16	*NA*	Delayed		1.15		
Lewis	1944	Z	14	Children	18	Heterogenous Tasks	Immediate		0.88		
Nowlis	1941	O	180	Students	1	Puzzle					70.50%
Rethlingshafer	1941	O	99	Students, Children, Persons with mental disabilities	11	Heterogenous Tasks					72.67%

Author	Year	Effect	Sample	Sample Description	Nr. Tasks	Task	Recall	Mean Ratios	Ratio Means	IR/TR	Resumption Rate
Katz	1938	O	177	Children	6	Heterogenous Tasks					88.67%
Mahler	1933	O	155	Children, Adults	1 - 12	Heterogenous Tasks					77.59%
Schlote	1930	Z	29	*NA*	18 - 24	Syllables and Heterogenous Tasks	Immediate and Delayed (up to 30 min.)	1.42	1.33	61.03%	
Ovsiankina	1928	O	124	Students, Children, Adults	8 - 12	Heterogenous Tasks					91.00%
Zeigarnik	1927	Z	164	Children, Adults	18 - 22	Heterogenous Tasks	Immediate	1.90	1.61	61.25%	

Note. For both the *Zeigarnik* and *Ovsiankina* effect, only their first experiment is presented. O = Ovisankina, Z = Zeigarnik. IR = interrupted recalled, TR = total recalled.

Appendix A

Supplementary materials

Table A1

Short Description of the Games Used and Their Controls

Game	Description	Controls
Fruit Basket	Fruits falling from the sky are to be collected using right-left movements with a basket. There are also fruits with a worm, which should not be collected. In the *difficult mode* the fruits fall down faster.	Arrow keys
Potions	Here, the subject is supposed to brew a potion. With the space bar she has access to the cookbook, which contains the right ingredients for it. In the *difficult mode*, the potions change every six seconds.	Mouse Space key
Duel	Rock-Paper-Scissor is played by choosing the appropriate response in each round. The Hand of the opponent is visible before making the decision. In the *difficult mode*, the player should lose on purpose, i.e., choose the wrong response when the opponent is wearing a ring.	Mouse
Ghost Driver	The subject is driving a car on a three-lane road and must avoid oncoming traffic. In the *difficult mode*, the cars drive faster, and the subject must react faster.	Arrow keys
Balloon	A balloon appears on the screen, which must be shot or clicked on. In the *difficult mode*, the balloons disappear after a couple seconds.	Mouse
Escape Plan	Here a knight is to be led to a ladder. The knight can be moved upwards, downwards, to the right and to the left on a checkerboard. There are moving bats that are to be avoided. Otherwise, the figure is ported back to the starting point. In the *difficult mode*, there are more bats on the field.	Arrow keys

Game	Description	Controls
Bank Robbery	In this game, a code is to be cracked, which consists of a visible number. By clicking buttons with hidden values, the subject can add up numbers to match the code. Once completed, another number appears as a code. In the *difficult mode*, the codes consist of higher numbers that require more inputs.	Mouse
Outer Space	The goal is to destroy the enemy spaceships coming towards them player. The ship can be controlled by moving right and left and firing with the spacebar. There are black holes that are to be avoided. In the *difficult mode*, more black holes appear.	Arrow keys Space key
Way Home	Oncoming obstacles are to be avoided by pressing the jump bar. In *difficult mode*, the objects approach faster.	Space key
Groceries	Food is to be sorted by placing three or more food items in a row as in a typical match-three game. Two adjacent foods must be clicked subsequently, which then swap positions. In the *difficult mode*, the foods change every five seconds.	Mouse
Moving	An object is shown, which must be found on the screen by clicking on it. In the *difficult mode*, the object changes if not found within 5 seconds.	Mouse Space key
Lawn Mower	A self-moving lawn mower is to be controlled on a field to mow flowers. In the *difficult mode*, the lawn mower moves faster, and the flowers change position every seven seconds.	Arrow keys
Fishing	Swimming fishes are to be hooked by moving a hook left and right and lowering it by pressing the space bar. In the *difficult mode*, the fish swim faster.	Arrow keys Space key
Dancing	The correct arrow keys are to be pressed when falling arrows land on the corresponding border. The arrows point up, down, left, or right and fall down. In the *difficult mode*, the arrows fall down faster.	Arrow keys
Soccer	A soccer ball is to be shot into goals. After each successful shot, the goals change position. The ball is aimed with an arrow that points to the mouse curser and is shot by pressing the space bar. In the *difficult mode*, the goals are smaller and harder to hit.	Mouse Space key

Game	Description	Controls
Runes	The task is to find each displayed rune in the rune collection by clicking on the displayed rune in an array of runes differing in colour and rune-carving. In the *difficult mode*, the time is limited to three seconds.	Mouse

Figure A1

Fruit Basket

Figure A2

Potions

Figure A3

Duel

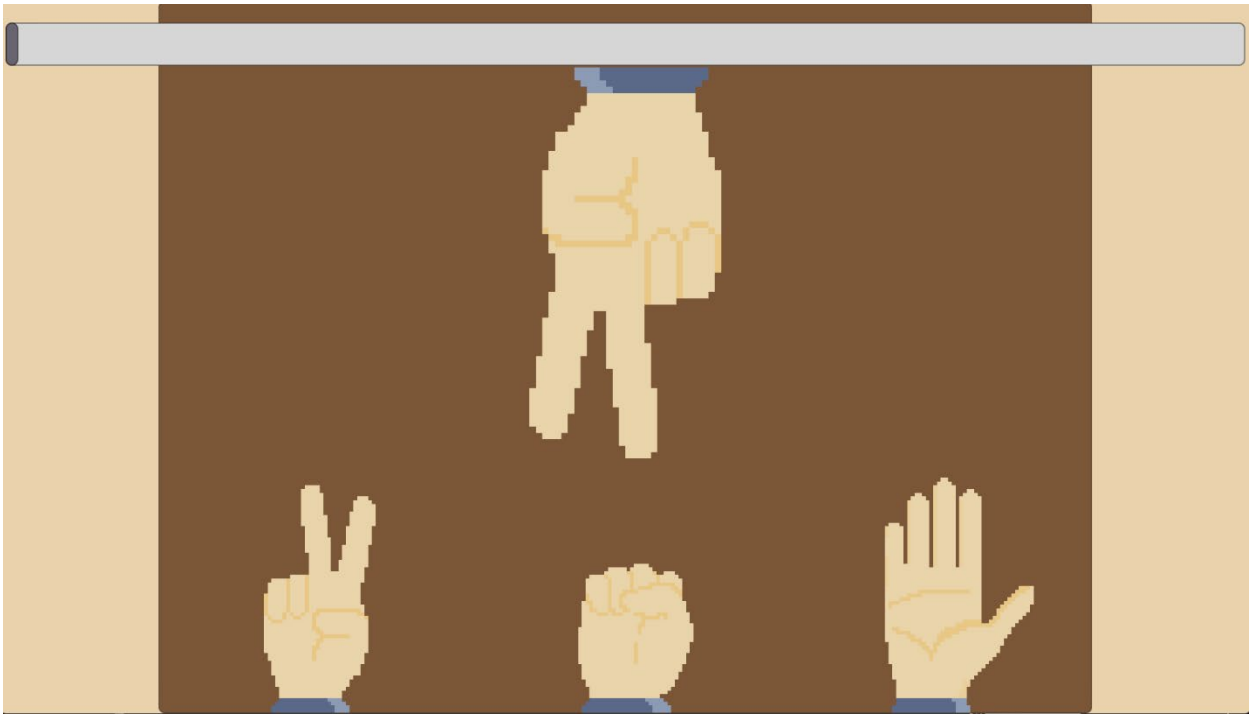


Figure A4

Ghost Driver

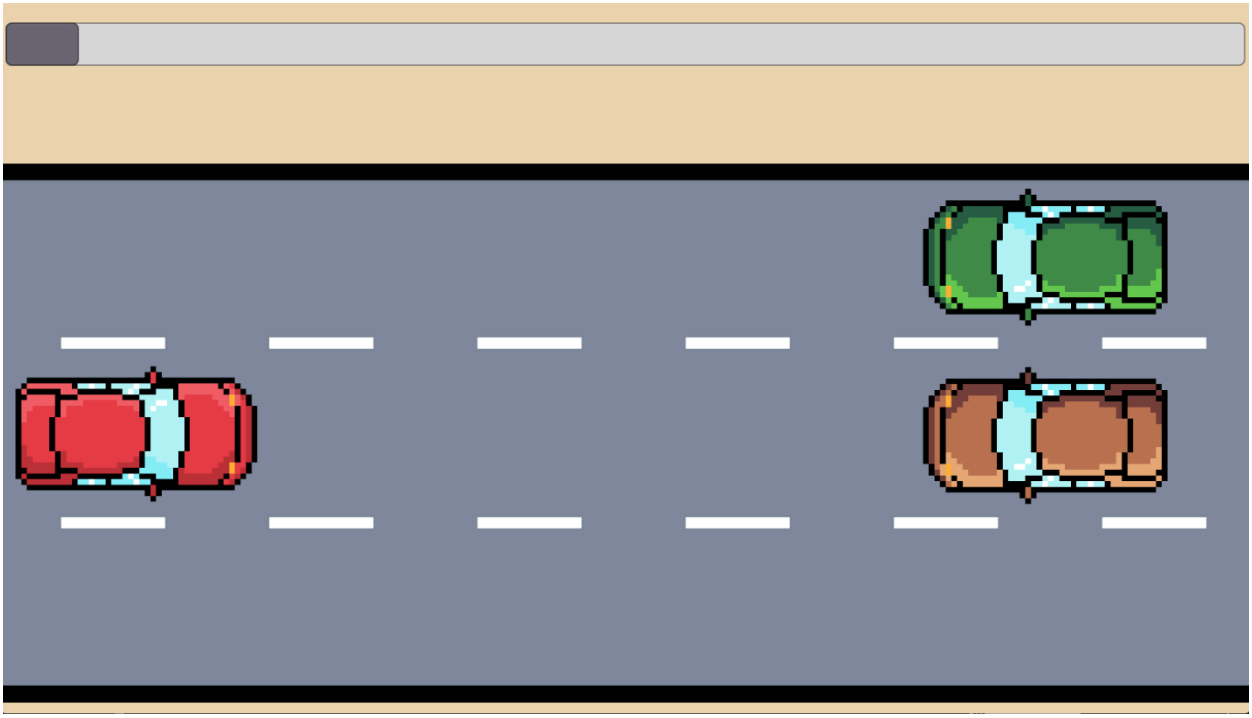


Figure A5

Balloon

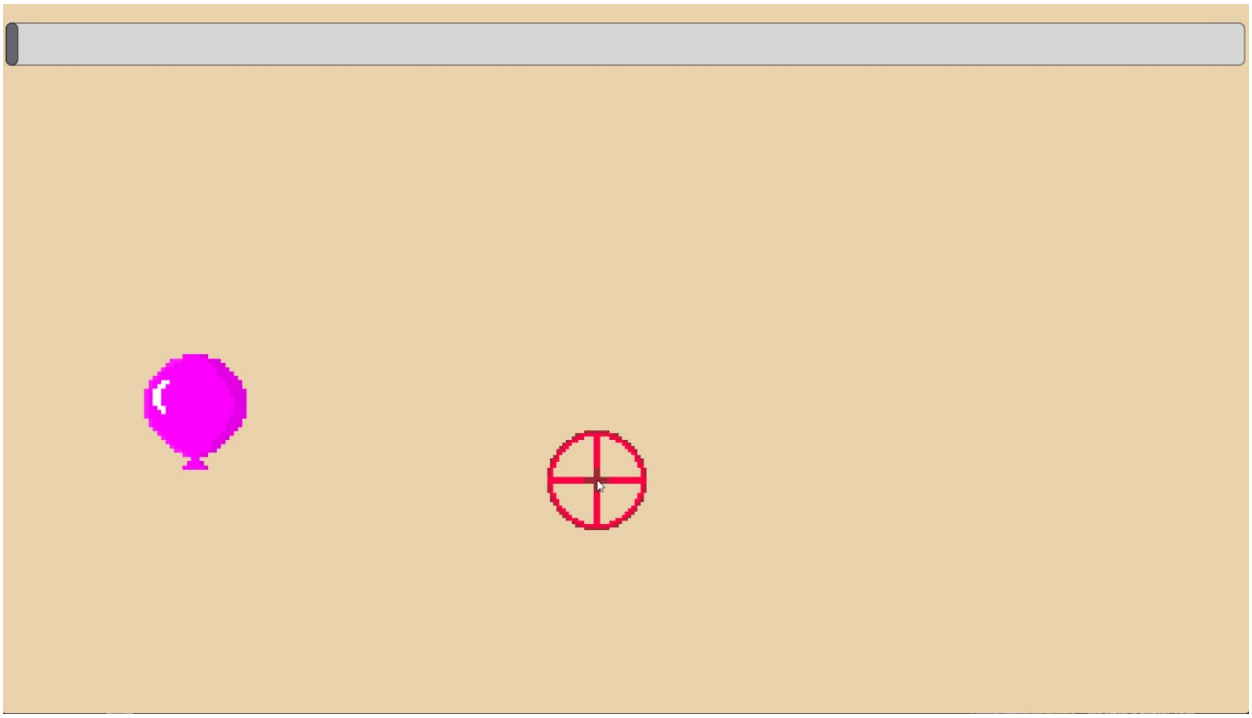


Figure A6

Escape Plan

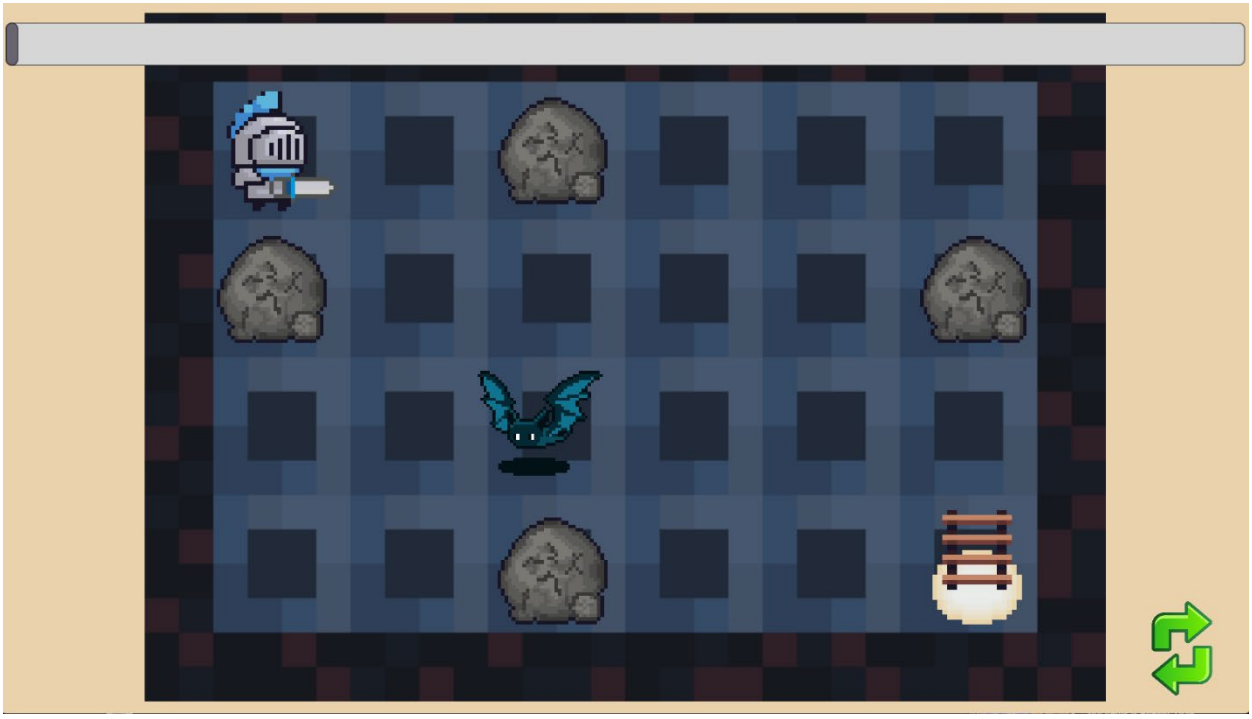


Figure A7

Bank Robbery

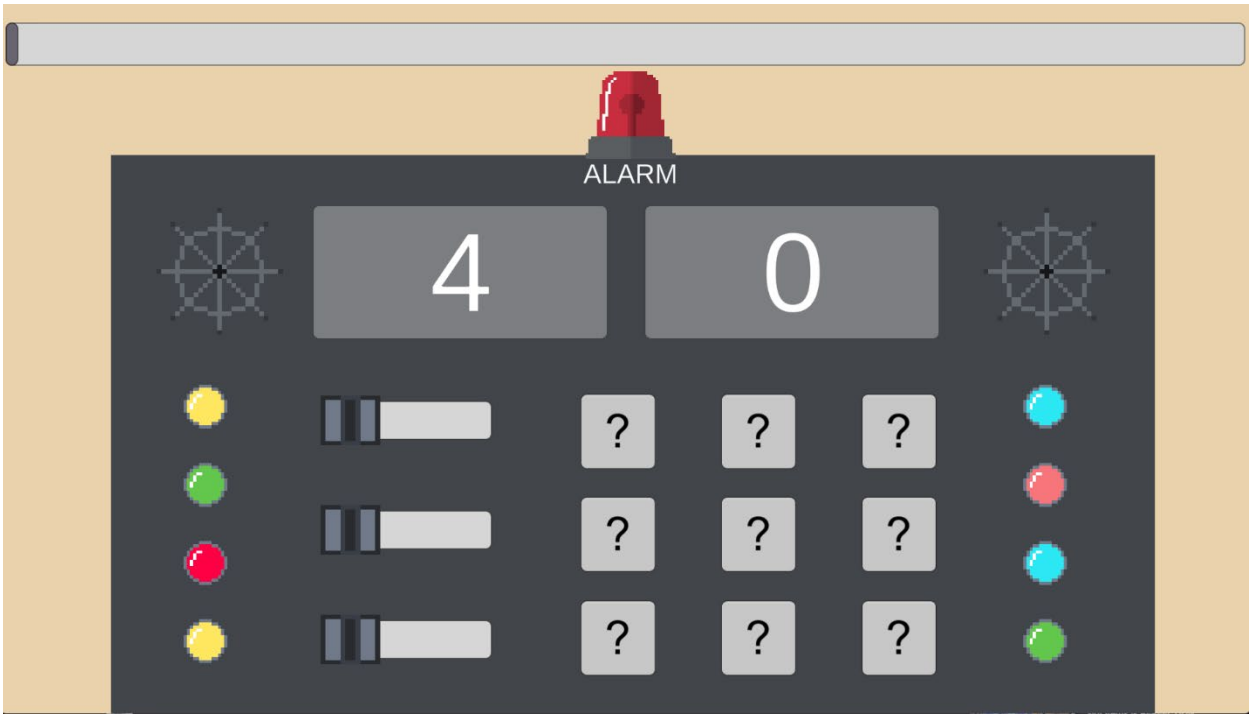


Figure A8

Outer Space

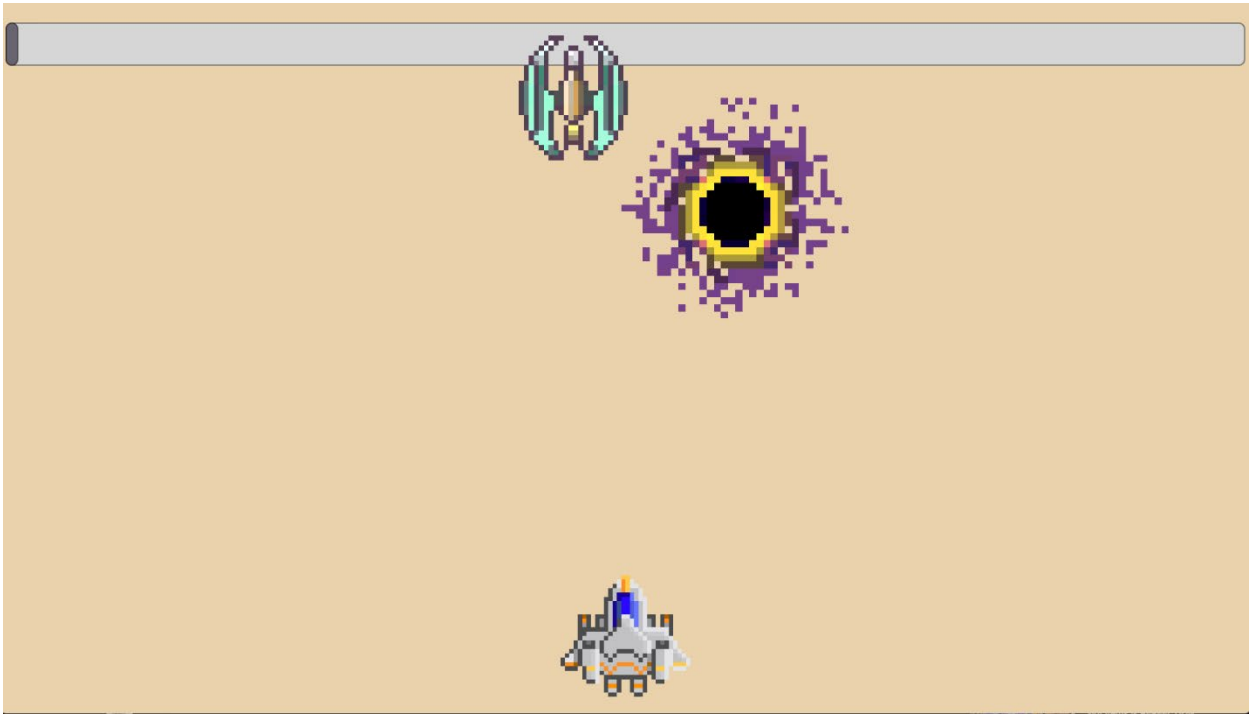


Figure A9

Way Home

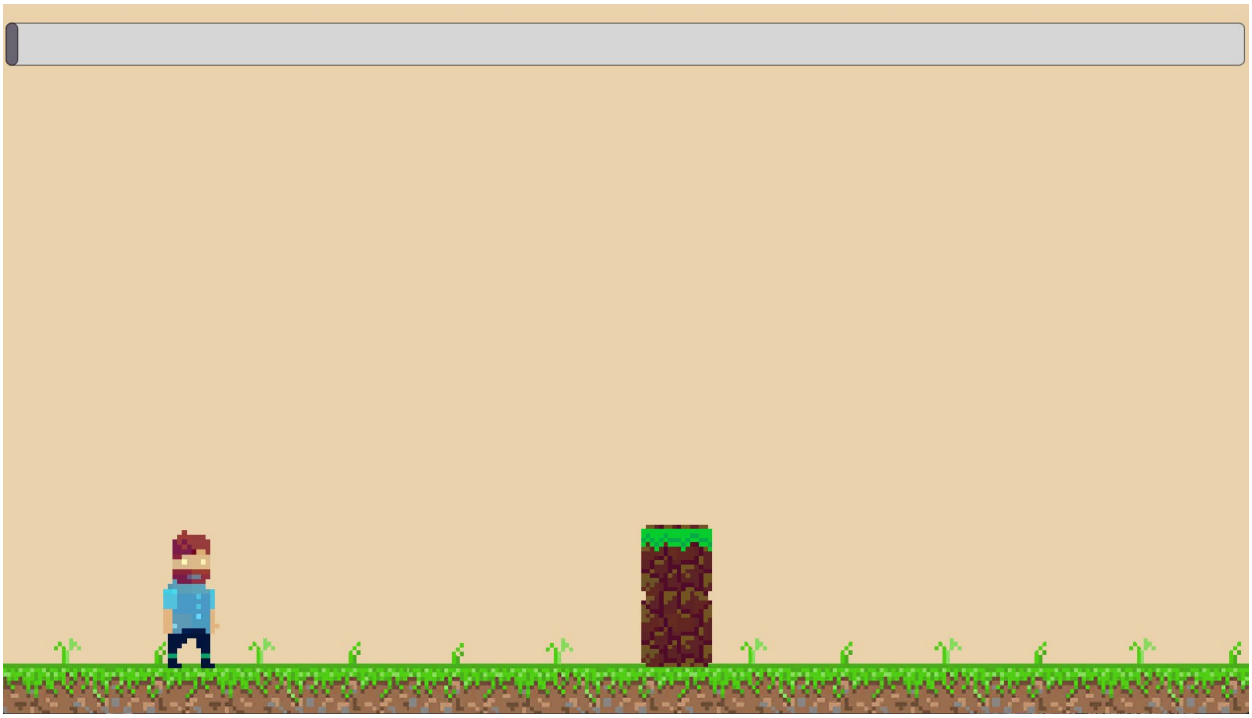


Figure A10

Groceries

Figure A11

Moving

Figure A12

Lawn Mower

Figure A13

Fishing

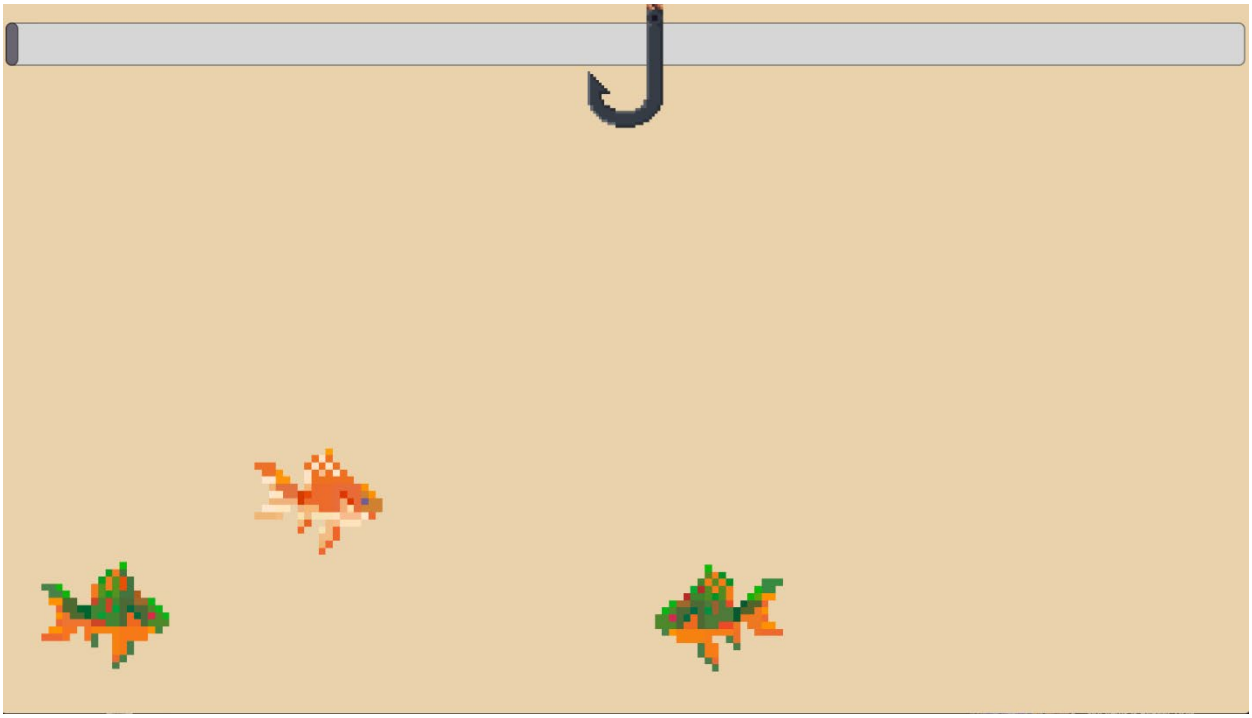


Figure A14

Dancing

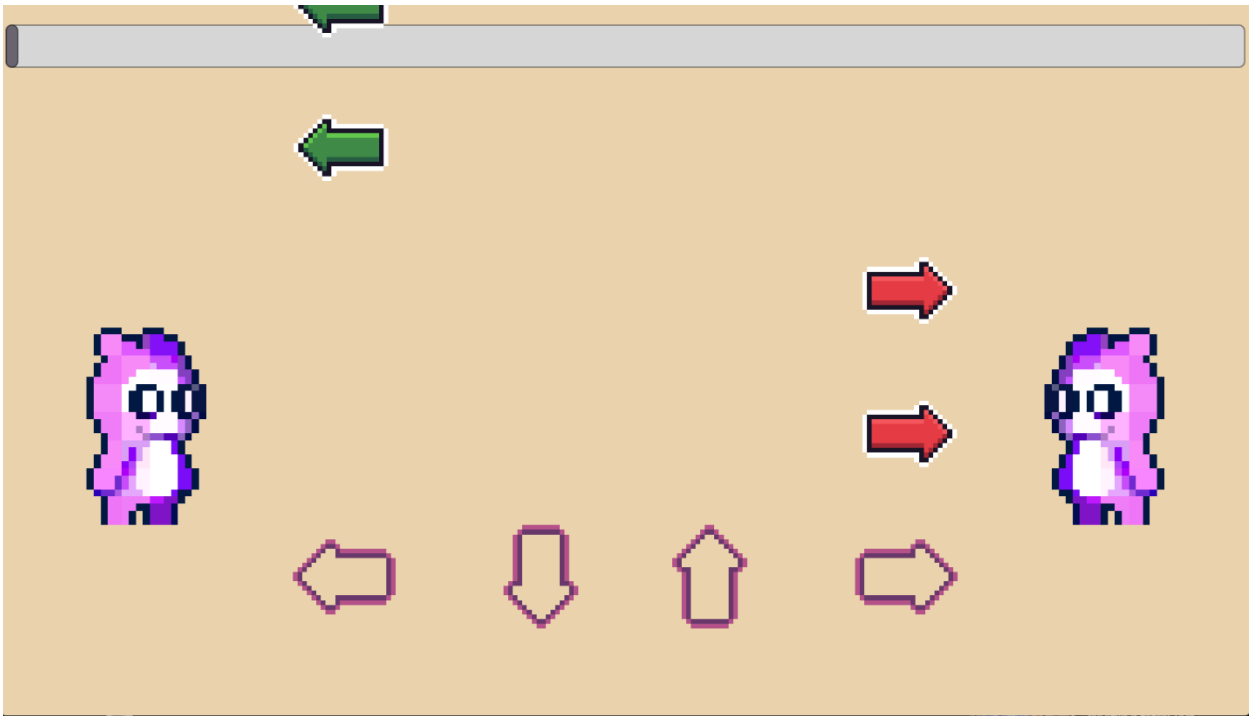


Figure A15

Soccer

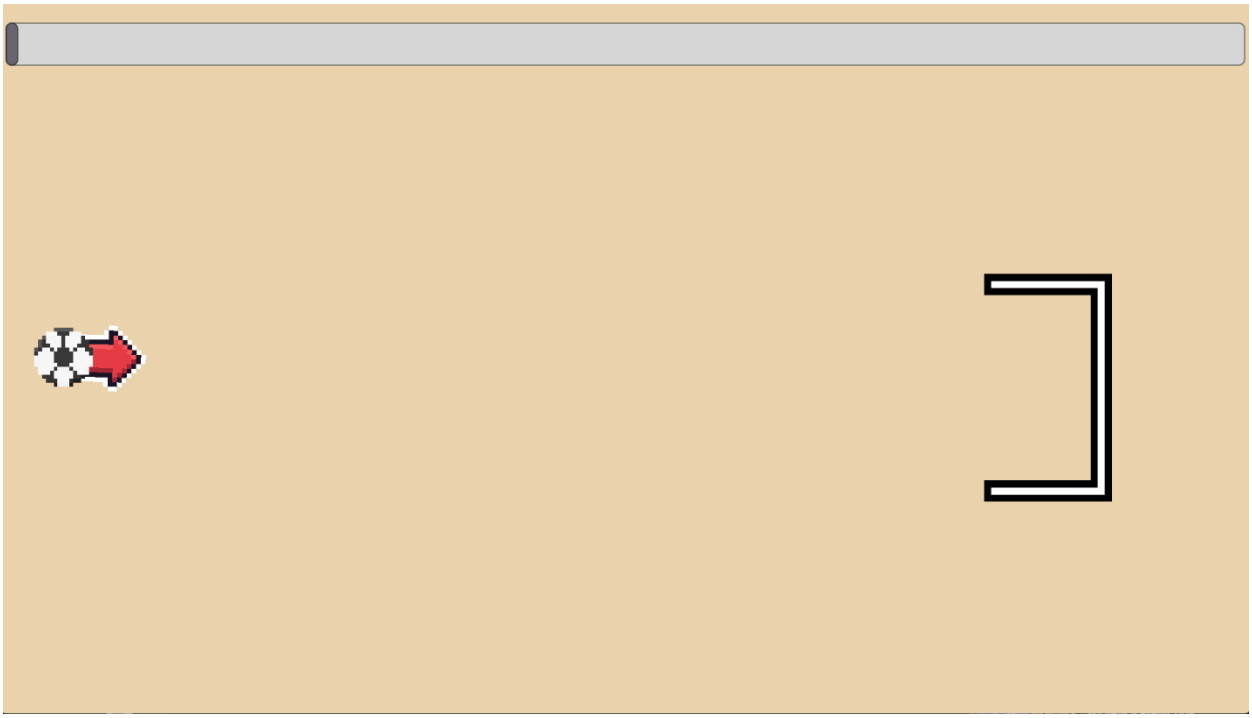


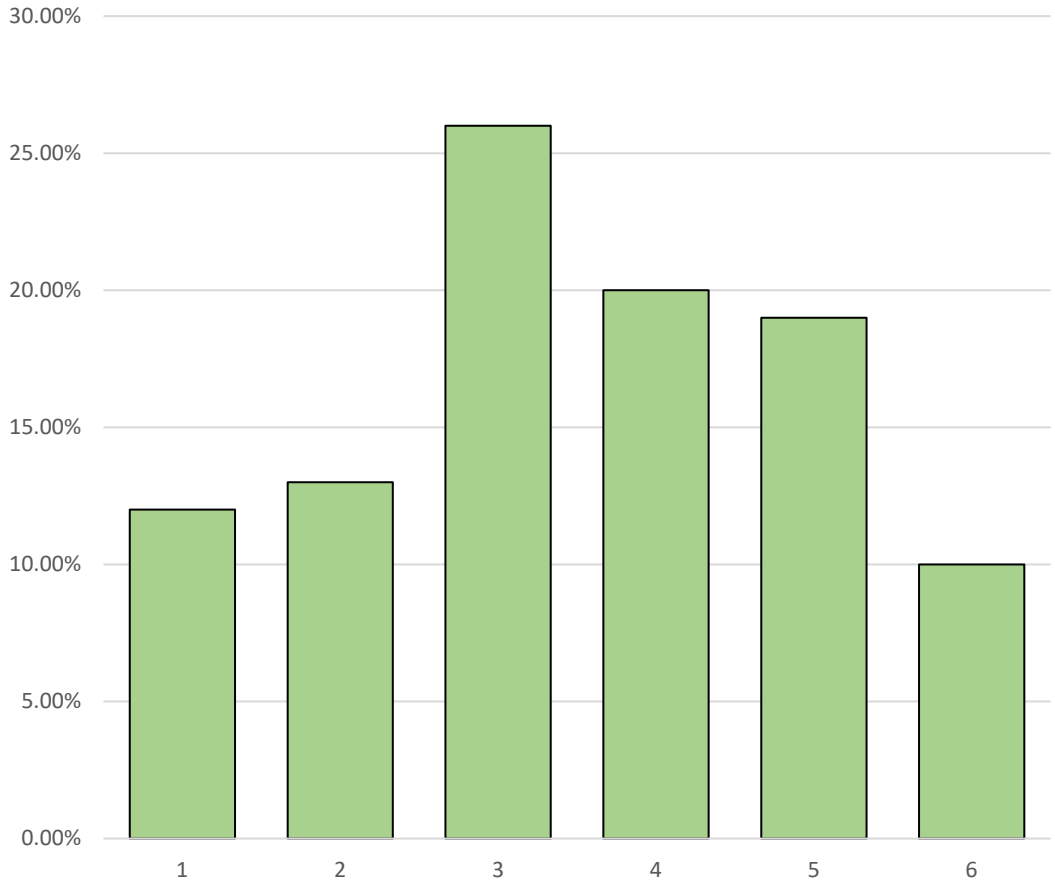
Figure A16

Runes

Appendix B

Figure B1

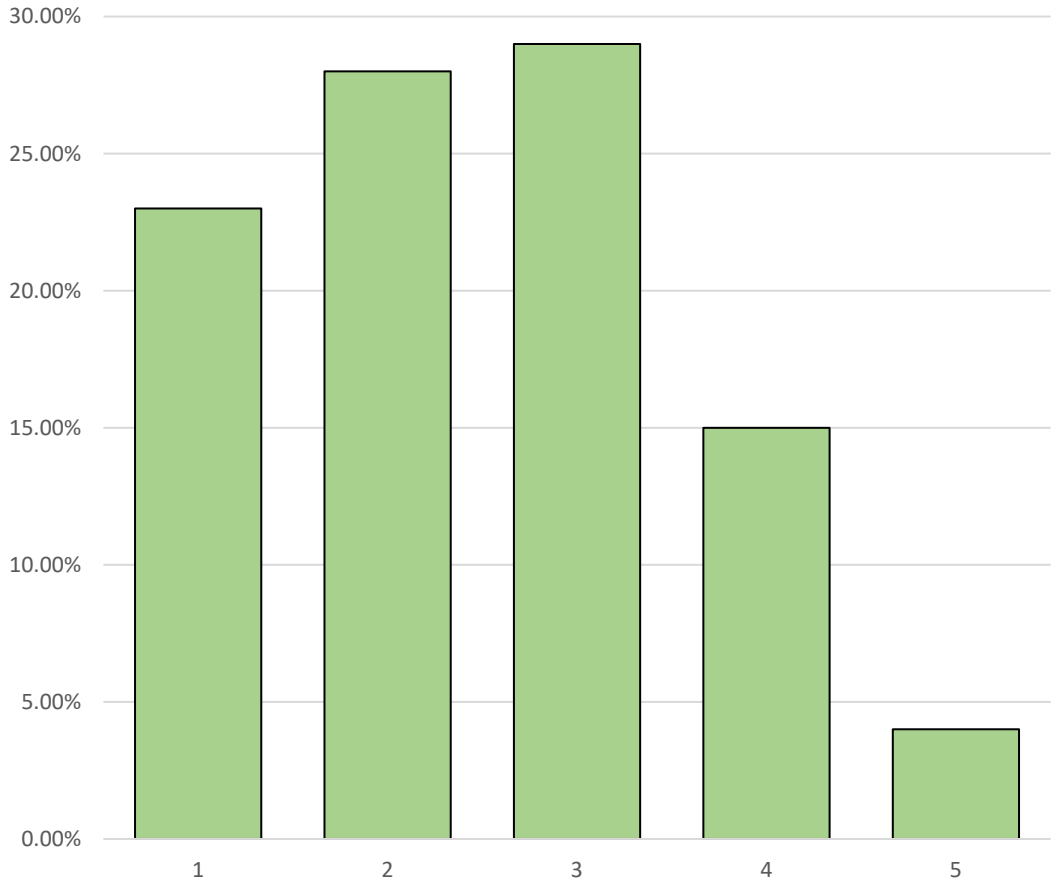
Reported Frequency of Playing Videogames



Note. How often do you play videogames? 1 = *Never*; 2 = *Less than once a year*; 3 = *Once a year or more*; 4 = *Once a month or more*; 5 = *Once a week or more*; 6 = *Daily*.

Figure B2

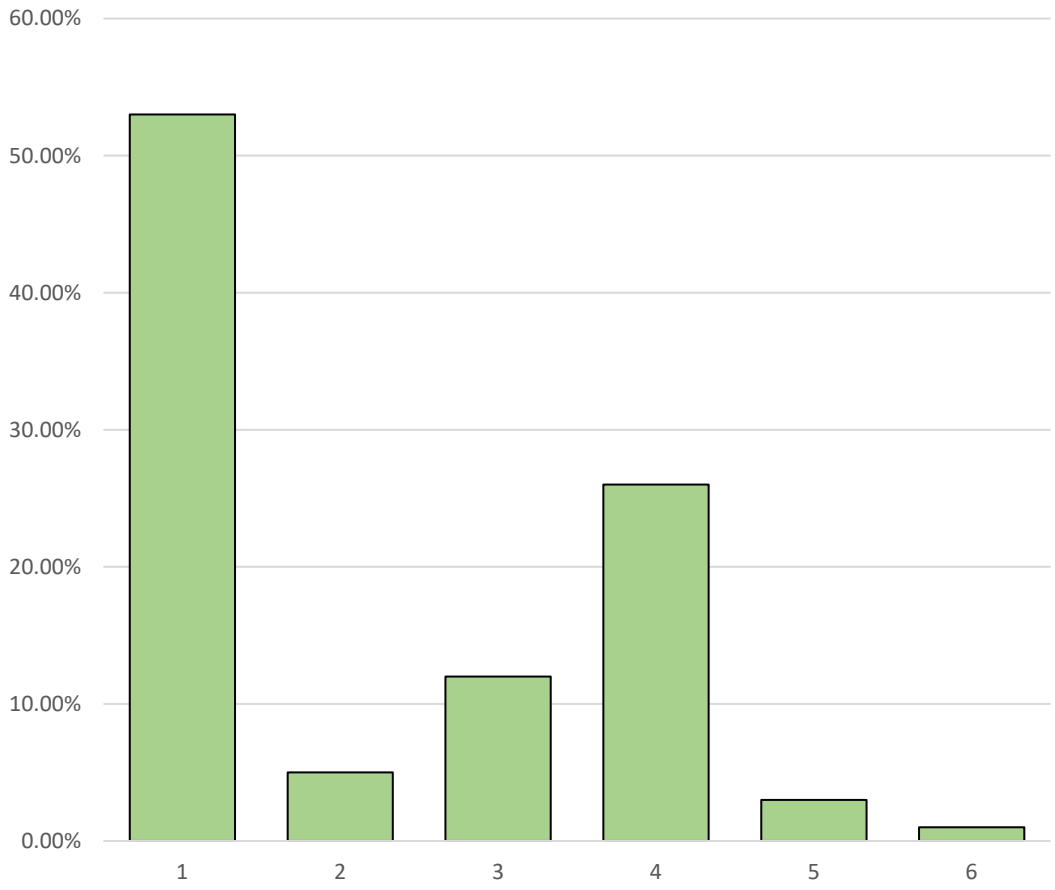
Reported Expertis in Playing Videogames



Note. How would you rate your videogame expertise? 1 = *Novice*; 5 = *Expert*.

Figure B3

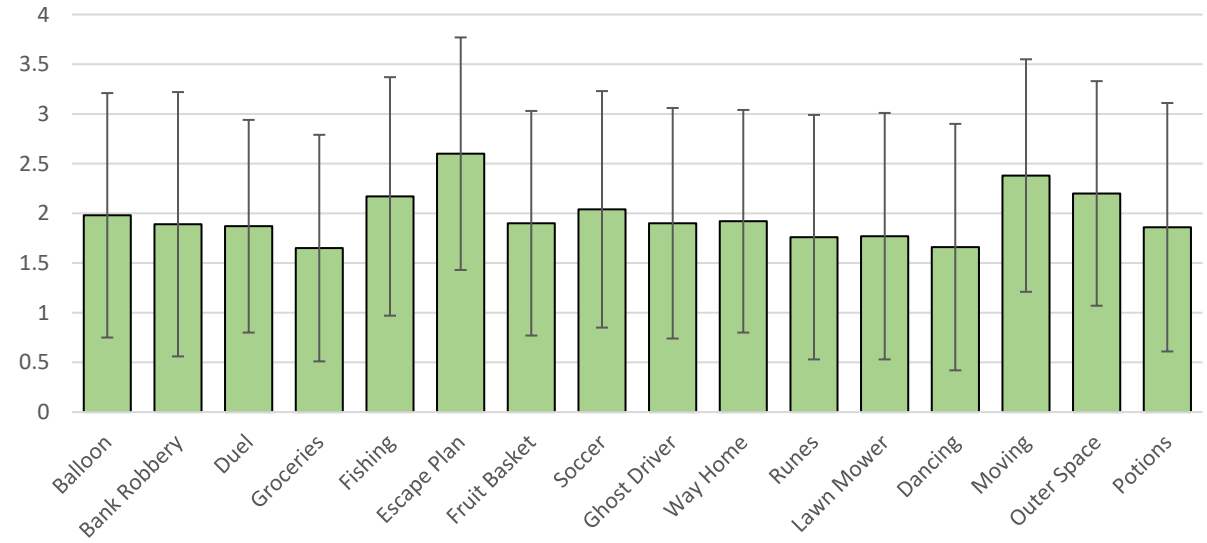
Reported Frequency of Playing Videogames



Note. If you play videogames regularly: How long have you been playing videogames for? 1 = *I don't play videogames regularly*; 2 = *Less than 5 years*; 3 = *More than 5 years but less than 10 years*; 4 = *More than 10 years but less than 20 years*; 5 = *More than 20 years but less than 30 years*; 6 = *More than 30 years*.

Figure B4

Average Game Ratings



Note. 0 = *no fun*; 4 = *a lot of fun*. Error bars represent standard deviations.

Hope of success increases memory for unfinished tasks

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Abstract

It has been claimed that unfinished tasks are better remembered than finished tasks (i.e., the Zeigarnik effect). However, this advantage has not consistently replicated. This study aimed to investigate the memory advantage of unfinished tasks and its relationship with achievement motivation, specifically considering hope of success. Participants were presented with anagrams for 60 seconds. If they managed to solve the anagram, the duration was recorded. If not, they were shown the anagram solution. We then measured free recall of the anagram solutions and assessed achievement motivation. Overall, the results showed that participants recalled more unsolved anagrams than solved anagrams. However, only individuals high in hope of success displayed a greater tendency to remember unsolved anagrams, whereas fear of failure showed no association with recall. This study highlights the influence of hope of success. It seems that the strength of the persistent activation of an unfinished intention is greater in individuals who anticipate success.

Keywords: Intention memory, anagrams, achievement motivation

Hope of success increases memory for unfinished tasks

Intentions are an integral part of our everyday life. We intend to send a letter, go grocery shopping after work, or take medicine before going to bed. Forming intentions helps us plan our life. However, we are often confronted with interruptions while carrying out a task. In these situations, our intentions remain in a state of activation. However, the representations of intentions and their recall are likely based on individual differences. For example, achievement motivation has been linked with increased recall of unfinished tasks, in particular hope of success, that is, the anticipation of reward (Atkinson, 1953, 1957; Kuhl, 1996). The goal of the present study was to investigate the memory advantage of unfinished tasks and its relationship with achievement motivation as a personality trait, specifically, hope of success and fear of failure.

Early on, researchers recognized the distinct characteristics of intentions, namely, a force that urges us towards their completion. Ach (1910), for instance, suspected a driving force behind our urge to complete intentions that he named *determination*, a subconsciously created association between the intention and our objective. The strength of an intention's determination was suspected to be a critical factor in the likelihood of its successful execution. Once executed, the intention would result in a state of relief. In contrast, Lewin (1926) proposed that the driving force behind executing intentions is not as much the association between the intention and the objective, but the tension caused by the intention, which vanishes after completing the intention. This tension is necessary, as intentions must be held in a state of constant activation to recognize situations in which they can be fulfilled or resumed.

The need for a mechanism maintaining the intention in an activated state becomes particularly apparent in prospective memory, that is, the ability to remember to perform an action in the future (Einstein & McDaniel, 1990). Prospective memory involves retaining an intention while engaging in other activities, and retrieving the intention at an appropriate time for execution, before deactivating it once completed (Meier & Cottini, 2023; Rummel & Kvavilashvili, 2023). A prospective memory task consists of

two components: A prospective component (knowing when to perform the intended action), and a retrospective component (remembering what the intended action entails; Cohen et al., 2001; Meier & Zimmermann, 2015). For instance, one might form the intention in the morning to buy groceries (retrospective component) after work (prospective component): While at work, this intention must be retained. When the appropriate situation for execution presents itself after work, this intention must be retrieved and executed. Once fulfilled, the need to buy groceries has been satisfied, and the intention is deactivated.

Contemporary research has diverged from the theory of tension introduced by Lewin (1926) towards a theory of activation. Newer explanations attribute a special dynamic status to intentions (Goschke & Kuhl, 1993). If an intention is not fulfilled, the intention is never deactivated, resulting in a persistent activation of unfinished intentions. This persisting activation was demonstrated in better memory for unfinished tasks (Zeigarnik, 1927), a tendency to resume unfinished actions unprompted (Rickers-Ovsiankina, 1928), and a faster reaction time to intention-related stimuli (Goschke & Kuhl, 1993). The persisting activation has also been demonstrated in prospective memory research. When a previously instructed intention, which could never be executed, is instructed to be over, but intention-related stimuli are presented nevertheless, this persistent activation becomes evident. In these cases, commission errors occur, wherein individuals respond with intention-related behaviour despite being instructed not to do so (Bugg & Scullin, 2013). Encountering previously intention-relevant stimuli also slows down performance (Walser et al., 2012). Moreover, slower reaction times also occur on subsequent trials (Meier & Cottini, 2023). These effects have also been attributed to the activated state of memory representations of unfinished intentions (Bugg & Streeper, 2019; Möschl et al., 2020).

It must be noted, however, that the original memory advantage for unfinished intentions could not be reliably replicated over the years (for an overview, see MacLeod, 2020). The memory advantage for unfinished tasks has shown great ambiguity, with some researchers reporting more finished tasks

recalled on average (see Butterfield, 1964; Van Bergen, 1968). One explanation for these inconclusive findings is that the preference for intentions might vary depending on individual differences (Atkinson, 1953).

One crucial individual difference that needs to be emphasized is *achievement motivation*. A behaviour is considered achievement motivated when competition with a standard of excellence is involved (McClelland et al., 1976). Therefore, a high achievement motive is seen as a stable disposition to strive for achievement or success (Atkinson, 1957). Early research demonstrated that participants high in achievement motivation prefer incomplete intentions, whereas participants low in achievement motivation exhibit the opposite profile (Atkinson, 1953). Later, most studies replicated these findings, with individuals with high achievement motivation generally recalling more interrupted tasks than finished tasks (Farley & Mealiea, 1973; Mandowsky, 2007; Weiner, 1966; but see Raffini & Rosemier, 1972).

Generally, two distinct aspects of achievement motivation were proposed: An approach motive involving the expectation of reward, called *hope of success*, and an avoidance motive involving the expectation of punishment, called *fear of failure* (Clark et al., 1956; McClelland et al., 1953). However, the influence of achievement motivation on selective recall of unfinished tasks has not been investigated for hope of success and fear of failure separately. Kuhl (1996) suggested that the anticipation of reward, that is, hope of success, and the anticipation of punishment, that is, fear of failure, determine the preferred form in which intentions are maintained in memory. Intentions associated with hope of success would be associated with procedural persistence, implicit respondent persistence, or explicit operant persistence, which should increase the probability of performing an intention at the right moment. On the other hand, intentions associated with fear of failure would be associated with increased physiological arousal, vigilance, and a constant conscious representation,

while simultaneously inhibiting action schemas to avoid premature actions. Under these circumstances, action schemas must be prevented in favor of planning, reflecting, and analyzing the situation.

Hence, we would argue that a memory advantage of intentions, and particularly unfinished ones, should relate to high hope of success: Higher hope of success would relate to a better representation and thus a higher activation of intentions, which would persist when unfinished, resulting in a memory advantage for those unfinished intentions. Regarding fear of failure, we would expect the constant conscious representation and inhibition of action-schemas to implement an intention only superficially, which should result in overall lower activation of intentions overall. Consequently, we would expect individuals high in fear of failure to recall finished and unfinished intentions comparably well, since the persistent activation of unfinished intentions would remain low.

The goal of the present study was to test the hypothesis that differences in hope of success primarily drive the differences in recall of interrupted or unfinished and completed. Still, differences between hope of success and fear of failure in the recall of intentions have been predicted, suggesting that intentions, in particular unfinished ones associated with hope of success may benefit from increased recall. To test this hypothesis, we used a paradigm introduced by Baddeley (1963), in which participants had to solve anagrams. These anagrams were presented in sequential order, and participant were allotted 60 seconds per anagram before they were interrupted and given the solution, if they did not manage to come up with it. Subsequently, recall of solved and unsolved anagram solutions was assessed.

Method

Participants

The sample consisted of 1076 participants, of which 600 identified as female (56%), 468 identified as male (43%), and eight identified as neither male nor female (1%), and was between 18 and 45 years (M = 23.32, SD = 4.84). Participants were required to be at least 18 and not older than 45 years

old. They were recruited by undergraduate students as part of a research course and were not compensated for their participation. Reports were collected anonymously, and the ethical committee of the human science faculty of the University of Bern approved the study.

Given the variable findings in research of memory for unfinished intentions, we opted for a larger sample size to detect very small effects of achievement motivation on recall of solved versus unsolved anagrams. We conducted an a priori power analysis using G*Power version 3.1.9.7 (Faul et al., 2009) to determine the minimum sample size required to detect an effect of $f^2 = .01$. Results indicated that a sample size of $N = 1053$ was necessary to achieve 90% power for detecting a small effect at a significance criterion of $\alpha = .05$. As we had to account for individuals who would solve all or none of the anagrams, which would not provide measures for both recalled unsolved and recalled solved anagrams, we decided to increase the sample size.

Materials

We created twelve anagrams using the following German five-letter words: *Paket*, *Trick, Liter, Kunst, Motiv, Frage, Rauch, Kleid, Stirn, Tafel, Karte,* and *Logik*, all with a medium to high frequency from the Celex-database (Baayen et al., 1996). Anagrams were created by rearranging the letters of each word in one of four ways, namely 31524, 35142, 52413, and 42531 (Hunter, 1959). We counterbalanced the anagrams and their order of presentation across participants. For practice, we used three additional anagrams formed with the German five-letter words *Notiz*, *Motor*, and *Sonne*. They were created using rearrangement orders which are easier to solve: 12354 for *Notiz* (“NOTZI”), 41235 for *Motor* (“OMOTR”), and 53241 for *Sonne* (“ENONS”). All anagrams were presented on a computer in black font on a white background, using the Calibri Light font typeface. The font size was set to 125.

To measure achievement motivation, that is, a general tendency to evaluate and act in situations with a standard of excellence to be met, we used the revised 10-item version of the Achievement Motives Scale (AMS-R; Lang & Fries, 2006). The scale consists of a 5-item hope of success

scale (Cronbach α = .71 – .80) and a 5-item fear of failure scale (Cronbach α = .76 – .85). Participants were instructed to rate each item on a four-point Likert scale (1 = *totally disagree*, 4 = *totally agree*).

Procedure

Participants were tested individually. Before beginning the experiment, they were given the following instruction: “Your task now is to solve anagrams. You will be presented with strings of letters with which you have to form a meaningful word by rearranging the letters. Following this instruction, you will see a few examples”. Next, participants were presented with the three practice trials. We did not limit the time for the completion of practice trials. After completing the three practice trials, testing began with the words, “Good! Now we will start with the actual testing”. Participants were then presented with the twelve anagrams in sequence. If the participant managed to solve the anagram or after 60 seconds elapsed, the participant was given the anagram’s solution with the words “the solution was [WORD]”, and proceeded with the next anagram. If the participant had managed to solve the anagram, the time to solve the anagram was recorded, and they were likewise shown the solution with the words “the solution was [WORD]”. After presenting all twelve anagrams, the participant was instructed to recall as many solutions as possible with the instruction, “Which of the solutions do you remember?”. We recorded the solutions and the order in which the solutions were recalled. At the end, participants filled out the AMS-R to measure achievement motivation.

Analyses

First, we analyzed the number of anagrams solved and recalled. We tested for differences using a paired sample t-test. Further, we investigated the relationship of hope of success and fear of failure separately for anagram recall using linear regression models.

Results

General Analysis

Participants solved a total of M_{solved} = 7.90 (SD_{solved} = 2.29) anagrams, with a minimum of Min_{solved} = 0 and a maximum of Max_{solved} = 12. They recalled a total of $M_{recalled}$ = 4.15 ($SD_{recalled}$ = 1.55) anagrams, with a minimum of $Min_{recalled}$ = 0 and a maximum of $Max_{recalled}$ = 11. In total, participants recalled more solved anagrams, M = 2.50 (SD = 1.64), than unsolved anagrams, M = 1.64 (SD = 1.12). As participants solved more anagrams on average than failed to do so, we computed percentages recalled of solved and unsolved anagrams, resulting in an average recall of 45.34% of unsolved and 31.15% of solved anagrams (Figure 1). A paired sample t-test confirmed that participants recalled more unsolved anagrams than solved anagrams, $t(1029) = 13$, $p < .001$, $d = .41$.

[Figure 1]

Hope of Success

The average hope of success score was M_{HS} = 10.91 and SD_{HS} = 2.45, with a minimum of Min_{HS} = 0 and a maximum of Max_{HS} = 15. We first conducted a Pearson correlation analysis between the hope of success score, the percentage of recalled unsolved anagrams, and the percentage of recalled solved anagrams. We found a small correlation effect of hope of success and the percentage of recalled unsolved anagrams, $r_{Pearson}(1028) = .11$, $p < .001$. There was no correlation effect of hope of success and the percentage of recalled solved anagrams, $r_{Pearson}(1028) < .01$, $p > .99$.

We fitted two linear regression models to predict the percentage of recalled anagrams with hope of success (Figure 2A). For unsolved anagrams, the model's total explanatory power was $R^2 = .01$, and was overall significant, $F(1, 1028) = 12.43$, $p < .001$. The effect of hope of success on the percentage of unsolved recalled anagrams was statistically significant and positive, B = 1.29, $t(1028) = 3.53$, $p < .001$; β = .11. For solved anagrams, the model's total explanatory power was $R^2 < .01$, and was not significant, $F(1, 1028) < 0.1$, $p = .959$. The effect of hope of success on the percentage of solved recalled anagrams was not statistically significant, B = 0.01, $t(1028) = 0.05$, $p = .959$; β < .01.

[Figure 2]

Fear of Failure

The average fear of failure score was M_{FF} = 6.75 and SD_{FF} = 3.58, with a minimum of Min_{FF} = 0 and a maximum of Max_{FF} = 15. We first conducted a Pearson correlation analysis between the fear of failure score, the percentage of recalled unsolved anagrams, and the percentage of recalled solved anagrams. We found no correlation effect of hope of success and the percentage of recalled unsolved anagrams, $r_{Pearson}$ (1028) < .01, p = .900, and no correlation effect of hope of success and the percentage of recalled solved anagrams, $r_{Pearson}$ (1028) = -.02, p = .500.

We also fitted two linear regression models to predict the percentage of recalled anagrams with fear of failure (Figure 2B). For unsolved anagrams, the model's total explanatory power was R^2 < .01, and was overall not significant, F(1, 1028) = 0.01, p = .903. The effect of fear of failure on the percentage of unsolved recalled anagrams was not statistically significant, B = 0.03, t(1028) = 0.12, p = .903; β < .01. For solved anagrams, the model's total explanatory power was R^2 < .01, and was overall not significant, F(1, 1028) = 0.45, p = .501. The effect of fear of failure on the percentage of solved recalled anagrams was also not statistically significant, B < -0.11, t(1028) = -0.67, p = .501; β = -.02.

Discussion

The goal of this study was to revisit previous research on the memory of unfinished tasks and its relation to achievement motivation, while integrating it in modern research on prospective memory. We measured participants recall of solved and unsolved anagrams and investigated these findings in relation to achievement motivation for hope of success and fear of failure separately, as we expected the memory advantage to predominantly relate to hope of success. Accordingly, we found a significant memory advantage for unsolved anagrams compared to solved anagrams.

The proportion of unsolved anagrams recalled was higher in individuals high in *hope of success*. Further, no association between the recall of unsolved anagrams and *fear of failure* was observed. Therefore, the observed relationship between achievement motivation and the increased recall of

interrupted tasks appears to be driven mainly by the approach tendency *hope of success*. The persistent activation of interrupted tasks is thus more pronounced in individuals who prefer challenging situations and anticipate reward, in line with Kuhl's (1996) predictions.

Regarding *fear of failure*, however, no significant association was observed with the recall of neither finished nor unfinished intentions. Therefore, activation did not differ between unsolved and solved anagrams in relation to fear of failure. We suspect that these results occurred because of the methodological approach used in this study. Each anagram was solvable with only one correct solution; therefore, there was no possibility for participants to make errors. Even if a participant exhibited a high score of fear of failure, there was no need to inhibit action-schemas to avoid a premature response. In addition, we did not induce pressure or create a highly competitive experimental environment, which in turn made the need for participants to adapt an avoidant strategy less likely, as the situation did not require participants to excel.

Therefore, a difference between hope of success and fear of failure can be observed in the context of the environment: Even when no standard of excellence is to be met, such as in our experiment, effects related to hope of success can be observed, unlike those effects related to fear of failure. These results indicate that individuals high in hope of success generally strive for excellence, even when such a standard is not required. On the other hand, individuals high in fear of failure might adapt an avoidant strategy to protect their "ego" only when threatened (Farley & Mealiea, 1973). We would therefore conclude that hope of success represents a general disposition independent of the environmental context, whereas fear of failure would emerge as an avoidance strategy under environmental circumstances threatening one's ego.

Taken together, these results provide a more detailed understanding of the relationship between the recall of unfinished intentions and individual differences. There is a general tendency to recall unfinished intentions more often than finished intentions due to their persistent activation. In

individuals with high hope of success, the representation of the intention and its activation is more strongly established, which persists when the intention remains unfulfilled. These circumstances account for the pronounced memory advantage for unfinished intentions in individuals high in hope of success. Regarding fear of failure, however, this study did not provide a suitable context to for participants high in fear of failure to adapt an avoidant strategy. We expect individuals to exhibit comparable recall of finished and unfinished intentions with increasing fear of failure in situations where an avoidance strategy can be adapted.

This memory advantage for unsolved anagrams occurred without the need to manipulate the experimental situation, such as by emphasizing the task-importance through instructions or by creating a competitive environment (see for example Atkinson, 1953, 1957). Moreover, the memory advantage occurred even when the experimenter forcefully finished the task through the presentation of the anagram's solution when time ran out, suggesting a continuous activation of the intention when the anagram was unsolved. These findings are in line with contemporary prospective memory research, demonstrating that the ability to perform a task is crucial for the successful deactivation of an intention, and a deactivation-instruction is not sufficient (Bugg & Scullin, 2013; Meier & Cottini, 2023; Streeper & Bugg, 2021). In other words, it was essential for participants to successfully solve the anagram to perceive the task as finished.

Some limitations need to be taken into consideration, however. First, we used a sample of 18 to 45-year-old individuals. It would have been beneficial to include older participants, as the samples in earlier studies also generally consisted of younger subjects. However, prospective memory studies in older adults suggest a stronger persistent activation of unfinished tasks (Bugg et al., 2016; Cottini & Meier, 2020; Scullin et al., 2011). Therefore, we would expect a stronger memory advantage for unfinished tasks in elderly participants. Second, effect sizes were generally small, and explained variance in the study was low. Hence, large samples are needed to detect such small effects. Third, the task of

solving anagrams is not representative of real-world memory tasks and intentions, which may limit the ecological validity of the findings. Last, we used a self-report measure to assess hope of success and fear of failure. In previous research, self-report measures showed little correlation with a more objective measure (Brunstein & Heckhausen, 2018). On the other hand, using self-report measures required considerably less time, which was favourable for the test economy.

Nonetheless, these findings have practical implications for future studies. In modern prospective memory research, motivation has been manipulated by providing a reward, manipulating instructions, or by providing social motives (see Walter & Meier, 2014 for a review). However, the present study suggests that individual differences such as achievement motivation may explain participant's receptivity to experimental manipulations of motivation in prospective memory research. Moreover, participants high in this predisposed motivation should exhibit better performance in the retrospective component of prospective memory performance (knowing what to do), as participants high in hope of success exhibited better recall of unfinished tasks in the present study. When in a performance situation, individuals high in fear of failure may exhibit impairment in their recall of intentions, which should be accounted for. In what sense motivation would relate to the prospective component of prospective memory, that is, remembering to perform an unfinished intention, remains the subject of future research.

Conclusions

In conclusion, unfinished tasks possess a memory advantage compared to finished tasks. This memory advantage is particularly pronounced among individuals high in achievement motivation, specifically highlighting the role of "hope of success". These findings underscore the interplay between task fulfilment and achievement motivation in shaping memory recall of finished versus unfinished intentions.

Author Contributions

R. Ghibellini and B. Meier wrote the manuscript and approved the final manuscript for submission.

Declaration of Conflicting Interests

The authors declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Data availability statement

The data of the present study are available on OSF (https://osf.io/uzvk8/).

References

Ach, N. (1910). *Über den Willensakt und das Temperament: Eine experimentelle Untersuchung*. Quelle & Meyer.

Atkinson, J. W. (1953). The achievement motive and recall of interrupted and completed tasks. *Journal of Experimental Psychology*, *46*(6), 381–390. https://doi.org/10.1037/h0057286

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. *Psychological Review*, *64*(6, Pt.1), 359–372. https://doi.org/10.1037/h0043445

Baayen, R. H., Piepenbrock, R., & Gulikers, L. (1996). *The CELEX lexical database (cd-rom)*.

Baddeley, A. D. (1963). A Zeigarnik-like effect in the recall of anagram solutions. *Quarterly Journal of Experimental Psychology*, *15*(1), 63–64. https://doi.org/10.1080/17470216308416553

Brunstein, J. C., & Heckhausen, H. (2018). Achievement Motivation. In J. Heckhausen & H. Heckhausen (Eds.), *Motivation and Action* (pp. 221–304). Springer International Publishing. https://doi.org/10.1007/978-3-319-65094-4_6

Bugg, J. M., & Scullin, M. K. (2013). Controlling intentions: The surprising ease of stopping after going relative to stopping after never having gone. *Psychological Science*, *24*(12), 2463–2471. https://doi.org/10.1177/0956797613494850

Bugg, J. M., Scullin, M. K., & Rauvola, R. S. (2016). Forgetting no-longer-relevant prospective memory intentions is (sometimes) harder with age but easier with forgetting practice. *Psychology and Aging*, *31*(4), 358–369. https://doi.org/10.1037/pag0000087

Bugg, J. M., & Streeper, E. (2019). Fate of suspended and completed prospective memory intentions. In J. Rummel & M. A. McDaniel (Eds.), *Prospective Memory* (1st ed., pp. 44–59). Routledge. https://doi.org/10.4324/9781351000154-4

Butterfield, E. C. (1964). The interruption of tasks: Methodological, factual, and theoretical issues. *Psychological Bulletin*, *62*(5), 309–322. https://doi.org/10.1037/h0039873

Clark, R. A., Teevan, R., & Ricciuti, H. N. (1956). Hope of success and fear of failure as aspects of need for achievement. *The Journal of Abnormal and Social Psychology*, *53*(2), 182.

Cohen, A.-L., West, R., & Craik, F. I. M. (2001). Modulation of the prospective and retrospective components of memory for intentions in younger and older adults. *Aging, Neuropsychology, and Cognition*, *8*(1), 1–13. https://doi.org/10.1076/anec.8.1.1.845

Cottini, M., & Meier, B. (2020). Prospective memory monitoring and aftereffects of deactivated intentions across the lifespan. *Cognitive Development*, *53*, 100844. https://doi.org/10.1016/j.cogdev.2019.100844

Einstein, G. O., & McDaniel, M. A. (1990). Normal aging and prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*(4), 717–726. https://doi.org/10.1037/0278-7393.16.4.717

Farley, F. H., & Mealiea, W. L. (1973). Motivation and the recall of completed and incompleted achievement items. *The Journal of Educational Research*, *66*(7), 302–306. https://doi.org/10.1080/00220671.1973.10884489

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.

Goschke, T., & Kuhl, J. (1993). Representation of intentions: Persisting activation in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(5), 1211–1226. https://doi.org/10.1037/0278-7393.19.5.1211

Hunter, I. M. (1959). The solving of five-letter anagram problems. *British Journal of Psychology*, *50*(3), 193–206. https://doi.org/10.1111/j.2044-8295.1959.tb00697.x

Kuhl, J. (1996). Wille und Freiheitserleben: Formen der Selbststeuerung. In J. Kuhl & H. Heckhausen (Eds.), *Motivation, Volition und Handeln* (Vol. 4). Göttingen, Hogrefe.

Lang, J. W. B., & Fries, S. (2006). A revised 10-item version of the Achievement Motives Scale. *European Journal of Psychological Assessment*, *22*(3), 216–224. https://doi.org/10.1027/1015-5759.22.3.216

Lewin, K. (1926). Vorsatz, Wille und Bedürfnis. *Psychologische Forschung*, *7*(1), 330–385. https://doi.org/10.1007/bf02424365

MacLeod, C. M. (2020). Zeigarnik and von Restorff: The memory effects and the stories behind them. *Memory & Cognition*, *48*(6), 1073–1088. https://doi.org/10.3758/s13421-020-01033-5

Mandowsky, D. (2007). The effect of achievement motivation on the Zeigarnik effect. *The Huron University College Journal of Learning and Motivation*, *45*(1).

McClelland, D. C., Atkinson, J. W., Clark, R. A., & Lowell, E. L. (1953). The achievement motive, 1953. *New York: Appleton-Century-Crofts*.

McClelland, D. C., Atkinson, J. W., Clark, R. A., & Lowell, E. L. (1976). *The achievement motive.* Irvington.

Meier, B., & Cottini, M. (2023). After-effects of responding to activated and deactivated prospective memory target events differ depending on processing overlaps. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *49*(3), 389–406. https://doi.org/10.1037/xlm0001154

Meier, B., & Zimmermann, T. D. (2015). Loads and loads and loads: The influence of prospective load, retrospective load, and ongoing task load in prospective memory. *Frontiers in Human Neuroscience*, *9*. https://doi.org/10.3389/fnhum.2015.00322

Möschl, M., Fischer, R., Bugg, J. M., Scullin, M. K., Goschke, T., & Walser, M. (2020). Aftereffects and deactivation of completed prospective memory intentions: A systematic review. *Psychological Bulletin*, *146*(3), 245–278. https://doi.org/10.1037/bul0000221

Rickers-Ovsiankina, M. A. (1928). Untersuchungen zur Handlungs- und Affektpsychologie. *Psychologische Forschung*, *11*, 302–379. https://doi.org/10.1007/bf00410261

Rummel, J., & Kvavilashvili, L. (2023). Current theories of prospective memory and new directions for theory development. *Nature Reviews Psychology*, *2*(1), 40–54. https://doi.org/10.1038/s44159-022-00121-4

Scullin, M. K., Bugg, J. M., McDaniel, M. A., & Einstein, G. O. (2011). Prospective memory and aging: Preserved spontaneous retrieval, but impaired deactivation, in older adults. *Memory & Cognition*, *39*(7), 1232–1240. https://doi.org/10.3758/s13421-011-0106-z

Streeper, E., & Bugg, J. M. (2021). Deactivation of prospective memory intentions: Examining the role of the stimulus–response link. *Memory & Cognition*, *49*(2), 364–379. https://doi.org/10.3758/s13421-020-01091-9

Van Bergen, A. (1968). *Task interruption* [Doctoral dissertation, Universiteit van Amsterdam]. North-Holland Publishing Company.

Walser, M., Fischer, R., & Goschke, T. (2012). The failure of deactivating intentions: Aftereffects of completed intentions in the repeated prospective memory cue paradigm. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *38*(4), 1030–1044. https://doi.org/10.1037/a0027000

Walter, S., & Meier, B. (2014). How important is importance for prospective memory? A review. *Frontiers in Psychology*, *5*. https://doi.org/10.3389/fpsyg.2014.00657

Weiner, B. (1966). Achievement motivation and task recall in competitive situations. *Journal of Personality and Social Psychology*, *3*(6), 693–696. https://doi.org/10.1037/h0023206

Zeigarnik, B. (1927). Das Behalten erledigter und unerledigter Handlungen. *Psychologische Forschung*, *9*, 1–85.

Figure 1

Memory Performance, for Solved and Unsolved Anagrams Separately

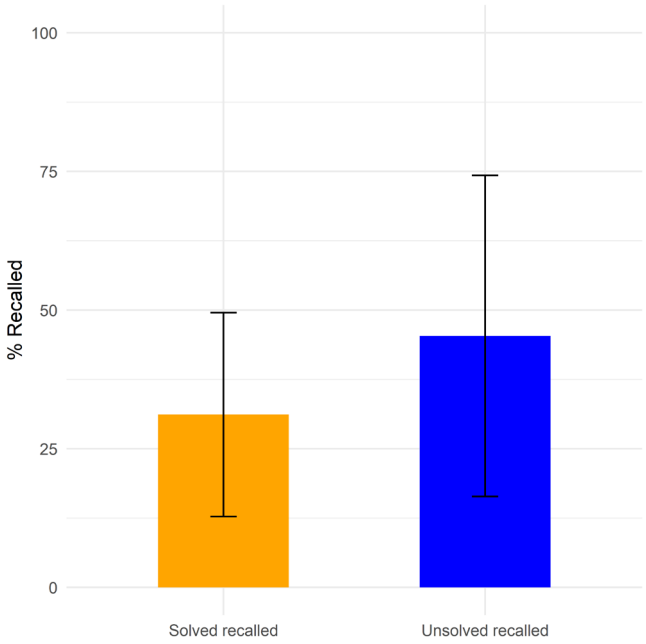

Figure 2

Association of Achievement Motivation and Memory Performance: Linear Regression Lines of (A) Hope of Success and (B) Fear of Failure Scores Predicting the Percentage of Solved and Unsolved Recalled Anagrams