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Quantitative evaluation of the impact of night shifts and alcohol consumption on construction tiling quality

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ABSTRACT

The adverse effects of night-shift work and alcohol consumption on performance have received considerable attention. However, how night shifts and alcohol affect productivity in workers has not been quantified. This paper describes the experiments featuring multiple tiling tasks and patterns. The tiling quality performed by the graduate student participants in four different statuses was objectively evaluated by an edge-detection computer program. The results indicate that both night shift and alcohol significantly reduce the quality in general, and the effects of the factors on position and alignment-angle qualities were dissimilar in distinct areas due to tile patterns and size. Both night-shift and alcohol conditions affected the basic (−34.01% and −25.79%) and advanced tiling abilities (−40.14% and −26.16%), and night shift had a larger impact than alcohol. These results provide jobsite managers with usable information regarding how night shifts and alcohol affect workers' abilities to execute basic and advanced tasks.

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1. Introduction

1.1. Effect of night shifts on productivity

Using night shifts (approximately 10 PM to 6 AM) is the most common approach employed to accelerate construction projects (Jun and El-Rayes, 2010). Night shifts have been suggested to provide more favorable work conditions than day shifts, such as reduced travel congestion, work interference, idle-machinery times, and temperatures (Arditi et al., 2007). However, the potential adverse effects of nighttime construction on worker productivity, safety, and health have also been widely reported (Hinze and Carlisle, 1990; Jun and El-Rayes, 2010; Price, 1986).

Night shifts disrupts a person's circadian rhythm and makes people drowsy and tired (Gillberg et al., 2003; Jay et al., 2006a), and thus impairs cognition and alertness (Åkerstedt and Wright Jr., 2009; Ohayon et al., 2010). Consequently, several studies have concluded that night shifts reduce performance and increase accident risks (Åkerstedt and Landström, 1998; Ullman et al., 2004). Night shifts have been reported to potently affect attention, memory, reaction times, decision making, motor skills, and higher-order cognitive processing in the workplace (Dorrian et al., 2005; Harrison and Horne, 2000; Jay et al., 2006b). These factors may explain the findings that night-shift workers make more errors and are less efficient at their work than are day-shift workers (Costa, 1996). Moreover, night shifts can also cause health, social, and family problems (Wright et al., 2013), which lead to a chronic reduction in competence at work.

Dorrian et al. (2003) determined that performance in the Psychomotor Vigilance Task deteriorated at a rate corresponding to the subjective sleepiness ratings provided by participants during a week of simulated night shifts. Andorre-Gruet et al. (1998) reported that supervisory activity was lower during night shifts than during day shifts in the control room of a chemical plant. Åkerstedt and Landström (1998) have summarized the studies related to the effects of night-shift work. Browne (1949) demonstrated that telephone operators connected calls considerably more slowly at night than they did during the day. Bjerner et al. (1955) observed that the number of errors in gas-meter readings at a gas company was higher at night than it was during the day. Hildebrandt et al. (1974) determined that train drivers failed to operate safety-alert devices more often at night than they did during the day.

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1.2. Effect of alcohol consumption on productivity

Construction workers are consistently ranked the highest among workers in all occupations and industries in terms for illicit-drug use and heavy alcohol consumption (Larson et al., 2007). The Substance Abuse and Mental Health Services Administration (2007) reported that the highest rates of heavy alcohol consumption occurred in the construction industry (15.9%); the rate was nearly twice the average of that in all industries (8.8%) combined in USA. Pidd et al. (2006) investigated alcohol consumption in Australia and found that the construction industry has a higher percentage of workers who drank amounts that were risky in the short- and long-term than do all industries. Regarding the long-term risk levels, the percentage in the construction industry (12.0%) is second only to that in the hospitality industry (14.6%). Alcohol abuse is the primary problem in the construction industry (Maloney, 1988), with the prevalence of alcohol dependence and abuse being roughly 25% in construction workers in USA (Mandell et al., 1992); approximately 12.4% of construction workers engage in heavy alcohol use in USA (Gerber and Yacoubian Jr., 2001). Moreover, approximately 19.1% of construction workers in Australia exhibit alcohol-related problems (Banwell et al., 2006), and nearly 20% of the construction workers consume alcoholic energy drinks regularly.

According to a survey conducted by Cheng et al. (2012), a high percentage (28.6%) of construction workers habitually consume alcoholic energy drinks, because construction work can be physically exhausting. Unlike in some Western countries in which alcoholic energy drinks are marketed to young adults, in Taiwan, alcoholic energy drinks are frequently targeted at manual workers and marketed as nutritional supplements that can combat drowsiness and fatigue at work. The two most popular energy drinks, Whisbi and Paolyta B, which contain alcohol as well as vitamin and caffeine, are approved and regulated by the Food and Drug Administration of Taiwan as “medicine,” and are therefore sold at pharmacies. Most construction workers questioned stated that consuming energy drinks can help relieve fatigue or eliminate drowsiness (Chang et al., 2009), which can explain why the workers consumed these energy drinks before or even during work. According to a report of The Council of Labor Affairs in Taiwan (1998), approximately 14% of all construction workers drank alcoholic beverages before work, and 22% of the workers drank the beverages during work.

Much like night-shift work, alcohol consumption in the workplace severely harms workers' physical and psychological well-being, diminishes job performance and productivity, and increases safety risks (Dave and Kaestner, 2002; Patussi and Mezzani, 2004). The other alcohol-related problems prevalent in the workplace are absenteeism (i.e., being either late or absent), increased use of sick leave, an increase in behavioral problems, and poor relationships with coworkers (French and Zarkin, 1995; Maloney, 1988).

The harmful effects of alcohol consumption on a person's work performance have been widely studied and demonstrated. Drinking alcohol adversely affects perceptual–cognitive and psychomotor abilities (Brumback et al., 2007) and also impairs information processing, memory, reasoning, visual-searching capability, attention, caution, reaction times, perception of space and movement, verbal expression, motor coordination, and recognition skills (Kim et al., 2007; Oxley et al., 2006).

Brumback et al. (2007) summarized the impact of alcohol at moderate-to-heavy BAC levels. BAC levels above 0.05% markedly impair performance in certain motor tasks such as tracking, tapping, reaction, and swaying. Dawson and Reid (1997) reported that performance on a tracking task decreased by 11.6% at a BAC level of 0.10%. Struik et al. (1988) indicated that information processing, perception, and motor abilities were substantially diminished at BAC levels exceeding 0.15%.

As discussed in this section, numerous studies have evaluated the effects of night-shift work and alcohol consumption on people's work efficiency and cognitive behavior; however, no study has focused on quantifying the effect of these factors on work quality, particularly in the construction industry. One reason that such quantitative analyses are lacking is that reliably measuring performance in real-life settings can be challenging (Gillberg et al., 2003). Furthermore, to quantify the impact of physiological statuses on productivity, studies must focus on using a simple and safe construction task whose quality can be measured objectively. Understanding how night shifts and alcohol consumption affect various quality measures of tasks of distinct types can help in managing construction work and workers and in avoiding poor work quality and unsafe working conditions caused by inappropriate work assignment.

In this study, our objective was to use experiments to quantify the impact of night shifts and alcohol consumption on tiling quality and task-executing ability. The tiling task, which was chosen because of its simplicity and safety, can be readily simulated and also repeated when cemented tiles are replaced with Velcro-attached tiles. Tiles of distinct patterns and sizes were designed and the quality of work was assessed based on the precision of tile alignment; this assessment included three measures that represented basic and advanced task-executing abilities.

2. Methodologies

2.1. Overview of the experiments

To evaluate the impact of night-shift work and alcohol consumption on work quality and efficiency, we designed four experiments, each including the same set of five tiling tasks in five specified areas and three tiling patterns. Each participant was required to participate in all four experiments under distinct statuses: (I) normal, (II) inebriation, (III) night shift, and (IV) inebriation in night shift (Table 1). The participants completed each of the experiments on separate days to avoid experiencing residual effects of previous experiments.

In the normal status, participants completed the experiment during daytime without having consumed any alcoholic beverage. In the night-shift status, the participants started the experiments at 1:00 AM, after not having slept for at least 12 h prior to the experiments. Participants were required to not sleep for a minimum of 12 h to mimic the sleep deprivation caused by night shifts. Consider a night shift worker who works from 10:00PM to 6:00AM, and sleeps from 8:00AM to 2:00PM. By the middle of the shift, the worker will have not slept for 12 h, and will have not slept for more than 12 h by the end of the shift. To create the inebriation status, participants were asked to consume a 40%-alcohol Vodka drink 1 h before the experiments; the amount consumed was designed to reach a BAC level of 0.07% (Section 2.4). After the tiling tasks were completed, work quality was determined by photographing the tiles that were fixed and comparing them with a standard tiling alignment by using a computer program.

The National Institute on Alcohol Abuse and Alcoholism (2013) evaluated the impairment caused by alcohol overdose based on BAC levels, which are expressed as a percentage of alcohol in the blood. In our experiments, we chose the BAC level of 0.07% as the inebriation status, which was reported to produce the adverse effects of impaired coordination, balance, attention, and memory. The Institutional Review Board of Taipei Veterans General Hospital approved the protocol of these experiments.

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