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## Disruptions in Your Light-Dark Cycle May be Leaving You in the Dark

*Ava Barjenbruch*

Shift work, made up of a rotation through morning, daytime, evening, and overnight shifts, becomes dangerous not only for the individual, but also for those under care of these occupations. Many essential and often life-saving jobs require 24-hour staffing. However, the rotating shifts needed to provide 24-hour coverage are shown to have negative effects on the employee's cognitive function. Due to the irregularities in the sleep-wake cycle of a shift worker, the cyclical functions that occur during sleep like memory consolidation, motor cortex synchronization, and neuronal remodeling, are also impaired. These functions play key roles in maintaining the domains of cognitive function. Eradicating shift work is not a possibility due to the necessity of the occupations that utilize a rotating schedule, so researchers have experimented with the implementation of blue-enriched lighting to potentially combat circadian rhythm dysregulation and therefore, errors in cognition.

**Keywords:** *cognition, circadian rhythm, shift work*

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**A**s irregular work schedules remain an essential part of the United States workforce, their negative impacts on cognitive functioning are becoming more dangerous and noticeable through an increase in workplace errors.<sup>1</sup> The most disruptive of the irregular work schedules are those with rotating shifts, in which employees switch between morning, daytime, evening, and overnight working hours. Per the United States Bureau of Labor and Statistics, shift workers account for approximately 16% of all salaried and wage employees.<sup>2</sup> Occupations that use rotating schedules include doctors, nurses, police officers, firefighters, and air traffic controllers. These professions require 24-hour surveillance due to their protective and often life-saving responsibilities. Depending on the employer, these rotations can last for up to 4 weeks before starting over again.<sup>2</sup> While jobs with rotating shifts often have higher wages than those with traditional working hours, the increase in compensation comes at the expense of the body's sleep-wake cycle, known as the circadian rhythm.

This evolutionary cycle was shaped by the earth's 24-hour axial rotation and responds to environmental changes in lighting. As the retinas sense a decrease in light, signals are sent to the brain via the optic nerve, which relays information to the pineal gland, found inferior to the hypothalamus. The pineal gland then secretes melatonin, a hormone that promotes sleep, into the bloodstream.<sup>3</sup> Thus, working an overnight shift will disrupt this cycle as the body's natural response to dark lighting is to release sleep hormones, while attempting to sleep during the daytime may be more difficult for the body to recognize it is time to sleep and therefore will not secrete melatonin. Quality of sleep is

not the only area of concern when it comes to disruptions in the circadian rhythm. Many essential processes occur during sleep and are regulated by the sleep-wake cycle, like memory consolidation, neuronal remodeling, and motor cortex synchronization.<sup>4</sup> When the circadian rhythm is disrupted by rotating shift work, these processes become less efficient and as a result, cognitive function suffers.

Cognitive function is made up of six domains: attention, language, behavior control, learning and memory, perceptual motor control, and social cognition memory.<sup>4</sup> Sleep disruption and deprivation have been linked to poor cognitive performance, specifically in the areas of concentration, reaction time, and learning ability. It may also contribute to irritability, impulsive decision making, and poor adaptability, which not only have negative impacts on social interactions, but also to physical health.<sup>5</sup> In those with predispositions to neurodegenerative disorders, sleep disturbances have been linked to the early onset or worsening of the disorder.

The same has been found in aging adults; sleep disturbances have been shown to worsen or hasten the cognitive deterioration that naturally occurs with age. As aging occurs, several changes occur in the brain's structure like loss of synapses, dysfunctional neural networks, and changed neuronal structure; these changes correlate to the discrepancies in cognitive functioning that accompany aging.<sup>6</sup> While cognitive function typically declines with age regardless of work hours, introducing additional factors, like an inconsistent sleep/wake cycle, may negatively affect neurological processing and can result in the early

onset of cognitive impairment.<sup>4</sup> Combining the normal neurological decline that occurs during aging with an irregular sleep pattern, such as that of a shift worker, can result in the worsening of these functional challenges or the early onset of neurodegenerative disorders.<sup>6</sup>

Considering the high-stakes nature of the fields that use rotating shift work, the likelihood of cognitive dysfunction and decline become dangerous. Studies have shown that multiple aspects of cognition, specifically reaction time and alertness, have contributed to and caused preventable errors in the workplace. Oil spills, chemical leaks, and nuclear disasters like Chernobyl have been proven to be caused fully or in part by shift work-induced human error.<sup>5</sup> The impacts of shift work become even more dangerous when considering emergency response. As sleep quality and length decrease, error rates and reaction times increase and therefore result in slower and inefficient emergency responses. This effect is worsened by working consecutive night shifts, as working three consecutive shifts results in a 17% increase in the likelihood of errors and accidents, while four consecutive shifts show a 36% increase in the likelihood of an error or accident.<sup>5</sup> Since the need for medical care, air traffic control, law enforcement, and maintenance of electrical and chemical plants is constant, outlawing shift work is not a possible solution.

Rotating shift work has remained a common feature of many essential jobs that require 24-hour maintenance, despite its linkage to negative effects on cognitive function and ultimately the worker's physical health. It is because of disruptions in the circadian rhythm, which regulates memory formation and neuron regeneration, that the inconsistent sleep wake cycle can have such a strong influence over the body's ability to function. As cognitive decline during aging is expected, working a rotating schedule towards late adulthood can worsen or accelerate the onset of cognitive decline or neurodegenerative disorders. In attempts to alleviate some of the negative effects of shift work, some researchers have suggested reducing overnight working hours, allowing staff members to nap during overnight shifts, and improving work lighting.<sup>5</sup>

Previous studies have shown that the blue light spectrum plays a key role in regulating the circadian rhythm, particularly by inhibiting the release of melatonin, therefore preventing feelings of sleepiness.<sup>7</sup> With the goal of reducing workplace errors caused by employee fatigue, researchers have experimented with the implementation of blue-enriched overhead lighting in a petrochemical control room. Compared to employees working under regular overhead lighting,

employees working overnight shifts with blue-enriched lighting showed a decrease in reaction time, short term memory errors, and omission errors. The change also proved to increase productivity, alertness, and improve overall cognitive performance in the blue light employees.<sup>7</sup>

While the implementation of blue lighting has not completely eradicated the issues posed by shift work, it has helped to alleviate them, proving to be a step towards reducing the safety and neurological concerns that accompany shift work.

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