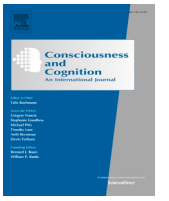
Consciousness and Cognition 115 (2023) 103582

Contents lists available at ScienceDirect

Consciousness and Cognition

journal homepage: www.elsevier.com/locate/concog



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

Romain Ghibellini *, Beat Meier

Institute of Psychology, University of Bern, Switzerland

ARTICLE INFO

Keywords:
Hypnagogia
Hypnagogic states
Dreams
Sleep paralysis
Imagination

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

* Corresponding author at: Institute of Psychology, University of Bern, Fabrikstrasse 8, 3012 Bern, Switzerland.
E-mail address: romain.ghibellini@psy.unibe.ch (R. Ghibellini).

https://doi.org/10.1016/j.concog.2023.103582
Received 27 April 2023; Received in revised form 20 September 2023; Accepted 27 September 2023
Available online 7 October 2023

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

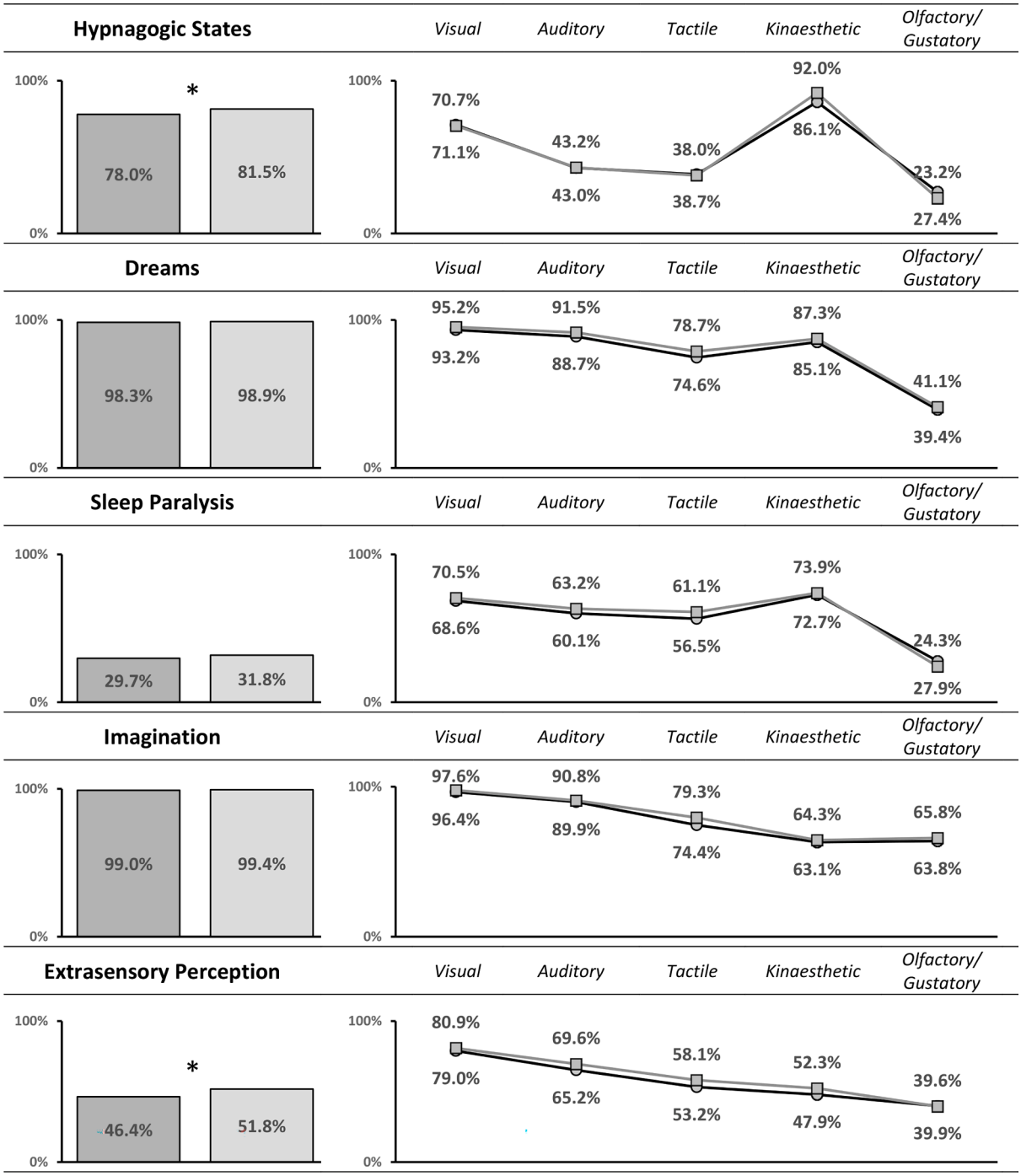


Fig. 1. Prevalences and frequency of modalities for the different phenomena. For prevalences, the left bar corresponds to men, and the right bar to women. For modalities, circles correspond to male and squares to female participants. The modalities were summarized across waves. Percentages are rounded 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.

Funding

No funding was received.

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.

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