Biometrics analysis on hazard awareness of construction workers

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Abstract
For many years the construction industry has had a poor reputation for safety standards. In this research, we interviewed construction workers who met with work related accidents over the past 5.5 years and discovered that some of the accidents can be prevented if the workers possess sufficient good hazard awareness. In view of this, this paper mainly sheds light on hazard awareness. It firstly provides a general overview of the factors that lead to construction accidents. Followed by the review of previous studies on construction hazard awareness. It summarizes the experiences of some accidents which are related to the lack of construction hazard awareness according to worker interview responses and subsequently proposes the application of mouse tracking, eye tracking and EEG methods as preventive safety measures, to study the hazard identification of the workers before they work on sites.

1. The background of construction safety awareness

As one of the largest employers worldwide, the construction industry plays a vital role in global economy (1), however, it has always recorded a high level of accident rates and insurmountable accident compensation (2, 3). Many of these occur due to unstable load and structure, equipment failure, etc. That may also happen when workers engage with formwork and reinforcement. Nevertheless, risk factors such as the dangers of hazardous chemicals and falling objects tend to frequently be neglected (4). Moreover, the construction industry faces challenges, such as shorter project completion deadlines but with an increase in scope requirements, project complexity, economic uncertainty and high business competition with low profit margins; factors which demand the development of new management approaches (5).

Furthermore, the construction practitioners rely on intuition and experience and tend to underestimate the production system dynamics (5). Therefore, construction works are considered high-risk activities.
Recently, albeit the construction industry is high risk, on-site workers possess poor hazard identification awareness and skills, as many workers lack education and training (6). Some workers are migrants who cannot understand the local language well, others may not be aware of the potential hazard at work. In fact, it is undeniable that carelessness and negligence at work often lead to accidents and subsequent unavoidable costs to contractors and developers who have the obligation on sites safety issues under the present legal framework (7). Thereby, safety training before and during construction is essential to all participants as collective safety behavior contributes to safety practices (8).

Apart from misconduct amongst the construction personnel on sites, the modified domino theory suggests the organization is equally important in sharpening the safety system (9). Therefore, it can further imply the construction accident is a consequence of a combination of multiple factors, while misconduct by workers is one of a broad range of concerns. Alarcon, Acuna (6) summarize the essential factors in construction safety management from literatures from 1976 to 2016. It denotes 12 possible factors while three of them are primarily agreed upon as the most significant in survey results, which are safety training, management commitment and worker involvement. Besides, there are various models and tools created to assess the construction safety awareness. For instance, Garrett and Teizer (10) devised the Human Factors Analysis Classification System (HFACS) based on the framework of human error awareness training (HEAT) to evaluate safety awareness in a construction project. Externally, the management safety commitment is another well-recognized concern in construction safety awareness enhancement (11).

2. Methods which may enhance construction hazard awareness

Construction safety awareness can be enhanced in the teaching and learning paradigm (12), which is especially important to young construction workers. Since sufficient safety knowledge is the precondition in safety awareness, safety training has become an indispensable element in enhancing safety awareness. And all the stakeholders on the construction sites should possess adequate skills in hazard identification (13). However, the impact and effectiveness of safety training on hazard awareness is still controversial, in spite of there being several literatures to support the significance of the correlation between safety training and working behavior (14, 15). Furthermore, the content of safety training is crucial to increase the engagement among trainees (16).

Regarding the content of training, there are different approaches, such as action regulation theory (17) and behavioral learning theories (18), indicating the training program does not merely provide information but also frames the behavioral pattern to trainees (19). Although behavior and knowledge acquisition can be enhanced by safety training, meanwhile, in evidence, the outcome is rather uncertain after eliminating the self-selection bias (19).

Apart from safety training, as has been discussed, there are multiple possible factors which potentially influence construction safety awareness, there exists several evidences on the composite factors research. In Australia, in the extent of funding to safety training issues, industry associations, and agency problems whereby funds are misallocated to unintended areas such as membership expansion (20).

Regarding organizational structure, the condition of agency problems is more dominant in that construction safety awareness tends to shift into unanticipated reluctance while associations generally perceive that training and construction safety related support is sufficient (21). However, after imposing the new Construction Induction Training (CIT) which is mandated by Australian government, the actual impact in awareness improvement is positive (21).

In Chile, according to Alarcon, Acuna (6), rewards increase the safety awareness while audit and monitoring have a slightly negative impact on it. In New Zealand, from a series of structural equation models, it emphasizes the importance of production pressure towards safety awareness (22). In China, the safety commitment and employee involvement are also noted as important factors to correct construction safety
culture (23). In Hong Kong, according to Li, Lu (24), the proactive construction management system (PCMS) based on the behavioral-based safety (BBS) approach can provide significant improvement in safety performance and knowledge.

3. Interview results of construction workers who met with construction accidents

To understand the causes of construction accidents, we conducted in-depth, semi-structured interviews with approximately 40 construction workers who met with accidents over the past 5.5 years. We asked them about what they were doing at the time of the accidents and their viewpoints with regard to the causes of construction accidents. We discovered that many of the accidents happened on skyscraper projects and civil engineering works, mainly due to the lack of safety awareness.

For example, in the case of skyscraper construction projects, one worker met with an accident when he placed a nail on the ground. He subsequently stepped on the nail and injured his foot. Another worker, wanting to complete a job earlier and who was not aware of a machine on site. His foot was broken by the machine. Another worker who was constructing the safety bridge for a skyscraper project, was injured when a piece of concrete dropped on the bamboo and crashed onto his head. Another worker was injured while working on a low-rise building on site when he fell into a hole with iron bars inside and his legs were pierced by the iron bars.

Likewise, on a civil engineering project, one of the workers was injured when he stepped into a burrow which had not been covered with its lid but simply with a canvas only. In another case, on a road construction project, a worker in a hurry to leave the site after completing his day’s work, decided to take a short cut by climbing over the worksite fence. He carelessly fell from the fence and injured both his knees.

4. The feasibility of application of EEG, mouse tracking, and eye tracking methods to enhance construction workers’ safety awareness

There are several psychological tools that can be applied in the construction industry to track workers’ safety awareness. For example, the electroencephalogram (EEG), mouse tracking and eye tracking methods are fantastic tools to evaluate and estimate worker safety awareness in the construction project before the workers begin their work on sites. Meanwhile, those methods have never been applied practically in the construction industry.

The eye tracking focus on the target object which the worker is about to handle. When a worker is observing an object, that demonstrates the idea "over the stack" of psychological procedures. This "eye-mind" speculation implies that eye-development accounts can give a dynamic hint of where a man's consideration is being guided in connection to a visual show. Estimating different parts of eye developments, for example fixations, can likewise uncover the measure of handling being connected to objects at one specific object. By and by, the way toward gathering helpful data from eye movement accounts includes the specialist characterizing areas of interests. Along these lines, the perception and location of interface components can be equitably assessed. For instance, in an errand situation where subjects are requested to seek for an object, a longer-than-anticipated gaze on the object before possible determination would show that it likely should be redesigned (25).

Furthermore, beyond the methods mentioned above, there is another innovative tool based on the mouse tracking method, called prospective memory (PM) (26). In the Hehman study, several techniques have been developed to examine the onset and timing of evolving decision processes or to test the competition between response alternatives at different time points and to assess movement complexity with spatial disorder analyses (27). Practically, it can concentrate and evaluate delayed behavior in a regular operational routine. Therefore, it can dominate the careless practice in operation.

The electroencephalogram (EEG) is the graphical note of the electrical movement of the cerebrum. It depends on a scientific procedure called the Fast Fourier Transform (FFT), which isolates a complex
sinusoidal wave into a total of straightforward wave types of particular voltage and frequency. In this way, cerebral rhythms can be utilized as biomarkers of physiological and neural conditions of rest and movement. Neural motions and their synchronization may speak to a multifunctional signal to comprehend the flexible correspondence inside and between cortical regions. There is wide proof that intellectual capacities are related with the synchronized oscillatory action, proposing a useful instrument of neural motions in cortical systems. Notwithstanding its role in typical psychological work, there is developing proof that the changed oscillatory movement may be related to certain neuropsychiatric issues, for example, schizophrenia (28).

On-site safety management can make use of EEG tracking to monitor potential worker misconduct. Generally, the application of this composite method has found that it is able to track the user behavioral patterns (29, 30). Therefore, it can systematically establish a regular operational routine during which the worker can be reminded remotely if they omit any safety concern.

All in all, an effective human-machine interface, the composite application of EEG and eye tracking methods is capable of distinguishing a human’s intentional and spontaneous eye movements (30). Similarly, the composition method of eye tracking and mouse tracking has an additional benefit in that it has a similar performance with lower costs (31).

5. Conclusion
Many of the construction accidents can be avoided if workers have high level of hazard awareness. In this research study, we have interviewed 40 construction workers who came across accidents over the past 5.5 years and discovered that quite a number of these accidents can be avoided if the workers have high level of safety awareness.

Acknowledgement
The authors would like to thank the financial support from Research Grant Council Faculty Development Scheme “Construction safety index for skyscrapers in Hong Kong: A Multi-criteria decision-making approach” UGC/FDS15/E01/15.

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