ACCSCIENCE PUBLISHING

Journal of Clinical and Basic Psychosomatics

REVIEW ARTICLE

Sleep-related threat processing in chronic insomnia: A psychosomatic framework for hyperarousal, learning, and treatment

Bruce D. Forman*

Department of Clinical Neurosciences, Charles E. Schmidt College of Medicine, Florida Atlantic University, Boca Raton, Florida, United States of America

Abstract

Chronic insomnia is maintained by interacting cognitive, emotional, behavioral, and physiological processes that may persist after precipitating factors resolve. Hyperarousal models emphasize persistent activation, whereas cognitive and behavioral models identify worry, selective attention, monitoring, conditioned arousal, sleep effort, dysfunctional beliefs, and safety behaviors as maintaining processes. This review examines whether sleep-related threat processing may provide an integrative psychosomatic framework connecting these mechanisms. For this review, sleep-related threat processing is conceptualized as the appraisal of sleep-related states, cues, uncertainty, or anticipated consequences as potentially harmful or requiring a defensive response, together with the attentional, cognitive, behavioral, emotional, and physiological processes recruited by that appraisal. The framework is not proposed as a replacement for Harvey's cognitive model or other established theories. Its proposed contribution is to organize conditioned learning, interoceptive interpretation, multidimensional hyperarousal, sleep effort, safety behavior, and cognitive processes within an explicitly reciprocal and testable system. Conditioning and predictive processing may contribute to persistence, while inhibitory learning provides a framework for understanding corrective experiences during cognitive behavioral therapy for insomnia. Trauma-related insomnia provides a particularly salient example because sleep itself may become associated with vulnerability and reduced vigilance. The model generates testable predictions concerning temporal ordering, threat content, physiological coupling, treatment mediation, and incremental validity beyond established insomnia and anxiety constructs. Sleep-related threat is not proposed as a universal cause of insomnia, an established etiological mechanism, or a validated treatment-matching system. Rather, it is presented as a hypothesis-generating psychosomatic framework whose value depends on prospective, experimental, and treatment-mechanism testing.

Keywords: Insomnia; Hyperarousal; Threat processing; Cognitive behavioral therapy for insomnia; Psychosomatic medicine; Inhibitory learning

***Corresponding author:**
Bruce D. Forman
(drbruceforman@gmail.com)

Citation: Forman BD. Sleep-related threat processing in chronic insomnia: A psychosomatic framework for hyperarousal, learning, and treatment. *J Clin Basic Psychosom*. doi: 10.36922/JCBP026350049

Received: August 28, 2026

Revised: September 18, 2026

Accepted: October 16, 2026

Published online: November 17, 2026

Copyright: © 2026 Author(s). This is an Open-Access article distributed under the terms of the Creative Commons Attribution License, permitting distribution, and reproduction in any medium, provided the original work is properly cited.

Publisher's Note: AccScience Publishing remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

Chronic insomnia is more than a nighttime failure to initiate or maintain sleep. Although sleep disturbance may initially arise in response to stress, illness, pain, medication effects, circadian disruption, environmental disturbance, or major life events, insomnia

can persist after the original precipitating factor has diminished. Contemporary models therefore emphasize mechanisms that transform transient sleep disruption into a self-maintaining disorder.[1-4]

Several theoretical traditions have attempted to explain this persistence. Behavioral models emphasize conditioned arousal and maladaptive extension of sleep opportunity.[2,3] Cognitive models emphasize worry, dysfunctional beliefs, selective attention, monitoring, and catastrophic appraisal of inadequate sleep and its consequences.[4,5] Hyperarousal models describe heightened cognitive-emotional, cortical, neuroendocrine, metabolic, and potentially autonomic activation.[6-8] The attention–intention–effort pathway emphasizes the paradoxical consequences of deliberately attempting to control a biological process that ordinarily occurs without conscious effort.[9] More recently, the psychobiological inhibition model has been reformulated to integrate behavioral, cognitive, emotional, and physiological processes that may interfere with normal expression of sleep.[10]

These models may be more complementary than their differing terminology suggests. Tang *et al.*[11] systematically reviewed cognitive factors across insomnia models and identified nine distinguishable theoretical models containing 20 cognitive factors and processes, with considerable conceptual overlap despite differences in terminology and measurement. This observation raises an important question: Rather than continuing to identify additional isolated mechanisms, might a broader functional process help explain why worry, monitoring, arousal, effort, conditioning, and protective behavior become mutually reinforcing?

This review examines sleep-related threat processing as one potential organizing framework. The central proposition is that insomnia can become self-perpetuating when wakefulness, inability to control sleep, or anticipated consequences of inadequate sleep acquire sufficient threat value to recruit processes ordinarily adaptive in the presence of danger. Vigilance increases, attention becomes biased toward threat-relevant information, cognitive-emotional and physiological activation may increase, protective behaviors are recruited, and deliberate attempts to control the threatened outcome intensify.

For this review, sleep-related threat processing is defined as the appraisal of sleep-related states, cues, uncertainty, or anticipated consequences as potentially harmful or requiring a defensive response, together with the attentional, cognitive, behavioral, emotional, and physiological processes recruited by that appraisal. *Threat appraisal* refers specifically to the evaluation that a sleep-related event or consequence may be harmful; *worry* refers to repetitive cognitive elaboration of that possibility; *fear* refers to the emotional response to perceived threat; and *sleep-related threat processing* refers to the broader reciprocal system through which appraisal, attention, arousal, behavior, and learning may interact. The construct is therefore proposed as an organizing process rather than as a synonym for sleep anxiety, dysfunctional sleep beliefs, cognitive arousal, conditioned arousal, or sleep effort.

These responses are understandable when an organism confronts danger. They are poorly suited, however, to sleep, which ordinarily requires reduced environmental engagement and relinquishment of voluntary control.

Evidence already supports several components of this formulation. Sleep-related attentional and interpretive biases have been demonstrated in insomnia.[12] Monitoring for sleep-related threat and associated safety behaviors have been described experimentally and clinically.[13,14] Sleep effort has developed into a substantial research construct rather than remaining solely a theoretical proposition. A 2024 scoping review identified 46 eligible studies and documented associations between sleep effort and insomnia severity, presleep arousal, dysfunctional beliefs, anxiety, subjective sleep disturbance, and sleep-state discrepancy.[15] Sleep-related stimuli may also acquire enhanced emotional salience.[16]

The proposed framework therefore does not introduce an entirely new collection of insomnia mechanisms. Its proposed contribution is functional integration: threat appraisal may provide a common organizing process through which hyperarousal, selective attention, monitoring, sleep effort, safety behavior, dysfunctional beliefs, and conditioning become mutually reinforcing. These components may become linked when sleep or wakefulness has acquired sufficient significance to activate a defensive regulatory system.

The framework is explicitly psychosomatic. Psychological appraisal may influence physiological state, while bodily arousal provides information that can itself be interpreted as evidence of impending sleeplessness. Biological and psychological processes are therefore reciprocal rather than competing explanations.

Importantly, this is a hypothesis-generating framework rather than an assertion that threat processing is an established cause of insomnia. It predicts that sleep-related threat should be distinguishable from general anxiety and insomnia severity; within-person increases in threat expectancy should predict subsequent monitoring, arousal, effort, and sleep disturbance; and reduction in relevant threat processes should precede at least some subsequent improvement if they are mechanistically important.

The framework also predicts meaningful individual differences in the content and intensity of threat. At present, these differences are proposed as dimensions for mechanism-informed clinical formulation and hypothesis generation rather than validated markers for treatment selection.

2. Methods

This article is a conceptual rather than systematic review. Literature was identified through targeted searches of PubMed and supplementary examination of reference lists using combinations of terms related to insomnia, threat, hyperarousal, cognitive arousal, sleep effort, attentional bias, monitoring, safety behavior, conditioning, predictive processing, sleep reactivity, trauma, and cognitive behavioral therapy for insomnia (CBT-I). Searches emphasized peer-reviewed English-language literature available through September 2026, while seminal earlier theoretical and empirical studies were retained where necessary to trace the development of major insomnia models. Reference lists of relevant reviews and key articles were also examined. The search was intended to identify evidence relevant to development and testing of the proposed framework rather than to provide exhaustive systematic coverage.

3. From hyperarousal to sleep-related threat processing

3.1. Hyperarousal as a multidimensional process

Hyperarousal is among the most enduring explanatory constructs in insomnia. Individuals with insomnia frequently describe racing thoughts, inability to "switch off," emotional activation, and heightened awareness of bodily and environmental stimuli. Research has identified differences across cortical, cognitive-emotional, neuroendocrine, metabolic, and autonomic domains, although findings vary considerably across measures and populations.[6-8]

Recent synthesis has clarified this complexity. Dressle and Riemann[8] concluded that evidence is particularly compelling for cortical and cognitive-emotional hyperarousal and aspects of neuroendocrine activation, whereas evidence concerning autonomic measures such as heart rate and heart-rate variability is less consistent. This argues against treating hyperarousal as synonymous with sympathetic nervous system activation.

Recent electrophysiological evidence also supports continued investigation of cortical hyperarousal. Dai *et al.*[17] reported increased high-frequency electroencephalographic activity during nighttime and daytime non-rapid eye movement sleep among individuals with insomnia disorder, suggesting that altered cortical activation may extend beyond the immediate period of attempted sleep.

Hyperarousal nevertheless describes a state more readily than it explains the psychological organization of that state. Why does approaching bedtime increase activation in some individuals who were relatively comfortable earlier in the evening? Why does noticing continued mental activity provoke alarm? Why does one poor night resolve naturally while another initiates weeks of monitoring and attempts to protect sleep?

Threat processing may help address these questions. Arousal becomes particularly relevant when thoughts, sensations, environments, or anticipated consequences acquire predictive significance. The clinical question therefore becomes not only "How aroused is the patient?" but also "What does the arousal mean?"

Threat appraisal is not proposed as invariably the first event in a linear causal sequence. A poor night, physiological activation, pain, environmental disturbance, or conditioned bedroom response may occur first and subsequently acquire threatening meaning. Threat appraisal may then amplify attention, arousal, effort, and protective behavior, which in turn provide additional information capable of strengthening threat expectancy. The proposed architecture is therefore reciprocal rather than strictly hierarchical: appraisal can function as an upstream amplifier while also being modified by bodily state, behavior, learning, and subsequent sleep experience.

3.2. When wakefulness acquires threat value

The feared consequences of insomnia differ among individuals. One person fears inability to function at work, another emotional instability, another deterioration in health, and another the experience of lying awake itself. For some, the principal threat is losing control over a biological function that previously occurred automatically.

Similar physiological events can therefore carry different meanings. Thirty minutes of nighttime wakefulness may be regarded as inconvenient by one individual and as evidence of impending catastrophe by another. The latter interpretation is more likely to recruit vigilance, monitoring, and attempts to prevent the anticipated outcome.

Harvey's[5] cognitive model anticipated much of this formulation by proposing that worry and negatively toned cognitive activity lead individuals with insomnia to selectively attend to and monitor internal and external

sleep-related threat cues. Subsequent research has supported many of these processes.

The present framework therefore should not be understood as replacing Harvey's[5] cognitive model or as claiming that sleep-related threat is a newly identified phenomenon. Its proposed extension is threefold. First, threat processing is treated as a candidate functional organizing principle linking cognitive processes with conditioned learning, sleep effort, safety behavior, interoceptive interpretation, and multidimensional hyperarousal rather than primarily as a consequence of negatively toned cognitive activity. Second, the framework is explicitly reciprocal: disturbed sleep may increase subsequent threat expectancy just as threat expectancy may contribute to subsequent sleep disturbance. Third, it generates content-specific and temporally ordered predictions that can be tested independently of insomnia severity and general anxiety. Whether these extensions provide incremental explanatory or predictive value beyond Harvey's model remains an empirical question.

A recent systematic review and meta-analysis found moderate sleep-related attentional and interpretive biases among individuals with insomnia, although limited longitudinal evidence prevented determination of causal direction.[12] This distinction is critical. Threat processing may contribute to insomnia, but insomnia may also teach individuals to regard sleep-related information as threatening.

The direction may therefore be reciprocal: poor sleep → increased threat value → increased vigilance → greater sleep disruption.

This reciprocal formulation is more consistent with chronic insomnia than a simple assertion that dysfunctional thinking causes sleeplessness. It generates several testable predictions. Within individuals, increases in evening sleep-related threat expectancy should temporally precede increases in monitoring, sleep effort, cognitive-emotional activation, and subsequent sleep disturbance if threat appraisal functions upstream in the proposed system. Conversely, poor sleep should predict greater threat expectancy on subsequent nights if the relationship is reciprocal. Threat content may also matter: fear of next-day performance failure, health damage, loss of control, nighttime distress, and reduced vigilance may recruit partly different patterns of monitoring and protective behavior. Finally, sleep-related threat measures should explain prospective variance beyond insomnia severity, generalized anxiety, dysfunctional sleep beliefs, and established cognitive measures if the framework provides genuine incremental value.

3.3. Emotional salience and anticipatory arousal

Threat systems are inherently predictive. Their adaptive value lies partly in preparing an organism before danger occurs. In chronic insomnia, activation may similarly begin before actual sleep difficulty.

Evening can become predictive. Individuals may calculate how much sleep remains available, evaluate whether they feel sufficiently sleepy, anticipate the following day's demands, or monitor for signs that another difficult night is beginning. Bedtime is no longer merely the time at which sleep occurs. It becomes a period in which the success or failure of sleep is about to be determined. The feared event may therefore recruit a state hypothesized to increase the likelihood of sleep disruption before another poor night has actually occurred.

Neurobiological findings are compatible with this possibility. Baglioni *et al.*[16] demonstrated increased amygdala reactivity to insomnia-related stimuli among individuals with insomnia, together with reduced habituation across repeated stimulus presentations. The study should not be interpreted as demonstrating that insomnia is an amygdala disorder. Rather, it provides evidence that insomnia-related information can acquire enhanced emotional salience.

The amygdala participates within broader neural networks involved in salience detection, emotional learning, and responses to biologically significant information. Sleep-related thoughts can therefore plausibly influence physiological and emotional activation even when the anticipated danger is prospective rather than immediate.

3.4. Monitoring and recursive amplification

Once poor sleep is anticipated, attention may shift toward information capable of confirming the prediction. External monitoring includes clock checking, environmental sounds, light, temperature, and awareness of a partner sleeping. Internal monitoring includes heart rate, breathing, muscular tension, mental activity, and the presence or absence of subjective sleepiness.

Semler and Harvey[13] reported greater nighttime and daytime sleep-related monitoring among individuals with insomnia compared with good sleepers. The significance of monitoring lies not merely in noticing information but in evaluating it as evidence.

Continued thinking becomes evidence that the brain is too active to sleep. Awareness of heartbeat becomes evidence of excessive physiological activation. Absence of subjective sleepiness becomes proof that sleep will not

occur. Looking at the clock transforms wakefulness into a progressively shrinking numerical sleep opportunity.

The hypothesized process may therefore become recursive: threat expectancy → monitoring → detection of threat-consistent cues → arousal and effort → disturbed sleep → apparent confirmation of threat expectancy.

This provides a particularly clear psychosomatic pathway. Physiological sensations influence psychological appraisal, while appraisal may modify physiological activation.

Interoception provides one plausible mechanism for this body-to-mind pathway. Cardiac acceleration, altered breathing, muscular tension, gastrointestinal sensations, temperature changes, or a subjective sense of internal activation may become salient when an individual is already uncertain about the ability to sleep. The critical process may be not the physiological signal alone but its interpretation: the same heartbeat may be ignored during daytime activity yet interpreted at bedtime as evidence that the body is "too activated" to sleep. Salience-processing and interoceptive systems may therefore provide a route through which bodily state influences threat appraisal, while threat appraisal simultaneously alters attention to bodily signals. This bidirectional hypothesis does not require a uniform autonomic abnormality across patients.

The sequence does not require a purely psychological origin. Pain, medication effects, environmental disturbance, autonomic activation, illness, or an objectively poor night may initiate it. Threat processing becomes clinically relevant when these experiences acquire meanings that amplify and perpetuate the original disturbance.

3.5. Safety behaviors and sleep effort

Threat ordinarily evokes protection. In insomnia, protective responses may include extending time in bed, going to bed unusually early, canceling activities after a poor night, conserving energy, rigidly controlling the sleep environment, checking the time repeatedly, or depending on increasingly elaborate bedtime rituals.[14]

Safety behavior may be important because it can interfere with corrective learning. If an individual believes that functioning after five hours of sleep will be impossible but cancels all activities after every poor night, the prediction is never adequately tested. Successful functioning may instead be attributed to the protective behavior.

Recent longitudinal evidence strengthens this aspect of the model. Lancee and Kamphuis[18] assessed presleep arousal, dysfunctional beliefs, sleep-related worry, and safety behaviors and found that although worry and presleep arousal were particularly associated with concurrent insomnia severity, sleep-related safety behaviors predicted insomnia symptoms one year later. This finding is preliminary, particularly because longitudinal retention was limited, but it provides unusually relevant prospective evidence that protective behavior may contribute to persistence rather than simply accompany insomnia.

Sleep effort represents another form of defensive control. The attention–intention–effort model proposed that deliberate attempts to sleep can interfere with normal sleep automaticity.[9] The Glasgow Sleep Effort Scale subsequently operationalized the construct.[19] The 2024 scoping review by Marques *et al.*[15] demonstrates how substantially this literature has developed, including associations between sleep effort and insomnia severity, presleep arousal, dysfunctional beliefs, anxiety, and subjective–objective sleep discrepancy. The paradox is central: The more consequential sleep becomes, the more deliberate control may be recruited; the more deliberate control is recruited, the less automatic sleep becomes.

Relaxation itself can become incorporated into the insomnia cycle when used as a performance test. Breathing, meditation, imagery, and progressive muscle relaxation may be helpful when they reduce general activation. They become different psychologically when governed by the rule: This must make me sleep.

The problem is not necessarily the technique. It is the function the technique has acquired. Sleep-related threat appraisal, shown in Figure 1, recruits anticipatory cognitive-emotional and physiological arousal, selective attention and monitoring, sleep effort, safety behaviors, and avoidance. These responses may interfere with normal sleep regulation and increase the salience of wake-related internal and external cues. Nocturnal wakefulness and perceived daytime impairment may subsequently be interpreted as confirmation of the original threat expectancy, strengthening anticipatory threat during subsequent sleep opportunities. Psychological appraisal and physiological activation are conceptualized as reciprocal rather than unidirectional.

4. Learning, prediction, and persistence of sleep-related threat

4.1. From conditioned arousal to conditioned threat

Conditioning has long been central to behavioral models of insomnia. Repeated pairing of bed with wakefulness, frustration, worry, and unsuccessful attempts to sleep can weaken associations between bed and sleep and strengthen associations with arousal.[2,3,20]

A threat-processing formulation extends this account. Through repeated difficult nights, bedtime and the

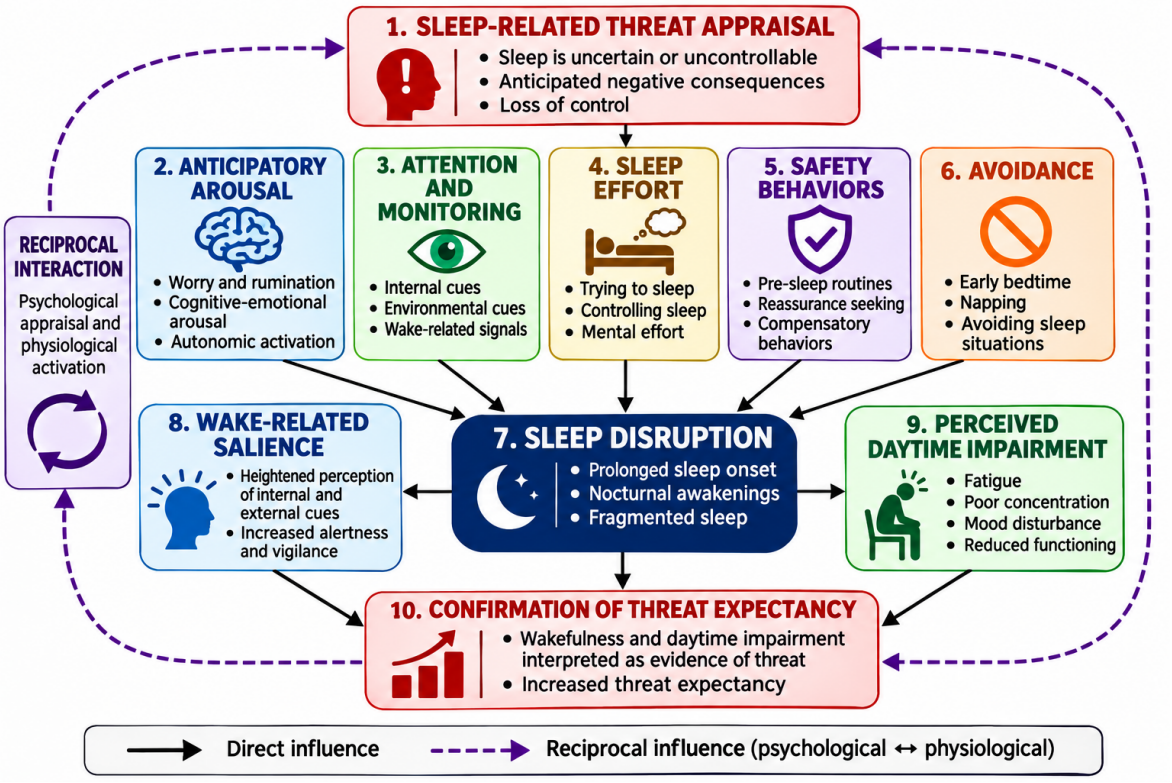


Figure 1. Sleep-related threat processing as a psychosomatic model of chronic insomnia

sleep environment may become predictors not merely of wakefulness but of anticipated sleep failure and its consequences.

The distinction is between conditioning to wakefulness and conditioning to the anticipated meaning of wakefulness. In the simpler pathway, the bed becomes associated directly with wakefulness or arousal through repeated pairing. As shown in Figure 2, in the threat-mediated pathway, the bed predicts anticipated sleep failure, which recruits vigilance, monitoring, and arousal before prolonged wakefulness has actually occurred. The second pathway therefore predicts that reducing the threat value of anticipated wakefulness could modify bedroom arousal even when prior conditioning history remains unchanged.

This may help explain why some patients feel sleepy while reading or watching television but become abruptly alert after entering the bedroom. The environment has acquired predictive significance. This distinction also explains why intellectual reassurance may be insufficient. A patient can recognize rationally that an occasional poor night is unlikely to be catastrophic while continuing to experience marked activation at bedtime. Learned responses are not necessarily eliminated by conscious recognition that danger has been exaggerated.

Espie's[10] contemporary reformulation of the psychobiological inhibition model similarly emphasizes how maladaptive conditioning and interacting cognitive, behavioral, emotional, and physiological processes may inhibit normal expression of sleep. The present framework is compatible with this account but places particular emphasis on the threat value acquired by sleep-related cues.

4.2. Expectancy and predictive processing

Conditioning describes how cues acquire predictive significance. Predictive-processing theory offers a complementary account of how established expectations may influence subsequent experience.

Perception can be conceptualized as an inferential process in which prior expectations interact with incoming sensory information.[21] Applied cautiously to insomnia, strongly weighted expectations of sleeplessness could influence interpretation of ambiguous nocturnal information. A person approaching bedtime with the prediction "I will be awake for hours" may preferentially

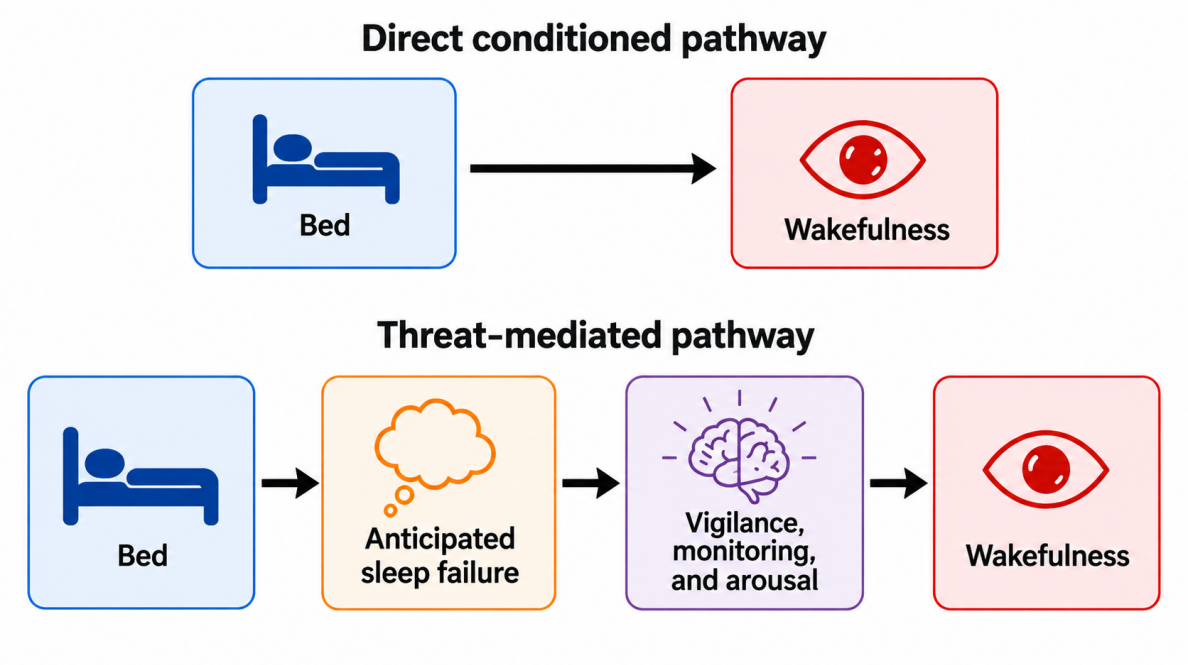


Figure 2. Direct conditioned wakefulness and threat-mediated conditioned arousal

notice mental activity, bodily activation, environmental awareness, or brief awakenings because these experiences are consistent with the predicted state.

This possibility is especially relevant because the transition between wakefulness and sleep is not continuously available to introspection. Harvey and Tang[22] reviewed mechanisms potentially contributing to discrepancies between subjective and objectively measured sleep, including worry, selective attention, physiological and cortical arousal, and memory processes.

A threat-processing account adds the possibility that prior expectations influence which nocturnal experiences receive the greatest weight. This does not imply that insomnia is a perceptual error. Many patients have objectively disturbed sleep, and subjective sleep disturbance remains clinically important regardless of objective measurement. The narrower hypothesis is that expectation, attention, arousal, and ambiguous nocturnal experience may interact in some individuals.

4.3. Limitations of contradictory experience in threat reduction

If expectations influence sleep-related experience, why are they not readily corrected when feared consequences fail to occur?

A patient may predict that five hours of sleep will make functioning impossible yet complete the workday reasonably well. Another predicts that awakening at 3 a.m. means remaining awake until morning but subsequently returns to sleep. Such experiences should theoretically weaken the original prediction. However, several processes may prevent this.

Successful functioning may be attributed to caffeine, extraordinary effort, canceled activities, or rest. A better-than-expected night may be attributed to medication or a ritual rather than to the patient's underlying capacity for sleep. Safety behavior is particularly important because it can prevent disconfirmation. The resulting lesson becomes: I was safe because I protected myself, rather than: The feared outcome was less inevitable than I believed.

The longitudinal association between safety behaviors and later insomnia symptoms reported by Lancee and Kamphuis[18] makes this possibility particularly worthy of prospective study.

4.4. Inhibitory learning and corrective experience

Contemporary learning theory conceptualizes extinction less as erasure of the original fear association than as development of new learning that competes with established threat learning. Inhibitory-learning models emphasize expectancy violation and strengthening of alternative associations.[23]

Applied to insomnia, treatment need not erase a patient's history of difficult nights. Instead, repeated

corrective experiences may establish competing learning: wakefulness can occur without catastrophe; the bed need not signal struggle; imperfect sleep does not necessarily produce the predicted degree of incapacity; sleep does not require constant protection; and the body remains capable of sleeping without deliberate control.

Corrective learning differs from reassurance. Telling patients that they will probably function adequately after imperfect sleep may be less powerful than comparing their predicted and actual functioning. Similarly, explaining that sleep cannot be forced may be less influential than experiencing what happens when sleep effort is reduced.

Paradoxical intention illustrates this principle. By temporarily relinquishing the immediate objective of falling asleep, the patient reduces the necessity to terminate wakefulness. Experimental and meta-analytic evidence suggests reductions in sleep effort, performance anxiety, and insomnia symptoms, although the evidence base is smaller than that supporting multicomponent CBT-I.[24,25]

Figure 3 depicts how repeated sleep difficulty may establish associations among bedtime cues, anticipated sleep failure, arousal, monitoring, sleep effort, and protective behavior. Prior expectations may influence interpretation of ambiguous sleep-related information, while safety behaviors can prevent disconfirmation. CBT-I and behavioral experiments may generate prediction error and new inhibitory learning by allowing individuals to experience sleep-related uncertainty without customary defensive responses. New learning is proposed to compete with, rather than necessarily erase, established threat associations.

5. Clinical expression and assessment

If threat processing differs across patients, assessment should extend beyond insomnia severity to ask a deceptively simple question: What does not sleeping mean to this patient?

The proposed framework does not replace standard assessment of insomnia, medical and psychiatric comorbidity, circadian factors, medication and substance effects, sleep-disordered breathing, movement disorders, or environmental contributors. Current clinical guidelines

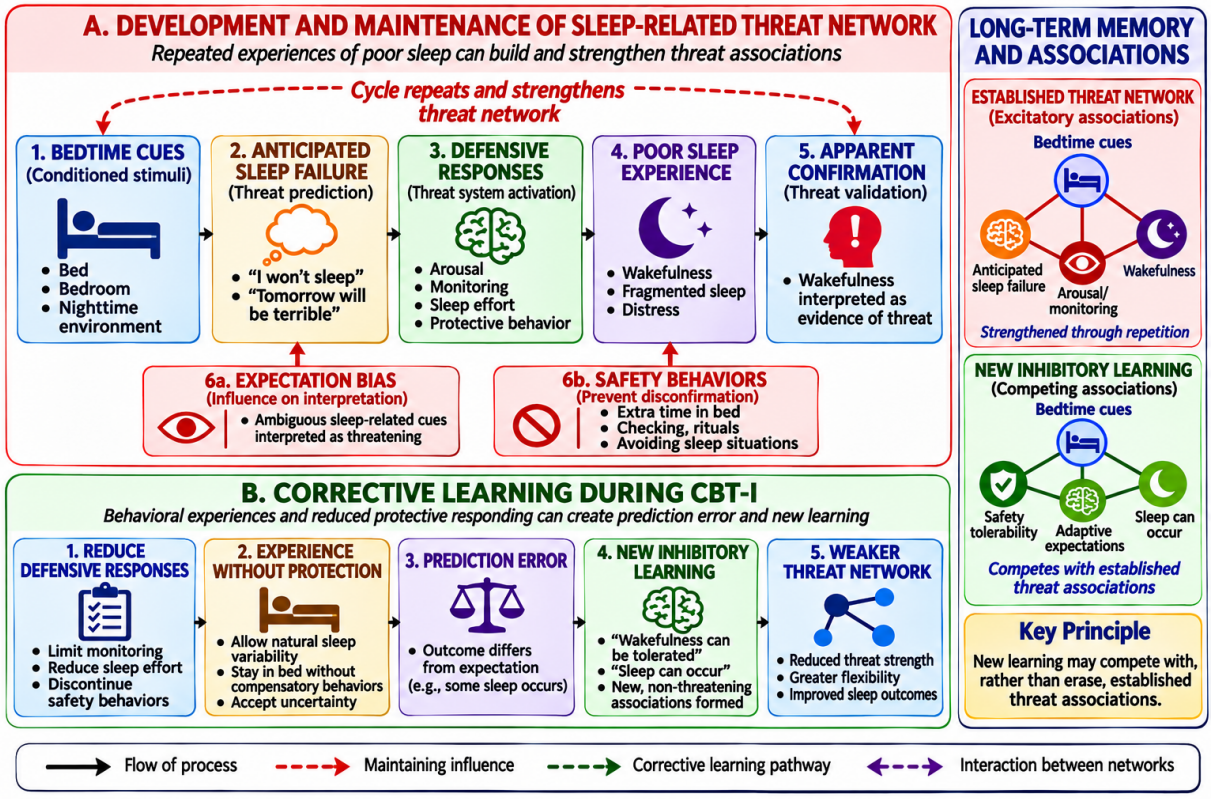


Figure 3. Conditioning, prediction, and corrective learning in chronic insomnia
Abbreviation: CBT-I: Cognitive behavioral therapy for insomnia.

remain the foundation for diagnostic assessment and treatment planning.[1] Threat assessment supplements that process by identifying the meaning assigned to sleeplessness and the defensive responses recruited by that meaning.

5.1. Threat domains

Some patients primarily fear next-day impairment: inability to concentrate, perform professionally, regulate emotion, parent effectively, or meet responsibilities. Population-level evidence associates aspects of insufficient or disrupted sleep with a range of adverse health outcomes.[26] Such information can become threatening when population-level associations are interpreted as immediate predictions about the consequences of an individual poor night. For another group, the central threat is uncontrollability. Sleep previously occurred automatically. Insomnia transforms it into an uncertain event that appears to require active management.

The Anxiety and Preoccupation About Sleep Questionnaire captures relevant concerns about the consequences and uncontrollability of poor sleep.[27] The Sleep-Associated Monitoring Index assesses monitoring of sleep-related information.[28] Sleep effort can be assessed using the Glasgow Sleep Effort Scale.[19]

The most clinically informative questions, however, may remain functional: What are you afraid will happen if you do not sleep? What do you monitor when you become concerned? What do you do to prevent a bad night? What do you do the next day to protect yourself from its consequences? What do you believe would happen if you stopped doing those things?

These questions connect threat appraisal to behavior and are shown in Table 1.

5.2. Adaptive concern versus threat amplification

A threat framework risks pathologizing legitimate concern if applied indiscriminately. Sleep matters. Severe sleepiness can impair performance and create genuine safety risks. The clinical issue is therefore not whether a patient values sleep; it is whether responses to sleep uncertainty have become disproportionate, rigid, and self-perpetuating through vigilance, catastrophic interpretation, defensive behavior, avoidance, and effortful control.

The therapeutic objective is not to persuade patients that sleep is unimportant. It is to improve calibration between actual risk and anticipated catastrophe while reducing responses that inadvertently maintain insomnia. No existing measure captures the entire proposed system. Whether worry, monitoring, effort, safety behavior, and threat expectancy constitute a coherent higher-order construct or several related but distinct processes remains an empirical question.

Existing instruments can therefore be used to assess component processes, but a dedicated sleep-related

Table 1. Clinical assessment of sleep-related threat processing

Domain	Assessment focus	Maintaining process	Treatment emphasis
Nighttime wakefulness	What is threatening about being awake?	Wakefulness acquires threat value	Reduce threat value; reappraisal
Next-day consequences	What do you predict will happen tomorrow?	Catastrophic expectancy	Compare prediction with outcome
Health consequences	What do you believe poor sleep is doing to your health?	Threat amplification	Calibrated psychoeducation
Uncontrollability	What does inability to make yourself sleep mean?	Loss of control increases effort	Reduce effort; tolerate uncertainty
Monitoring	What do you check internally or externally?	Threat surveillance	Reduce evaluative monitoring
Sleep effort	What do you do to make sleep happen?	Performance arousal; effortful control	Restore sleep automaticity
Safety behaviors	How do you protect sleep or compensate afterward?	Prevents disconfirmation	Behavioral experiments; reduce protection
Conditioned cues	What happens as bedtime approaches?	Context predicts wakefulness or struggle	Stimulus control; corrective learning
Trauma-related vulnerability	Does sleep or reduced vigilance feel unsafe?	Defensive vigilance	Trauma-informed formulation; present safety

Note: Assessment of sleep-related threat processing supplements rather than replaces standard insomnia evaluation.

threat measure may ultimately be needed if the proposed framework is to be tested as more than a descriptive umbrella. Such a measure would need to demonstrate discriminant validity from generalized anxiety, health anxiety, dysfunctional sleep beliefs, presleep arousal, sleep effort, and insomnia severity, as well as incremental prospective validity beyond those established constructs.

6. Cognitive behavioral therapy for insomnia as threat modification and corrective learning

Cognitive behavioral therapy for insomnia remains the recommended first-line treatment for chronic insomnia.[1,29,30] The proposed framework does not require a new therapy. Instead, it offers a complementary account of what patients may learn through established CBT-I interventions.

6.1. Stimulus control and conditioned threat

Stimulus control traditionally aims to restore the bed as a cue for sleep rather than wakefulness.[2,29] Within a threat formulation, it may additionally weaken the association between bed and anticipated struggle.

Repeatedly staying awake in bed while worrying, monitoring, and attempting to sleep permits the sleep environment to become a setting in which failure is anticipated. Temporarily leaving the bed when wakefulness becomes prolonged or associated with increasing arousal or frustration interrupts this pairing.

The learning objective may therefore extend beyond "bed predicts" sleep to "bed does not require vigilance, monitoring, or struggle."

How the intervention is presented matters. Highly rigid instructions can inadvertently encourage patients to monitor the clock to determine whether they have exceeded an allowable period of wakefulness. A threat-informed implementation instead emphasizes the functional state of becoming increasingly frustrated, alert, or effortful.

6.2. Sleep restriction or compression and perceived fragility

Sleep restriction or compression reduces excessive time in bed and subsequently adjusts the sleep window as sleep becomes more consolidated.[1,29] Its established rationale includes strengthening homeostatic sleep pressure and reducing prolonged wakefulness in bed. It may also challenge the belief that sleep must be protected by maximizing opportunity.

Extending time in bed is an understandable response to inadequate sleep. However, it can increase opportunities for wakefulness, monitoring, and frustration. Appropriately implemented treatment can therefore provide corrective information: the biological sleep system may be more robust than the patient believes.

This interpretation does not justify unnecessary sleep deprivation. Sleep restriction requires appropriate clinical screening and modification where excessive sleepiness or comorbid conditions create risk.[1] The relevant mechanism is corrective learning during evidence-based treatment, not exposure to unsafe sleep loss.

6.3. Cognitive intervention and behavioral experiments

Cognitive interventions address dysfunctional beliefs, worry, and catastrophic appraisal.[5,29] The threat-processing framework places particular emphasis on translating beliefs into explicit predictions.

Tomorrow will be a disaster becomes clinically useful only when "disaster" is specified. Does the patient predict inability to work? Serious mistakes? Emotional collapse? Complete inability to concentrate?

Once specified, predicted and observed outcomes can be compared.

This emphasis is supported by contemporary treatment literature. Parsons *et al.*[31] reviewed CBT-I mediation studies and found the strongest evidence for reductions in dysfunctional sleep beliefs as a mediator of symptom improvement, although temporal precedence had generally not been established.

Nielson *et al.*[32] subsequently reviewed 17 studies examining maladaptive sleep beliefs and CBT-I outcomes. Reductions in maladaptive beliefs were associated with improvement in insomnia severity, but relationships with specific sleep parameters were less consistent, and in some studies, sleep improvement preceded belief change.[3] These findings argue against simplistic causal claims while supporting dysfunctional beliefs as clinically meaningful treatment targets.

Behavioral experiments can strengthen this process. The purpose is not to prove the patient wrong. It is to generate information. A patient predicting complete incapacity after a poor night can compare anticipated with actual functioning during appropriate, nonsafety-sensitive activities. A patient convinced that sleep depends on an elaborate ritual can alter a nonessential component and observe the result.

The objective is calibration rather than reassurance.

6.4. Monitoring, effort, and restoration of automaticity

Reducing clock-checking interrupts one form of threat surveillance. Internal monitoring requires a subtler approach because attempting not to notice thoughts or bodily sensations can itself become another form of monitoring.

The objective is therefore not necessarily elimination of awareness but reduction of evaluative significance. Continued thinking can be noticed without becoming proof that sleep is impossible. A heartbeat can be experienced without being interpreted as evidence that the nervous system is malfunctioning.

Sleep effort requires a similar distinction. Relaxation, breathing exercises, meditation, imagery, and other strategies can be helpful. They can also become performance tasks when governed by the belief that they must help sleep. The 2024 sleep-effort review reinforces the contemporary relevance of this construct and documents its relationships with insomnia severity and other cognitive-emotional processes.[15]

A broader therapeutic objective may therefore be restoration of sleep automaticity. Patients can regulate sleep opportunity and create conditions favorable to sleep. The transition into sleep, however, remains something the nervous system does rather than something consciousness executes.

6.5. Threat reduction as a candidate mechanism

The distinction between a plausible mechanism and demonstrated mediation is critical. CBT-I is effective.[33] However, reduction of a unitary sleep-related threat construct has not been established as the mechanism responsible for that efficacy.

The systematic review by Parsons *et al.*[31] found stronger evidence for dysfunctional beliefs than for hyperarousal or behavioral mediators and emphasized the failure of existing studies to establish temporal precedence. The review by Nielson *et al.*[32] similarly demonstrated that relationships between belief change and sleep improvement can be bidirectional.

These findings make the present framework more testable, not less useful. If threat processing is mechanistically important, changes in threat expectancy, monitoring, safety behavior, or effort should occur before, rather than merely alongside, subsequent sleep improvement.

Established components of CBT-I may influence different elements of sleep-related threat processing, as shown in Figure 4. Stimulus control modifies conditioned

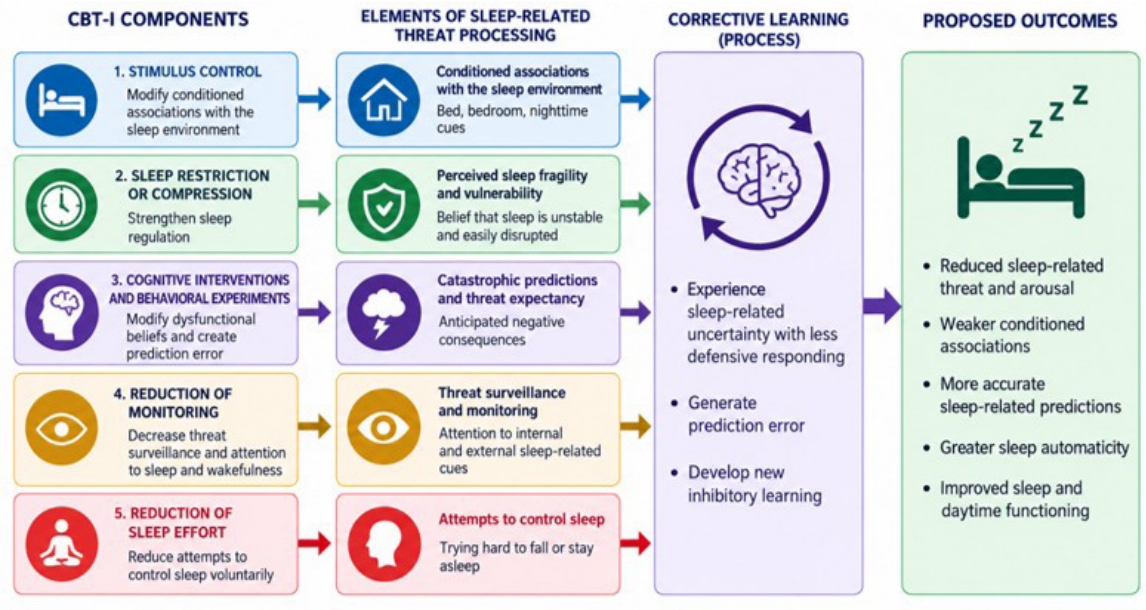


Figure 4. Cognitive behavioral therapy for insomnia (CBT-I) as threat modification and corrective learning. Established CBT-I components may influence different elements of sleep-related threat processing through overlapping pathways.

associations with the sleep environment; sleep restriction or compression strengthens sleep regulation and may challenge perceived fragility; cognitive interventions and behavioral experiments modify catastrophic predictions and create prediction error; reduction of monitoring decreases threat surveillance; and interventions targeting sleep effort reduce attempts to control sleep voluntarily. These processes are hypothesized to converge on reduced sleep-related threat and restoration of sleep as a predominantly automatic biological process.

7. Trauma, vulnerability, and precision behavioral sleep medicine

Sleep-related threat is unlikely to play an equivalent role in every patient. Chronic insomnia is heterogeneous, and individuals differ in sleep reactivity, biological vulnerability, cognitive style, learning history, circadian characteristics, medical and psychiatric comorbidity, and environmental circumstances.[34,35]

Some individuals experience substantial insomnia with little evidence of anticipatory fear, excessive monitoring, or defensive control. A threat formulation should not be imposed when threat processing is not prominent.

For others, anticipation becomes central. Sleep is increasingly protected during the day, bedtime produces apprehension, bodily sensations are monitored, and minor variations in sleep are interpreted as evidence that insomnia is returning.

7.1. Trauma and fear of sleep

Trauma provides an especially salient example because sleep inherently involves reduced responsiveness to the environment and relinquishment of vigilance.

Werner *et al.*[36] proposed a model of fear of sleep in trauma-induced insomnia, emphasizing safety concerns, loss of control, fear of reduced vigilance, and fear of re-experiencing trauma during sleep. Their review concluded that fear of sleep may contribute significantly to trauma-induced insomnia while emphasizing the need for stronger prospective evidence.

This literature is important for positioning the present model. The proposition that sleep can acquire threat value is not new. Trauma research already provides a specific example. The present framework extends the principle beyond trauma-specific fear of sleep. In non-trauma insomnia, the threatened outcome may instead be next-day incapacity, health deterioration, emotional dysregulation, nighttime distress, or inability to control sleep.

For trauma-exposed individuals, vigilance may once have been genuinely protective. Treatment therefore should not imply that the original threat response was irrational. The corrective distinction concerns past danger versus present context. Reduced vigilance can gradually become associated with present safety rather than vulnerability.

Importantly, treatment evidence indicates that insomnia in trauma-exposed populations remains responsive to behavioral sleep intervention. Randomized trials have demonstrated clinically meaningful improvement in insomnia following CBT-I among individuals with post-traumatic stress disorder (PTSD), and more recent work has examined CBT-I integrated with trauma-focused treatment.[37,38] These findings support treatment of insomnia as a clinically meaningful target in trauma-exposed populations, although they do not establish reduction in sleep-related threat as the mechanism responsible for improvement.

This is consistent with a trauma-informed threat model previously proposed by Forman,[39] which emphasizes hyperarousal, extinction, and inhibitory learning within CBT-I.

7.2. Sleep reactivity and vulnerability

Sleep reactivity represents another important dimension. Individuals differ substantially in the degree to which stress disrupts their sleep, and elevated sleep reactivity has been identified as a vulnerability factor for insomnia.[34,35,40] A threat-processing framework therefore predicts interaction rather than a purely cognitive pathway.

Two individuals can experience similar sleep-related concern yet have different sleep consequences because one possesses a more stress-reactive sleep system. Conversely, repeated experience of stress-induced sleep disruption may make future expectations of insomnia increasingly credible.

This preserves the psychosomatic character of the model. Psychological appraisal does not simply cause physiology. It interacts with a biological sleep system whose sensitivity varies among individuals.

7.3. Sleep-state misperception and other boundary conditions

Sleep-state misperception represents an important boundary condition. Some individuals with insomnia systematically experience sleep as shorter or wakefulness as longer than indicated through conventional objective measures. Contemporary evidence suggests that altered sleep–wake perception may involve cognitive and neurophysiological hyperarousal, sensory-gating processes, attention, memory, and characteristics of sleep measurement itself.[41] Sleep-related threat could plausibly

amplify monitoring or increase the weight assigned to wake-like nocturnal experiences, but it should not be assumed to account for sleep-state misperception. Conversely, repeatedly perceiving oneself as awake despite evidence of sleep could itself strengthen threat expectancy and monitoring. The relationship between threat processing and sleep perception therefore requires direct empirical testing.

Additional boundary conditions concern comorbidity, age, and culture. In generalized anxiety or health anxiety, sleep-related threat may be difficult to distinguish from a broader tendency to anticipate harm, making discriminant assessment especially important. Older adults may differ in both the content and credibility of sleep-related concerns because medical comorbidity, medication use, caregiving demands, retirement, bereavement, and age-related changes in sleep can alter the meaning assigned to nocturnal wakefulness. Cultural context may likewise shape what poor sleep is believed to signify, including beliefs about health, productivity, emotional control, family obligation, and acceptable sleep practices. The proposed framework therefore predicts that the content and function of sleep-related threat will vary across populations rather than constitute a culturally invariant set of beliefs.

7.4. Toward precision behavioral sleep medicine

The differences in sleep-related threat processing, sleep perception, comorbidity, age, and cultural context raise the possibility of mechanism-informed therapeutic emphasis. Prominent conditioned bedroom activation might warrant particular emphasis on stimulus control. Catastrophic next-day predictions may call for cognitive restructuring and behavioral experiments. Pronounced sleep effort may require explicit work on relinquishing deliberate control. Extensive safety behavior may require systematic behavioral testing. Trauma-related vigilance may require safety-focused formulation and coordination with trauma treatment.

Such an approach remains a research direction rather than an established treatment-matching algorithm. This caution is strongly supported by the most recent evidence. Smith *et al.*[42] published a 2026 systematic review of predictors and moderators of outcomes from cognitive behavioral interventions for insomnia. Across 103 reports, they identified 195 candidate predictors or moderators, but 92.3% were infrequently studied and/or rarely demonstrated statistically significant prediction.

That finding is important. It suggests that the intuitive appeal of precision behavioral sleep medicine currently exceeds the strength of the evidence supporting reliable treatment matching.

A conservative precision approach would therefore preserve core evidence-based CBT-I while varying therapeutic emphasis according to individualized formulation. Threat processing could represent one dimension within a broader model incorporating sleep reactivity, circadian factors, biological characteristics, psychiatric and medical comorbidity, and environmental context.

Chronic insomnia is conceptualized as heterogeneous. Potential threat domains include nighttime distress, anticipated daytime impairment, health consequences, loss of control, interoceptive arousal, conditioned environmental cues, and trauma-related vulnerability. These interact with sleep reactivity, biological vulnerability, circadian regulation, comorbidity, and environmental context. Mechanism-based assessment may eventually permit differential therapeutic emphasis within established CBT-I, although treatment matching based on these dimensions requires prospective validation. This process is shown in **Figure 5**.

8. Limitations and research priorities

The conceptual breadth of threat processing is simultaneously a potential strength and an important limitation. Conditioning, worry, attentional bias, monitoring, sleep effort, safety behavior, hyperarousal, and altered sleep perception can be organized within a threat framework. Conceptual integration, however, does not demonstrate a common causal mechanism. Indeed, Tang *et al.*'s[11] systematic review demonstrates substantial overlap among cognitive insomnia constructs without requiring a unitary threat process. The present framework therefore becomes scientifically useful only if it explains variance or generates predictions beyond existing constructs.

8.1. Construct validity

A priority is construct validity. Measures already exist for sleep-related worry and preoccupation,[27] monitoring,[28] sleep effort,[19] and safety behaviors.[14] However, it remains unknown whether these processes constitute a coherent higher-order sleep-related threat construct or several related but distinct mechanisms.

A useful threat measure would need to demonstrate discriminant and incremental validity beyond generalized anxiety, health anxiety, PTSD symptoms, dysfunctional sleep beliefs, presleep arousal, and insomnia severity. It would also need to capture content, not merely intensity. Fear of next-day occupational failure may function differently from fear of cardiovascular harm, fear of nighttime wakefulness, or trauma-related fear of reduced vigilance.

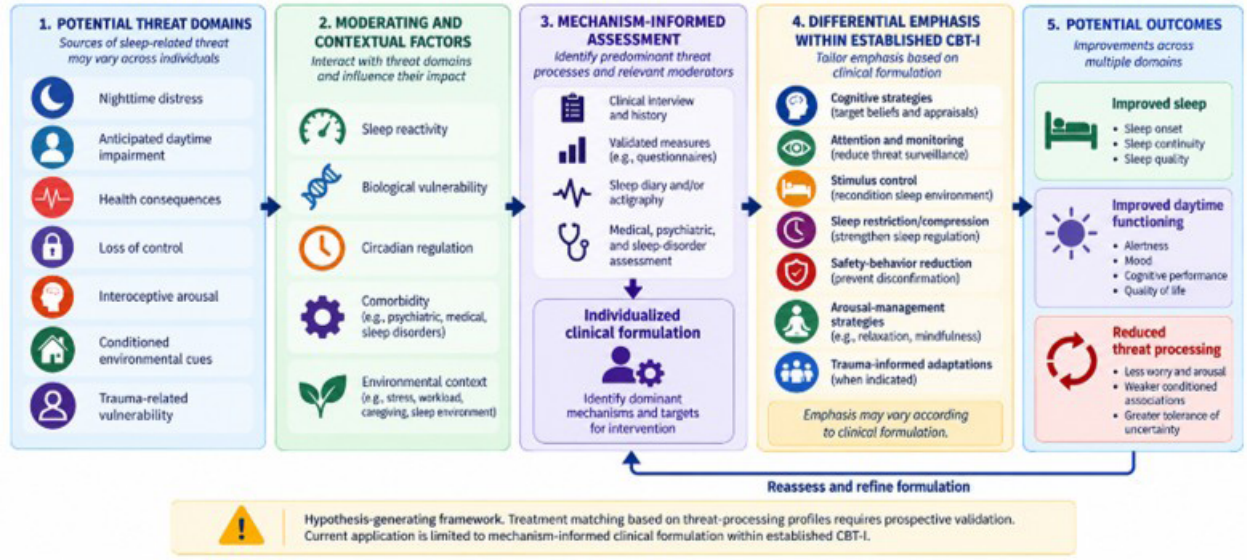


Figure 5. Precision behavioral sleep medicine framework for sleep-related threat processing: From mechanism-informed assessment to individualized emphasis within established cognitive behavioral therapy for insomnia (CBT-I)

8.2. Temporal relationships

Temporal relationships require investigation. Much of the literature linking insomnia with cognitive and behavioral processes remains cross-sectional.[12,15] The longitudinal safety-behavior findings reported by Lancee and Kamphuis[18] are therefore important, but require replication in larger clinical samples. Ecological momentary assessment and intensive longitudinal designs could measure evening threat expectancy, monitoring, effort, and arousal together with subsequent sleep.

The model predicts reciprocal within-person effects: evening threat expectancy should predict subsequent monitoring, effort, arousal, and sleep disturbance, while poor sleep should predict greater threat expectancy on subsequent nights. Demonstrating such temporal relationships would substantially strengthen the framework.

8.3. Physiological testing

The psychosomatic hypothesis generates physiological predictions. Experimental manipulation of sleep-related expectancy could be combined with electroencephalography, autonomic measures, neuroendocrine measures, or neuroimaging. The amygdala findings of Baglioni *et al.*[16] provide one proof of concept that insomnia-related information can produce differential neural responses.

Contemporary hyperarousal research simultaneously cautions against expecting every physiological system to show parallel activation.[8] Threat-related activation may be predominantly cognitive-emotional or cortical in one patient and involve stronger autonomic or neuroendocrine responses in another. This variability itself may prove clinically meaningful.

At least three specific hypotheses follow. First, experimentally increasing anticipated sleep failure should increase presleep cortical or autonomic activation relative to a neutral expectancy condition, with the magnitude of change associated with subjective threat appraisal. Second, individuals with greater interoceptive threat sensitivity should show stronger coupling between fluctuations in bodily arousal and subsequent ratings of anticipated sleeplessness, even when absolute physiological activation is modest. Third, during treatment, reductions in the threatening interpretation of bodily arousal should predict decreased presleep monitoring and cognitive-emotional activation even if baseline autonomic measures themselves do not normalize. Experimental expectancy manipulation, ambulatory psychophysiology combined with ecological momentary assessment, and repeated physiological measurement during CBT-I could test these predictions.

8.4. Treatment mediation

Treatment studies should test temporal mediation. If sleep-related threat contributes causally to insomnia maintenance, reductions in threat expectancy, monitoring,

safety behavior, or sleep effort should precede at least some subsequent improvement during CBT-I. Current mediation evidence does not establish this sequence consistently.[31,32]

A particularly informative design would repeatedly assess sleep-related threat domains during treatment rather than only before and after CBT-I. Cross-lagged or intensive longitudinal analysis could then determine whether threat reduction predicts later sleep improvement or whether improving sleep primarily reduces threat. The answer may be bidirectional.

8.5. Interaction with sleep reactivity

The framework predicts interaction with sleep reactivity. Identical levels of sleep-related concern may have different consequences depending on biological vulnerability to stress-induced sleep disruption.[34,40] Highly reactive sleepers may repeatedly experience confirmation that stress interferes with sleep, thereby strengthening threat expectancy. Individuals with more resilient sleep systems may experience similar cognitive concern without developing persistent insomnia.

Prospective studies examining both sleep reactivity and sleep-related threat could therefore provide a more genuinely psychosomatic test of the model than studies examining cognition alone.

8.6. Incremental clinical utility

The framework must demonstrate incremental clinical utility. Threat assessment should predict treatment response, relapse, persistence, or clinically meaningful differences in therapeutic needs beyond information already provided by insomnia severity, sleep reactivity, general anxiety, dysfunctional beliefs, and established clinical variables. The 2026 systematic review of CBT-I predictors and moderators provides an appropriately high evidentiary threshold.[42] Most proposed predictors have not shown consistent clinical utility.

Sleep-related threat should therefore not be used as a formal treatment-matching system until prospective evidence demonstrates that doing so improves outcomes. Until these questions are answered, sleep-related threat processing is best regarded as an integrative psychosomatic and research framework rather than an established etiological model or treatment-matching system. Table 2 summarizes the principal hypotheses generated by the framework and designs capable of testing them.

Table 2. Testable hypotheses generated by the sleep-related threat-processing framework

Hypothesis	Recommended design	Expected result
Threat expectancy precedes maintaining processes	Ecological momentary assessment or intensive longitudinal study	Evening threat predicts subsequent monitoring, effort, arousal, and sleep disturbance
The relationship is reciprocal	Cross-lagged intensive longitudinal study	Poor sleep predicts greater subsequent threat expectancy as well as the reverse pathway
Threat content matters	Prospective phenotyping	Different threat domains predict different monitoring and protective behaviors
Bodily signals contribute through interpretation	Ambulatory physiology combined with ecological momentary assessment	Physiological activation predicts threat most strongly when interpreted as sleep-relevant
Threat appraisal can be experimentally modified	Randomized expectancy manipulation	Increasing or decreasing perceived sleep threat alters monitoring and arousal
Threat reduction may mediate CBT-I	Repeated-measures treatment mediation	Reduction in threat processes temporally precedes at least some subsequent sleep improvement
Sleep reactivity moderates threat effects	Prospective cohort	Threat more strongly predicts insomnia among highly reactive sleepers
Threat has incremental validity	Multivariable prospective study	Threat measures predict persistence or response beyond anxiety, dysfunctional beliefs, insomnia severity, and sleep reactivity

Abbreviation: CBT-I: Cognitive behavioral therapy for insomnia.

9. Conclusion

Chronic insomnia reflects interactions among biological vulnerability, learning, cognition, emotion, behavior, and physiological regulation. Existing models have identified conditioned arousal, worry, selective attention, monitoring, sleep effort, safety behaviors, dysfunctional beliefs, hyperarousal, and sleep reactivity as important processes.

Recent systematic reviews demonstrate considerable conceptual overlap among cognitive insomnia constructs and underscore the need to understand how these processes interact.[11]

This review proposes sleep-related threat processing as one possible functional organizing principle. When wakefulness, inability to control sleep, or anticipated consequences of inadequate sleep acquire threat value, the individual may respond in ways organisms normally respond to danger: vigilance increases, attention narrows, activation may rise, protective behavior is recruited, and attempts to control the threatened outcome intensify. These responses are understandable but poorly suited to a biological state requiring reduced environmental engagement and relinquishment of voluntary control. These processes may form a reciprocal system in which anticipated sleep difficulty and subsequent sleep experience progressively reinforce one another. Conditioning may attach these responses to bedtime and the sleep environment, while expectations may influence interpretation of ambiguous nocturnal experience.

The framework also offers a complementary interpretation of CBT-I. Established interventions may create experiences in which patients discover that bed need not signal struggle, sleep does not require continuous protection, imperfect sleep is often more manageable than anticipated, and wakefulness need not trigger escalating attempts at control. Contemporary treatment-mechanism literature makes clear, however, that threat reduction has not yet been demonstrated as a mediator and should be investigated rather than assumed.[31,32]

Sleep-related threat is not proposed as a universal explanation for insomnia. Its importance is likely to vary according to biological vulnerability, sleep reactivity, learning history, trauma, comorbidity, age, culture, and contextual factors. Current evidence is also insufficient to support formal treatment matching according to these dimensions.[42] If validated, however, the framework may contribute to a more integrated psychosomatic understanding of chronic insomnia and eventually to precision behavioral sleep medicine while preserving established CBT-I principles. For some patients, recovery from chronic insomnia may therefore involve more than improving sleep itself. It may require learning that sleep no longer needs to be continually anticipated, monitored, protected, and controlled.

Acknowledgments

None.

Funding

None.

Conflict of interest

The author declares no conflicts of interest.

Author contributions

This is a single-authored article.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

Not applicable.

AI tools statement

During preparation of this manuscript, the author used OpenAI ChatGPT (GPT-5 series) to assist with language refinement, organization, editing, and development of selected figures using OpenAI image-generation tools. All AI-assisted content was critically reviewed, edited, and verified by the author. The author takes full responsibility for the accuracy and integrity of the final manuscript.

References

1. Riemann D, Espie CA, Altena E, *et al.* The European Insomnia Guideline: an update on the diagnosis and treatment of insomnia 2023. *J Sleep Res*. 2023;32(6):e14035.

   doi: 10.1111/jsr.14035

2. Spielman AJ, Caruso LS, Glovinsky PB. A behavioral perspective on insomnia treatment. *Psychiatr Clin North Am*. 1987;10(4):541-553.

   doi: 10.1016/S0193-953X(18)30532-X

3. Bootzin RR, Epstein D, Wood JM. Stimulus control instructions. In: Hauri PJ, ed. *Case Studies in Insomnia*. Plenum Medical Book Company; 1991:19-28.

   doi: 10.1007/978-1-4757-9586-8_2

4. Perlis ML, Giles DE, Mendelson WB, Bootzin RR, Wyatt JK. Psychophysiological insomnia: the behavioural model and a neurocognitive perspective. *J Sleep Res*. 1997;6(3):179-188.

   doi: 10.1046/j.1365-2869.1997.00045.x

5. Harvey AG. A cognitive model of insomnia. *Behav Res Ther*. 2002;40(8):869-893.

   doi: 10.1016/S0005-7967(01)00061-4

6. Riemann D, Spiegelhalder K, Feige B, *et al.* The hyperarousal model of insomnia: a review of the concept and its evidence. *Sleep Med Rev*. 2010;14(1):19-31.

doi: 10.1016/j.smrv.2009.04.002

7. Levenson JC, Kay DB, Buysse DJ. The pathophysiology of insomnia. *Chest*. 2015;147(4):1179-1192.

doi: 10.1378/chest.14-1617

8. Dressle RJ, Riemann D. Hyperarousal in insomnia disorder: current evidence and potential mechanisms. *J Sleep Res*. 2023;32(6):e13928.

doi: 10.1111/jsr.13928

9. Espie CA, Broomfield NM, MacMahon KMA, Macphee LM, Taylor LM. The attention-intention-effort pathway in the development of psychophysiologic insomnia: a theoretical review. *Sleep Med Rev*. 2006;10(4):215-245.

doi: 10.1016/j.smrv.2006.03.002

10. Espie CA. Revisiting the Psychobiological Inhibition Model: a conceptual framework for understanding and treating insomnia using cognitive and behavioural therapeutics (CBTx). *J Sleep Res*. 2023;32(6):e13841.

doi: 10.1111/jsr.13841

11. Tang NKY, Saconi B, Jansson-Fröjmark M, Ong JC, Carney CE. Cognitive factors and processes in models of insomnia: a systematic review. *J Sleep Res*. 2023;32(6):e13923.

doi: 10.1111/jsr.13923

12. Akram U, Barclay N, Milkins B, Stevenson J, Gardani M. Sleep-related attentional and interpretive-bias in insomnia: a systematic review and meta-analysis. *Sleep Med Rev*. 2023;67:101713.

doi: 10.1016/j.smrv.2022.101713

13. Semler CN, Harvey AG. An investigation of monitoring for sleep-related threat in primary insomnia. *Behav Res Ther*. 2004;42(12):1403-1420.

doi: 10.1016/j.brat.2003.09.003

14. Hood HK, Carney CE, Harris AL. Rethinking safety behaviors in insomnia: examining the perceived utility of sleep-related safety behaviors. *Behav Ther*. 2011;42(4):644-654.

doi: 10.1016/j.beth.2011.02.004

15. Marques DR, Pires L, Broomfield NM, Espie CA. Sleep effort and its measurement: a scoping review. *J Sleep Res*. 2024;33(6):e14206.

doi: 10.1111/jsr.14206

16. Baglioni C, Spiegelhalder K, Regen W, *et al.* Insomnia disorder is associated with increased amygdala reactivity to insomnia-related stimuli. *Sleep*. 2014;37(12):1907-1917.

doi: 10.5665/sleep.4240

17. Dai Y, Ma J, Vgontzas AN, *et al.* Insomnia disorder is associated with 24-hour cortical hyperarousal. *Sleep Med*. 2024;124:681-687.

doi: 10.1016/j.sleep.2024.11.002

18. Lancee J, Kamphuis JH. Sleep-related safety behaviours predict insomnia symptoms 1 year later in a sample of university students. *J Sleep Res*. 2025;34(3):e14381.

doi: 10.1111/jsr.14381

19. Broomfield NM, Espie CA. Towards a valid, reliable measure of sleep effort. *J Sleep Res*. 2005;14(4):401-407.

doi: 10.1111/j.1365-2869.2005.00481.x

20. Morin CM. *Insomnia: Psychological Assessment and Management*. Guilford Press; 1993.

21. Friston K. The free-energy principle: a unified brain theory? *Nat Rev Neurosci*. 2010;11(2):127-138.

doi: 10.1038/nrn2787

22. Harvey AG, Tang NKY. (Mis)perception of sleep in insomnia: a puzzle and a resolution. *Psychol Bull*. 2012;138(1):77-101.

doi: 10.1037/a0025730

23. Craske MG, Treanor M, Conway CC, Zbozinek T, Vervliet B. Maximizing exposure therapy: an inhibitory learning approach. *Behav Res Ther*. 2014;58:10-23.

doi: 10.1016/j.brat.2014.04.006

24. Broomfield NM, Espie CA. Initial insomnia and paradoxical intention: an experimental investigation of putative mechanisms using subjective and actigraphic measurement of sleep. *Behav Cogn Psychother*. 2003;31(3):313-324.

doi: 10.1017/S1352465803003060

25. Jansson-Fröjmark M, Alfonsson S, Bohman B, Rozental A, Norell-Clarke A. Paradoxical intention for insomnia: a systematic review and meta-analysis. *J Sleep Res*. 2022;31(2):e13464.

doi: 10.1111/jsr.13464

26. Gao C, Guo J, Gong TT, *et al.* Sleep duration/quality with health outcomes: an umbrella review of meta-analyses of prospective studies. *Front Med (Lausanne)*. 2022;8:813943.

doi: 10.3389/fmed.2021.813943

27. Jansson-Fröjmark M, Harvey AG, Lundh LG, Norell-Clarke A, Linton SJ. Psychometric properties of an insomnia-specific measure of worry: the Anxiety and Preoccupation about Sleep Questionnaire. *Cogn Behav Ther*. 2011;40(1):65-76.

doi: 10.1080/16506073.2010.538432

28. Jansson-Fröjmark M, Sunnhed R. Psychometric properties of two brief versions of cognitive, insomnia-specific measures: the Anxiety and Preoccupation About Sleep Questionnaire and the Sleep-Associated Monitoring Index. *Psychol Rep*. 2020;123(3):966-982.

doi: 10.1177/0033294119832980

29. Edinger JD, Arnedt JT, Bertisch SM, *et al.* Behavioral and psychological treatments for chronic insomnia disorder in adults: an American Academy of Sleep Medicine clinical practice guideline. *J Clin Sleep Med*. 2021;17(2):255-262.

doi: 10.5664/jcsm.8986

30. Qaseem A, Kansagara D, Forciea MA, Cooke M, Denberg TD; Clinical Guidelines Committee of the American College of Physicians. Management of chronic insomnia disorder in adults: a clinical practice guideline from the American College of Physicians. *Ann Intern Med*. 2016;165(2):125-133.

doi: 10.7326/M15-2175

31. Parsons CE, Zachariae R, Landberger C, Young KS. How does cognitive behavioural therapy for insomnia work? A systematic review and meta-analysis of mediators of change. *Clin Psychol Rev*. 2021;86:102027.

doi: 10.1016/j.cpr.2021.102027

32. Nielson SA, Perez E, Soto P, Boyle JT, Dzierzewski JM. Challenging beliefs for quality sleep: a systematic review of maladaptive sleep beliefs and treatment outcomes following cognitive behavioral therapy for insomnia. *Sleep Med Rev*. 2023;72:101856.

doi: 10.1016/j.smrv.2023.101856

33. van Straten A, van der Zweerde T, Kleiboer A, Cuijpers P, Morin CM, Lancee J. Cognitive and behavioral therapies in the treatment of insomnia: a meta-analysis. *Sleep Med Rev*. 2018;38:3-16.

doi: 10.1016/j.smrv.2017.02.001

34. Drake CL, Friedman NP, Wright KP Jr, Roth T. Sleep reactivity and insomnia: genetic and environmental influences. *Sleep*. 2011;34(9):1179-1188.

doi: 10.5665/SLEEP.1234

35. Kalmbach DA, Pillai V, Arnedt JT, Drake CL. Identifying at-risk individuals for insomnia using the Ford Insomnia Response to Stress Test. *Sleep*. 2016;39(2):449-456.

doi: 10.5665/sleep.5462

36. Werner GG, Riemann D, Ehring T. Fear of sleep and trauma-induced insomnia: a review and conceptual model. *Sleep Med Rev*. 2021;55:101383.

doi: 10.1016/j.smrv.2020.101383

37. Talbot LS, Maguen S, Metzler TJ, *et al.* Cognitive behavioral therapy for insomnia in posttraumatic stress disorder: a randomized controlled trial. *Sleep*. 2014;37(2):327-341.

doi: 10.5665/sleep.3408

38. Colvonen PJ, Hunt C, Park J, *et al.* Cognitive behavioral therapy for insomnia with prolonged exposure compared to sleep hygiene and prolonged exposure: a randomized controlled trial. *J Clin Psychiatry*. 2025;86(3):24m15584.

doi: 10.4088/JCP.24m15584

39. Forman BD. Insomnia as a disorder of threat perception: hyperarousal, extinction, and trauma-informed implications for CBT-I. *J Contemp Psychother*. Published online April 29, 2026.

doi: 10.1007/s10879-026-09725-w

40. Kalmbach DA, Anderson JR, Drake CL. The impact of stress on sleep: pathogenic sleep reactivity as a vulnerability to insomnia and circadian disorders. *J Sleep Res*. 2018;27(6):e12710.

doi: 10.1111/jsr.12710

41. Joo EH, Altier HR, Selai C, *et al.* Neurobiological mechanisms of sleep state misperception in insomnia disorder: a theoretical review. *Sleep Med Rev*. 2025;81:102096.

doi: 10.1016/j.smrv.2025.102096

42. Smith ML, Oldenhof E, Byrne J, McNeill I, Sweetman A, Staiger PK. Predictors and moderators of treatment outcomes from cognitive behavioural interventions for insomnia in adults: a systematic review. *Sleep Med Rev*. 2026;87:102269.

doi: 10.1016/j.smrv.2026.102269