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SLEEP AND PSYCHOLOGICAL DISORDERS (DT PLANTE, SECTION EDITOR)

# Psychological Impact of Shift Work

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**Abstract**

**Purpose of Review** Technology and globalization have been central forces driving the need for shift work. This review examines recent scientific developments that inform our understanding of how psychological processes contribute to and are impacted by shift work.

**Recent Findings** Nascent research is beginning to expand beyond circadian misalignment to elucidate the phenomenology of shift work and the associated psychological impairments. Psychological processes and their interaction with biology are considered in the pathophysiology of shift work sleep disorder. Additionally, a review of the adverse consequences of shift work in the cognitive, emotional, and psychosocial domains are reviewed and discussed.

**Summary** The phenomenology of shift work encompasses multiple domains of biopsychosocial functioning. As such, interventions to reduce the adverse impact of shift work may benefit from an integrated approach.

**Keywords** Shift work sleep disorder · Circadian rhythms · Stress · Cognitive functioning · Social functioning · Affective functioning

## Introduction

In a globalizing economy with demands for 24-h consumer service, the impact of shift work is increasingly relevant. Shift work may encompass any work schedules that deviate from the traditional day shift (typically starting between 7 am and 10 am), and is typically categorized as fixed night, early morning, and late afternoon/evening shifts, or rotating shifts. Recent estimates of the prevalence of shift work indicate that between 15% and 30% of the European and American workforce are engaged in shift work [1, 2]. However, there is some evidence that shift work has been on the rise. An analysis of the distribution of work times in the UK between the years 2000 and 2001 indicated that 38% of the workforce worked early mornings (5 am–8 am, Mon–Fri), 29% worked evenings (7 pm–midnight, Mon–Fri), and 9% worked nights (midnight–5 am, Mon–Fri) [3]. In contrast, the distribution of the same work shifts in the years 2014–2015 revealed that the rate of morning work increased to 43% (5% increase), the rate of evening work increased to 42% (13% increase), and the rate of night work increased to 13% (4% increase).

Shifts that deviate significantly from the traditional work schedule inevitably require employees to work at times when sleep typically occurs (i.e., during the night) and sleep during the daytime. The reversal of sleep and wake schedules is often at odds with the workers' endogenous circadian rhythms, which leads to a range of adverse consequences impacting various domains of functioning. The most apparent and well-studied consequences are excessive sleepiness and insomnia, and much of the functional impairments associated with shift work are related to sleepiness, fatigue, and/or insomnia. A recent report using a nationally representative sample of the workforce in the Netherlands indicated that whereas 24.6% of day workers report general sleep disturbance, almost 40% of shift workers endorsed sleep disturbance [4]. Another study of Italian nurses found that nurses engaged in shift work reported higher levels of lethargy and exhaustion of moderate to large effect sizes compared to day shift nurses (Cohen's *d*: lethargy = 0.52, exhaustion = 0.74) [5].

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## Shift Work Sleep Disorder

Although some shift workers are eventually able to adapt to their atypical work schedules, a significant number of shift workers experience functional impairments. Approximately 10–20% of shift workers meet criteria for shift work sleep disorder (SWSD), which is characterized by insomnia and/or excessive sleepiness during wakefulness, accompanied by a reduction of total sleep time. Symptoms of SWSD should be temporally associated with a work schedule that overlaps with usual sleep time prior to starting shift work, and should be present for at least 3 months [6].

The symptoms of SWSD are commonly attributed to the ensuing circadian disruption consequent to the atypical work schedules. A nocturnal work schedule, for example, operates in opposition to zeitgebers (e.g., daylight) that synchronize the biological clock to a diurnal schedule. As such, many night shift workers are unable to significantly delay their circadian rhythms to match the nocturnal work schedule, resulting in circadian misalignment. Consequently, night shift workers are attempting to perform their jobs at a time when their biology is anticipating sleep, and attempting to sleep after their shift (commonly in the morning or early afternoon) at a time when their biology is prepared to be active and alert.

## Expanding Beyond Circadian Misalignment: Psychobiological Factors Impacting Response to Shift Work

Though circadian misalignment is a widely understood cause of SWSD and the associated performance impairments, emergent evidence indicates that other mechanisms are also important to consider. In particular, individuals who are prone to sleep disturbances after stressors (i.e., high sleep reactivity) are also at higher risk of developing SWSD [7•]. Those with high sleep reactivity commonly experience sleep disturbance in response to a wide range of stressors including personal stress, anticipatory anxiety, caffeine, and alterations to one's habitual sleep-wake schedule [8–11]. In addition to the sleep and circadian disruptions, shift workers also face a number of psychosocial challenges (see "Psychosocial Functioning" section below) that make shift work a stressful experience across multiple facets. As such, individuals predisposed with high sleep reactivity to stress are also at heightened risk for SWSD. Specifically, a prospective study followed those with high versus low sleep reactivity as they transitioned to shift work and revealed that the odds for developing SWSD were over five times greater for highly reactive individuals than for low reactive participants [7•].

Emerging evidence also indicates that there may be genetic influences that increase vulnerability to SWSD. Much of this research has focused on the *PERIOD3* gene (*PER3*), which is among the most rhythmic genes in both the central and peripheral nervous systems. *PER3* belongs to the family of period genes that regulate circadian rhythms through a core feedback loop [12]. This variable-number tandem repeat (VNTR) polymorphism consists of a sequence of 18 amino acids in the coding area that is repeated either four (4-repeat) or five (5-repeat) times. Individuals may be homozygous, carrying copies of the same allele on both chromosomes ($PER3^{4/4}$ or $PER3^{5/5}$), or heterozygous, carrying one copy of each allele ($PER3^{5/4}$). This VNTR polymorphism impacts the availability of phosphorylation sites. Proteins transcribed from the 4-repeat allele have less phosphorylation sites and thus are phosphorylated at a lower rate [13]. This results in a prolonged feedback loop which can lengthen the period of circadian oscillation [14].

In humans, the *PER3* VNTR polymorphism has been associated with diurnal preference, non-visual responses to light, and neurocognitive responses to circadian disruption and sleep loss [15]. All of these processes impact psychological response to shift work. For example, individuals with the 5-repeat allele typically exhibit a stronger diurnal preference, and night shift workers carrying the 5-repeat allele show greater levels of objective and subjective sleepiness than their 4-repeat allele counterparts [16]. Furthermore, there is also research suggesting that carriers of the 4- versus 5-repeat alleles may show differential vulnerabilities. Specifically, whereas shift workers carrying the 5-repeat allele are vulnerable to insomnia associated with circadian misalignment, those with the 4-repeat allele ($PER3^{4/4}$) are instead more likely to develop insomnia associated with the stress of shift work [17].

Interestingly, recent evidence also indicates that shift workers may be at increased risk for other sleep disorders (e.g., insomnia, parasomnias, hypersomnolence, and periodic leg movement disorder) in addition to shift work sleep disorder [4], which may exacerbate or add to the psychological impact of shift work. Indeed, the rate of comorbidities among sleep disorders was greater than twofold in shift workers (18.8%) compared to day workers (8.1%). Notably, sleep-disordered breathing appeared to be an exception as no differences in prevalence rates were detected between day workers and shift workers.

## Maladjustment to Shift Work: Impact on Domains of Psychological Functioning

### Cognitive Functioning

Because shift workers are often suffering from the compounded effects of circadian misalignment and sleep deprivation, it is not surprising that shift workers are vulnerable to deficits in the cognitive domain. Deficits in this domain are particularly relevant to occupational performance because they impact productivity, employee safety, and public safety.

Despite its importance, research delineating the specific cognitive vulnerabilities associated with shift work is still nascent. Extant research has focused on vigilance as measured by the psychomotor vigilance task (PVT), with many studies showing increased attentional lapses and slowed reaction time during the biological night [18–20].

More recent research has begun to examine specific types of cognitive functioning, and results suggest that not all types of cognitive activities are equally impacted. For instance, a crossover study of nurses working the day and night shifts [21] found moderate differences in global cognitive impairment (Cohen's $d = .73$) as measured by the Montreal Cognitive Assessment (MoCA). However, varying effect sizes were detected across different types of cognitive processes. Consistent with existing research, the largest effects were found in vigilance (Cohen's $d$ for errors of omission 1.44, errors of commission 1.65) and simple reaction time (Cohen's $d = 1.45$). A large effect was also found for response inhibition (Cohen's $d = 0.90$). Finally, the smallest effect was found in the domain of mental speed (Cohen's $d = 0.28$), measured using time to completion of a collection of 25 mathematical problems. This may have important translational implications, as different industries and occupations require workers to perform disparate cognitive tasks. For example, operations where reaction time and sustained vigilance are critical (e.g., long-distance truck driving) may be especially impacted by the cognitive impairments associated with shift work.

Emerging evidence also suggests that specific cognitive components may be differentially associated with psychophysiology versus symptom presentation [22]. In a study that dismantled cognitive flexibility into the sub-components of attending to new stimuli versus suppression of old stimuli, results showed that attentional flexibility for new stimuli was most strongly associated with circadian phase as opposed to symptoms of sleepiness or insomnia. Furthermore, symptoms of insomnia versus sleepiness were also differentially associated with specific deficits: whereas shift workers with insomnia symptoms exhibited difficulties in suppressing previous information that is now irrelevant to the task at hand, sleepy shift workers exhibited difficulties repeating previously completed tasks. This finding is consistent with prior research indicating that while shift workers with insomnia show increased cortical activity, they are less attentive to novel stimuli in their environment [23, 24]. Importantly, the specific components of cognitive flexibility had differential impact on task performance. Those who exhibited difficulties with attentional flexibility for new stimuli took longer to complete tasks, with some requiring two times the amount of time for task completion. This has significant implications for efficiency and productivity. In contrast, shift workers exhibiting difficulties with suppression of task-irrelevant stimuli showed reduced accuracy, particularly with greater occurrences of perseverative errors. This also has important implications for productivity and safety. For example, cognitive fixation (i.e., inflexibility) was cited as a contributing cause to the 2005 British Petroleum (BP) America Refinery explosions [25], which killed 15 people and injured another 180. Although this disaster occurred during daytime hours, the refinery relied on shift workers working 12-h shifts across consecutive days. Additionally, investigations tracing events leading up to the explosion also included errors made during the night shift, as well as the transition between the night and day shift personnel.

To date, only one study has prospectively examined the effects of chronic exposure to shift work on cognitive functioning, and the reversibility of these effects [26••]. Overall, the study revealed that exposure to shift work was associated with a 1.6-point decrease in global cognitive performance on a scale of 0 to 100. Assuming a linear decline of cognitive functioning over 30 years for an average 32 years old, the magnitude of the effect of overall exposure to shift work was equivalent to 4.3 years of age-related decline. However, further analyses comparing exposure duration revealed that exposure to over 10 years of shift work was associated with greater global declines in cognitive functioning compared to those with 10 or less years of exposure to shift work. Specifically, those with over 10 years of shift work exposure exhibited a 2.5-point decrease (equivalent to 6.5 years of age-related decline) compared to those without exposure to shift work, whereas those with 10 or less years of shift work exhibited a 0.9-point decrease (equivalent to 2.4 years of age-related decline). Analyses were also completed to examine how long these cognitive deficits lingered following the transition away from shift work. Results revealed that those who were within 5 years of exposure to shift work continued to show reduced cognitive functioning, whereas those who had greater than 5 years of recovery from shift work showed no differences compared to those with no history of shift work.

## Emotional/Affective Functioning

Given the close relationship between sleep, circadian rhythms, and affective functioning, there has been some concern regarding the deleterious effects that shift work may have on emotional health. Prior research indicates that global affect exhibits a circadian rhythm, with the trough occurring nocturnally, at approximately 0200 [27]. This is consistent with evidence that physiological systems involved in affect and affective regulation (i.e., serotonin, norepinephrine, and dopamine) are also under circadian control and exhibit a circadian rhythm (for review, see [28]). Furthermore, there is also evidence that monoaminergic activity (implicated in mood disruption) can be modulated by melatonin activity, which is critical for the maintenance of the central circadian pacemaker. For example, murine research has shown that administration of a melatonin receptor agonist (agomelatine, marketed as an atypical antidepressant) leads to both direct and indirect increases in

monoaminergic activity [29]. The increased monoaminergic activity can also be subsequently blocked with a melatonin receptor antagonist. This suggests that melatonin activity can have downstream effects for mood and mood regulation, and further indicates that disruptions to the circadian pacemaker would also lead to dysregulations in mood. In particular, the monoaminergic system contributes to arousal, motivation, and reward, all of which are critical factors for mental health. As such, shift workers operating in opposition to their central pacemaker may be spending their waking hours when the monoaminergic system is downregulated, leading to reduced arousal, motivation, and reward seeking.

Circadian genes have also been implicated in various mood disorders [30], further suggesting a causal relationship between circadian disruption and mood dysregulation. For example, induced mutation of the *Clock* gene in mice leads to a behavioral profile consistent with mania (e.g., hyperactivity, decreased sleep, reduced inhibition, increased reward sensitivity and reward seeking), which can be normalized with administration of lithium [31]. Several studies in the last decade have also found associations between unipolar mood disorders and circadian genes, including CRY1 [32], CRY2 [33], RORA [34], PER2 [35], NPAS2 [32], ASMT [36], and the melatonin receptor 2 gene [37].

In line with the basic research, qualitative research in night shift nurses also indicates that depression is a common complaint [38]. Another study also found that nurses on a rotating shift schedule reported moderately greater psychiatric symptoms compared to day shift nurses (Cohen's *d* for difference = 0.41) [5]. However, a recent systematic review suggests that the accumulating evidence for shift work as a general risk for depression is mixed [39•], with some studies finding increased risk while others do not. One explanation may be that risk for depression in shift work may be more specific to the maladjustment to shift work; not all who engage in shift work experience significant impairments, and those who do may self-select out of occupations with shift work (i.e., the "healthy worker effect"). Specifically, a prospective study of individuals transitioning to shift work found that both depression and anxiety 1 year after onset of shift work were mediated by the development of shift work sleep disorder [7•].

## Psychosocial Functioning

One important, but sometimes neglected, domain of the phenomenology of shift work is psychosocial functioning. Indeed, some studies have found that the association between shift work and depression may be accounted for in part by the psychosocial work conditions [40–42], particularly for occupations outside of the health sector [39•]. A more recent study found that job satisfaction was moderately lower in rotating shift nurses compared to day shift nurses (Cohen's *d* for difference = 0.66) [5], while another study found that that shift workers report feeling less support from managers and leaders [42]. It is also common that employee well-being initiatives offered through the workplace (including social gatherings) are less accessible to shift workers due to scheduling conflicts. On the other hand, there have also been reports that shift workers may develop strong comradery around their uniquely shared challenges [42, 43].

Outside of the occupational setting, shift workers may also be at higher risk for social isolation, likely due to their irregular or nocturnal work schedules. A recent report showed that rates of intimate partnership (i.e., spouse, significant other, or otherwise regular partner) were lower in shift workers compared to day workers [4]; whereas 20.8% of day workers were single, 30.8% of shift workers were single. Another study found that 31% and 27% of evening and night shift workers respectively endorsed feeling socially isolated [44]. In comparison, the rate of social isolation was reported at 9% in a large representative community sample [45], suggesting that social isolation may be substantially higher among shift workers. Importantly, increased social isolation may also further exacerbate sleep difficulties associated with shift work; in comparison to shift workers who were partnered, the prevalence rate of sleep disorders was 20% higher in shift workers who were single [4].

Family life can also be impacted when a member of the household is engaged in shift work. In a recent study of health perception among shift work nurses, participants endorsed family stress as among the highest impact factors on their health. Other factors included mood disruption, lack of support around fatigue, risk of medical difficulties, risk of obesity, reduced social activity, and risk of diabetes [38]. This is particularly relevant as many families are drawn to shift work because it increased the availability of parental care to children in two parent households (i.e., "shift-parenting"). However, a large epidemiological study on time use indicated that children of shift workers actually spend less time with their parents [3]. This time is seldom compensated with more time on off days, or with more time with the non-shift-working parent. This impacts important parent-child activities such as meals together, reading, playing, and other social activities. In opposite sex couples, this effect is especially evident when it is the mother who is engaged in shift work rather than the father.

Social engagement also appears to be negatively impacted by shift work. An analysis of time dedicated to social participation in the UK suggested that shift workers were somewhat less socially engaged [46]. Activities representative of social participation included eight domains: general engagement with social support network, helping members of the community (e.g., helping neighbor with shopping), civic engagement (e.g., attending a town hall), volunteering, attendance at cultural and artistic events, playing sports/games, extracurricular learning, and religious activities. Whereas day workers dedicated an average of 8.25 h per week towards social

participation, shift workers averaged closer to 6.75 h per week. A significant portion of the reduction in social participation was associated with weekend work, as social participation often occurs during the weekends. Additionally, a study of time and activities outside of work in a sample of nurses found that 52% of night shift workers and 27% of evening shift workers reported rarely or never having spare time [44], which also likely accounts for the reduced social engagement among shift workers. Given the importance of social connectedness to mental health, it is also likely that mood disturbances associated with shift work are exacerbated by social isolation and reduced social participation.

## Conclusions

The psychological impact of shift work is varied and far-reaching. Though the emphasis of research related to shift work has historically focused on circadian misalignment and its direct consequences for sleep and sleepiness, emerging research indicates that psychological processes can also serve as risk factors for shift work sleep disorder and are important to the phenomenology of shift work. Future research may explore how specific risk factors lead to phenotypic differences in response to shift work, and how resilience to the adverse psychological and biological impacts of shift may be promoted. Furthermore, research in the recovery from shift work should be extended beyond cognitive impairments to also include affective functioning and psychosocial functioning.

### Compliance with Ethical Standards

**Conflict of Interest** Philip Cheng and Christopher L Drake declare no conflicts of interest.

**Human and Animal Rights and Informed Consent** This article does contain studies with human subjects performed by any of the authors.

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- • Of importance:
- •• Of major importance


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