The availability of wearable-device-based physical data for the measurement of construction workers’ psychological status on site: From the perspective of safety management

Hongling Guoa,⁎, Yantao Yua, Tian Xianga, Heng Lib, Dan Zhangetc

a Department of Construction Management, Tsinghua University, Beijing, China
b Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, China
c Department of Psychology, Tsinghua University, Beijing, China

ARTICLE INFO

Keywords:
Construction safety management
Construction worker
Unsafe behavior
Psychology
Wearable devices

ABSTRACT

Workers’ unsafe behaviors have been recognized as one of the main causes to construction accidents, while the existing research shows that workers’ psychological status on site has a direct influence on their behaviors. Thus monitoring workers’ psychological status may benefit the reduction of unsafe behaviors on site, thus preventing accident from occurring. However, due to the lack of appropriate methods to collect jobsite workers’ psychological data, it is difficult for the existing research to reveal the relationship between psychological status and unsafe behavior. This research proposes an efficient wearable technology-based method to collect jobsite workers’ psychological data to support such an analysis. Wearable-device-based physical data collection has been regarded as a promising approach to study human’s psychological status in the field of psychology, and applied to pedagogy and clinical psychology, but seldom in the construction industry. The purpose of this research is to study the availability of the approach in construction safety management. To do this, an on-site experiment was conducted to collect workers’ physical data via using wearable devices, as well as psychological data through the use of PANAS (Positive and Negative Affect Schedule) and DRM (Day Reconstruction Method). Based on the data, the correlations between workers’ psychological status and physical data are analyzed. The results show that jobsite workers’ physical data is available for the measurement of workers’ psychological status. This research will contribute to the research on jobsite workers’ psychology in the context of real construction sites, as well as the identification of the mental causes of workers’ unsafe behaviors on site, thus improving the performance of construction safety management.

1. Introduction

Due to the high hazard of the construction industry, construction safety management is attracting academics and practitioners more and more. It has been proved that jobsite workers, as the direct victims of accidents, are one of the main reasons for construction accidents [9,10,33,38]. Workers’ behaviors and safety awareness are two important aspects of construction safety management. Although a variety of safety measures have been taken to improve workers’ safety awareness and behaviors, such as safety education and training [17,29], safety inspection [31] and safety monitoring [8,18], etc. construction accidents caused by workers’ unsafe behaviors still occur in construction sites every day. This means that some jobsite workers still perform unsafe behaviors even though they know how to safely operate in construction sites via safety education and training. Therefore, it is significant to further reveal the mental causes of unsafe behaviors to aid in the development of safety management measures.

According to the theory of behavioral psychology, human behavior is always the outward manifestation of a certain psychological status [2,30], and external intervention often affects human behavior through mental factors [32,44]. Things go the same in construction safety management. It has been proved that mental factors influence workers’ safety behavior directly, and other factors, such as safety culture, work conditions, ages and so on, also affect workers’ safety behavior by influencing their psychological status [7,39]. For example, both positive emotion induction and negative emotion induction decrease workers’ hazard identification skills [4]; workers’ optimism has an impact on decision-making on unsafe behaviors [37]; workers’ psychological climate influences their safe behaviors [26]. Thus, it is crucial to analyze construction workers’ psychological status to improve the performance...
of construction safety management.

The psychological data of jobsite workers is the foundation of analyzing workers' psychological status, but it is a tough task to collect such kind of data due to the following reasons:

1) Instantaneity: Psychological status varies continuously with time, therefore it is necessary and important to collect relevant data in a real-time way. However, this is still an unsolved problem in the construction industry, because the previous data collection equipment is too big, thus disturbing workers' operating activities.

2) Contextuality: Psychological data has a close relationship with construction environments, thus relevant data needs to be collected on site. As mentioned above, it lacked available devices to do this. Although the Day Reconstruction Method (DRM) [17] may be used to collect the data related to workers' psychology, it is difficult to do this in practice particularly for a large number of workers. The method normally requires a series of short-term-interval questionnaire or interview to responders or interviewees, who are asked to recall what happened to themselves in the past interval time. It is found from a pilot study that it is difficult for the workers to do this even for half a day. This may be due to that the workers felt exhausted so much after work.

Previous research on construction workers' safety psychology involves workers' safety awareness, safety thinking rules, and the influence of psychological status on safety behaviors. Construction workers' safety awareness has a great effect on their safety behavior [7,40]. To understand workers' safety awareness better, an indicator system was established to evaluate workers' safety awareness, and was applied in real construction projects to collect and analyze workers' safety awareness. Relevant safety measures, e.g. safety training [25,29], have also been taken to improve workers' safety awareness, but it is useless to reduce deliberate violations. Some research, therefore, studied workers' safety thinking rules for a certain safety behavior or accident type, such as the psychological causes for not wearing personal protective equipment [11] and workers' estimation of occurring probabilities of different types of accidents [6]. All the above research contributes to the improvement of construction safety management to some extent, but the results are not persuasive enough as the data collected are not objective and timely. Psychological data is commonly collected through on-site observation, questionnaire, interview, scene simulation, etc. [1,7,10,21,39], which are easy to be operated, but have the following drawbacks:

1) Not objective enough

The questionnaire or interview methods are to collect data based on workers' responses. It is difficult to judge whether or not a worker lies, as the worker may lie because of distrust in the privacy of experiment or vague memory, thus resulting in inaccurate data.

2) Not timely enough

Questionnaire or interview can only be conducted when a worker is taking rest. At that time, the worker may provide inaccurate answers due to forgetting relative information. In addition, the data before and during violation contains some important information, which is useful for the analysis of the causes of unsafe behaviors. Thus the timeliness of data is very important.

3) Highly-cost

The questionnaire method requires much time and labor force to send out and collect questionnaires. Besides, some workers, especially in the developing countries or regions, are not educated well. As a result, extra time is needed to explain the questionnaire and record the workers' responses. On the other hand, the interview method is almost not feasible since many interviewers are needed to match with a large number of workers. In order to solve the problem, some research in the field of psychology proposed an indirect method to monitor workers' psychological status by collecting their physical data. Physical indicators include three categories: cardiovascular system indicators, electrodermal indicators, and respiratory indicators [24]. Cardiovacular system indicators include heart rate, heart rate variability, stroke volume, etc. [3,14,28,34,41]. Electrodermal system indicators mainly measure skin conductance, which varies because of sweat [12,16]. Respiratory indicators include respiration rate, respiration depth, end-expiratory pCO2, etc. All of the above indicators have been proved to be related to psychological status. However, most of the above indicators require heavy devices, limiting their application in the construction industry.

Wearable sensors make it possible to collect physical data timely and accurately without influencing construction workers' normal work [13]. They are so small and light, thus being easily quipped on site workers directly or with work clothes or watches. Moreover, such kind of sensors is not easily disturbed by complex or dynamic environment, therefore making sure the accuracy of physical data. It is believed that wearable technology is more available for the collection of jobsite workers' physical data. For example, wearable sensors have been used to identify workers' emotions with ANS (Autonomic Nervous System) indicators [15], distinguish positive and negative emotions with heart rate average, heart rate variability and skin electricity [43], and reveal psychological characteristics such as personality, emotion and happiness, etc. [19,22]. Although the technology has been applied in pedagogy and clinical psychology [5], it doesn't necessarily means that the technology is also suitable for construction safety management. The experiments of other industries were usually conducted indoors, where human's daily activities are very simple. On the contrast, construction workers' operating activities are more tiring and diversified. These activities can also lead to changes in physical indicators, disturbing the potential relationships between psychology and unsafe behaviors. As a matter of fact, such physical indicator monitoring methods have been applied in the construction industry to monitor workers' physical status such as fatigue and musculoskeletal disorders [23,27], but none of the research focused on construction worker's psychological status.

This research proposes a real-time and objective method to collect workers' psychological data by using wearable technology and demonstrates its feasibility with real data collected from real construction sites. The proposed method improves an indoor psychological method through involving indicators reflecting sports amount to eliminate the influence of operating activities on physical indicators, and demonstrates the feasibility of using physical data to measure construction workers' psychological status on site with wearable devices. In the following sections, the research method is presented first; then an experiment is designed and conducted, and workers' physical and psychological data is collected; furthermore the research results are described with data analysis and discussed; in the end, a conclusion is drawn.

2. Research method

This research explore the possibility of a new approach to measuring construction workers' psychological status by using workers' physical data collected by wearable devices in real time. The logical framework of research method is shown in Fig. 1.

2.1. Psychological data collection

Jobsite workers' psychological data needs to be collected to aid in the analysis of the possibility of using physical data to measure psychological status. There are many different kinds of indicators that can describe psychological status, such as emotions, personalities and...
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات