Heliyon 9 (2023) e20370

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

# Characterizing the relationship between personality traits and safety motivation among construction workers

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ARTICLE INFO

*Keywords:*
Construction worker
Safety
Personality traits
Psychological needs
Motivation

ABSTRACT

Injury rates in the construction industry have been high. Losses from a construction accident are not limited to the high expenses of the delay in construction and the compensations for the injured workers, sometimes even the worker's life. The worker's unsafe behaviors have been the direct cause of an accident, and it is urgent to reduce them effectively. This study examines the relationships between personality traits, psychological needs, and safety motivation. It attempts to provide evidence and support for using personality traits and psychological needs in improving practical construction safety interventions. First, the constructs for personality traits, psychological needs, and safety motivation have been contextualized for application in the construction industry. Second, hypotheses about the relationships among the three constructs were established based on the literature, and a social survey was conducted to collect data for testing the hypotheses. Third, structural equation modeling was used to investigate the association between the three key constructs. The study found that conscientiousness is associated with social identity and intrinsic safety motivation, and extraversion is related to the worker's self-efficacy and extrinsic motivation. Openness to experience is positively associated with work autonomy and self-efficacy; conscientiousness is positively related to social identity, as well as extraversion to self-efficacy, agreeableness to work autonomy, and neuroticism to self-efficacy. The findings of this study contribute toward a better understanding of how personality accounts for differences in psychological needs and safety motivation and how these differences can be used in customized safety interventions. This study guides using personality traits in promoting safety motivation and shows that assessing personality traits can be a helpful tool in designing customized safety interventions.

## 1. Introduction

### 1.1. Background

Safety has been one of the most important goals of onsite construction management. The accident rate at a construction site is still high, although it has been reduced [1]. For example, according to the U.S. Bureau of Labor Statistics, fatal work injuries in the

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https://doi.org/10.1016/j.heliyon.2023.e20370
Received 22 April 2023; Received in revised form 15 September 2023; Accepted 20 September 2023
Available online 21 September 2023

construction industry dropped from 1102 in 2019 to 1034 in 2020, which still accounts for over 1 in 5 workplace deaths. Accidents are costly. According to the U.S. Workplace Safety and Insurance Board, the average cost of one lost-time accident on a construction site is $35,000, in addition to the litigation fee, medical expenses, and compensation. It is important to enhance construction safety management. Construction workers' unsafe behaviors have been regarded as the major cause of onsite accidents and incidents [2,3]. Thus, the worker's unsafe behavior has been a key concern of safety management.

Motivation is important in the construction worker's behaviors at work [4]. It refers to "the set of psychological processes that cause the initiation, direction, intensity, and persistence of behavior" [5], and safety motivation can be defined as "an individual's willingness to exert efforts to perform safety behaviors and the valence associated with those behaviors" [6,7]. The role of safety motivation on safety behavior has been investigated by many studies [6,8–10], and it has been an important factor in occupational health and safety for construction workers. For example, it is essential to the worker's compliance with safety rules and participation in relevant safety activities [7]. According to the Fogg Behavior Model [11], a targeted behavior must be sufficiently motivated to be triggered. Safety motivation also mediates the relationship between psychological capital and safety behaviors [10]. Researchers also have attempted to discover the drivers behind safety motivations. For instance, safety attitude and leadership can partially predict safety motivation [8]. However, the impact of safety motivation has attracted more public attention [12] other than the factors influencing safety motivation or how to raise or promote the motivation for safe behavior on a construction worksite.

Safety management measures can encourage positive safety behavior by raising the workers' safety motivation [6,13]. Higher safety participation is more likely to result from intrinsic rather than extrinsic motivation [14], where intrinsic motivation is the motivation generated by one's inherent satisfaction, while extrinsic motivation is the motivation that can be extrinsically pressured [15]. Thus, the level of safety motivation and its type are both important. However, safety interventions such as behavior-based safety programs emphasize external stimuli more [16], focusing more on the symptoms than the root causes, namely the internal processes of behavioral engagement [17]. To be specific, safety management has long used monetary incentives and punishment to motivate construction workers [4], but the effects are not long-lasting because of neglecting the construction worker's psychological characteristics [17]. Socio-psychological factors such as worker participation, recognition, and team belongingness can effectively motivate construction workers [18]. Thus, it is an important opportunity to use safety motivation to reduce the worker's unsafe behaviors. Nevertheless, there is a gap in finding a way to improve the worker's source of safety motivation from an inner perspective.

According to the self-determination theory, the type of motivation is determined by three psychological needs: (i) autonomy, which refers to freedom from manipulation or coercion; (ii) competence, which refers to the belief that one can control the outcome; and (iii) relatedness, which refers to a sense of affiliation or belonging to the group [15]. Self-determination theory offers a more detailed understanding of human motivation by addressing psychological needs. Based on this theory, motivation, being a cognitive phenomenon, is fueled by psychological needs. However, there has been no answer for whether the logic of self-determination theory is suitable for construction safety management, how to contextualize these three needs in construction workers, and how to examine the relationships between the psychological needs of construction workers and their safety motivation.

In addition, personality trait testing can reveal a person's behavioral pattern and cognitive style [19,20]. Links have been found between personality traits and workplace safety [21] and a construction worker's safety behavior [22], and they even have a significant impact on behavioral intentions [23]. A construction worker's personality has also been related to their perception of job stress [24] and their opinion of the safety climate [25] that can influence their level of safety motivation. However, there is a research gap in investigating the relationship between personality traits and safety motivation. Bridging this gap can help recognize the importance of individual differences and explore the workers' psychological characteristics, which is of great importance for improving the understanding of safety behaviors at the workplace and contributes to implementing better onsite safety interventions.

### *1.2. Aims and hypotheses*

To this end, this study aims to look into the relationship between personality traits, psychological needs, and safety motivation and to provide implications for promoting safety motivation by taking psychological needs and personality traits into account in safety practice.

#### *1.2.1. Self-determination theory*

Self-determination theory provides a solid theoretical foundation for hypothesis development. It helps define the types of safety motivation, guide the contextualization of the construction worker's psychological needs, and elaborate the relationships between the two constructs.

Self-determination theory [15] distinguishes six motivation categories according to the regulatory style and the degree of autonomy: amotivation, extrinsic, introjected, identified, integrated, and intrinsic motivation. Amotivation refers to a person who is not motivated due to being non-intentional and incompetent [15]. Extrinsic motivation refers to external stimuli such as punishment and rewards. Introjected motivation elicits behavior motivated by regulations, but the worker personally cares little about the behavior itself. Integrated motivation is present when the person fully accepts the extrinsic regulations, but the purpose of the behavior is still to attain external outcomes. Identified motivation indicates that the worker is conscious of the behavioral goal and is somewhat driven by personal value. Intrinsic motivation occurs when the behavior is performed because of self-satisfaction. Introjected, identified, and integrated motivations can be extrinsically regulated and categorized into extrinsic motivations [15], which was also confirmed by Fleming and Scott [26]. In response to management interventions, construction workers can exhibit intrinsic or extrinsic motivation [12,14]. For the purpose of this study and the practicality of implementation in construction, we distinguish three different kinds of safety motivation: amotivation, extrinsic, and intrinsic motivation.

Self-determination theory also posits three basic psychological needs directly related to mental well-being: autonomy, competence, and relatedness [15]. Fulfilling needs is considered central to motivation [4]. A more supportive social context of autonomy, competence, and relatedness can promote positive change in motivation [15]. The need for work autonomy refers to the ability to control the method and actions used to complete tasks [27]. Construction workers may select their preferred working method for some tasks. The need for competence refers to self-perception and belief in competence at work [15]. On the construction site, self-efficacy at work refers to the belief in one's capabilities to accomplish the assigned task [28]. The need for relatedness or a sense of affiliation is met by identifying with the project and workgroup and feeling like a project member [29].

### *1.2.2. Big-five theory of personality*

Personality traits are the observable behavioral, thoughts, and emotional patterns that can group persons [30]. The Big Five framework of personality traits by McCrae and Costa [31] has been a reliable and practical model for analyzing the connection between personality and work behaviors [32]. It posits that personality traits comprise five dimensions: Openness to experience (O), Conscientiousness (C), Extraversion (E), Agreeableness (A), and Neuroticism (N) [20].

Openness to experience shows that the person is innovative and excited about the new experience [20,33]. The workers with high openness to experience also showed highly intelligent creativity in work [20]. They may also be more stimulated and more likely to engage in risky behaviors in a new environment [23]. Conscientiousness indicates the level of the worker's organization, persistence, dependability, and hard work [20]. A high score in extraversion means that the worker is more likely to draw motivation (energy) from social interactions [20]. Agreeableness can provide information on the worker's cooperativeness and friendliness to others [20]. The highly agreeable person tends to care about the benefits and safety of others [20]. Neuroticism measures the worker's emotional stability, self-consciousness, impulsiveness, and vulnerability [20]. The worker with lower neuroticism is more emotionally stable. Personality traits have been found to be stable in working-age adults [34], making them meaningful for safety management.

### *1.2.3. Hypotheses development*

a) Psychological needs and safety motivation

Work autonomy is limited and controlled by extrinsic pressure sources such as norms and regulations on a construction site. Work autonomy can decrease work engagement, including safety-related participation [30], revealing a possibility of work autonomy relating to amotivation. Self-efficacy has been regarded as one of the dimensions of psychological capital [35] and its relationship with safety behavior has been tested [10,36] as well as that between social identity and safety behavior [37]. Motivation is a necessary driver for behavior [26]. These lead to the second hypothesis, H1 (see Fig. 1). In this paper, the following mentioned "amotivation", "extrinsic motivation", and "intrinsic motivation" refer to the three kinds of safety motivation.

**H1.** *Psychological needs are associated with different safety motivations: amotivation, extrinsic, or intrinsic motivation.*

b) Personality traits and psychological needs

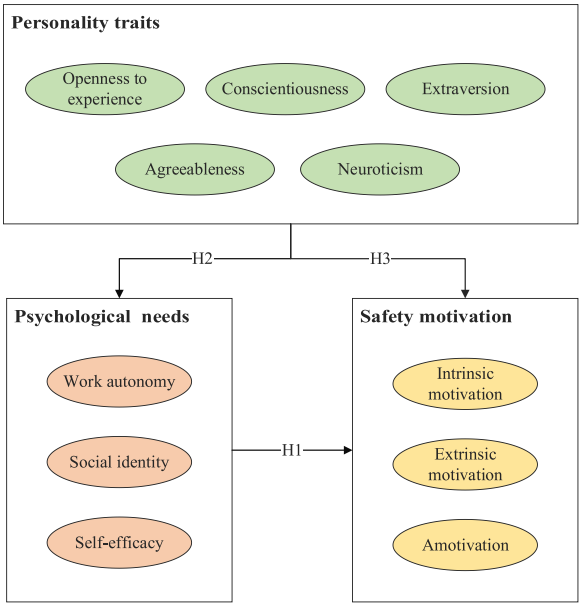


**Fig. 1.** Study hypotheses.

Theoretically, the Big Five traits are regraded correlated with psychological need satisfaction [38]. In terms of autonomy, conscientiousness's goal-driven persistence and extraversion's reward-driven desire promote the degree of autonomy, while negative relationships between neuroticism and a degree of autonomy stem from its ability to regulate emotions like regret and pride [39]. Evidence also shows that personality links to the level of self-efficacy among adolescent samples [40]. Conscientiousness and neuroticism were found related to relatedness [41]. The literature suggests some connection between personality traits and psychological needs, but whether the same links and their strengths exist in construction workers has not been investigated. This leads to the first hypothesis, H2 (shown in Fig. 1).

**H2**. Personality traits are related to psychological needs among construction workers.

c) Personality traits and safety motivation

Motivation is a complex psychological process that influences a person's behaviors [5]. Personality traits have been found to be predictors of a person's motivation [42] and influence how people face the environment and how they can be motivated [43]. For example, extraversion is associated with intrinsic motivation for active coping [44]. Safety motivation is crucial to construction workers' safe behavior [26]. Evidence shows that personality traits possibly link to safety motivation. For instance, consciousness has been found to be the most-related personality trait to safe behavior because the responsible nature of these traits motivates the workers to obey safety regulations [23]. In addition, personality traits are associated with construction workers' risk propensity [23] that weakens motivation for safety, and influence the motivational force for unsafe behavior [45]. Thus, there is the possibility that personality traits reveal information about the construction workers' safety motivation. This leads to the third hypothesis, H3 (see Fig. 1).

**H3**. Personality traits can be associated with the construction workers' safety motivation.

## 2. Materials and methods

### *2.1. Data collection*

A social survey including two steps was conducted for data collection. The first step was the interviews with the project managers from the construction company and the two subcontractors before sending the questionnaire to the participants, to ensure that the questionnaire items were understandable for them. The second step was inviting the construction workers to respond to the online questionnaires. The idea of the cluster sampling strategy was used to select the participants. Two general types of workers on a construction site are managerial personnel and frontline workers. Thus, the two groups should be included. Considering that the frontline workers are the majority on a construction site and the number of them is based on the construction stage, the research team did not set a percentage of the two groups. Then the workers from the two groups were invited to participate in the social survey through simply random sampling, and their trades were supposed to include the common ones on a construction site.

The online questionnaire contained 11 variables from the three dimensions, as shown in Fig. 1. The five-point Likert scale (1 = strongly disagree to 5 = strongly agree) to measure each variable except for personal particulars. The items of the online questionnaire were adopted from previous studies, and the details are as follows. The whole questionnaire can be found in the supplementary material.

a) Personal particulars

Background information on gender, age, educational level, work experience, and the type of project experience was gathered using multiple-choice questions.

b) Personality traits

A questionnaire (BFI–S) adopted from Zhang, Xiang [23] assessed personality traits. There were three questions for each personality variable, making 15 questions. The items were coded into O1, O2, O3, C1, C2, C3, E1, E2, E3, A1, A2, A3, N1, N2, N3.

c) Psychological needs

Work autonomy was assessed using three questions (i.e., WA 1), WA 2), WA3)) from Cheung, Zhang [35], social identity was measured by the items developed by Choi, Ahn [29] (i.e., SI1), SI2), and SI3)), and the measurement for elf-efficacy is through SE1), SE2), and SE3) developed by Nykanen, Salmela-Aro [13], He, Jia [36].

d) Safety motivation

Several scales can measure safety motivation [4,10,12–14]. To shorten the questionnaire and make it less time-consuming, the authors adopted the scale for measuring safety motivations from Wen Lim, Li [14]. This survey categorized safety motivation into amotivation (AM1, AM2, AM3), extrinsic motivation (EM1, EM2, EM3), and intrinsic motivation (IM1, IM2, IM3).

### 2.2. Participants

Up to 1150 construction workers were invited, but only 784 valid responses, giving a recall rate of 68.17%. Among the 784 respondents, only 39 workers have had injury experience in the recent five years, as shown in Table 2. There were 597 frontline workers, 59 supervisors, 56 safety officers, 32 construction technicians, 31 safety/project managers, and nine documenters (the person in charge of the construction documentation) among the respondents, as shown in Table 1. Many of the respondents were aged 31–40, the youngest participant was under 20 years old, and the oldest worker was over 50 years old. The educational level was mostly technical school or compulsory education (i.e., preliminary school and middle school). A large percentage of the respondents were not highly experienced, for 51.66% of the participants have less than six years of work experience. The trades of the 597 frontline workers include common ones on a construction site, namely 84 steel fixers, 78 handymen, 66 plumbers, 51 curtain wall installers, 44 scaffolders, 66 concreters, 14 crane operators, 42 equipment workers, 68 form fixers, 26 steel erectors, and 58 foremen, as shown in Fig. 2.

This study obtained ethical approval from the Ethical Review Committee on scientific and technological research involving humans of Shanghai Jiao Tong University with batch No. E2022002I. All the participants were informed about the aims of the social survey, and their consent for the data analysis was obtained.

### 2.3. Statistical analysis method

Factor analysis was first used to establish the validity of the survey. The I.B.M. Statistic Package for Social Science [46] version 24.0 was employed to examine the reliability and structure of the questionnaire data as the basis for a Structural Equation Model (SEM). The SEM includes both a measurement test of the relationships between the latent variable and its indicators, and a structural test of the relationship between different latent variables. It can test the hypotheses of the causal relationship between the latent variables and the indicators, and the theoretical model formed by the interaction between the latent variables [47]. The SEM technique is appropriate for exploring the relationships between personality traits, psychological needs, and safety motivation hypothesized in Fig. 1. It was performed using SPSS AMOS 24.0. The confirmatory factor analysis through SEM also provided information to check convergent validity and discriminant validity. Ten indices were used to test the model's fitness.

## 3. Results

### 3.1. Preliminary analysis

11 factors were identified in the data. Personality traits (OCEAN), psychological needs (WA, SI, SE), and safety motivation (AM, EM, IM) are the three dimensions covered by the factors. The data for each question has been numbered to identify the associated question item, e.g., the three indicator questions used to measure openness to experience were labeled as O1, O2, and O3.

Table 2 presents factor loading for each indicator in order of decreasing value and has been bolded to distinguish them from the values of cross-factors. Factor loading is indicative of the significance of a factor. The criteria of factor loading have been different. For instance, Kolar and Zabkar [48] claimed that the factor loading should be over 0.6 in their study, while a more common threshold was 0.4 by Byrne [49]. The cross-loading should also be less than 0.3 to discriminate between factors [50], and the low the better [51]. In this study, all the factor indicators generally had loading values greater than 0.6, and all cross-factor loadings were less than 0.3. The 33 items, divided into 11 factors, account for 84.726% of the total variance. In addition, $\chi^2 = 20882.121$ and $p < 0.001$ indicate that the data can be used to attempt to build the SEM.

### 3.2. Measurement model test

The Cronbach's Alpha value for all the variables is over 0.7, indicating that the reliability and stability of the dataset are acceptable [52]. T-tests were carried out to test the difference between the indicators. In this study, all the indicators passed the T-tests; the results

**Table 1**
Participants' distributions.

| Gender | | Age | | Education | | Work experience | | Trades | |
|---|---|---|---|---|---|---|---|---|---|
| Female | 159 (20.28%) | <20 | 10 (1.28%) | Compulsory | 170 (21.68%) | <1 | 99 (12.63%) | Frontline worker | 597 |
| Male | 625 (79.72%) | 21–30 | 279 (35.59%) | High school | 139 (17.73%) | 1–5 | 306 (39.03%) | Supervisor | 59 |
| | | 31–40 | 336 (42.86%) | Technical school | 336 (42.86%) | 6–10 | 210 (26.79%) | Safety officer | 56 |
| | | 41–50 | 119 (15.18%) | Bachelor | 132 (16.84%) | 11–15 | 92 (11.73%) | Manager | 31 |
| | | >50 | 40 (5.10%) | Master | 7 (0.89%) | >15 | 77 (9.82%) | Documenter | 9 |
| | | | | | | | | Construction technician | 32 |

**Table 2**
Factor analysis results.

| Indicator | O | C | E | A | N | WA | SI | SE | AM | EM | IM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| O1 | **0.878** | 0.098 | 0.110 | 0.100 | 0.194 | 0.071 | 0.100 | 0.081 | 0.096 | 0.079 | 0.064 |
| O2 | **0.844** | 0.206 | 0.012 | 0.000 | 0.189 | 0.073 | 0.091 | 0.158 | 0.029 | 0.021 | 0.112 |
| O3 | **0.818** | 0.237 | 0.022 | −0.045 | 0.201 | 0.097 | 0.152 | 0.087 | 0.089 | −0.001 | 0.155 |
| C3 | 0.197 | **0.844** | 0.085 | 0.139 | 0.137 | 0.099 | 0.135 | 0.056 | 0.035 | 0.025 | 0.210 |
| C1 | 0.164 | **0.783** | −0.024 | −0.017 | 0.148 | 0.077 | 0.225 | 0.079 | −0.162 | −0.033 | 0.273 |
| C2 | 0.251 | **0.747** | −0.017 | −0.161 | 0.193 | 0.085 | 0.212 | 0.072 | −0.051 | −0.041 | 0.205 |
| E2 | 0.140 | 0.135 | **0.883** | 0.143 | 0.090 | 0.051 | 0.063 | 0.123 | 0.053 | 0.046 | 0.026 |
| E1 | 0.012 | −0.066 | **0.878** | 0.255 | −0.015 | 0.027 | −0.009 | 0.020 | 0.138 | 0.079 | −0.031 |
| E3 | −0.014 | −0.023 | **0.847** | 0.264 | −0.124 | 0.037 | −0.059 | 0.001 | 0.140 | 0.104 | −0.035 |
| A1 | 0.063 | −0.003 | 0.185 | **0.932** | 0.007 | 0.051 | −0.030 | −0.003 | 0.118 | 0.053 | −0.005 |
| A2 | 0.009 | −0.075 | 0.208 | **0.916** | −0.044 | 0.055 | −0.045 | 0.009 | 0.147 | 0.061 | −0.028 |
| A3 | −0.018 | 0.061 | 0.231 | **0.869** | 0.047 | 0.034 | −0.006 | 0.027 | 0.110 | 0.051 | −0.024 |
| N1 | 0.143 | 0.134 | −0.142 | −0.073 | **0.876** | 0.009 | 0.119 | 0.126 | −0.095 | −0.031 | 0.065 |
| N2 | 0.188 | 0.107 | 0.039 | 0.094 | **0.861** | 0.083 | 0.084 | 0.101 | 0.037 | 0.072 | 0.079 |
| N3 | 0.233 | 0.163 | 0.058 | −0.014 | **0.838** | 0.045 | 0.113 | 0.178 | 0.025 | −0.001 | 0.117 |
| WA1 | 0.066 | 0.079 | 0.019 | 0.070 | 0.057 | **0.913** | 0.190 | 0.084 | 0.046 | 0.047 | 0.075 |
| WA2 | 0.089 | 0.042 | 0.049 | 0.037 | 0.008 | **0.849** | −0.035 | 0.164 | 0.134 | 0.066 | 0.025 |
| WA3 | 0.056 | 0.091 | 0.040 | 0.032 | 0.065 | **0.820** | 0.196 | 0.153 | 0.004 | 0.102 | 0.039 |
| SI1 | 0.076 | 0.114 | −0.016 | 0.000 | 0.134 | 0.098 | **0.893** | 0.017 | −0.094 | −0.066 | 0.159 |
| SI3 | 0.187 | 0.104 | 0.002 | −0.045 | 0.081 | 0.143 | **0.812** | 0.187 | −0.030 | 0.008 | 0.133 |
| SI2 | 0.073 | 0.313 | 0.013 | −0.047 | 0.105 | 0.133 | **0.770** | 0.103 | −0.095 | −0.030 | 0.170 |
| SE3 | 0.055 | 0.043 | 0.028 | 0.010 | 0.098 | 0.113 | 0.096 | **0.927** | 0.034 | 0.030 | 0.038 |
| SE1 | 0.098 | −0.011 | 0.058 | 0.058 | 0.110 | 0.166 | 0.030 | **0.856** | 0.118 | 0.091 | −0.011 |
| SE2 | 0.149 | 0.150 | 0.052 | −0.038 | 0.174 | 0.134 | 0.153 | **0.818** | −0.029 | 0.048 | 0.081 |
| AM1 | 0.071 | −0.078 | 0.126 | 0.127 | −0.018 | 0.069 | −0.069 | 0.029 | **0.882** | 0.242 | −0.107 |
| AM2 | 0.014 | −0.010 | 0.122 | 0.157 | 0.017 | 0.061 | −0.095 | 0.050 | **0.872** | 0.270 | −0.108 |
| AM3 | 0.129 | −0.059 | 0.108 | 0.140 | −0.032 | 0.081 | −0.060 | 0.065 | **0.866** | 0.259 | −0.090 |
| EM3 | 0.001 | −0.020 | 0.092 | 0.074 | 0.032 | 0.048 | −0.015 | 0.039 | 0.232 | **0.911** | −0.018 |
| EM1 | 0.019 | 0.050 | 0.049 | 0.018 | 0.057 | 0.074 | −0.035 | 0.026 | 0.231 | **0.857** | −0.022 |
| EM2 | 0.065 | −0.064 | 0.070 | 0.068 | −0.049 | 0.089 | −0.026 | 0.098 | 0.192 | **0.850** | 0.033 |
| IM3 | 0.097 | 0.126 | −0.024 | 0.020 | 0.077 | 0.045 | 0.144 | 0.034 | −0.004 | 0.044 | **0.911** |
| IM2 | 0.065 | 0.229 | 0.007 | −0.025 | 0.063 | 0.039 | 0.121 | 0.032 | −0.138 | 0.002 | **0.833** |
| IM1 | 0.136 | 0.189 | −0.023 | −0.057 | 0.106 | 0.057 | 0.160 | 0.037 | −0.140 | −0.063 | **0.820** |

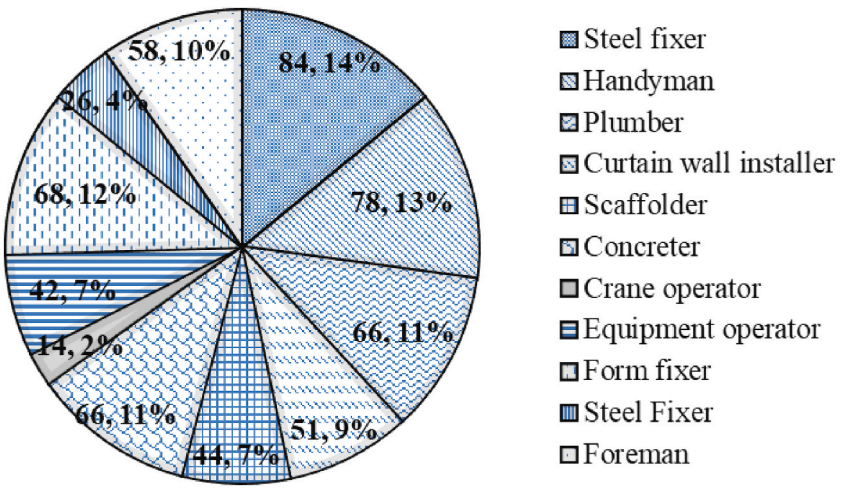


**Fig. 2.** Distribution of the frontline workers' trades.

are shown in Table 3. The consistency of the observable variables in relation to latent variables can be demonstrated by convergent validity. In this research, the composite reliability (CR) [52] and the average variance extracted (AVE) [53] were calculated to measure the convergent validity as well as the standardized factor loading (SFL) [54]. Convergence is acceptable when CR > 0.7, AVE >0.5, and SFL> 0.5 [54]. The indicators all meet the criteria, as shown in Table 3.

### 3.3. Structural model test

a) Overall fitness

The coefficients of the relationship between the 11 factors were estimated through the maximum likelihood estimate method [23]. Construct validity is assessed using ten commonly used metrics, as shown in Table 4. Three kinds of indexes can be used to examine the overall model fit: 1) parsimonious indexes, including PGFI (parsimony goodness-of-fit index), PNFI (parsimony normed-fit index), PCFI = parsimony comparative fit index, and $C^2$/d.f. = chi-square/degree of freedom); 2) incremental indexes (i.e., CFI = comparative fit index, TLI = Tucker-Lewis index, IFI = incremental fit index); and 3) absolute indexes (i.e., RMSEA = root-mean-square error of approximation, RMR = root mean square residual, GFI = goodness-of-fit index, AGFI = adjusted goodness-of-fit index) [55]. All the metrics for the indicators, tabulated in Table 4, meet the recommended values indicating that the overall model fit is good and the data is suitable for further analysis.

b) Results of the test of hypotheses

The three hypotheses H1 – H3 were tested and the association coefficients were calculated. H1 (psychological needs are associated with safety motivation: amotivation, extrinsic, or intrinsic motivation) is accepted to a large degree. As shown in Fig. 3, work autonomy is very significantly positively related to amotivation ($\beta = 0.124$), and so are social identity and intrinsic motivation ($\beta = 0.19$), whereas social identity and amotivation are negatively correlated ($\beta = -0.34$). There are three groups of positive related factors (i.e., self-efficacy & amotivation with $\beta = 0.09$, work autonomy & extrinsic motivation with $\beta = 0.117$, and self-efficacy and extrinsic motivation with $\beta = 0.105$) and one group of negative related factors (project identity & extrinsic motivation with $\beta = -0.192$). The exception is the relationship between conscientiousness and self-efficacy.

H2 (personality traits are associated with certain psychological needs) is partially supported. Conscientiousness has been positively associated with work autonomy ($\beta = 0.292$) and social identity ($\beta = 0.478$), and neuroticism is positively with self-efficacy ($\beta = 0.385$), as shown in Table 5. Agreeableness is positively related to work autonomy ($\beta = 0.136$) as well as neuroticism to social identity ($\beta = 0.101$), openness to experience to self-efficacy ($\beta = 0.236$), and extraversion to self-efficacy ($\beta = 0.177$) (see Table 5).

The results of the H3 (Personality traits can influence the workers' safety motivations) tests are shown in Table 5 and Fig. 3. H3

**Table 3**
Reliability, and convergent validity of factors.

| Dimension | Construct | Indicator | S.F.L. | T-value | Cronbach's Alpha | CR | AVE |
|---|---|---|---|---|---|---|---|
| Personality traits | O | O1 | 0.899 | 32.284*** | 0.753 | 0.907 | 0.765 |
| | | O2 | 0.858 | – | | | |
| | | O3 | 0.866 | 31.251*** | | | |
| | C | C1 | 0.850 | – | 0.738 | 0.879 | 0.707 |
| | | C2 | 0.847 | 28.516*** | | | |
| | | C3 | 0.826 | 26.767*** | | | |
| | E | E1 | 0.909 | 30.455*** | 0.744 | 0.898 | 0.747 |
| | | E2 | 0.834 | 27.849*** | | | |
| | | E3 | 0.848 | – | | | |
| | A | A1 | 0.96 | 58.793*** | 0.730 | 0.934 | 0.832 |
| | | A2 | 0.958 | – | | | |
| | | A3 | 0.811 | 35.516*** | | | |
| | N | N1 | 0.861 | 30.628*** | 0.751 | 0.898 | 0.746 |
| | | N2 | 0.834 | 29.331*** | | | |
| | | N3 | 0.895 | – | | | |
| Psychological needs | WA | WA1 | 0.992 | 26.812*** | 0.758 | 0.885 | 0.723 |
| | | WA2 | 0.758 | – | | | |
| | | WA3 | 0.782 | 23.61*** | | | |
| | SI | SI1 | 0.893 | 26.58*** | 0.711 | 0.875 | 0.701 |
| | | SI2 | 0.829 | 23.762*** | | | |
| | | SI3 | 0.786 | – | | | |
| | SE | SE1 | 0.869 | 34.465*** | 0.717 | 0.925 | 0.805 |
| | | SE2 | 0.928 | 37.75*** | | | |
| | | SE3 | 0.893 | – | | | |
| Motivations | AM | AM1 | 0.921 | – | 0.772 | 0.94 | 0.84 |
| | | AM2 | 0.921 | 43.637*** | | | |
| | | AM3 | 0.907 | 41.864*** | | | |
| | EM | EM1 | 0.823 | – | 0.797 | 0.902 | 0.755 |
| | | EM2 | 0.807 | 26.924*** | | | |
| | | EM3 | 0.967 | 32.473*** | | | |
| | IM | IM1 | 0.832 | – | 0.725 | 0.888 | 0.726 |
| | | IM2 | 0.823 | 25.982*** | | | |
| | | IM3 | 0.899 | 29.187*** | | | |

Note: *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$.

**Table 4**
Estimated values for goodness-of-fit indices.

| Fit index | Recommended value | Estimate |
|---|---|---|
| $C^2$/d.f. | ≥1 and ≤ 5 | 4.831 |
| GFI | ≥0.8 | 0.855 |
| AGFI | ≥0.8 | 0.815 |
| CFI | ≥0.9 | 0.920 |
| NFI | ≥0.9 | 0.902 |
| TLI | ≥0.9 | 0.904 |
| RMR | ≤0.08 | 0.068 |
| RMSEA | ≤0.1 | 0.070 |
| PNFI | ≥0.05 | 0.750 |
| PGFI | ≥0.05 | 0.765 |

Note: the recommended value is from Refs. [35,55,62,63].

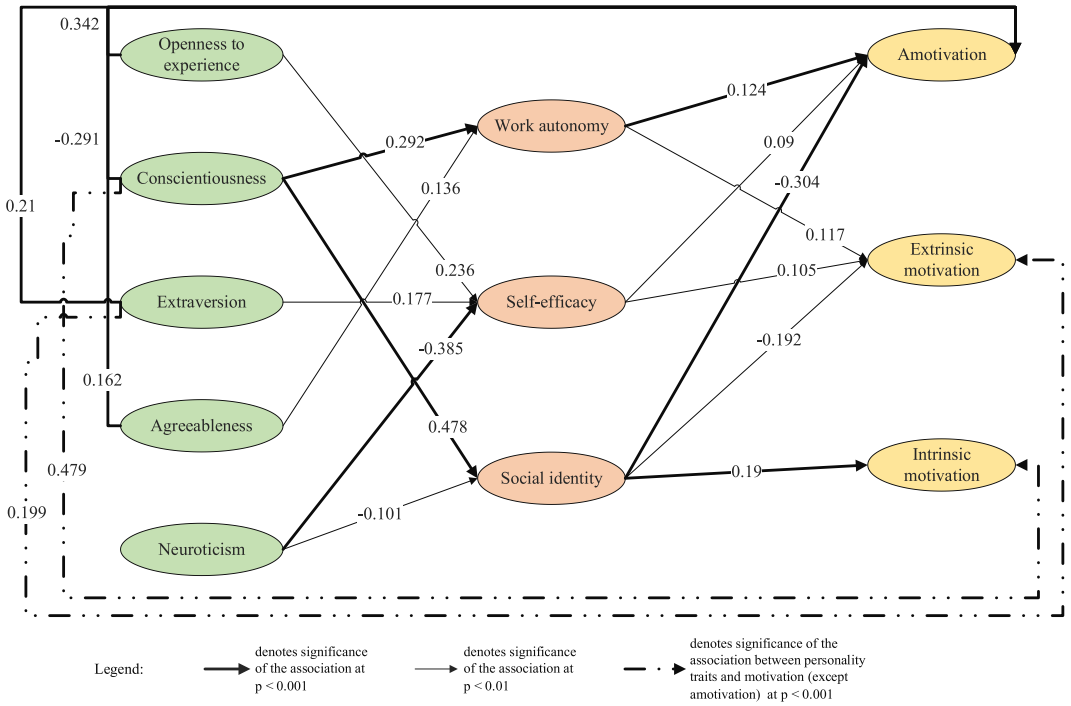


**Fig. 3.** Significant associations among the construction workers' personality traits, psychological needs, and safety motivation.

cannot be fully accepted. The supported hypotheses are: positive associations of openness to experience and amotivation (β = 0.342), conscientiousness and intrinsic motivation (β = 0.479), extraversion and amotivation (β = 0.21), agreeableness and amotivation (β = 0.162), extraversion and extrinsic motivation (β = 0.199), and a negative link between conscientiousness and amotivation (β = −0.291).

In addition, this study used bootstrapping techniques to test whether the mediator existed (see Table 6). The confidence interval of the effects did not include 0, indicating that social identity is a mediator in the relationship between conscientiousness and intrinsic motivation.

## 4. Discussion

Personality has been regarded as the set of a person's feelings, thinking, and reactions [56]. Traits reveal the characteristics of people's reactions to a situation [43]. Personality traits explain a person's specific behavior and why the person acts in a certain way. Safety motivation is important in deciding the worker's safe behavior, and differences in safety performance can be partly attributed to differences in safety motivation. Personality traits are indicative of the kind of motivation people respond to. The relationships between personality traits and safety motivation offer another explanation of the differences in individual safety behaviors. The assessment of personality traits can be a tool in designing customized safety interventions. The results of the investigation reveal that customization of safety interventions will have to take into account particular personality traits, as well as psychological needs.

Conscientiousness was found to play an important role in the worker's engagement in incidents [57], and it can be a predictor of a

**Table 5**
Coefficients of the associations.

| Hypotheses | No. | Relationship | Beta | S.E. | P value |
|---|---|---|---|---|---|
| H1 | H1-1 | WA→AM | 0.124 | 0.035 | *** |
| | H1-2 | SI→AM | −0.304 | 0.061 | *** |
| | H1-3 | SE→AM | 0.09 | 0.033 | 0.007** |
| | H1-4 | WA→EM | 0.117 | 0.041 | 0.004** |
| | H1-5 | SI→EM | −0.192 | 0.071 | 0.007** |
| | H1-6 | SE→EM | 0.105 | 0.039 | 0.007** |
| | H1-7 | WA→IM | 0.004 | 0.026 | 0.885 |
| | H1-8 | SI→IM | 0.19 | 0.046 | *** |
| | H1-9 | SE→IM | −0.022 | 0.025 | 0.384 |
| H2 | H2-1 | O→WA | 0.144 | 0.072 | 0.046* |
| | H2-2 | C→WA | 0.292 | 0.076 | *** |
| | H2-3 | E→WA | 0.021 | 0.052 | 0.682 |
| | H2-4 | A→WA | 0.136 | 0.045 | 0.002** |
| | H2-5 | N→WA | −0.043 | 0.056 | 0.44 |
| | H2-6 | O→SI | 0.054 | 0.049 | 0.265 |
| | H2-7 | C→SI | 0.478 | 0.053 | *** |
| | H2-8 | E→SI | −0.022 | 0.035 | 0.532 |
| | H2-9 | A→SI | −0.012 | 0.03 | 0.687 |
| | H2-10 | N→SI | −0.101 | 0.038 | 0.007** |
| | H2-11 | O→SE | 0.236 | 0.078 | 0.003** |
| | H2-12 | C→SE | 0.012 | 0.082 | 0.88 |
| | H2-13 | E→SE | 0.177 | 0.056 | 0.002** |
| | H2-14 | A→SE | −0.019 | 0.048 | 0.695 |
| | H2-15 | N→SE | −0.385 | 0.061 | *** |
| H3 | H3-1 | O→AM | 0.342 | 0.065 | *** |
| | H3-2 | C→AM | −0.291 | 0.075 | *** |
| | H3-3 | E→AM | 0.21 | 0.046 | *** |
| | H3-4 | A→AM | 0.162 | 0.04 | *** |
| | H3-5 | N→AM | −0.041 | 0.052 | 0.423 |
| | H3-6 | O→EM | 0.131 | 0.075 | 0.081 |
| | H3-7 | C→EM | −0.137 | 0.086 | 0.111 |
| | H3-8 | E→EM | 0.199 | 0.054 | *** |
| | H3-9 | A→EM | 0.06 | 0.046 | 0.191 |
| | H3-10 | N→EM | 0.027 | 0.06 | 0.652 |
| | H3-11 | O→IM | 0.022 | 0.048 | 0.653 |
| | H3-12 | C→IM | 0.479 | 0.058 | *** |
| | H3-13 | E→IM | −0.058 | 0.035 | 0.092 |
| | H3-14 | A→IM | 0.035 | 0.03 | 0.237 |
| | H3-15 | N→IM | −0.009 | 0.039 | 0.812 |

Note: *** denotes $p < 0.001$, ** denotes $p < 0.01$, * denotes $p < 0.05$.

**Table 6**
Mediating effect of social identity in the relationship between C and I.M.

| Effects | Point estimation | Bootstrapping | | | |
|---|---|---|---|---|---|
| | | Bias-corrected 95% | | Percentile 95% | |
| | | Lower | Upper | Lower | Upper |
| Total | 0.571 | 0.443 | 0.696 | 0.446 | 0.698 |
| Direct | 0.479 | 0.341 | 0.624 | 0.34 | 0.623 |
| Indirect | 0.092 | 0.046 | 0.156 | 0.043 | 0.151 |

person's safe-related behaviors [21], which aligns with the findings that conscientiousness is negatively associated with amotivation but positively associated with intrinsic motivation. This study found that agreeableness positively links to the construction worker's work autonomy. When the worker has more autonomy, there is a possibility of caring more about self-interest than safety [35]. Neuroticism reflects the person's negative emotions, affect, and thus poorer levels of subjective mental well-being so that it is negatively related to psychological needs [39]. A positive association between self-efficacy and extrinsic motivation has been found, which expands the findings of Wang, Wang [10] that found self-efficacy was related to safety motivation on a general level. As a result, this study sheds light on the deeper connections between personality traits and the construction worker's safety behavior from the motivational perspective.

Although construction workers have been considered "cheap labors", their occupational safety and health has attracted more attention from researchers and the government. Personalization has been found effective in changing the target behaviors [58], and it is a good opportunity for improving construction safety interventions. It also can be seen as a needed transformation in construction safety management. Because of lacking quality education and complex onsite conditions, the workers' behaviors are hard to change,

which is challenging for personalizing the safety interventions. This research incorporated self-determination theory and Big Five theory into construction safety management, and its findings provide implications for considering personality traits in safety management. Safety training and instruction are common safety interventions in the safety management system context. These measures have neglected the workers' individual differences, and personalization can increase their effectiveness [59]. Personality traits can provide directions for customizing interventions to improve safety motivations. Conscientious workers are the relatively 'safer' ones since their safety motivation is likely to be intrinsic. In safety training, the social identity of these workers can be enhanced by the teamwork process, helping them perceive the membership of the workgroup and the project. For extraverted workers, praise and reward content in safety communication can be used to increase their self-efficacy, and safety instructions can be delivered by other persons since workers with high openness to experience are talkative and social. Extrinsic stimuli such as pressure from the family or foremen or harsh punishment can be enhanced because safety motivation tends to be more extrinsic among these workers. Self-determination theory also mentions that motivation tends to be more intrinsic once the psychological needs are more fully fulfilled [15]. Thus, the relationships between openness to experience, agreeableness, neuroticism, and the three psychological needs can be used to make safety motivation more intrinsic and incorporate safety into the worker's personal value. For the workers with high openness and agreeableness, appropriate work autonomy can be given, and encouragement delivered by safety instruction should also be sent to these workers. Work autonomy is generally limited on a construction site, and over-self-efficacy may cause cognitive bias, leading to workers' risk-taking behaviors [60]. Thus, there is a boundary of satisfying these two psychological needs, and social identity should be paid more attention to. Uniforms, badges, and group activities can help increase social identification [29] and strengthen communication within a group [61].

This study has several limitations to be addressed in the future. Firstly, the data were cross-sectional and can only address empirical links between personality traits, psychological needs, and safety motivation, and future studies can examine the causes of these relationships. Secondly, the sample of this study was only Chinese construction workers. The samples can be enlarged by inviting foreign workers to make comparisons among countries.

## 5. Conclusion

This study examines the relationship between Chinese construction workers' personality traits, psychological needs, and safety motivations. The results show that these three constructs are related to some extent. The safety motivation of workers with high conscientiousness is more intrinsic. Workers with high openness and agreeableness can be more extrinsically motivated through work autonomy. Those high on extraversion, neuroticism, and openness can be more extrinsically motivated through self-efficacy. Personality traits provide directions for using a worker's psychological needs and safety motivations in safety management. Conscientious workers can be easily motivated extrinsically by being given work autonomy or intrinsically by cultivating a strong sense of social identity. It should be noted that constraints should be placed on promoting task autonomy and self-efficacy. Onsite safety management measures can be customized by considering personality traits and ways to satisfy basic psychological needs.

## Author contribution statement

Zhe Hu: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Weng Tat Chan: Conceived and designed the experiments.

Hao Hu: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

## Data availability statement

The data that has been used is confidential.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e20370.

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