CellPress

Trends in Cognitive Sciences

Opinion

Where is my mind? A neurocognitive investigation of mind blanking

Thomas Andrillon[1,2,*], Antoine Lutz[2,3], Jennifer Windt[2,4], and Athena Demertzi[5,6,*]

During wakefulness, our thoughts transition between different contents. However, there are moments that are seemingly devoid of reportable content, referred to as mind blanking (MB). It remains unclear what these blanks represent, highlighting the definitional and phenomenological ambiguities surrounding MB. We map out MB in terms of its reportable expressions, neurophysiology, and relationship to adjacent phenomenology, including meditative practices and sleep. We propose a mechanistic account linking MB to changes at the physiological, neural, and cognitive levels. We suggest that ongoing experiences are characterized by degrees of richness, and that contentless events represent distinct mental states with their own diversity. We encourage future research to acknowledge MB as a reportable mental category, leading to a comprehensive understanding of ongoing experience.

Highlights

Ongoing experience comes in shades with varying richness of mental content. Mind blanking (MB) implies that there can be moments that are seemingly devoid of mental content.

MB is gaining attention as a reportable mental state. The multiple definitions it has received point to its current conceptual and methodological ambiguities.

MB may be phenomenologically diverse – different types can bear similarities and differences to 'empty minds', such as during meditative practices and sleep (white dreams).

MB reports have distinguishable neurobehavioral profiles, pointing to arousal as a key foundational backbone for MB reportability.

We propose a mechanistic account in which MB is the end-result of physiological, neural, and cognitive changes, which provides insights for future empirical and phenomenological research of MB.

Mind blanking: a newly explored mental state

When awake, our thoughts appear to occur seamlessly, and resemble a stream continuously flowing [1]. This ongoing inner experience encompasses various contents, including inner speech, inner seeing, unsymbolized thinking, feelings, and sensory awareness [2]. Viewing wakefulness as a dynamic flow of contentful thoughts inspired the investigation of **mind wandering** (see Glossary) [3,4], which explores the frequent shifts of focus from tasks towards endogenous task-unrelated or stimulus-unrelated thoughts [5]. A prominent proposal from the mind-wandering literature is that inner experiences form diverse mental states that are characterized by a content (what the state is 'about') and the relation one bears to this content, such as imagining, remembering, or fearing [6]. Collectively, mind-wandering research highlights that, when we are awake and engaged in a task, we are often not focused on the 'here' and 'now', but on the 'there' and 'then'.

Interestingly, there is a class of conscious states in which our minds go 'nowhere' because they seem to lack content. When external observers probe the dynamics of thought, there are moments in which we may report that 'we were not thinking of anything', a phenomenon referred to as MB. Over the years, several definitions have been proposed for MB (Box 1), and the nature of MB remains debated; there is uncertainty about whether it reflects an absence of conscious awareness, attentional lapses, or deficits in memory, language, or content access. To bring clarity to the phenomenon of MB, we propose a conceptual cartography that summarizes the behavioral and neural correlates of MB and contrasts MB with similar experiences in meditation and sleep. Building on empirical work, we outline a mechanistic approach to explain the diverse manifestations of MB, aiming for a clearer understanding of this phenomenon.

Overall, we believe that the investigation of MB is insightful, important, and timely. Insightful because it challenges the common conception that wakefulness involves a constant stream of

[1]Paris Brain Institute, Centre National de la Recherche Scientifique (CNRS) and Institut National de la Santé et de la Recherche Médicale (INSERM), Sorbonne Université, 75013 Paris, France
[2]Monash Centre for Consciousness and Contemplative Studies, Monash University, 3168 Clayton, Victoria, Australia
[3]Eduwell team, Lyon Neuroscience Research Center, INSERM Unité 1028 and CNRS Unité Mixte de Recherche (UMR) 5292, Lyon, France
[4]Department of Philosophy, Monash University, 3800 Clayton, Victoria, Australia
[5]GIGA–CRC Human Imaging Unit, GIGA Institute, University of Liège, 4000 Sart Tilman, Belgium
[6]Psychology and Neuroscience of Cognition Unit (PsyNCog), University of Liège, 4000 Sart Tilman, Belgium

 https://doi.org/10.1016/j.tics.2025.02.002

*Correspondence:
thomas.andrillon@icm-institute.org (T. Andrillon) and
a.demertzi@uliege.be (A. Demertzi).

Box 1. Definitions of mind blanking (MB) in the literature

Definitions of MB have varied widely. MB was initially characterized by Ward and Wegner as involving a 'lack of conscious awareness' during which 'the individual is not focally aware of any stimuli, either internal or external' [16]. In that experimental study, participants were asked to report episodes of MB during reading. MB was defined to them as instances when 'not only were you not really thinking about the text, you were not thinking about anything at all – your mind was a complete blank' [16]. With this definition, MB was associated with the absence of thought and blankness, which, although related, can nevertheless be distinct phenomena [8]. Indeed, in their second experiment, Ward and Wegner took this distinction into consideration and defined MB as follows: "The only difference between mind-wandering and mind-blanking is that in mind-wandering you are thinking about something else, and in mind-blanking you aren't" [16].

Another approach to studying MB involved a thought-probing protocol in which the authors did not account for MB explicitly but included a thought category where individuals could state "I am not very alert/my mind is blank or I'm drowsy" [17], thus linking MB with arousal and vigilance. The link between arousal and thought reporting was also made using experience sampling, during which participants could rate their attention state as a somnolent state (drowsy) after reporting their thoughts on preselected categories, including 'absence' – defined as MB or an empty state of mind [14].

Another definition of MB that links it to attention comes from fMRI protocols, where participants were instructed to actively think of nothing and, when they noticed that they were thinking of something, to shift back their attention and continue to think of nothing [21]. Finally, in a recent work of ours using a sustained attention to response task, we defined MB as 'subjective reports of reduced awareness and a temporary absence of thought (empty mind) or lack of memory for immediately past thoughts' [30]. A list of these verbatim definitions is summarized in Table I.

Table I. Verbatim definitions for mind blanking

Definition	Refs
'Lack of conscious awareness' during which 'the individual is not focally aware of any stimuli, either internal or external'	[16]
'Not only were you not really thinking about the text, you were not thinking about anything at all – your mind was a complete blank'	[16]
"The only difference between mind-wandering and mind-blanking is that in mind-wandering you are thinking about something else, and in mind-blanking you aren't"	[16]
"I am not very alert/my mind is blank or I'm drowsy"	[17]
'Absence', having 'an empty mind' or 'thinking about nothing'	[14]
'You were trying to think of nothing (as instructed)' or 'your mind genuinely blanked out'	[11]
'Subjective reports of reduced awareness and a temporary absence of thought (empty mind) or lack of memory for immediately past thoughts'	[30]

thoughts. Important because MB highlights the interindividual differences in subjective experience, whose distinct psychological and neurophysiological substrates could be informative for potential pathologies (e.g., [7]). It is also timely because it may add to the conceptual search for a thorough and nuanced definition of MB [8,9]. At the theoretical level, MB may also pose a challenging case for theories of consciousness [10] which will need to account for the mechanisms of reportable no-thinking while awake and responsive.

Behavioral characterization of MB

The behavioral profile of MB has been primarily studied through the theoretical and methodological framework of mind wandering (Box 2). In these setups, participants are typically instructed to perform attention-demanding tasks and report instances of MB either spontaneously (self-caught) or following an explicit prompt. Participants can also be instructed to self-maintain MB while performing a task or at rest [11]. MB instances are then analyzed in relation to behavior and brain activity. A list of studies with verbatim instructions to report MB is summarized in Box 1.

MB is typically reported 5–20% of the time [7,12–14], a third of the typical proportion of mind wandering [15,16]. MB also has a distinct behavioral profile compared to mind wandering and

being on task: in a **sustained attention task**, participants reported feeling sleepier and made more omission errors before reporting MB. In addition, although participants tended to respond faster to visual stimuli before reporting mind wandering, their responses slowed down before reporting MB [12]. The association between MB and behavioral sluggishness was also supported by evidence showing that 'inattentiveness/blanks' increase toward the end of a long sustained-attention task [17], and after sleep deprivation and intense physical exercise [18].

At the same time, MB occurrences are not uniquely observed during long and demanding tasks. Indeed, a uniform distribution of MB reports across the scanning session was identified during a rest in the scanner protocol [19]. In addition, MB was reported more quickly than content-oriented categories, and there were low but equal probabilities of transitioning from a content-oriented state to MB. Such low probabilities and faster responses of MB reports could imply that MB works as a transient mental relay because cognitive evaluation of 'no content' may require less time than evaluating the particularities of contentful reports [19,20]. According to this view, MB results from the dynamic nature of the stream of consciousness rather than reflecting a type of experience in its own right [20]. Such report dynamics were also influenced by variations in arousal levels, where mind-wandering reports were more likely to be followed by MB after sleep deprivation or immediately after intense physical exercise [18].

Together, the quantification of MB can differ drastically from one study to another (Box 2). Important interindividual differences can also arise because some people never report MB, whereas others, such as adults and children with attention deficit hyperactivity disorder (ADHD), report MB more frequently than neurotypical people [7] (Box 3). Despite heterogeneity, previous approaches and definitions of MB can be organized based on what is being reported (an absence of thoughts, of sensory experience, of any phenomenal content) and the relationship of the

Box 2. Current and future methodologies of how to assess mind blanking (MB)

There is currently no definitive guidance on how to reliably measure MB. However, existing methodologies from research on mind wandering, sleep, and meditative practices provide useful frameworks (Table I). Depending on the research question, specific setups can facilitate MB quantification, as discussed below.

Experience sampling

If the aim is to investigate mental content at large, MB can be included as a predefined probe category alongside others, such as task-related and task-unrelated thoughts. This method allows numerous probes, thereby ensuring statistical power. It also allows MB events to be captured even in the absence of the subject's meta-awareness of these events. Finally, this approach can help to isolate signatures of MB by identifying specific moments in the task during which MB occurred. However, random probes may not reflect the spontaneous nature of MB occurrences. It is also important that the participants should answer these probes based on their subjective experience and not, for example, based on their own perceived task performance.

Self-caught methodology

For studies focused exclusively on MB, participants can report MB events whenever they realize that they have just come out of an MB state. This approach allows more precise timing of MB reports because participants themselves control the timing of these reports. However, this method does not allow the detection of MB events for which the participants are not aware of the MB. In addition, participants may struggle to reliably differentiate MB from other mental states if they are not asked to report on these other mental states as well.

Hybrid methodology

To overcome the limitations of both approaches, a hybrid methodology may be employed. Given that MB reports can be classified against content-oriented mental states with high accuracy [18,19], this approach can be a simplified version of the classic experience sampling approach. In this setup participants can be instructed to report MB either using self-caught reports or following random probes (probe-caught). In the latter, subjects can report their mental state by selecting between two discrete categories: 'I was in an MB state' or 'I was not in an MB state'. This hybrid approach would permit a clearer differentiation between MB and other states while preserving the advantages of both probe-caught and self-paced reporting.

Glossary

Access consciousness: the availability of information for reportability, referring to the cognitive aspects of consciousness such as attention, working memory, and decision making.
Cessation: a meditative state without a meditative object, described as an internally induced absence of consciousness.
Classification accuracy: a performance metric used in machine learning to evaluate the effectiveness of a classification model. It represents the percentage of correct predictions over the total number of predictions.
Default mode network: a set of interconnected brain regions (primarily medial prefrontal cortex, posterior cingulate cortex/precuneus, lateral temporal regions, and hippocampal formation) which is typically activated during wakeful resting conditions.
Dual meditation: a meditative practice which recognizes the duality between the experience of the meditator (subject) and the observed phenomenon (object), such as breathing, thoughts, or sensations.
fMRI global signal: the average signal across all brain voxels which reflects widespread fluctuations that include both neural activity and non-neural influences such as physiological noise (e.g., respiration, cardiac cycles). It is often used to study large-scale brain dynamics or as a regressor to remove global noise, although its exact role and interpretation remain debated.
Functional connectivity: the statistical dependencies between physiological signals across brain areas which are assessed using biomedical techniques such as fMRI and electroencephalography (EEG).
Ignition: in computational neuroscience, the ability of a brain area to propagate feed-forward and recurrent neuronal activity to other regions.
Local field potentials (LFPs): electrical signals that reflect the collective activity of neurons within a specific brain region. LFPs capture both excitatory and inhibitory synaptic inputs as well as other local neural processes.
Local sleep: the intrusion of electrophysiological markers of sleep within a global context of wakefulness, or local intrusions of markers of wakefulness within a global context of sleep.

Table I. Methodologies for quantifying contentless experiences

Methodology	Description	Applications
Surveys/questionnaires	They provide structured frameworks for collecting self-reported data. They facilitate cross-cultural and longitudinal investigations, but only provide limited insights into the nuanced qualities of subjective experiences	Meditation [37], *non-duality* [67], minimal phenomenal experience [39], dream research, mind blanking [64]
Microphenomenological interviews	These involve a structured conversation with a participant about a particular experience. They allow participants to furnish a detailed account of their thoughts, feelings, sensations, and perceptions during the experience (synchronic dimension) and their temporal dynamic (diachronic dimension) as free as possible from the judgment of the interviewer	Examination of an individual's experience in detail [68,69]; also proposed for studying dreams [70] and sleep-related experiences [42,71]
Experience sampling	Typically conducted through electronic devices. It allows the collection of data about the thoughts, emotions, and other mental states of individuals at random or predefined intervals indicated by auditory and visual probes	Mind wandering (e.g., [4,72,73]), MB [12,18,19,23,25]
Descriptive experience sampling	An open-ended, generative, and minimally retrospective tool that uses a portable beeper that participants take into their natural environments. Participants pay attention to the experience at the moment of the sound, jot down notes about it, and describe it in an interview taking place within the following 24 h	Detailed qualitative quantification of inner experience [2,74]
Explicit instructions	They guide participants to clear their thoughts, thereby providing a controlled environment to explore the effects of intentional mental content suppression on both neural activity and phenomenology	MB [11]
Self-catching	Participants self-identify and report instances when their minds naturally enter the mental state of interest	MB [16]
Evidence synthesis	Offers a rigorous and structured way to select, review, and analyze existing descriptions of a phenomenon in the literature	Meditation [47,75,76], dreams [77]

individual with this report (awareness of the blank during the blank, lack of reflective awareness, memory failure, verbalization failure). Collectively, the behavioral signature of reports of MB so far indicates that mind blanks occupy a special place in mental state quantification. Previous studies focusing only on mind wandering or off-task thoughts may have aggregated MB with other thought categories, leaving much of the variance of MB unexplained.

Neural correlates of MB

Recordings obtained by fMRI and electroencephalography (EEG) reveal that specific neural signatures precede probed MB reports during rest. In one of the first fMRI studies, the prompt 'think of nothing' elicited a differential profile compared to the instruction 'let your mind wander':

Low-dimensional brain states: the concept that, despite the complexity of brain activity, the functional states of the brain can be effectively described by a relatively small number of variables or dimensions, thereby simplifying the analysis and interpretation of neural processes.
Mind wandering: freely moving attention, thoughts (task-unrelated), and mental images that unfold spontaneously and associatively, and occur largely independently of the here/now and ongoing tasks.
Minimal phenomenal experience: a candidate for the simplest form of consciousness and any other form of conscious content, in which experience persists in the absence of particular thoughts and images, but can still be retrospectively reported.
Non-dual meditation: a meditative practice that is not structured by the subject–object duality. Core meditation instructions include to drop thoughts of past, present, and future, with the aim of generating a natural state of clear, non-conceptual awareness – an experience sometimes referred to as 'pure awareness'.
Phenomenal consciousness: the subjective character of conscious experience or "what it's like to have a particular experience".
Pure awareness: a subjective experience that arises in meditation practice, characterized by a contentless, non-conceptual, timeless, and spaceless awareness, accompanied by feelings of peacefulness and unboundedness.
Sustained attention task: a computer-based cognitive task that uses a random series of single digits presented on average every second. The test requires the participant to press a response key following each digit presentation except for a nominated no-go digit, to which no response should be made.
Time-varying functional connectome: the mapping of correlational interactions between different brain regions over time, as measured by neuroimaging techniques such as fMRI and EEG.
Univariate analysis: in fMRI, this refers to the analysis of brain activity by looking at the relationship between a single independent variable (e.g., a stimulus) and the activity of individual brain voxels. It focuses on to what extent the activity in

Box 3. Clinical aspects of mind blanking

Reports of MB can manifest in different situations and thus shed light on the potential significance of MB in atypical and clinical contexts. MB occurrences were directly investigated in individuals with attention deficit hyperactivity disorder (ADHD) [7]. This work showed that unmedicated children with ADHD exhibited a higher number of MB reports during a sustained attention task compared to children treated with methylphenidate, children with no ADHD but with a psychiatric disorder, and a neurotypical group.

MB is also part of the clinical characterization of generalized anxiety disorder, as mentioned in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5): 'Individuals with generalized anxiety disorder report subjective distress due to constant worry and related impairment in social, occupational, or other important areas of functioning. The anxiety and worry are accompanied by at least three of the following additional symptoms: restlessness or feeling keyed up or on edge, being easily fatigued, difficulty concentrating or mind going blank' [78].

Another condition in which MB is relevant is the autoactivation deficit (AAD) syndrome. AAD is a neuropsychological syndrome resulting from a bilateral damage to the basal ganglia and is characterized by acute apathy and a loss of self-driven behavior that is partially reversible with external stimulation [79]. Patients with AAD also express the feeling that their mind is empty when they are not stimulated, hence echoing the mind blank reported in healthy people.

Kleine–Levin Syndrome (KLS), also known as the 'Sleeping Beauty syndrome', is another rare neurological disorder that primarily affects primarily teenage males and which is characterized by recurring episodes of excessive sleepiness, up to 20 h per day[i]. The recurrent episodes of hypersomnia are usually accompanied by behavioral and cognitive disturbances. Although people with KLS behave typically between episodes, they may not be able to remember everything that happened during the episodes, leading to reports that resemble MB reports.

Another rare sleep disorder is idiopathic hypersomnia. Patients with idiopathic hypersomnia suffer from excessive daytime sleepiness despite casual or increased night-time sleep duration, and many suffer from long but unrefreshing naps [80]. Some of these patients may report experiencing a specific night 'blackout' when sleeping, namely an absence of consciousness encompassing not only the absence of dreams but also the feeling of an absence of thoughts and conscious experiences during the night [46].

Finally, during absence seizures children appear to briefly lose responsiveness (5–30 s) while they remain altogether wakeful[ii]. This is manifested as sudden blank stares, pauses in ongoing activity, and a temporary interruption in responsiveness with their surroundings, and features generalized spike-wave bursts at the low frequency of the EEG, accompanied by normal background brain activity. After the seizure ends, individuals may not always be aware that they were absent or had a seizure, although in some cases they might notice a gap in their memory or a brief disruption in their ongoing activities.

one voxel (or brain region) is associated with a particular experimental condition.
White dreams: reports of having had experiences during sleep, but where no specific content can be recalled; such reports usually occur upon awakening from non-rapid eye movement (NREM) sleep stages 2 and 3.

there were stronger correlations among the **default mode network**, frontal, temporal, and visual networks, highlighting that MB has a different profile from mind wandering [21]. The differences between MB and other mental states were also shown in a reanalysis of a dataset combining fMRI and experience sampling, including content-oriented categories and MB [14,19]. Using the **time-varying functional connectome**, we showed that MB is characterized by a pattern of globally positive connectivity, suggestive of a uniform communication between brain regions, possibly mediated by low vigilance [19].

Considered together, important differences in the neural correlates of MB can be observed across studies, and these differences are primarily driven by whether MB is intentionally induced or is reported without induction. Indeed, the instruction to actively try to 'empty the mind' correlated with deactivations in the inferior frontal gyrus, Broca's area, supplementary motor cortex, and hippocampus [11], which the authors interpreted as reduced internal verbalization of thoughts. However, these correlates do not necessarily reveal the neural correlates of MB *per se* because they could reflect the task of voluntarily emptying one's mind [8]. It is also possible that participants were not completely successful in inducing MB, making these correlates different from spontaneous MB. Indeed, following the instruction 'try to think of nothing during the scans', an additional activation of the anterior cingulate and the medial prefrontal cortex was observed accompanied by widespread deactivations of the cortical regions mentioned above [11]. Because activation of such medial frontal regions is typically associated with self-evaluative processes [22], it might reflect active thought suppression rather than MB [8]. We recently tested this

hypothesis by using **univariate analysis** to investigate the neural correlates of MB in participants who were not instructed to induce MB, but who were required to report it when prompted [23]. Our analysis showed similar widespread deactivations, but no recruitment of medial frontal regions [23]. Together, these results stress the possibility that MB may take various forms, such as deliberate or spontaneous, similar to what has been shown for mind wandering (Table 1). We recognize, however, that the deliberate aspects of MB may present a conceptual challenge because they resemble cultivated mediation states. They also raise mechanistic questions as to whether MB could begin deliberately (i.e., I put effort into not thinking about anything) but then might be maintained spontaneously.

Using EEG, which allows better temporal resolution than fMRI, we showed that MB during a sustained attention task was associated with lower signal complexity over parietal electrodes compared to mind wandering [12]. This is interesting because lower complexity in EEG recordings is typically observed in unconscious, hypovigilant, or less cognitively rich states [24]. Because MB also resulted in increased levels of delta power and disruption of non-linear frontoparietal **functional connectivity**, we considered that local and global information processing might be altered before MB reports. When examining the neural responses to visual stimuli during MB,

Table 1. A proposal to map variant forms of empty mindedness[a,b]

Variant form	Phenomenology	Arousal state	Dimensions						
			Memory	Selective attention	Meta-Awareness	Propositional content	Intentionality	Richness	Sense of duration
On-task	'I am paying attention to what I do'	Vigilant	Yes	Engaged	Present	Yes	Deliberate	Variable	Accurate
Spontaneous mind wandering	'My thoughts wandered away from what I was doing'	Vigilant/ drowsy	Yes	Distracted	Present or absent	Yes	Spontaneous	Variable	Variable
Intentional mind wandering	'I decided to let my thoughts wander'	Vigilant/ drowsy	Yes	Distracted	Present	Yes	Deliberate	Variable	Variable
Spontaneous MB	'I am not thinking of anything'	Vigilant/ drowsy	No	Low	Low or absent	No	Spontaneous	Low	Reduced
Deliberate MB	'I'm trying not to think of anything'	Vigilant	No	Engaged	Low or absent	No	Deliberate	Low	Reduced/ variable
Undetected MB	'I did not notice having had a blank'	TBD	No	No	No	No	Spontaneous	Low	Reduced
White dreams (spontaneous)	'I know I dreamed of something but I cannot recall what'	Asleep	No	No	Absent	Variable	Spontaneous	Low/variable	Variable
Meditative state (open monitoring practice)	'I felt like a quiet observer, aware of everything but clinging to nothing'	Vigilant	Yes	No or low	High	No/low	Deliberate	Rich	Variable

[a]We propose that different types of empty mindedness can be identified based on mechanistic and phenomenological dimensions when comparing them to on-task states and mind wandering. It is important to note that these dimensions are a preliminary proposal because (i) they are not exhaustive, (ii) their exact definition or interpretation can be refined, and (iii) for some cases, the empirical evidence needs to be determined (TBD). We think that, by contrasting these different dimensions, we can identify key features that separate MB and allegedly contentless states from content-oriented experiences, therefore providing a roadmap for empirical and theoretical studies.
[b]Phenomenology: representative statements of each state. Arousal: a type of physiological state as indicated at the level of the brain or the body. Memory: recollection of elements of the experience, not the occurrence of the experience itself. Selective attention: focusing on a specific content while ignoring other irrelevant information. Meta-awareness: the ability to reflect on one's own experience at the time of the experience. Propositional content: for example, thinking in words. Intentionality: willful initiation of the experience. Richness: complexity and/or diversity of perceptual, imagistic, or linguistic content of the experience. Sense of duration: feeling of how much time has passed in the same experiential state.

we also observed a disruption of late sensory processing in the front of the brain, which contrasts with the preservation of early sensory processes in the back of the brain (visual cortices) [25]. Compared to task-focused states, MB was also characterized by an increase in the occurrence and amplitude of EEG sleep-like slow waves. Together, the expression of sleep-like markers (slow waves, delta power), the disruption of non-linear connectivity and the diminished sensory processing are reminiscent of the changes occurring at sleep onset [26,27], during which consciousness may transform into a state involving rich and dynamic contents (i.e., dreaming) or fade away [28,29]. However, because these occurrences took place while participants were both awake and responsive, we proposed that MB could represent a state of **local sleep** rather than outright sleep onset [30]. Collectively, these results reflect, at least partially, the different ways of defining and operationalizing MB, which might target different phenomena, and which stress the need for a common phenomenological framework for MB studies.

MB in relation to contentless experiences in meditation and sleep

Sometimes the content of experience can appear to be reduced or absent. For example, periods of sleep might involve a minimal form of conscious experience, and during meditation practice 'empty mind' reports are not unusual. We describe these cases in more detail to assess their relationship to waking MB episodes.

Meditation practices

There are consistent reports across various contemplative traditions of contentless experience induced by meditation practices [31]. 'Contentless' here refers to experiences that are characterized by the absence of particular forms of reportable content, such as propositional (linguistic-like thought, or concepts), imagistic (i.e., mental images), and perceptual content (i.e., ordinary perception; Table 1). Such experiences occur either during mindfulness **dual meditation** and **non-dual meditation** [32], or in the vicinity of the so-called **cessation** states [33,34]. For example, during open monitoring meditation (a style of dual mindfulness meditation) the practitioner intentionally maintains a vigilant monitoring state, and, moment by moment, remains attentive to anything that occurs in experience without focusing on any explicit object [35]. When novice meditators practiced this technique for several days in retreat they consistently reported gradual increase in meta-awareness and mental stability compared to their baseline [36]. The objects of experience, such as perceptions, emotions, or thoughts, were experienced as being less adhesive and as mental processes rather than subjectively real entities [37]. Thoughts also became shorter [36] and more self-directed and spiritually-related [37]. In that sense, meditators can monitor contentless states of quiescence when there is momentary absence of object-related mental processes during this practice. It is therefore possible that open monitoring differs from MB in terms of cognitive function and phenomenology, particularly regarding the dimensions of vigilance, meta-awareness, and agency (Table 1).

During open monitoring and open presence meditation, many structural features of conscious experience, such as the sense of time and the dualistic relationship between the perceiver and the content, are altered or even suspended [32]. This is close to the concept of **minimal phenomenal experience** which was initially introduced in the context of dreamless sleep to describe conscious experience in the absence of specific thoughts or images [38]. Indeed, a recent online survey of 1403 responses exploring experiences of **pure awareness** in meditators identified a dimension of 'emptiness and non-egoic self-awareness' which anti-correlated with the factor of 'time, effort, and desire'. This suggests that pure awareness might lack time representation, agency, and autobiographical self-awareness [39]. According to this perspective, pure awareness takes an unstructured form of global content which is devoid of specific perceptual, motor, affective, conceptual, and propositional content. Finally, although cessation states remain

highly speculative and require confirmation, they raise the intriguing possibility of studying self-induced deep states of MB [33,34].

Black nights and white dreams

During sleep, individuals may have a variety of conscious experiences, including vivid dreams, but can also report **white dreams** [40]. White dreams have also been interpreted as contentful dreams from which the individual fails to access or remember the contents, known as 'forgotten dreams'. However, the debate about the nature of white dreams is ongoing and concerns whether white dreams reflect (i) forgotten rich contentful experiences, (ii) low-quality contentful experiences mistaken as contentless experiences, or (iii) genuine contentless experiences or minimal phenomenal experiences [41] (Table 1). It is important to point out that these are not necessarily competing accounts. White dream reports could have variant subtypes where, for example, some involve forgetting whereas others involve a minimal form of experience.

Exactly as in some meditative states, sleep sometimes involves objectless awareness – a state of awareness without any specific object [42]. Whether conscious experience persists during dreamless sleep is a matter of debate in Indian philosophy and has recently been discussed in the context of how to define and operationalize consciousness [43]. White dreams have been proposed as a possible example of minimal phenomenal experiences that arises spontaneously during sleep, and that are characterized by temporal content in the form of a subjectively experienced 'now' and a sense of duration [44]. Along the same lines, white dreams could stem from the experience of a minimal sense of self-awareness – a form of minimal phenomenal experience without any perceptual or semantic content to report beyond the feeling of being 'there' [45]. Another proposal is that they involve the feeling of being alive [43].

Interestingly, during sleep some individuals may report 'black-outs', namely the absence of experiences or recall of experiences from sleep onset to sleep offset [46]. These reports share a resemblance with cessation states in contemplative traditions and could reflect a complete loss of phenomenological experience, including self and time awareness.

Are all contentless experiences the same?

Overall, research in meditation and dreaming suggests that seemingly contentless states can occur. However, are these instances identical to MB? We think they are not because we do not think they represent the same phenomenon, either in terms of phenomenology or neural underpinnings [47,48]. We hold, though, that by focusing on states that bear similarities to instances of MB, we can move closer to the more specific characterization of MB. It is important to state that we do not claim that all seemingly contentless reports necessarily form a unified family of conscious experiences, as has been similarly argued for mind wandering [5]. Neither do we claim that they share identical neural substrates (although some types might refer to the same family).

We argue instead that contentless reports may arise from the maintenance of a minimal state of awareness, although they may involve different mechanistic and phenomenological dimensions such as arousal, attention, perceptual richness, and temporal awareness. This is similar to recent proposals regarding dreamless sleep [49] where these dimensions might be absent or vary across different types of contentless reports.

By contrasting these different dimensions, we believe we will be able to identify key features that separate MB and alleged contentless experiences from standard content-oriented conscious experiences, and also distinguish between the contentless experiences themselves (Table 1). This perspective aligns with the view that the differences between conscious states can be accounted

for using a multidimensional model in which different conscious experiences arise from the unique pattern of expression of these dimensions [50].

A mechanistic account for MB reports

The variant definitions of MB that have been proposed (Box 1) could correspond, either jointly or separately, to different putative mechanisms leading to blank episodes. Among these mechanisms, we can differentiate between lapses of attention, failure of memory retrieval, cessation of inner speech, lack of content meta-awareness, low arousal, and complete absence of conscious experience. Based on our current understanding, we propose a hierarchically organized physiocognitive account to guide future empirical investigations of the mechanisms underlying MB (Figure 1).

Background arousal levels

We first identify arousal as the backbone upon which MB can occur. Arousal refers here to cortical and tonic arousal, encompassing the overall state of vigilance of the individual. Arousal states range from wakefulness to drowsiness and sleep, which are evidenced by changes in oscillatory brain activity. We also consider the contribution of autonomic arousal, which reflects changes in bodily functions and which is indexed by modulations of physiological signals.

Cortical and tonic arousal are controlled by the reticular formation, propagate through thalamic and subthalamic pathways, and are indexed by the ratio between fast (alpha, beta) and slow (theta, delta) frequencies in electrophysiological signals [EEG, magnetoencephalography (MEG), **local field potentials (LFPs)**] during wakefulness. As mentioned above, evidence

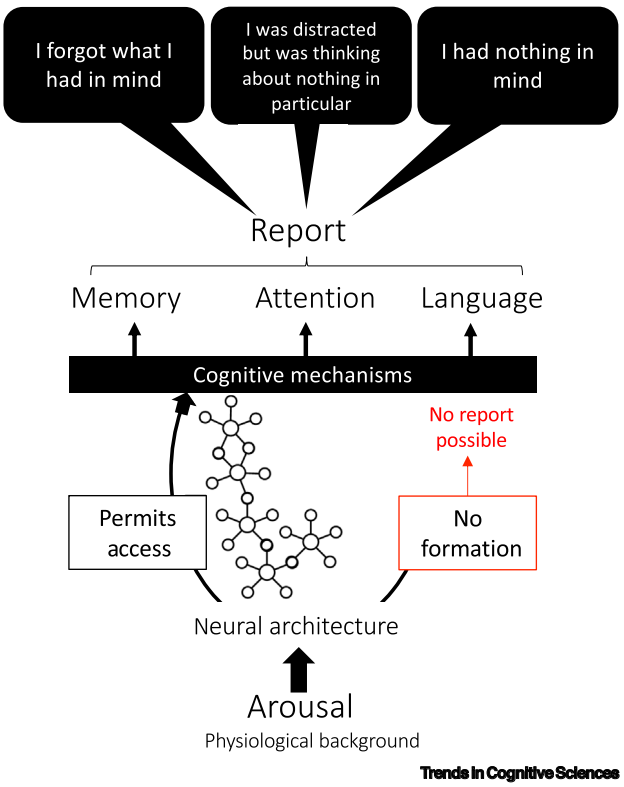

Figure 1. A physiocognitive account of the phenomenology of mind blanking (MB). Viewed hierarchically, tonic background arousal sets the physiological foundation that permits (or not) the neural assemblies to form (or not) a dynamic architecture, upon which further cognitive mechanisms will operate. Arousal then influences MB reports, but not all MB types necessarily occur in the same window of arousal. Depending on the way that people report MB, these reports can provide insights into the cognitive mechanisms involved in the expression of MB reports. For example, reports such as 'I forgot what I had in mind' may indicate the involvement of the memory system in leading to this MB type. Note that the cognitive mechanisms of memory, attention, and language may involve distinct (although overlapping) functional networks.

suggests that arousal plays a role in the occurrence of MB episodes. For instance, MB reports probed during rest were associated with a positive all-to-all fMRI functional connectivity profile [19], which suggests homogeneous communication among cortical regions during MB, and has a similar functional organization to periods of non-rapid eye movement (NREM) sleep [51]. In addition, the identified high amplitude of the **fMRI global signal** during MB reports, which was previously linked to low vigilance [52,53], further supports the idea that variation in arousal mediates MB experiences. This hypothesis is supported by earlier empirical findings using EEG which found that localized slow-wave activity was associated with MB reports. This suggests that local sleep-like episodes may occur during MB [12]. Recent findings also showed an association between an increase in slow-wave power over posterior regions and MB [25]. This topographical pattern is regarded as a proxy for sleep-related activity or a reduction in the richness of conscious content during sleep [54], mirroring the neural correlates of dreaming [55]. According to this view, an increase or decrease of fast desynchronized neural activity in a key network of posterior cortical regions could lead to contentful (e.g., dreaming or mind-wandering) or MB experiences.

Autonomic arousal links the body and the brain through spinal cord projections from peripheral organs to the brainstem. It is indexed by physiological changes that reflect the sympathetic/parasympathetic balance, such as heart rate, galvanic skin response, and pupil size. We recently explored the role of autonomic arousal in MB in a protocol involving sleep deprivation (leading to low arousal levels) and intense physical exercise (leading to high arousal levels) [18]. MB reports were more frequent after sleep deprivation, whereas reports after intense exercise tended to occur more often only during the first half of the experience sampling period. The reason we examined the impact of increased arousal on MB was because of its role in attentional orientation and perception [56]. As shown in the Yerkes–Dodson curve, high arousal enhances performance, but only up to a limit. At the point where arousal is high and input is oriented internally, attentional performance drops, leading to 'racing thoughts' or ruminations [57]. Such high-speed thinking may hinder clear content formulation, translated as MB. Notably, we observed that the high-arousal effects post-exercise dissipated over time [18]. Therefore, manipulations leading to sustainably increased arousal levels can shed more light on the effect of high arousal on MB reporting.

At the same time, we found that MB reports had higher **classification accuracy** using both EEG indices (beta, delta, theta power bands) and physiological indices (e.g., eyelid gaps, blink duration, and heart-rate variability) [18]. Similar findings were observed in typical wakefulness during sustained attention task performance, and MB has been reported to be associated with decreases in heart rate and pupil size [58], illustrating the complexity of task disengagement from a cognitive and physiological perspective.

Taken together, we suggest that arousal is linked to the occurrence of MB reports by setting the physiological prerequisites for sustaining (or not) a continuous stream of thought. Accordingly, tonic alertness, defined as the adequate control of the arousal level allowing sustained attention and content- or goal-oriented experiences, has been proposed as a core functional property that allows the emergence of a minimal phenomenal experience [45]. We speculate that MB occurs at an intermediate level of arousal – between typical wakeful arousal and sleep – thereby representing an intermediate state in which a minimal phenomenal experience is maintained but experiential contents are minimized.

Neural architecture

As explained above, arousal variations are an important physiological prerequisite for reporting MB. On the one hand, this is because reduced arousal may prevent the neural composition

necessary for thought formation. As we have recently proposed [23], the widespread deactivations during MB reports as well as local down-states [12] might hinder communication between key cortical nodes as a result of decreased corticocortical connectivity. In addition, in the context of a visual task, MB has been associated with a decrease in complexity over posterior electrodes, and this could reflect a perturbation of the processing of visual inputs at an early stage and facilitate the occurrence of MB reports [25].

On the other hand, variations in arousal can influence the propagation of already formatted content, thereby influencing whether a person can access this content. Indeed, during a task, neural activity rapidly reconfigures the network architecture of the brain to facilitate coordination between cortical regions [59]. A recent study showed that, when arousal was modulated within the ascending arousal system, ongoing and **low-dimensional brain state** dynamics were constrained in a manner that supports changes in conscious awareness, as shown in expert meditators [60]. Moreover, a vast literature supports the importance of frontoparietal long-range connections for conscious access to sensory information [61]. This conscious access is facilitated by **ignition** dynamics [62], and failure of such ignition would prevent conscious experience from occurring [63]. For example, in the context of MB, when we examined the impact of MB reports on visual processing, there was a disruption of late, frontal activity which aligns with a failure to propagate sensory content from the back of the brain to the front, resulting in a lack of conscious access [25]. However, we do not mean to claim that restricted access necessarily equates to unconsciousness. Rather, we suggest it is possible for **phenomenal consciousness** to coexist with limited **access consciousness**, resulting in reports of self-awareness or feelings of having had an experience without the ability to recall specific details [41].

Cognitive mechanisms

Based on how people report MB, we speculate that MB, or a subset of MB reports, may be related to a malfunction of key cognitive mechanisms such as memory [64,65], language [9], or attention [17]. Two pathways are possible.

First, arousal levels may directly influence these mechanisms. Because the brain and the body are intrinsically and dynamically coupled, perception and emotion can change based on the state of the body [56]. Hence, cortical and autonomic arousal can influence mental functions by enhancing or diminishing attention to and processing of important information [66]. In the context of MB, this means that an individual might have access to a specific content but may be unable to recall it, may be distracted and fail to report it, or may be unable to verbalize it internally, leading to a report of MB. Therefore, different cognitive mechanisms could lead to distinctive types of MB, such as deliberate or undetected (Table 1).

Second, clinical conditions that influence these cognitive functions could also result in more MB reports. For example, patients with autoactivation deficits report difficulties in spontaneously generating thoughts or actions, which can result from neurodegenerative disorders, traumatic brain injury, or strokes (Box 3). Generally, however, the cognition-related mechanisms of MB remain widely uncharted.

Concluding remarks

The experience of a 'blank mind' is as intimate and direct as that of bearing thoughts. Our aim here is to start a conversation about whether MB is a distinct mental state that has unique neural and cognitive characteristics. We realize that the investigation of MB presents methodological and conceptual challenges (see Outstanding questions). For example, it is unclear whether MB represents a fundamentally distinct state of consciousness, or, given the overlapping

Outstanding questions

Can we differentiate between distinct types of MB based on their behavioral or neurophysiological profiles, or does MB have a unitary character? For example, studies suggest the existence of different types of MB, such as spontaneous or intentional. This variability could arise from different methods of probing MB, but it could also reflect a genuine diversity within the phenomenon itself. In other words, when we discuss MB, are we referring to the same family of phenomenal experiences, a single phenomenon, or a spectrum of phenomena?

Is there a common neurobiological component that underlies all types of MB types, and which research methods are most suitable for investigating it?

If MB is reported differentially across vigilance states, contexts, and syndromes, could (some types of) MB also be intentionally cultivated through practice?

Can there be episodes of MB that go unreported because participants are unaware of these episodes? Are there alternative methods for capturing or reporting MB which could shed light on its phenomenological and mechanistic diversity?

Could MB be used as a preclinical marker, given that it is reported more frequently in some clinical conditions (Box 3)? Eventually, could we identify a pathological condition based on the phenomenology of MB alone?

How can we best describe the experience of absence that characterizes MB? Which phenomenological tools can help to facilitate the description of a contentless or minimally contentful experience?

How can current theories and models of consciousness address the possibility of MB as a reportable (but minimally contentful) experience? Which of their predictions does MB challenge? Could MB offer new insights for these theories and models?

phenomenological and functional features with other seemingly contentless episodes, it should be classified as part of this broader category of experiences. Our proposed model emphasizes that when phenomenology is informed by its underlying physiology, then the dimension of content is not the mere criterion to define mental states. This means that in the future MB could be characterized both at the level of the phenomenology and physiology. This is already the case with dreaming, which refers to a particular type of experiences occurring in a specific physiological state (i.e., sleep). We also note that MB may represent a collection of different but overlapping phenomena. Some MB reports might involve reduced cortical arousal, whereas others might be more akin to what is seen in meditation – and such variation may even occur in sleep, in the form of white dreams.

Collectively, we stress that ongoing experiences come in shades with varying degrees of awareness and richness of content. Given that past studies on mind wandering and spontaneous thinking did not include MB as a mental category, we wish to draw attention to the possibility that MB might account for important variance in thought reportability. Therefore, we believe that investigating MB will encourage future research to consider MB among the reportable choices for mental categories, leading to a more comprehensive understanding of ongoing experience.

Acknowledgments

This work was supported by the European Research Council starting grant 'SleepingAwake' (101116748 to T.A.), and the French Research Agency (ANR) Project 'Connectomics, Ageing, and Med' (ANR-23-CE37-0022, to A.L.). A.D. is supported by the Belgian Fund for Scientific Research (FRS-FNRS), the EU Horizon 2020 Research and Innovation Marie Skłodowska-Curie RISE programme “neuronsXnets” (101007926), the European Cooperation in Science and Technology COST Action 'NeuralArchCon' (CA18106), the Léon Fredericq Foundation, and the University of Liège.

Declaration of interests

The authors declare no competing interests.

Resources

[i]www.ninds.nih.gov/health-information/disorders/kleine-levin-syndrome

[ii]https://my.clevelandclinic.org/health/diseases/22194-absence-seizures

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