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Changing to Daylight Saving Time Cuts Into Sleep and Increases Workplace Injuries

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The authors examine the differential influence of time changes associated with Daylight Saving Time on sleep quantity and associated workplace injuries. In Study 1, the authors used a National Institute for Occupational Safety and Health database of mining injuries for the years 1983–2006, and they found that in comparison with other days, on Mondays directly following the switch to Daylight Saving Time—in which 1 hr is lost—workers sustain more workplace injuries and injuries of greater severity. In Study 2, the authors used a Bureau of Labor Statistics database of time use for the years 2003–2006, and they found indirect evidence for the mediating role of sleep in the Daylight Saving Time–injuries relationship, showing that on Mondays directly following the switch to Daylight Saving Time, workers sleep on average 40 min less than on other days. On Mondays directly following the switch to Standard Time—in which 1 hr is gained—there are no significant differences in sleep, injury quantity, or injury severity.

Keywords: sleep, fatigue, safety in the workplace, work injuries, work scheduling

Workplace injuries have long been an important topic in the management and applied psychology literatures (for a recent review, see Clarke, 2006). Workplace injuries can lead to a host of problems for organizations, including lost productivity, legal action, turnover, and lost human capital. Workplace injuries also lower the quality of life of employees, may result in lost income, and in extreme cases can result in death. The National Safety Council (2008) reported that there were 3.7 million disabling work injuries and 4,988 work fatalities in the United States in the year 2006, with an estimated cost to businesses of $164.7 billion. Researchers have examined many antecedents of workplace injuries, including organizational climate (Hofmann & Stetzer, 1996; Zohar, 1980, 2000), work design (Barling, Kelloway, & Iverson, 2003), transformational leadership (Barling, Loughlin, & Kelloway, 2002), and perceived organizational support (Hofmann & Morgeson, 1999).

Despite the many antecedents that have been studied, to date, the management and applied psychology literatures have not considered the set of twice-yearly time changes associated with Daylight Saving Time. As of 2008, 74 countries around the world participate in Daylight Saving Time (Timeanddate.com, 2008). In the spring, there is a 1-hr shift such that clocks are set forward 1 hr—referred to as a phase advance—to switch from Standard Time to Daylight Saving Time. In the fall, there is a 1-hr shift in the opposite direction—referred to as a phase delay—to reset to Standard Time.

As organizational researchers have noted, changes to time schedules can have important implications to members of organizations (Blount & Janicik, 2001), and changes to systems that are linked to cycles of time can be far-reaching and powerful (Ancona & Chong, 1996). Human sleep and activity cycles are both linked to the 24-hr cycles of the Earth's rotation. Twice yearly, countries adjust their activity cycles, which have important implications for sleep cycles (Monk, 1980). Given the importance of sleep to brain functioning (Maquet et al., 1997; Saper, Scammell, & Lu, 2005), this is likely to impact organizational phenomena, including workplace injuries.

Researchers in fields outside of management and applied psychology have examined the influence of time changes associated with Daylight Saving Time on accidents in general, with conflicting results (cf. Coren, 1996; Hicks, Lindseth, & Hawkins, 1983; Holland & Hinze, 2000; Monk, 1980). Studies examining clock change effects on car accidents have found significant results in traffic settings (Coren, 1996; Hicks et al., 1983; Monk, 1980); however, confounds with light patterns noted by Holland and Hinze (2000) and Coate and Markowitz (2004) limit the applicability of this effect in most organizations. Holland and Hinze examined the effect of time changes on accidents in a construction setting in which light is more likely to be controlled, making the results of their study more applicable to organizations. They found no significant relationship between time changes and accidents, but the small number of days included in their study limited their statistical power, and thus their findings should be interpreted with caution. Nevertheless, Holland and Hinze's null findings may reinforce the assumption that 1-hr clock adjustments could not impact injury rates in organizations.

The purpose of this article is to challenge that potentially dangerous assumption. Drawing from previous theory and research examining schedule entrainment and circadian rhythms of sleep, we contend that the spring and fall time changes associated with Daylight Saving Time have differential effects on sleep quantity. Drawing from research examining the effects of human sleep quantity on human brain function, we contend that these changes

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in sleep are associated with important differences in the number and severity of workplace injuries. Moreover, we explore whether employees with low levels of experience are especially vulnerable to these effects. Finally, we close with a discussion of the practical implications that our findings have for managers, suggesting work scheduling strategies that might mitigate the effects of time changes on workplace injuries. We hope that knowledge of these effects will enable future actions that can prevent injuries associated with time change and potentially save lives.

Workplace Injuries

Highlighting the importance of safety and work injuries to organizations and employees, the National Safety Council (2008) reported that American work injuries cost $164.7 billion in the year 2006 alone. Despite this enormous cost, Barling et al. (2002) noted that less than 1% of organizational research published in top journals has focused on workplace safety. The majority of this research has considered antecedents of work injuries that are relatively stable over time, such as organizational climate, work design, leadership, and management–employee relations (Barling et al., 2002; Clarke, 2006; Hofmann & Morgeson, 1999; Hofmann & Stetzer, 1996; Neal & Griffin, 2006; Wallace, Popp, & Mondore, 2006; Zacharatos, Barling, & Iverson, 2005; Zohar, 1980, 2000). One would expect these antecedents to remain relatively stable from day to day. Perhaps this focus on relatively stable antecedents is because, as Neal and Griffin (2006) noted, the majority of this research has been cross-sectional in nature; we add that researchers have also conceptually focused on relatively stable antecedents of workplace injuries (for an exception, see Humphrey, Moon, Conlon, & Hofmann, 2004).

However, management and applied psychology researchers have also begun to examine antecedents of work injuries that could demonstrate substantial variation across time. For example, Frone (1998) examined the influence of workload on workplace injuries, and although Frone did not examine this relationship dynamically, previous research suggests that workload can vary over time (Barnes et al., 2008; Huey & Wickens, 1993; Ilies et al., 2007). Likewise, the antecedents of personal and work accidents examined by Legree, Heffner, Psotka, Martin, and Medsker (2003) included stress, fatigue, sleep, and distractions; each of these antecedents is likely to be more dynamic over time than the relatively stable antecedents of safety climate and leadership. In the next section, we draw from theory examining entrainment to offer one explanation for accidents and injuries across time.

Entrainment Theory and 24-hr Cycles

Several researchers have recently emphasized the importance of time in organizations (Ancona, Goodman, Lawrence, & Tushman, 2001; Ancona, Okhuysen, & Perlow, 2001; Blount & Janicik, 2001; Mitchell & James, 2001). One especially important type of time is cyclical time, in which the timing of events recurs regularly (Ancona, Okhuysen, & Perlow, 2001). Ancona and Chong (1996) noted that cycles in organizations can be captured by outside cycles in a process they refer to as *entrainment*. More specifically, they define entrainment as adjustment of the pace or cycle of one activity to match or synchronize with that of another. That adjustment could be in the phase, periodicity, or magnitude of the activity (Ancona & Chong, 1996).

According to Ancona and Chong (1996), the fundamental idea behind entrainment theory in organizations is that endogenous cycles exist within individuals, groups, organizations, and environments. They contend that these endogenous cycles are often influenced by other cycles within or outside of the system resulting in synchrony between the systems; in entrainment language, the cycles are “captured” by an external pacer so as to have the same phase, periodicity, or magnitude.

Perhaps the most powerful external pacer of a very broad set of cycles on the planet Earth is the 24-hr cycle of the Earth’s rotation. This cycle has been important to humans throughout their evolutionary development, in part because humans are generally better suited for activity during daylight than during darkness (Siegel, 2005). Thus, two sets of complimentary periods of human behavior have been entrained to this 24-hr period: sleep and waking activity.

Sleep is a recurring period in human activity that is defined as a state of immobility with greatly reduced responsiveness, which can be distinguished from coma or anesthesia by its rapid reversibility (Siegel, 2005). Borbely and Achermann (1999) noted that a major process that underlies sleep regulation is the circadian process, a clocklike mechanism that is basically independent of prior sleep and waking and determines the alternation of periods with high and low sleep propensity. This process regulates sleep such that it conforms to the 24-hr rotation cycle of the Earth, with sleep and activity phases regulated within this 24-hr cycle.

A large body of research indicates that the suprachiasmatic nuclei of the hypothalamus are the locus of an endogenous self-sustaining circadian pacemaker in the mammalian brain (Dijk & Czeisler, 1995; Ruby, Dark, Burns, Heller, & Zucker, 2002; Saper et al., 2005; Weaver, 1998). Working on a 24-hr cycle that is generally entrained with the light cycle created by the Earth’s 24-hr rotation, the suprachiasmatic nuclei relay neural signals to the pineal gland to secrete melatonin (Dijk & Czeisler, 1995; Lavie, 2001). Melatonin inhibits the wakefulness-generating mechanisms, thereby enabling the brain’s sleep-related structures to be activated unopposed by the drive for wakefulness (Lavie, 1986, 1997, 2001).

Research indicates that exposure to light can promote the production of melatonin (Lavie, 2001), suggesting the direct influence of daylight periods associated with the Earth’s rotation on sleep entrainment. Despite the importance of daylight for human cycles of sleep and wakefulness, research also indicates a powerful endogenous component of the circadian sleep period, such that even in the absence of variance in light exposure humans still conform rather closely to a 24-hr cycle in sleep (Czeisler et al., 1999). Consistent with Siegel’s (2005) suggestion that humans are better suited for daytime activity than nighttime activity, Czeisler et al. (1999) speculated that natural selection has favored this endogenous circadian rhythmicity. Further consistent with these contentions is research that indicates that although there are individual differences in sleep schedules (cf. Lavie, 1986; Soehner, Kennedy, & Monk, 2007), sleep periods generally occur during hours of darkness, usually beginning within 1–2 hr of 11:00 p.m. (Lavie, 1986; Monk, Buysse, Carrier, & Kupfer, 2000; Soehner et al., 2007). Consequently, activity periods including work generally occur in complementary phases that overlap daylight hours.

In addition to physiological mechanisms that regulate phases of human activity, societal norms promote the use of clocks, which are an additional mechanism for regulating periods of human activity within the 24-hr cycle. Research indicates that clocks are very influential in how humans schedule and pace their work activity (Blount & Janicik, 2001; Gersick, 1988, 1989; Labianca, Moon, & Watt, 2005). "Clock time" allows for more precise coordination and scheduling of activities than do internal physiological clocks or observation of the position of the sun. Although most of the time the period of the Earth's rotation and the period of clocks are identical (i.e., 24 hr), as we note below, twice a year 74 countries make adjustments to clock periods that are independent of the Earth's natural daylight cycle. Because most activity within organizations is scheduled on the basis of clock time, this time shift in 74 countries is particularly important for organizations and workers throughout the world. Thus, even though humans were initially entrained to the 24-hr rotation period of the Earth, reliance on clocks as a tool for tracking the 24-hr cycle has led to the entrainment of human activity to clock time.

Daylight Saving Time and Entrainment

As proposed by Benjamin Franklin, the purpose of Daylight Saving Time is to better match the waking activity phase of the human sleep/wake cycle with the daylight phase of the Earth's rotation cycle (Kamstra, Kramer, & Levi, 2000). As noted above, researchers suspect that humans have been selected over time such that the waking phase of their sleep/wake period corresponds with the daylight phase of the Earth's period (Czeisler et al., 1999; Siegel, 2005). Therefore, one would expect that implementing Daylight Saving Time would be beneficial to human activity, including work. However on the basis of entrainment theory, we contend that there are also negative consequences associated with the phase changes associated with Daylight Saving Time. We develop these arguments below, beginning with the influence of clock changes on sleep.

Ancona and Chong (1996) noted that when systems are entrained, altering one system can have considerable effects on the other. In the current context, altering clock time influences human activity schedules. Phase advances in which clocks are set forward 1 hr bring waking activity, including work, 1 hr sooner ("spring forward"). Phase delays in which clocks are set backward 1 hr push waking activity, including work, later ("fall backward"). In America, these phase adjustments occur at 2:00 a.m. on Sundays, adding or subtracting 1 hr of clock time in the very early morning hours. As an example, a 9:00 a.m. work shift that would normally occur 9 hr after midnight occurs 8 hr after midnight on phase advance days, and 10 hr after midnight on phase delay days. Because work is scheduled on clock time, work can proceed uninterrupted.

However, planned clock changes have no mechanism for creating corresponding phase advances or delays in the human endogenous circadian period, which is a major component to sleep regulation. This endogenous circadian period leads most people to go to sleep within 1–2 hr of 11:00 p.m. On average, people will experience the same sleep propensity function on Saturdays immediately preceding these clock changes as they do throughout the rest of the year. However, on phase advance days, the time at which they would normally begin waking activity is advanced by 1 hr, and on phase delay days, the time at which they would normally begin waking activity is delayed by 1 hr. Therefore, we contend that in comparison with days in which no phase change occurs, phase advance days will lead to lower quantities of sleep, and phase delay days will lead to higher quantities of sleep.

Previous research indicates that the effects of phase advances and phase delays are asymmetric. In a series of three within-subjects studies involving a total of 22 participants spending 24 hr in the laboratory, Lavie (1986) found that humans experience a low point in sleep propensity from approximately 10:00 p.m. to 11:00 p.m. Following the low point in sleep propensity, melatonin production increased, and the onset of the nocturnal sleep period was abrupt, generally occurring within 1–2 hr (Lavie, 1986). Lavie refers to the low point in sleep propensity as the forbidden zone and refers to the following rapid increase in sleep propensity as the opening of the sleep gate. Thus, melatonin is implicated with the opening of the sleep gate, such that sleep propensity declines just before bedtime, after which it rapidly increases culminating in the sleep phase of the 24-hr period (Lavie, 2001). The sleep gate remains open for several hours, so sleep propensity remains high for several hours (Lavie, 1986). This suggests that it is especially difficult to fall asleep earlier than normal, as would be required to keep sleep constant on a phase advance day. However, there is no biological mechanism that prevents people from delaying sleep onset by 1 hr on phase delay days. On the basis of this research, we contend that the negative effect of phase advances (losing 1 hr) on sleep quantity will be stronger than the positive effect of phase delays (gaining 1 hr) on sleep quantity.

Previous research provides support for our contentions regarding time changes and sleep. Folkard and Barton (1993) and Monk and Folkard (1976) examined forward rotating shift schedules, and several researchers examined phase shifts due to time zone crossing (Aschoff, Hoffmann, Pohl, & Wever, 1975; Flower, Irvine, & Folkard, 2003; Klein, Wegmann, & Hunt, 1972; Monk et al., 2000). Both bodies of research found that people are more effective at adjusting their sleep period to compensate for phase delays than for phase advances. Although this research did not examine the influence of time changes associated with Daylight Saving Time on sleep, the phase changes associated with rotating shifts and time zone crossings are conceptually similar to phase changes associated with switching to and from Daylight Saving Time.

> *Hypothesis 1:* In comparison with non phase change days, people will sleep less on phase advance days (losing 1 hr).

> *Hypothesis 2:* In comparison with non phase change days, people will sleep more on phase delay days (gaining 1 hr).

> *Hypothesis 3:* The relationship between phase advances (losing 1 hr) and less sleep will be stronger than the relationship between phase delays (gaining 1 hr) and more sleep.

Phase Shifts, Sleep Quantity, and Workplace Injuries

Researchers in the fields of physiology, ergonomics, and experimental psychology have spent decades investigating the effects of sleep quantity on human behavior and performance (for recent reviews, see Dang-Vu et al., 2007; Harrison & Horne, 2000a; Pilcher & Huffcutt, 1996; Siegel, 2005). Although the exact functions of sleep are still under investigation, this body of research indicates that sleep has restorative effects on the brain (Maquet et al., 1997; Saper et al., 2005). The loss of sleep induces a homeostatic process that increases the propensity to sleep (Borbely & Achermann, 1999), generally resulting in extra recovery sleep that is proportional to sleep loss (Saper et al., 2005). Only recently have researchers in the fields of management and applied psychology begun to consider the importance of sleep to organizationally relevant variables (cf. Barnes & Hollenbeck, 2009; Barnes & Van Dyne, 2009; Harrison & Horne, 1999; Scott & Judge, 2006; Sonnentag, Binnewies, & Mojza, 2008).

Of particular importance in the context of workplace injuries is the influence of sleep quantity on cognitive functioning. Electroencephalograph data show decrements in central nervous system arousal as a function of increased sleepiness (Caldwell, Caldwell, Brown, & Smith, 2004). Brain imaging studies of sleep-deprived participants have found that the greatest decrease in cerebral metabolic rate is in the prefrontal cortex (Petiau et al., 1998; Wimmer, Hoffmann, Bonato, & Moffitt, 1992). The prefrontal cortex is an especially important part of the brain for such functions as temporal memory and divergent thinking tasks (Harrison & Horne, 2000b), as well as control of emotional responses and attention (Johnson & Proctor, 2004). Consistent with this contention, empirical research indicates that sleep is an important determinant of alertness and attention deployment and control (Dijk, Duffy, & Czeisler, 1992; Flower et al., 2003; Jewett & Kronauer, 1999; Smith, McEvoy, & Gevins, 2002).

We contend that decrements in alertness and attention are problematic in work contexts, because of the importance of detecting and monitoring cues in the work environment for avoiding workplace injuries (Barkan, 2002; Barkan, Zohar, & Erev, 1998). This is especially problematic as it relates to severe injuries that are often accompanied by complex combinations of cues. An example is the 1994 incident in which American fighter pilots shot down two U.S. Army Blackhawk helicopters in northern Iraq, resulting in the deaths of 26 peacekeepers. As Snook (2002) has indicated, had a number of cues been assembled, this major disaster could have been averted. Sleep quantity is an important determinant of whether employees notice and utilize such important cues that could be utilized to prevent workplace injuries. Consistent with this contention is a Texas train wreck report filed by the National Transportation and Safety Board (2008), which noted that train crew fatigue resulted in the failure of the engineer and conductor to appropriately respond to wayside signals governing the movement of their train, resulting in three deaths and $5.85 million in damages. Moving beyond case studies, Legree et al. (2003) examined vehicle accidents across 400 U.S. Army soldiers and found a correlation of .20 between insufficient sleep and driver-at-fault accidents. Therefore, we expect that in comparison with non phase change days, phase advances that result in lower sleep quantities will lead to more workplace injuries. Similarly, we expect that in comparison with non phase change days, phase delays that result in higher sleep quantities will lead to fewer workplace injuries.

Beyond the effects of phase changes on the frequency of workplace injuries, we also contend that phase changes will have important effects on the severity of workplace injuries. Injuries can vary in their severity from minor injuries requiring mild first aid treatment all the way up to fatal injuries. Workplace hazards that are highly dangerous are more likely to be protected by multiple safeguards (e.g., multiple keys and switches that must be initiated to start a large and potentially dangerous piece of machinery), whereas smaller hazards might be protected by fewer safeguards (e.g., yellow paint on a doorway with low clearance). Therefore, employees must miss multiple cues to be harmed by highly dangerous workplace hazards, whereas less dangerous hazards, related to less severe injuries, might be encountered by missing only one or a few cues. For example, it might be more likely for an employee to bump his head, resulting in little or no injury, than to inadvertently start a piece of dangerous machinery by pressing the wrong keys, which could subsequently result in severe injury. However, fatigued workers will have less available attention and are more likely to miss cues that might prevent more serious injuries from occurring. On the basis of the logic that phase changes influence sleep and the deployment and control of attention, we expect the same relationships between phase changes and injury severity as we do between phase changes and workplace injuries. That is, we expect that in comparison with non phase change days, phase advances that result in lower sleep quantities will lead to a higher level of workplace injury severity. Similarly, we expect that in comparison with non phase change days, phase delays that result in higher sleep quantities will be negatively related to the severity of workplace injuries.

To date, management and applied psychology researchers have not examined the influence of phase delays and phase advances on injury frequency or severity. Researchers outside of the fields of management and applied psychology have investigated the effects of phase delays and phase advances on accident frequency, which one would expect to be related to injury frequency. This research has generally found a greater risk of traffic accidents following phase advance days but has found conflicting results with respect to accidents following phase delay days (Coren, 1996; Hicks et al., 1983; Monk, 1980; Stevens & Lord, 2006).

A major limitation of the applicability of these traffic accident studies to the workplace is that the phase changes on clock time are confounded with changes in light distribution throughout the day, which is an important determinant of traffic accidents (Coate & Markowitz, 2004; Monk, 1980). Indeed, perhaps the different patterns of light distribution inherent in the different latitudes examined across these studies account for differences among these findings. However, in most organizational contexts, employers and employees have better control over lighting conditions than is seen in traffic settings. A second consideration that might limit the applicability of these studies to organizational settings is that perhaps organizations have better procedures or equipment in place that would minimize the effects of phase changes on accidents than do people driving vehicles. Indeed, one would expect that a majority of the vehicle operators included in these studies were not acting as employees or in a workplace setting while they were driving. Finally, each of these studies only investigated 4 years or fewer, meaning they only included up to four phase advances and/or up to four phase delays. This would not be problematic if there was variance in each event that could allow for the level of analysis to be the event. However, in all of these studies each event had no variance in the accident variable (records were entered only for accidents, not for nonaccidents). Therefore, to obtain variance in accidents, the researchers of those studies had to aggregate to the day level of analysis. Aggregating to the day level of analysis and studying the sum of accidents allows comparisons between the number of accidents on phase change days in comparison with non phase change days. This would be acceptable if there were enough days included in the analysis to ensure adequate statistical power. However, each of these studies made a comparison between four or fewer phase advances with pre- and post controls, and each of these studies made a comparison between four or fewer phase delays with pre- and postcontrols. Such small sample sizes limit the inferences that can be drawn from these studies and raises the question of whether these studies had sufficient statistical power to detect their hypothesized effects.

In contrast to the research on traffic accidents and time changes, a study performed by Holland and Hinze (2000) examined the effect of Daylight Saving Time on construction workplace accidents, finding no significant effects between the constructs. Given the organizational setting of this study, concerns about lighting patterns or nonwork behaviors are mitigated, leading to the assumption that time changes have no bearing on workplace accidents. However, the directions of the effects in the study were consistent with those that we propose, such that there were more accidents following phase advances and fewer accidents following phase delays. Furthermore, Holland and Hinze used only 21 data points (the three Mondays closest to the phase change over a 7-year period) in their analyses, yielding insufficient power to detect even modest relationships. Thus, we argue that the failure to find significant results was due to a lack of statistical power and not to a lack of substantive relationship between phase changes and workplace accidents.

In summary, on the basis of Hypotheses 1 and 2 and in conjunction with research examining the effects of sleep quantity on alertness and attention deployment and control, we hypothesize that in comparison with non phase change days, there will be more workplace injuries and more severe workplace injuries following phase advances, and the opposite to be the case for phase delays. Hypotheses 4 and 5 note these expectations. Moreover, as we note in Hypothesis 3, we expect the phase advance effect on sleep to be stronger than the phase delay effect on sleep. Therefore, in Hypothesis 6 we note that we expect the phase advance effect on workplace injuries to be stronger than the phase delay effect on workplace injuries.

> *Hypothesis 4:* In comparison with non phase change days, there will be (a) more workplace injuries and (b) injuries of greater severity following phase advance days (losing 1 hr).

> *Hypothesis 5:* In comparison with non phase change days, there will be (a) fewer workplace injuries and (b) injuries of lesser severity following phase delay days (gaining 1 hr).

> *Hypothesis 6:* The relationship between phase advances (losing 1 hr) and increases in (a) workplace injuries and (b) workplace injury severity will be stronger than the relationship between phase delays (gaining 1 hr) and decreases in (a) workplace injuries and (b) workplace injury severity.

Exploratory Hypotheses

As noted above, sleep restriction has a disproportionately negative effect on the prefrontal cortex (Petiau et al., 1998; Wimmer et al., 1992), which is especially important for divergent thinking tasks (Harrison & Horne, 2000b). Harrison and Horne (2000b) theorized that this heavier impact of fatigue on the prefrontal cortex is why complex, divergent tasks are more heavily impacted by fatigue than simpler tasks. Research is consistent with this position (Caldwell et al., 2004; Haslam, 1984). For example, Harrison and Horne (1999) found that a single night of sleep deprivation had a stronger influence on a task requiring high levels of innovative thinking than on a task requiring lower levels of innovative thinking.

This body of research suggests that tasks that are novel will be more heavily influenced by sleep restriction than tasks that are well learned (Barnes & Hollenbeck, 2009). In many workplace settings, an important determinant of the novelty of a set of tasks is job experience. Employees who have low levels of experience with a given job should experience more novelty in their tasks than those who have high levels of experience with a given job. Thus, variance in sleep should be more influential to the injury rates of employees with low levels of job experience than to the injury rates of employees with high levels of job experience. Therefore, on the basis of Hypotheses 1–6, it is reasonable to expect that (a) phase advances, which lead to lost sleep, will lead to high levels of injuries involving employees with low levels of experience, and (b) phase delays, which lead to gained sleep, will lead to low levels of injuries involving employees with low levels of experience. This, therefore, suggests that employees who are involved in injuries following phase advance days (losing 1 hr) will have a lower average level of job experience than employees involved in injuries on non phase change days. Similarly, employees who are involved in injuries on phase delay days (gaining 1 hr) will have a higher average level of job experience than employees involved in injuries on non phase change days.

> *Exploratory Hypothesis 1:* The level of job experience of employees involved in injuries following phase advance days (losing 1 hr) will be lower than the average level of job experience of employees involved in injuries on non phase change days.

> *Exploratory Hypothesis 2:* The level of job experience of employees involved in injuries following phase advance days (gaining 1 hr) will be higher than the average level of job experience of employees involved in injuries on non phase change days.

Overview

To test our hypotheses, we conducted two studies. In Study 1, we examined the influence of time changes on workplace injuries, and we utilize national mining injury data from the National Institute for Occupational Safety and Health to test Hypotheses 4–6 and Exploratory Hypotheses 1 and 2. To support sleep as the likely mediator of the effects of time changes on workplace injuries, in Study 2 we utilized data from the American Time Use Survey of the Bureau of Labor Statistics (2008) to establish the link between phase changes and sleep quantity (Hypotheses 1–3).

Study 1

Method

Mine Safety and Health Administration Injury Data

According to Title 30 of the U.S. Department of Labor, all operators of mines located in the United States are legally required to immediately investigate and report to the Mine Safety and Health Administration all injuries stemming from mining injuries (U.S. Department of Labor, 2008). This regulation stipulates that each report contain data including the time and date of each injury and the specific details of each injurious mining accident. As of the writing of this article, the Mine Safety and Health Administration had available data for these mining injuries for the years 1983–2006.

Participants

Participants included in this study were miners working in the United States from 1983–2006 who were injured while mining. Across these 24 years, there were 576,292 such mining injuries reported to the Mine Safety and Health Administration. Among all these injured workers, 98% were male workers. The mean age of these injured workers was 39.01 years. The mean level of experience of these injured workers in the job that they held when injured was 6.49 years.

Measures

Phase changes. Date of the workplace injury was recorded by mine operators, including year, month, and day. We created two dummy codes for phase changes. The phase advance variable was coded 1 on phase advance days and 0 on all other days. The phase delay variable was coded 1 on phase delay days on 0 on all other days. From 1983 to 1986, phase advances took place on the last Sunday of April, and phase delays took place on the last Sunday of October. From 1987 to 2006 phase advances took place on the first Sunday of April, and phase delays took place on the last Sunday of October.

Workplace injuries. We counted the number of mining injuries for each of the 8,766 days included in the Mine Safety and Health Administration data set, consistent with past research (cf. Hofmann & Morgeson, 1999; Hofmann & Stetzer, 1996; Humphrey et al., 2004; Neal & Griffin, 2006).

Workplace injury severity. Workplace injury severity was operationalized as the total number of days work missed because of mining injuries (U.S. Department of Labor, 2008).

Job experience. U.S. Department of Labor regulations also stipulate that mine operators report the work experience of each injured worker (U.S. Department of Labor, 2008). This included the number of years worked in the job title that the injured worker held at the time of the injury, which serves as our measure of job experience.

Control variable. Because people may work less and therefore have fewer workplace injuries on federal holidays than on other days, holidays were dummy coded as 1, and all other days were dummy coded as 0.

Analysis

We expect that employees will work less during certain times of the week (e.g., weekends) or year (e.g., the days surrounding holidays). To control for these patterns of work activity, we created a hierarchical linear model (HLM), with a grouping code specifying the week of the year and the day of the week. For example, March 22, 2003, fell on a Saturday. Therefore, all observations for this date were given the code number 1207, with "12" representing the 12th week of the year and "07" representing the day of the week (Saturday). In similar fashion, March 22, 2004, was coded 1302, with "13" representing the 13th week of the year and "02" representing the day of the week (Monday). Weeks ran from Sunday to Saturday and Week 1 began with the first Sunday to Saturday period to include January 1. By using these codes as our Level-2 grouping variable, we separate variance in sleep that is due to day-of-the-week effects or to seasonal effects (week of the year) from variance attributable to our Level-1 predictors (e.g., phase advance days, phase delay days).

We used this identification variable as a Level-2 grouping variable in HLM, thereby controlling for effects of day of the week and week of the year on injury frequency and severity. Analyses to test Hypotheses 4 and 5 were performed at Level 1 of various models, with no Level-2 predictors, and the Level-2 grouping variable capturing the variance attributable to seasonal influences. Hypothesis 6 was evaluated by comparing the magnitudes of the regression coefficients, as suggested by Schwab (2005).

Our exploratory hypotheses were also tested in HLMs to control for seasonal effects. In these tests, we regressed job experience on phase change, phase delay, and holiday variables to assess the extent to which the occurrence of injuries at the time of phase changes is contingent upon worker experience in the job. By regressing experience on the phase change variables, we are able to assess the average level of experience of workers injured on particular days (e.g., phase change days), thus providing us with a fitting approach for testing our hypotheses.

Results

Correlations for the variables in Study 1 are given in Table 1. Hypothesis 4 predicted that following phase advance days, a higher number of injuries will occur, and injuries of greater severity will occur, than following non phase change days. Results indicate that, on average, 3.6 more injuries occurred ($p < .01$) and 2,649 more days of work were lost because of injuries ($p < .05$) on days following phase advances than on non phase change days (see Table 2). Not only does this represent a 5.7% increase in the number of injuries on these days but a 67.6% increase in days work lost because of these injuries, representing a considerable increase in injury severity on days following phase advances. These data strongly support Hypothesis 4. Hypothesis 5 predicted that there would be a smaller number of injuries and that injuries would be less severe on days following phase delays. However, the results indicate that phase delays are related to neither the number of injuries nor the severity of these injuries, failing to support Hypothesis 5. Finally, Hypothesis 6 predicted that the relationship between phase advances and injury outcomes is stronger than the relationship between phase delays and injury outcomes. Comparison of the regression coefficients indicates that the coefficients for the phase advance relationships are statistically significant and larger than the coefficients for the phase delay relationships. Further analyses indicate that the coefficient for phase advances predicting injury severity is significantly larger than the coefficient for phase delays predicting injury severity ($z' = 2.25$, $p < .05$), whereas the difference in the magnitude of the coefficients when predicting the number of injuries suffered is not significant ($z' = 0.37$, $p = .36$). Taken together, these findings offer general support for Hypothesis 6 (see Table 3).

Table 1
Correlations Among Phase Change and Accident Data for Mining Sample

Variable	*M*	*SD*	1	2	3	4	5	6
1. Work accidents	63.147	53.644	—					
2. Days lost to injury	3,872.562	4,963.896	.309**	—				
3. Job experience	6.562	1.545	−.045**	−.028**	—			
4. Phase delay	0.003	0.052	.021	.000	.016	—		
5. Phase advance	0.003	0.052	.026	.000	.017	−.003	—	
6. Holidays	0.027	0.163	−.118**	−.074	.002	−.008	−.007	—

Note. Level-1 $N = 8{,}766$ observations; Level-2 $N = 372$ days. Correlations were computed in a hierarchical linear model, with Level-2 grouping variables accounting for the nonindependence of data collected during the same week or day across various years.
** $p < .01$ (two-tailed).

Finally, our exploratory hypotheses examined the levels of experience on the job that were related to mining injuries following phase change days. Findings indicate that phase advances (the loss of 1 hr) were not related to employee experience on the job, whereas phase delays (gaining 1 hr) were positively related to employee job experience ($p < .01$). This suggests that injuries following a phase delay are likely to include more experienced employees than injuries at other times of the year. By inference, this suggests that newer employees, for whom the task is arguably more novel, are less likely to be injured following phase delay days when they might enjoy extra sleep and thereby increased levels of attention and cue recognition, as compared with days when they do not enjoy greater amounts of sleep.

These findings highlight the relationships between clock changes associated with Daylight Saving Time and workplace injury. As indicated in the introduction, we contend that sleep is the mechanism by which this relationship occurs. However, the National Institute for Occupational Safety and Health's data set included in Study 1 did not include sleep. To examine the relationship between clock changes associated with Daylight Saving Time and sleep, we conducted Study 2. Establishing the link between these clock changes and sleep will help uncover the likely causal mechanism between these clock changes and workplace injuries.

Table 2
Influence of Phase Delays and Phase Advances on Total Injuries and Injury Severity

Predictor	No. of injuries	*T* value	Days lost to injury	*T* value
Intercept (β_0)	63.89	42.62**	3,916.74	39.99**
Holiday (β_2)	−35.47	−7.34**	−2,255.70	−6.69**
Phase delay (hour gain) (β_3)	2.18	0.61	200.47	1.02
Phase advance (hour loss) (β_4)	3.61	2.52**	2,649.21	2.48*

Note. Level-1 $N = 8{,}766$ observations; Level-2 $N = 372$ days. These values were estimated in hierarchical linear models that regressed job experience on a control variable and substantive predictors (phase advance and phase delay) at Level 1.
* $p < .05$. ** $p < .01$ (two-tailed).

Study 2

Method

American Time Use Survey

The American Time Use Survey is a survey conducted by the Bureau of Labor Statistics that measures the amount of time Americans spend doing various activities, such as paid work, child care, volunteering, socializing, and sleeping (Bureau of Labor Statistics, 2008). Employees of the Bureau of Labor Statistics conduct phone interviews with participants and ask participants to describe minute by minute their activity from 4:00 a.m. the day before the interview to 4:00 a.m. the day of the interview. Interviewers code these minute-by-minute activities into specified categories as outlined by the Bureau of Labor Statistics (2008), including the categories utilized by this study. Interviews are conducted nearly every day of the year. As of the time we conducted this study, American Time Use Survey data were posted online and available for years 2003–2006. However, category coding changes between 2003 and 2004 led us to include only years 2004–2006.

Participants

These data were collected from a nationally representative sample of American civilian, noninstitutionalized persons ages 15 years and older. This representative sample was obtained via a

Table 3
Relationship Between Experience and Injuries During Phase Delays and Phase Advances

Predictor	Job experience	*T* value
Intercept (β_0)	6.56	367.92**
Holiday (β_2)	−0.01	−0.04
Phase delay (hour gain) (β_3)	0.33	16.17**
Phase advance (hour loss) (β_4)	0.31	1.28

Note. Level-1 $N = 8{,}766$ observations; Level-2 $N = 372$ days. These values were estimated in hierarchical linear models that regressed job experience on a control variable and substantive predictors (phase advance and phase delay) at Level 1.
** $p < .01$ (two-tailed).

stratified random sampling approach. To focus on members of organizations, we include data only from individuals who worked greater than 0 min during the period surveyed. The years 2004–2006 included 820,737 call attempts; of these attempts, 41,204 resulted in interviews in which data were collected, whereas 103,148 of these attempts were met with refusals to participate, resulting in a 28.5% participation rate by those who were successfully contacted. The remaining attempts did not result in contact with potential participants. As noted above, to ensure that we were examining employees, we only included participants who worked greater than 0 min during the period noted in the interview. Data were available for 14,310 such interviews. The mean age of respondents was 42.3 years, and 50.8% of the participants were female.

Measures

Phase changes. Date of the interview was recorded by interviewers, including year, month, and day. We created two dummy codes for these interviews. The phase advance variable was coded 1 on phase advance days and 0 on all other days. The phase delay variable was coded 1 on phase delay days and 0 on all other days. In the United States during the years included in this study, phase advances took place on the first Sunday of April, and phase delays took place on the last Sunday of October.

Sleep quantity. A category of activity in the American Time Use Survey was the number of minutes spent sleeping. This category was separate from the number of minutes spent lying in bed awake or tossing and turning. Our measure of sleep quantity was the self-reported number of minutes spent sleeping.

Control variables. Because people may sleep more on federal holidays than on other days, interviews were dummy coded 1 for holidays and 0 for all other days. Previous research indicates a negative correlation between time spent sleeping and time spent working (Basner et al., 2007). Accordingly, we entered number of minutes spent working as a control variable.

Analysis

As discussed above, data from this sample were collected over several years from a large stratified random sample of Americans, and because we are interested in the impact of phase changes on sleep and work, our analyses include those who worked during the time period surveyed. In addition to holidays having an impact on the amount of sleep people might get on any particular day, we expect there to be daily patterns in sleep quantity. In other words, social events might dictate that people tend to get differing amounts of sleep on weekends than they do on weekdays. Likewise, we expect to observe seasonal patterns in sleep quantity, as people may be more inclined to participate in social events during summer months or during months that tend to have a high number of social events (e.g., December).To account for this seasonality, we created an identification variable similar to that used in Study 1; this identification variable captured the week and day of the week for each of the dates included in the data set. We used this identification variable as a Level-2 grouping variable in HLM, thereby controlling for effects of day of the week and week of the year on sleep.

To test Hypotheses 1 and 2, that people would sleep less following phase advances and more following phase delays, we regressed minutes of sleep on variables indicating whether the day was a phase advance day, phase delay day, a holiday, and the amount of time the individual worked that day. Again, the Level-2 structure of the model allows us to account for differences due to the seasonal and daily influences. To test Hypothesis 3, that the negative effect of phase advances on sleep quantity is stronger than the positive effect of phase delays on sleep quantity, we compared the magnitudes of the beta coefficients from the tests described to test the first two hypotheses.

Results

Correlations among the variables in Study 2 are given in Table 4. Results from our regression analyses indicate that, on average, people tend to sleep 40 min less following phase advances as compared with all other non phase change days ($p < .05$; see Table 5). These results support Hypothesis 1. Results from our HLM analyses also indicate that there is no statistically significant difference in the amount of time that people tend to sleep following phase delays, failing to support Hypothesis 2. Although the relationship between phase advances and sleep was not significant, it is worth noting that the sign of the relationship is in the direction predicted. Finally, in Hypothesis 3 we suggested that the loss of sleep following phase advances would be larger than the gain in sleep following phase delays. Comparison of the coefficients, as suggested by Schwab (2005), suggests that this is indeed the case, with this difference being statistically significant ($z' = 2.01$, $p < .05$), offering support for Hypothesis 3.

General Discussion

We hypothesized that the phase advance and phase delay time changes associated with Daylight Saving Time would influence

Table 4
Correlations Among Phase Change and Sleep for U.S. National Sample

Variable	*M*	*SD*	1	2	3	4	5
1. Sleep quantity	465.653	110.626	—				
2. Phase delay	0.003	0.058	.014	—			
3. Phase advance	0.004	0.064	−.011	−.004	—		
4. Time working	430.334	197.521	−.340**	−.021*	−.036**	—	
5. Holidays	0.010	0.097	.041**	−.006	−.006	−.077**	—

Note. $N = 14{,}310$ cases.
* $p < .05$. ** $p < .01$ (two-tailed).

Table 5
Influence of Phase Delays and Phase Advances on Sleep Quantity

Predictor	Sleep quantity	*T* value
Intercept (β_0)	546.22	245.64**
Time working (β_1)	−0.19	−41.53**
Holiday (β_2)	13.48	1.41
Phase delay (hour gain) (β_3)	12.39	0.65
Phase advance (hour loss) (β_4)	−40.41	−2.24*

Note. Level-1 $N = 14{,}310$ observations; Level-2 $N = 363$ days. These values were estimated in hierarchical linear models that regressed sleep quantity on control variables and substantive predictors (phase advance and phase delay) at Level 1.
$^{*} p < .05$. $^{**} p < .01$ (two-tailed).

sleep quantity, frequency of workplace injuries, and severity of workplace injuries to a differential degree. Study 1 indicated that in comparison with non phase change days, there are 3.6 more American mining injuries each year on Mondays following phase advances, and that there are over 2,600 more days lost because of work injuries each year, suggesting higher levels of injury severity. Study 2 indicated that in comparison with non phase change days, phase advances (i.e., losing 1 hr in the spring) led a stratified random sample of Americans to sleep on average about 40 min less. This provides preliminary support for sleep as the likely mediator of the influence of time changes on workplace injuries.

In contrast, the effects of phase delays were not as powerful. In Study 2, we found that in comparison with non phase change days, phase delays led a random sample of Americans to sleep on average 12.4 more minutes. However, this effect was not significant. Perhaps because there was no significant effect of phase delays on sleep, there were also no significant phase delay effects on injury frequency or injury severity. This is consistent with previous research that indicates that although people have difficulties adjusting their sleep schedules to phase advances, they are better able to adjust their sleep schedules to phase delays (Folkard & Barton, 1993; Monk & Folkard, 1976). Our data indicate that people tend to utilize the extra hour in phase delays for waking activity rather than for sleep.

Our exploratory hypotheses examined experience in the context of time phase changes. We hypothesized that employees with low levels of experience would be more susceptible to the effects of phase changes and, therefore, that the mean levels of experience of workers injured following phase changes would be lower following phase advances and higher following phase delays. Contrary to our expectations, in comparison with non phase change days, there was no significant difference in experience levels following phase advances. However, on phase delays, the mean level of experience was higher, indicating that fewer employees with low levels of experience were injured following phase delays. Given that our expectation that people would get more sleep following phase delays was not supported, it is unclear to us why phase delays would lead to this effect. This finding is a bit surprising and warrants further conceptual and empirical examination in future research. We speculate that there may be heterogeneity in which types of employees alter their sleep schedule to match phase delays. Although there is no overall effect of the phase delay on sleep quantity, perhaps future research may find that employees with low levels of experience do get more sleep following phase delays.

There are several strengths in the design of this study. First, by conducting Study 1 in a mining setting in which workers tend to be in environments that are often isolated from daylight pattern changes, this study avoids the daylight confound that has been present in previous studies investigating Daylight Saving Time phase changes on injuries. Second, the external validity of our study is high because in Study 2 we examined a large nationwide random sample, and in Study 1 we examined actual workplace injuries. Third, the statistical power of our studies is considerably higher than previous studies examining Daylight Saving Time phase shifts. In Study 1, we examined 576,292 mining injuries across 8,766 days. In Study 2, we examined 14,310 sleep periods across 1,067 days.

There are three main limitations in the design of our study. First, we did not explicitly analyze the link between sleep and workplace injuries. The archival data sets that we examined did not allow for such tests, and the low base rate of workplace injuries makes it difficult to measure the relationship between sleep and workplace injuries. However, previous research examining sleep restriction and deprivation has clearly established the link between sleep restriction and difficulties with alertness and attention (Beaumont et al., 2001; Caldwell et al., 2004; Dijk et al., 1992; Falleti, Maruff, Collie, Darby, & McStephen, 2003; Flower et al., 2003; Jewett & Kronauer, 1999; Smith et al., 2002). Researchers have gone as far as to delineate the role of the prefrontal cortex in this process, and they measured the disproportionately negative effects of sleep deprivation on the prefrontal cortex in tightly controlled laboratory settings (Harrison & Horne, 2000b; Petiau et al., 1998; Wimmer et al., 1992). Moreover, previous research has already established the link between sleep quantity and workplace accidents (Legree et al., 2003). Finally, the patterns between phase changes and sleep match the patterns between phase changes and workplace injuries, with sleep effects preceding those accidents. Therefore, it seems reasonable that sleep restriction plays an important role in the influence of phase changes on workplace injuries.

A second limitation is that in Study 1 we relied on archival data reported to the National Institute for Occupational Safety and Health. Reporting of such workplace injuries is a legal requirement. However, it is possible that some injuries were not reported. Nevertheless, we have no reason to believe that the tendency to report or not to report injuries was different on phase change days than on other days. A third limitation is that the measure of work experience in Study 1 was the number of years that each worker has held the current job title. This does not take into account the fact that some employees may have gained similar experience in other job titles. We partly addressed this by controlling for age, which should be, on average, higher for individuals who have gained similar work experience under different job titles. However, unmeasured work experience may have weakened our ability to find effects in our exploratory analyses.

Theoretical Implications

From the standpoint of entrainment theory, our research indicates the importance of considering multiple iterations of interaction between entrained systems. Previous research examining entrainment has suggested that when two or more cycles are entrained, influencing one cycle can influence the other (Ancona & Chong, 1996). Our study suggests that there may be more iterations of reciprocal influence than previously suggested. We found that changes to the scheduled waking activity cycles and work activity can influence sleep cycles, which can in turn influence waking activity cycles. Researchers applying entrainment theory to other contexts may similarly find that cyclically entrained systems that are disturbed may take several cycles of mutual influence to return to a state of equilibrium.

A second theoretical contribution is to further theory examining workplace injuries by noting the importance of work scheduling. We find that simply shifting a work schedule by 1 hr can increase the risk to employees. Whereas previous theory and research examining work scheduling has often focused on the pace of work, we find that changes to work schedules can also be important.

A third theoretical contribution of this article is to further extend theory examining sleep deprivation into the management and applied psychology literatures. Despite being a heavily researched topic in the fields of medicine and physiology, sleep deprivation has been a topic largely ignored by management and applied psychology. Perhaps this is due to the extreme nature of many studies examining sleep deprivation in the physiology literature, such as 37, 43, or 64 continuous hours of continuous sleep deprivation (Baranski, Cian, Esquivie, Pigeau, & Raphel, 1998; Beaumont et al., 2001; Blagrove, 1996; Caldwell et al., 2004). Such extreme contexts are rare in most organizations. However, the extremity of these studies belies the power that even small restrictions of sleep can have on employees. Researchers have found that periods of sleep deprivation and sleep restriction that are more common in organizations have important effects, such as losing 1 night of sleep (Harrison & Horne, 1999), losing as little as 5 hr of nocturnal sleep (Friedman, 1971), or restricting sleep to 4–5 hr per night for a week (Dinges et al., 1997). Even as little as a 6-min nap has been associated with improved memory (Lahl, Wispel, Willigens, & Pietrowsky, 2008). Our study indicates that phase advances associated with a 40-min decrement in sleep led to increased injury frequency and increased injury severity. This body of research suggests that sleep, a construct typically ignored by management and applied psychology researchers, has meaningful implications for organizations and employees.

Practical Implications

Our findings also have important practical implications for managers and organizations. The ability to predict workplace injuries helps to enable managers and members of organizations to take preventative measures that can mitigate these effects. One manner in which organizations can attempt to avoid the increase in workplace injuries associated with the Daylight Saving Time phase advance is to schedule particularly dangerous work on other days, perhaps later in the week after employees have had more time to adjust their sleep schedules to the phase change. By moving dangerous activities to safer days, organizations can attempt to avoid the dangers of phase advances.

A second manner in which organizations could attempt to mitigate these effects would be to schedule extra safety monitors on days following phase advances. Such employees could be helpful in anticipating potential workplace injuries before they occur. Multiple observers may partly offset the fact that on average employees will tend to be less observant of cues indicating impending injuries. Extra safety monitors may also be vulnerable to restricted sleep following phase advances, but they may contribute to workplace safety nonetheless.

A third strategy for mitigating these effects is suggested by Monk, Buysee, and Billy (2006). They found that the negative effects of a 6-hr phase advance were largely avoided by trickling in the phase change with daily 30-min phase advances. This suggests that breaking up a phase advance into smaller phase advances can aid phase adjustment. Perhaps managers could trickle phase advances into organizations in a similar manner, stretching out phase changes over smaller chunks by adjusting the starting times of employee work shifts.

Future Research

Because sleep is a topic largely ignored by the management and applied psychology literatures, there are many avenues for future research that remain unexplored at this time. One of the most promising such avenues is examining sleep restriction and deprivation in group and team contexts (cf. Barnes & Hollenbeck, 2009). To date, even in other research fields that have focused heavily on sleep restriction and deprivation, group and team contexts have largely gone unexplored. This is an important oversight given the importance of teams to contemporary organizations. Team behaviors, such as backing up behavior (Barnes et al., 2008; Porter et al., 2003) and team monitoring (Marks, Mathieu, & Zaccaro, 2001), could aid groups and teams in mitigating the effects of sleep in organizations.

Future research should consider other organizationally relevant variables that are influenced by phase changes and variance in sleep. To date, researchers have examined innovative decision making (Harrison & Horne, 1999), job satisfaction (Scott & Judge, 2006), and team performance (Barnes & Hollenbeck, 2009) in these contexts. However, there are potentially many other organizationally relevant variables that are influenced by phase changes and variance in sleep. Previous research indicates powerful effects of sleep on mood (Pilcher & Huffcutt, 1996). This suggests that mood may mediate the effects of sleep and phase changes on variables such as organizational citizenship behavior or goal setting.

Finally, future research should investigate moderators of the effects of phase changes on workplace injuries. Such research may find that phase changes are more likely to result in injuries for some types of tasks than others. For example, tasks that are stable over time and do not require novel thinking may be less vulnerable to the effects found in our article than are tasks that are dynamic and require higher levels of novel thinking.

Conclusion

In summary, we found that time phase changes that are intended to better align waking activity with daylight periods have negative side effects on organizations. Following phase advances, employees slept 40 min less, had 5.7% more workplace injuries, and lost 67.6% more work days because of injuries than on non phase change days. Phase delays did not have any significant effects on sleep, injury frequency, or injury severity. Thus, on balance, implementing Daylight Saving Time phase changes costs employees sleep and injuries. We therefore conclude that schedule changes, such as those involved in switches to and from Daylight Saving Time, place employees in clear and present danger. Such changes put employees in a position in which they are more likely to be injured—these injuries being especially severe, and perhaps resulting in death. It is not often that management and applied psychology researchers can highlight effects that can lead to death, but our research points in that direction. These findings beg for immediate attention given to employee schedules, sleep, and safety, because, as this study reveals, Daylight Saving Time may save daylight, but not without painful costs.

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