

# **Title: The Role of Bright Light Therapy in Neuropsychiatric Symptoms of Dementia**

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## **Key Highlights**

- Bright light therapy has been shown to consistently improve sleep outcomes by targeting circadian dysregulation in people with dementia.
- Emerging meta-analytic data suggests potential benefits for depressive and broader neuropsychiatric symptoms, though findings remain heterogeneous.
- Substantial variability in light intensity, timing, duration, and outcome measures limits definitive conclusions regarding optimal treatment protocols.
- Well-designed, adequately powered randomized controlled trials with standardized implementation parameters are needed to guide clinical integration.

## **Introduction**

In 2021, the World Health Organization estimated the global prevalence of major neurocognitive disorders/dementias to be around 57 million individuals, a figure projected to triple by 2050 (1). This public health challenge is compounded by the near-universal presence of neuropsychiatric symptoms (NPS), previously known as

Behavioral and Psychological Symptoms of Dementia (BPSD), including apathy, depression, anxiety, and sleep disturbances. These symptoms are associated with reduced quality of life, increased morbidity and mortality, accelerated cognitive decline, earlier institutionalization, and substantial caregiver burden (2).

Although pharmacologic agents remain widely used to manage NPS, their modest efficacy and significant adverse-effect profile highlight the need for safer non-pharmacological interventions (3). One such intervention is Bright Light Therapy (BLT), a well-tolerated, non-pharmacological modality involving controlled exposure to high-intensity artificial light, typically delivered by a 10,000-lux light box, for approximately 30 minutes each morning at a distance of 30–90 cm (4).

Unlike ambient light, which is unpredictable, prone to environmental changes, and often at intensities that are not sufficient to reliably entrain the circadian system, BLT is specifically designed to elicit physiological effects through stimulating photoreceptors that modulate circadian rhythms, sleep-wake cycles, and neurobehavioral functioning (5).

This article reviews the current evidence for BLT in the management of NPS, discusses practical implementation limitations, and outlines future directions for research and clinical practice.

### **Biological Basis of Bright Light Therapy**

Circadian rhythm disruption is common in major neurocognitive disorders and contributes to several NPS, including agitation, sundowning, and depression (6).

Both environmental and pathophysiological factors contribute to circadian dysregulation in this population. People living with major neurocognitive disorders are frequently exposed to insufficient daytime light, particularly in institutional settings where ambient illumination is low and outdoor exposure is limited.

Moreover, intermittent nighttime light and noise in nursing homes further disrupt circadian cycles. Neurodegenerative changes affecting the suprachiasmatic nucleus (SCN), the brain's central circadian pacemaker, impair internal rhythm regulation.

In addition, age-related ocular conditions such as cataracts and macular degeneration reduce retinal light transmission, worsening circadian misalignment (6, 7).

Light is the primary "zeitgeber", synchronizing the circadian cycle with the external environment (6). This process begins in the retina, where melanopsin-containing ganglion cells transduce light into neural signals. These signals travel via the retino-hypothalamic tract (RHT) to the suprachiasmatic nucleus (SCN), activating excitatory neurotransmission and coordinating downstream circadian hormonal signaling (8-10).

The SCN governs the circadian rhythm of melatonin, with levels increasing at night to promote sleep and decreasing in response to daytime light to facilitate

wakefulness (11, 12). Moreover, light exposure is associated with increased serotonergic activity in the synaptic cleft, a neurotransmitter that plays a key role in mood regulation (4). *Figure 1* illustrates the neurobiological pathways through which light influences circadian regulation, melatonin secretion, and serotonergic signaling.

## **Evidence for Bright Light Therapy**

### Depression

Recent systematic reviews suggest that BLT may improve depressive symptoms in dementia. Aini et al. (2024) reported significant reductions in depression severity and identified treatment frequency as a potential moderator, with twice-daily exposure producing larger effects (5). Zang et al. (2023) similarly found pooled improvements using the Cornell Scale for Depression in Dementia (13). In contrast, Fong et al. (2023) did not observe a significant overall effect. These discrepancies likely reflect heterogeneity in light parameters, delivery methods, and outcome measures (7).

### Sleep Disturbances

BLT has demonstrated beneficial effects across multiple sleep-related outcomes in people living with dementia. Meta-analytic findings indicate that BLT significantly improves several sleep parameters, including sleep quality, sleep disturbances,

number of nocturnal awakenings, circadian rhythm measures, sleep latency, sleep efficiency, excessive daytime sleepiness, wake after sleep onset, and total sleep time. These findings suggest that BLT may enhance both sleep continuity and circadian regulation, addressing core mechanisms underlying sleep–wake disruption in dementia (5).

However, evidence regarding durability of effect remains limited. Follow-up analyses did not demonstrate statistically significant sustained improvements in sleep parameters, a finding likely attributable to the small number of studies assessing longer-term outcomes and consequently limited statistical power (5).

Importantly, treatment timing appears to influence therapeutic response. Exposure to bright light during the morning, coupled with avoidance of bright light in the evening, may help optimize circadian entrainment and improve sleep timing and overall sleep quality. These chronobiological considerations underscore the importance of appropriately timed light exposure protocols when implementing BLT in clinical settings to target sleep disturbances (5).

### Other Neuropsychiatric Symptoms

Beyond depression and sleep, the effects of BLT on other NPS have most frequently been examined in relation to agitation and, less consistently, broader neuropsychiatric symptom composites such as total NPI scores. Earlier evidence,

including a 2014 Cochrane review, concluded that there was insufficient evidence to support a significant overall effect of BLT on neuropsychiatric symptoms or challenging behaviors, citing small sample sizes, heterogeneous outcomes, and variability in light parameters and delivery methods (6). Since then, systematic reviews and meta-analyses have largely echoed these findings, reporting that although BLT may improve certain sleep outcomes, pooled analyses did not demonstrate significant reductions in agitation (7).

More contemporary meta-analytic data suggest a broader potential benefit. In pooled analyses of randomized controlled trials, BLT was associated with significant reductions in overall neuropsychiatric symptoms, including melancholic features such as appetite disturbances, mood lability, and dysphoria, as well as affective symptoms and agitation-related behaviors including aggression, disinhibition, and irritability. However, substantial heterogeneity across trials limit certainty regarding the magnitude and consistency of the observed effects (5).

### **Current Limitations**

The current evidence base for BLT applications for individuals living with dementia is limited by substantial methodological heterogeneity. Studies vary widely in light intensity, spectral composition, timing (morning, evening, or all-day), duration (days to months), and delivery method (light boxes versus ambient

lighting), precluding clear conclusions regarding optimal protocols. Sample sizes are frequently small, many trials use short intervention periods (<2–4 weeks), and several employ crossover designs without adequate washout, raising concerns about carry-over effects (14).

Outcome measurement further contributes to inconsistency. Sleep parameters are operationalized differently across actigraphy protocols, and behavioral outcomes rely heavily on proxy ratings, which are vulnerable to recall bias and limited sensitivity to change (4, 14).

### **Conclusion, Clinical Implications, and Future Directions**

BLT represents a promising, low-risk, non-pharmacological intervention for behavioral and psychological symptoms of dementia. Current evidence suggests the most consistent benefits are observed in sleep and circadian rhythm regulation, with more variable but emerging support for improvements in depressive and broader neuropsychiatric symptoms. Given its favorable safety profile compared to psychotropic medications, BLT may be considered as an adjunctive, first-line non-pharmacological strategy, particularly for patients with prominent sleep–wake disturbances or circadian dysregulation. Careful attention to treatment timing, intensity, and duration is essential to optimize clinical response.

Future research should prioritize adequately powered randomized controlled trials with standardized light parameters, consistent and validated outcome measures, and longer follow-up periods, and specific neuropsychiatric symptoms as primary outcomes. Stratification by dementia subtype, severity, and baseline circadian phase may help clarify moderators of response. Establishing clear implementation protocols will be critical to translating BLT from research settings into routine clinical practice.

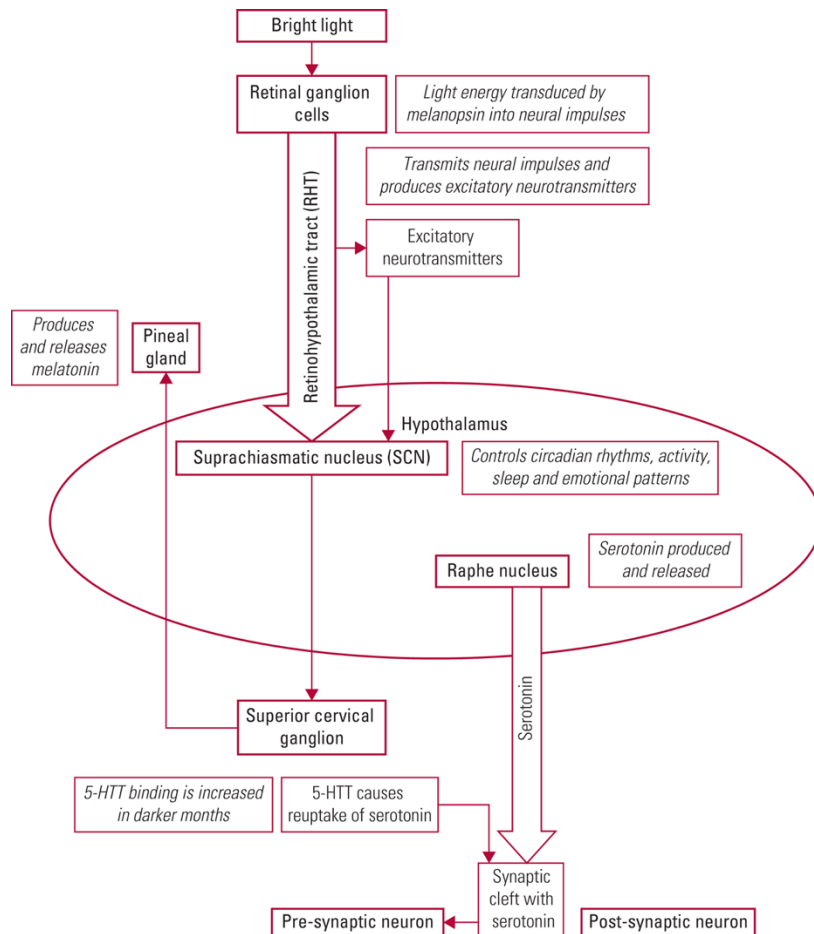


Figure 1 Neurophysiology of Bright Light Therapy. Adapted from Onega LL, Pierce TW. Use of bright light therapy for older adults with dementia. *BJPsych Advances*. 2020;26(4):221-228. doi:10.1192/bja.2020.5

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