5-16-2016

An Integrative Model of Situation Awareness

Andrew Thurston
University of South Florida, ajthurston@mail.usf.edu

An Integrative Model of Situation Awareness

by

Andrew J. Thurston

A thesis submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
Department of Psychology
College of Arts and Sciences
University of South Florida

Co-Major Professor: Stephen E. Stark, Ph.D.
Co-Major Professor: Walter C. Borman, Ph.D.
Winny Shen, Ph.D.
Marina A. Bornovalova, Ph.D.

Date of Approval:
April 28th, 2016

Keywords: job experience, tenure, cognitive ability, personality, situation awareness, workplace safety

Table of Contents

List of Tables

List of Figures

Abstract

In aviation safety incident reports, lack of situation awareness (SA) is often attributed as the cause of negative safety outcomes, such as accidents. While the predominant model of SA has identified three components of SA, perception, comprehension, and projection, assumptions of their relationships with each other and external criteria are yet tested empirically. Specifically, SA theory suggests comprehension SA fully mediates the relationship between perception and projection SA. Additionally, research on the relationships between individual differences and SA is lacking. The purpose of the current study is to test a comprehensive model of SA which simultaneously examines the described mediation, relationships with individual differences antecedents of SA, and its utility as a predictor of safety using structural equation modeling (SEM). A sample of 349 employees from a diverse background of occupational areas were recruited via Amazon Mechanical Turk to test the model. While self-report measurement of SA was an excellent predictor of safety, the current study did not find empirical support for the presumed mediation among the SA components, and found the relationships between individual differences and SA which contradict extant SA theory. The results suggest differentiating between typical versus maximal SA. Implications for theory and practice are discussed.

Chapter One
Introduction

Preventing accidents and injuries in the workplace is of paramount importance to organizations. According to the Bureau of Labor Statistics Census of Fatal Occupational Injuries, there were 4,585 fatal accidents on the job in the U.S. alone in 2013 (Bureau of Labor Statistics, 2013). The costs of these accidents, to both organizations and individuals alike, are substantial. In 2012 there were 4.9 million on-the-job injuries that required medical consultation, and the estimated combined cost of on-the-job injuries and deaths was $198.2 billion (National Safety Council, 2014). Injuries on the job result in direct costs, such as medical bills and workers compensation, and indirect costs, such as days lost on the job and poor publicity for the organization.

In an effort to prevent or reduce workplace accidents and injuries, organizational researchers have attempted to identify individual differences that predict accident and injury involvement (Kaplan & Tetrick, 2011, p. 458). In layman's terms, researchers have sought to identify employees who are accident prone. In their review, Kaplan & Tetrick note, "this idea of accident proneness dates to an early study by Greenwood and Woods (1919), who found that accident occurrence in a British munitions factory was unevenly distributed among workers, with a relatively small proportion of workers accounting for most of the accidents" (2011, p. 458). If a few individuals are primarily responsible for accidents and injuries in the workplace, organizations ought to be able to screen out these individuals during the selection process.

Unfortunately, this is difficult because the connection between individual differences, measured by most applicant screening tools, and negative safety outcomes in the workplace is not clear.

One hurdle in connecting individual differences to safety is the definition of safety itself. Research on safety has historically focused on safety outcomes (i.e., accidents and injuries); however, these phenomena are rare and difficult to predict (Christian, Bradley, Wallace, & Burke, 2009). In order to understand the unsafe behaviors that lead to safety outcomes, others have suggested it may be more fruitful to conceptualize safety in terms of performance, borrowing from the distinction between task and contextual job performance (Borman & Motowidlo, 1993). For example, Neal, Griffin, and Hart (2000) defined two components of *safety performance*: *safety compliance*, which involves adhering to an organization's safety policies and procedures, and *safety participation*, which involves actively championing and reinforcing safety behaviors. Defining safety this way helps to focus attention on aspects of behavior that are directly under an individual's control and, as noted by Christian et al. (2009), "conceptualizing safety performance as individual behaviors provides researchers with a measurable criterion, which is more proximally related to psychological factors than accidents or injuries" (p. 1104).

By viewing accidents and injuries as outcomes of a broader safety performance construct, it raises the possibility that they may be predicted by the same individual difference variables that best predict overall job performance - namely cognitive ability and personality. Interestingly, however, incident reports typically don't directly link accident or injuries to broad individual difference variables. Instead, incident reports attribute causes of accidents to a loss of *situation awareness* (SA) (Endsley, 1995a). In simple terms SA means "knowing what is going on around you (p.5)" (Endsley, 2000b). More formally, SA has been defined as "the perception

of the elements in the environment within a volume of times and space, the comprehension of their meaning, and the projection of their future status" (Endsley, 1988, p. 792). Endsley suggests SA has three components, or levels, which unfold sequentially. Level 1 (*perception SA*) involves the perception of one's environmental elements or cues. Level 2 (*comprehension SA*) involves the comparison of perceived environmental elements with one's mental schemas to ascribe meaning and understand the implications. Level 3 (*projection SA*) involves using this information to anticipate or predict what is likely to occur. Importantly, this conceptual model implies that comprehension SA fully mediates the relationship between perception SA and projection SA, and the broader theoretical framework suggests that SA provides the link between broad individual differences variables and safety performance.

Purpose of Research

For decades, loss of SA has been cited as the cause of accidents attributable to human error in aircrews and air traffic controllers (Endsley, 1995a). However, few if any reports explain what SA is or how the loss of SA is connected with accidents. Similarly, there have been very few detailed definitions of SA proffered in research circles. Endsley (1995b) provided what is perhaps the only viable model, and there have been only a handful of studies exploring its validity (Endsley, 1990; Endsley, 2000a). Questions remain, therefore, as to whether the assumptions of Endsley's model are tenable and whether measures of SA predict accidents and injuries or, more generally, safety performance beyond broad individual difference constructs. The study that follows attempted to answer these questions using structural equations modeling (SEM) methodology.

Following a brief discussion of the origins of SA and some measures that have been developed, this paper presents a study that tested the mediation process implied by Endsley's

model and examined the relationships between perception SA, comprehension SA, and projection SA in conjunction with general cognitive ability, personality, and job experience as predictors of safety performance. An integrative SEM model was proposed, along with alternative models that were examined because the initial model was not supported. Further, in an effort to broaden the implications of this research, participants were drawn from fields beyond those traditionally studied in the SA domain.

Situation Awareness: Theory and Measurement

The earliest references to situation awareness appear in military reports from World War I (Endsley, 2000b, p. 9), which describe how military leaders sought to eliminate an enemy's "element of surprise" by maintaining awareness on the battlefield (Fracker, 1991). However, SA received little empirical attention until its use in military communities necessitated an operational definition. Military aviation reports frequently attributed unsafe incidents (e.g., a plane crash) involving pilot error to loss of SA (Endsley, 1995a), but the incident reports typically provided no working definition or discussion of the mechanisms. In the 1990s, some descriptions of SA were proposed in the human factors literature, but most were too diffuse to be operationalized for validity studies. For example, Taylor (1990) suggested that SA is "a combination of a number of perceptual and cognitive skills," and Smith and Hancock (1995) suggested SA is an "adaptive, externally directed consciousness." Endsley's (1995b) component model thus, represented and is to date the most thorough and well-articulated description of the construct.

Based on this component model, Endsley developed a simulation-based tool known as the Situation Awareness Global Assessment Technique (SAGAT) to measure pilots' SA (Endsley, 1988). Pilots participate in a flight simulation and, during periodic pauses, they are asked questions (probes) pertaining, for example, to the location or position of their aircraft,

characteristics of the terrain, or the direction of enemy aircraft. A pilot's report is then compared to the actual state of events in the simulation, and an overall assessment of the pilot's SA is determined by the average correct responses.

Taylor (1990) proposed measuring SA using a somewhat similar method known as the Situation Awareness Rating Technique (SART). Simulation scenarios were developed by asking pilots to describe examples of high and low SA (see Selcon, Taylor, & Koritsas, 1991), and Likert-type scales were created for expert judges to rate pilots during the scenarios, which proceeded without interruptions. In one variation of the SART, an expert judge rates the SA of a pilot using a 7-point Likert scale measuring three factors: the supply of attentional resources, demands to attentional resources, and understanding. The difference between the scores on the supply and demand dimensions are subtracted from the score on the understanding dimension to obtain an overall SA rating.

Like the SAGAT, the SART is designed to measure SA in the context of a high fidelity simulation using the judgments of expert observers. This leads to high face validity, but might be seen as limiting generalizability to work environments and tasks that can be effectively modeled. Moreover, the costs of developing realistic simulations and calibrating judges to increase inter-rater agreement is substantial, if not prohibitive, for many occupations. Consequently, as interest in SA has burgeoned beyond the jobs initially studied, researchers have starting exploring the merits of simpler, more cost-effective self-report alternatives.

Sætrevik (2013), for example, developed the Context General Self-Report measure of SA based on Endsley's three component model. Items general enough to apply in a variety of job domains were developed and refined through factor analysis by assuming a three-correlated factor structure. In the end, 13 items measuring three factors were retained. According to the

author, the item scores can be added to produce a total SA score having an internal consistency reliability of .74. Although such self-report measures are not without shortcomings, they may be equally if not more effective in capturing an individual's typical or dispositional SA than monitored simulation-based tasks, which are designed to invoke maximum performance. Furthermore, although self-report SA measures likely have lower face validity than simulation-based measures, the generality of the self-report items should expand research possibilities and facilitate comparisons across different types of jobs.

SA and Safety

To date, only a few studies have examined the relationships between SA and safety-related criteria based on the complete model proposed by Endsley. One example is a study of SA during a driving simulation by Gugerty (1997), which examined hazard detection, recall error, and blocking car detection reflecting perception, comprehension, and projection SA, respectively. The correlations with the outcome measure, crash avoidance, were substantial, ranging from .35 to .67 in magnitude. Other studies have focused instead on constructs that have been likened to SA, such as cognitive failures (Broadbent, Cooper, FitzGerald, and Parkes, 1982), which include items suggestive of SA lapses. For example, Wallace and Vodanovich (2003) reported correlations between Broadbent et al.'s (1982) Cognitive Failures Questionnaire (CFQ) and unsafe workplace behaviors and accidents of .32 and .23, respectively, in a military sample of machinists and mechanics. More recently, Sneddon, Mearns, and Flin (2013) developed a measure they called Work SA, containing items adapted from the CFQ, which correlated -.51 with safety performance among offshore drilling workers. Together, these studies suggest that SA and conceptually similar constructs correlate significantly with safety criteria,

but research is needed to link Endsley's model to safety performance in a broader organizational context.

Personality, SA, and Safety

Research exploring the links between safety criteria and personality variables has revealed significant correlations with two of the Big Five factors, conscientiousness and emotional stability. Not surprisingly conscientious measures, which contain items related, for example, to orderliness, rule following (Cattell, Eber, & Tatsuoka, 1970), vigilance (Houston, Borman, Farmer, & Bearden, 2005), attention to detail, and self-control (Costa & McCrae, 1992), have received the most attention and shown the most consistent relationships with safety criteria. Arthur and Graziano (1996) found that conscientiousness correlated with accidents -.14 among college students and -.19 among temporary workers. Wallace and Vodanovich (2003) found that conscientiousness correlated -.17 with accidents and -.33 with unsafe behaviors in machinist and mechanics jobs, and Postlethwaite et al. (2009) found a correlation of .19 with safety performance in a broad sample of job incumbents and vocational trainees. Finally, Christian et al. (2009) conducted a meta-analysis and found that conscientiousness correlated with safety performance $\rho = .18$.

Emotional stability and negative affectivity measures have also been shown to have significant relationships with safety criteria in some fairly recent studies, perhaps because persons low in emotional stability experience negative emotional states that affect attention and information processing and/or they fixate on environmental cues and fail to adapt to changing conditions. Although Neal and Griffin (2006) found no relationship between neuroticism and safety performance, Paul and Maiti (2007) found negative affectivity correlated .37 with injuries and -.22 with safety performance, and Christian et al.'s (2009) meta-analysis found that

emotional stability correlated with safety outcomes $\rho = .19$. Finally, a larger meta-analysis by Hogan and Foster (2013) found that emotional stability and safety performance correlate $\rho = .26$.

Thus far, only one published study (N=34) has explored the relationships between personality variables and SA. Saus, Johnsen, Eid, and Thayer (2012) found a global self-report measure of SA (Waag & Houck, 1994) correlated .54 with conscientiousness, .44 with emotional stability, .44 with extraversion, .22 (n.s.) with agreeableness, and -.04 (n.s.) with openness to experience. Because the sample was small, it is impossible to know whether the findings will replicate. Moreover, because they used a global SA-measure, no information is available to determine how the personality scores related to the perception, comprehension, and projection components of Endsley's model. In sum, research to date suggests that conscientiousness and emotional stability are the two Big Five factors most likely to influence safety performance and SA.

Cognitive Ability, SA, and Safety

Research has consistently shown that general cognitive ability is the best predictor of overall performance across job domains (Schmidt & Hunter, 1998). However, relatively few published studies have reported correlations with safety performance or accidents and injuries. As noted by Kaplan and Tetrick (2011), this apparent lack of attention might reflect beliefs that complex reasoning skills are less relevant to workplace safety than absentmindedness and lapses in attention or concentration. However, it could also be the case that the relationships have been explored, but small correlations have been found and not reported. Regardless, Postlethwaite et al. (2009) found a correlation of just .15 between general cognitive ability and safety peformance, whereas Wallace and Vodanovich (2003) found forgetfulness and distractibility correlated .31 and .29 with unsafe behaviors and accidents, respectively.

Research exploring the connection between cognitive ability and SA is also limited. A literature search for this investigation revealed just a few published studies. Carretta, Perry, and Ree (1996) treated SA as an outcome variable in a study involving pilots. After controlling for flight hours, they found that general cognitive ability accounted for significant variance in SA, and the regression results suggested a positive correlation. More recently, Durso, Bleckley, and Dattel (2006) conducted a study involving air traffic controllers and found that a SAGAT-like measure of SA correlated positively with working memory and fluid intelligence measures, yet provided incremental validity for predicting simulator performance with respect to some combinations of cognitive and personality measures. Finally, Sulistyawati, Wickens, and Chui (2011) examined the relationships between several cognitive ability measures and the components of Endsley's model using a sample of pilots. Their correlations were not significant after controlling for flight hours, but the sample size was too small (N=15) to have adequate power; the reported correlations with SA were as large as .58 in absolute value. In sum, the few studies which have been conducted with SA and cognitive ability suggest that the two constructs are at least moderately correlated.

Job Experience, SA, and Safety

Researchers have long speculated that job experience is an important antecedent of SA, because it takes time to develop mental models that facilitate perception, comprehension, and projection concerning environmental cues (Endsley, 1988). In a study of pilots, for example, Carretta et al. (1996) found that SA correlated highly with experience, operationalized as the number of flight hours. More recently, Kass, Cole, and Stanny (2007) found that experience accounted for SA differences among participants in a driving simulation.

Research also suggests that job experience predicts safety performance. For example, Benavides et al. (2006) found employees with one month's experience were between 4 and 6 times more likely to be injured on the job than their counterparts with one year of experience. Breslin and Smith (2006) found the relative risk of fatal and non-fatal on-the-job injuries was significantly higher among temporary workers than permanent personnel. A meta-analysis by Nahrgang, Morgeson, and Hofmann (2007) found tenure was not significantly correlated with the compliance dimension of safety performance, but was significantly correlated with the participation dimension. Most recently, Ng and Feldman's (2010) meta-analyis found that tenure correlates .18 with safety performance.

Collectively, these results suggest that models of safety performance should account for both SA and job experience. Moreover, theory and the pattern of correlations suggests that SA mediates the relationship between job experience and safety performance.

The Current Study

Endsley's (1988) model was a significant step forward in defining SA and theorizing about its relationship with performance. Most methods of measuring SA today refer back to this model and the tasks that Endsley developed in one way or another. Yet our understanding of how the model components relate to each other and combine with individual difference variables to influence safety performance is very limited. The purpose of this study was therefore to 1) test the tenets of Endsley's model, and 2) explore how SA predicts safety performance in conjunction with cognitive ability, personality, and job experience. The initially proposed structural equations model for this study is shown in Figure 1.

Based on Endsley's theory (1988) and Sætrevik's (2013) results, which indicated higher correlations among proximal than distal SA components (perception and comprehension

correlated .76, comprehension and projection correlated .85, but perception and projection correlated just .45), the following hypotheses were proposed:

H1: Comprehension SA will fully mediate the relationship between perception SA and projection SA.

H2: Projection SA will predict safety performance.

Second, meta-analytic evidence has suggested two dimensions of personality correlate significantly with safety performance: conscientiousness and emotional stability (Christian et al. 2009; Hogan & Foster, 2013). These same two personality dimensions have been shown to correlate with overall SA (Saus et al., 2012), but no published studies have examined their relationships with individual SA components. As shown in Figure 1, the proposed model suggests personality predicts perception SA: conscientious individuals are more likely to remain vigilant and attend to details in their environment; emotionally stable individuals are less likely to fixate on one environmental cue and fail to attend to others. Lastly, meta-analytic evidence has suggested emotional stability and conscientiousness are correlated (Judge et al., 2007).

H3: The relationship between conscientiousness and safety performance will be partially mediated by perception SA.

H4: The relationship between emotional stability and safety performance will be partially mediated by perception SA.

H5: Conscientiousness and emotional stability will be positively correlated.

Third, two broad individual differences are related to all three components of SA: cognitive ability and job experience. Since, by definition, the component of Endsley's model are products of cognitive factors, cognitive ability should be related to them (Endsley, 2000b). Similarly, job experience is related to each dimension of SA (Sulistyawati et al., 2011).

H6: The relationship between cognitive ability and safety performance will be fully mediated by each SA component.

H7: The relationship between experience and safety performance will be fully mediated by each SA component.

Finally, for organizations that want to know whether SA can predict safety performance above and beyond cognitive ability, personality, and job experience variables, the incremental validity of SA was examined using hierarchical regression. Note that although the proposed SEM model included only conscientiousness and emotional stability personality factors, agreeableness, extraversion, and openness were measured, as they are usually assessed together in organizational settings.

Chapter Two
Method

Data for this study were collected using a self-report survey. Participants completed the survey in one session, and average survey completion time was 19.29 minutes (*SD* = 10.25). Institutional review board (IRB) review certified the study as exempt.

Participants

Participants were recruited via Amazon.com's Mechanical Turk (AMT) online work marketplace, and the survey was hosted on Qualtrics. The targeted sample size was *N* = 350 based on *a priori* power analyses using Monte Carlo simulation methodology in MPLUS 7.1. This analysis was conducted according to the conventions described by Muthén & Muthén (2002). A total of 353 participants were recruited, but 4 participants indicated their data should not be included in the analyses, thus, reducing the final sample size to 349. Participants were allowed to participate in the study if they are current U.S. residents, currently employed outside of AMT, are required to wear safety equipment at least once per week, and work at least 10 hours per week. Participants were excluded if they failed to appropriately answer items designed to detect aberrant responding (e.g., "please select 'Strongly Agree' for this item).

Procedures

Informed consent and recruitment. Participants were recruited via AMT advertisement, which displayed the inclusion criteria and directed them to a survey hosted on Qualtrics. The Qualtrics survey first provided informed consent, which described the purpose of the study, inclusion criteria, study procedures, and compensation information. Participants then completed the inclusion criteria questions and, if eligible, proceeded to the study measures

(described in the Measures section below). Following the study measures, participants were asked if their data should be excluded from the analysis, and, if so, why. Participants were also given an opportunity to provide open-ended comments about the survey.

Compensation. Originally, individuals were compensated $.50 for their participation; however, pilot testing indicated participants were bypassing the cognitive ability measure altogether. After discussing this issue with other industrial and organizational psychology researchers who use the AMT platform, a decision was made to differentially incentivize participant performance according to the following convention: participants were paid $.50 for completing the survey, a small $.02 bonus for every cognitive ability question answered correctly, and a bonus of $.18 for answering at least 2 questions correctly from each of the four cognitive ability measure areas (described below). This convention was adopted to encourage participants to attempt the cognitive ability items, while not penalizing those with low scores. In order to promote test security, participants were not told which cognitive ability items they answered correctly; however, to ensure timely performance feedback and verification of their total payment, participants were told the overall number they answered correctly and the bonus they would receive. The average bonus paid was .18 (SD = .13).

Measures

Demographics. These items included current employment status, use of protective equipment in the workplace, age, sex, ethnicity, and race. Ethnicity and race questions were consistent with Revisions to the Standards for the Classification of Federal Data on Race and Ethnicity (1997). Participants also self-reported their O*NET occupational area, job code, and context code via a provided drill-down menu; this menu first asks respondents to identify their occupational area and then provides the list of jobs specific to that occupational area. Participant

occupation was classified according to the Standard Occupational Classification (Bureau of Labor Statistics, 2010). Context code refers to the O*Net Work Context code, which classifies the SOC codes based on the extent workers are typically required to wear common protective or safety equipment, such as safety shoes, glasses, gloves, hearing protection, hard hats, and life jackets. This context code ranges from 0 (never) to 100 (every day). This value was automatically populated from the drill-down menu described.

Personality. Personality was assessed using the 50-item International Personality Item Pool (IPIP) from Big Five factor markers inventory (Goldberg, 1992). Each factor was measured by 10 items using a 5-point, Likert-type format (1 = Very Inaccurate, 5 = Very Accurate). IPIP scale scores correlate well with many commercial personality measures used in organizational settings; for example, correlations between IPIP factors and NEO-PI (Costa & McCrae, 1985) range in magnitude from .50 to .68 (Goldberg, 1992). Goldberg (1992) reported high internal consistency for each domain scale: extraversion (α = .88), agreeableness (α = .88), conscientiousness (α = .85), emotional stability (α = .88), openness to experience (α = .84). Internal consistency was also high in the current sample, as shown in Table 2.

International Cognitive Ability Resource (ICAR) 16-item version. Cognitive ability of the participants was assessed using the International Cognitive Ability Resource (ICAR) short version (Condon & Revelle, 2014). ICAR items assess verbal reasoning, letter and number series comprehension, matrix reasoning (similar to the Raven's Progressive Matrices [Raven, Raven, & Court, 1998]), and spatial rotation capabilities. The verbal reasoning, letter and number, and spatial rotation items have eight response options, and the matrix reasoning items have six. Based on a sample of nearly 100,000 participants from 199 countries, Condon and Revelle (2014) found an internal consistency reliability of .81 and correlations with SAT and ACT

composite scores of .59 and .52, respectively. Overall reliability was similar in the current AMT sample (α = .79).

Job Experience. The majority of studies measuring job experience typically assess the construct using only a single-item measure of participants' tenure in their current job (Quińones, Ford, & Teachout, 1995). However, job experience theory suggests persons with the same tenure can differ in the depth and quality of their job experience (DuBois & McKee, 1994). Further, measurement of job experience should also consider differences between position, organizational, and occupational experience (Tesluk & Jacobs, 1998). Therefore, to capture the full range of the experience construct, tenure items were administered as well as a short self-report measure that was created for this study. Six items, shown in Appendix B, were written to assess the quality or depth of job experience, using a 5-point Likert-type response format (1 = Strongly Disagree, 5 = Strongly Agree). Internal consistency was high for both the Likert-type items (α = .90) and the tenure items (α = .92).

Situation awareness - context general self-report. The 13-item Context General Self-Report measure of SA was used to assess participants typical or dispositional SA (Sætrevik, 2013). This measure (see Appendix B) was selected because the items were developed to comport with Endsley's model - assessing perception, comprehension, and projection SA. Responses were collected using a 5-point Likert-type format (1 = Completely disagree, 5 = Completely agree), and values associated with endorsed categories were summed to obtain an overall SA score. As discussed previously, Sætrevik (2013) found support for a three-factor model, with factor correlations ranging from .49 to .85, and an internal consistency reliability of .74 for the overall SA score. Overall internal consistency was high in the current sample as well (α = .87).

Safety Performance. Neal et al. (2000) conceptualized safety performance as having two components: safety compliance and safety participation. Safety performance was assessed using the safety compliance and safety participation subscales (Neal & Griffin, 2006), with the response categories relabeled from low to high (1 = Strongly Disagree, 5 = Strongly Agree) for consistency with other measures in this study. According to Neal et al. (2000), the safety compliance and participation subscales have internal consistency reliabilities of .94 and .89, respectively. In this study, overall safety performance was used, and the internal consistency reliability of the scale was $\alpha = .89$.

Chapter Three
Results

The results are organized as follows. The first section presents descriptive statistics, reliabilities, and correlations for the measures used in the study. The second section presents validity data for the context-general self-report measure of SA, as well as the newly created job experience scale. The third section presents ordinary least squares (OLS) results concerning the incremental validity of SA for predicting safety performance; in addition, relative weights analysis findings are presented to show how variance in SA and safety performance was accounted for by various predictors. The last section presents the results relevant to evaluation and modification of the proposed structural equations models.

Descriptive Statistics

Study descriptive statistics, including means, standard deviations, scale coefficient α, and correlations are presented in Tables 1 and 2. Table 1 reports participants' occupational classifications, and Table 2 reports the correlation among study variables. Participants were predominately Male (55.59%), White (80.23%), few were ethnically Hispanic or Latino (5.76%), and their average age was 37.28 (SD = 10.60). They worked an average of 38.72 (SD = 8.49) hours per week. As shown in Table 1, participants represented a diverse range of occupational areas, according to their self-reported O*NET SOC code. The top three Occupational Areas were: Production Operations (13.87%), Construction and Extraction Operations (9.83%), and Food Preparation and Serving Related Occupations (9.25%).

*Table 1. Participants' Self-reported Standard Occupational Classification (SOC) Occupational Area (*N = *346)*

Occupational Area	Frequency	Percent
Architecture and Engineering Occupations	16	4.62%
Arts, Design, Entertainment, Sports, and Media Occupations	7	2.02%
Building and Grounds Cleaning and Maintenance Occupations	19	5.49%
Business and Financial Operations Occupations	6	1.73%
Community and Social Service Occupations	2	0.58%
Computer and Mathematical Occupations	15	4.34%
Construction and Extraction Occupations	34	9.83%
Education, Training, and Library Occupations	9	2.60%
Farming, Fishing, and Forestry Occupations	10	2.89%
Food Preparation and Serving Related Occupations	32	9.25%
Healthcare Practitioners and Technical Occupations	21	6.07%
Healthcare Support Occupations	12	3.47%
Installation, Maintenance, and Repair Occupations	12	3.47%
Legal Occupations	3	0.87%
Life, Physical, and Social Science Occupations	13	3.76%
Management Occupations	14	4.05%
Office and Administrative Support Occupations	6	1.73%
Personal Care and Service Occupations	5	1.45%
Production Occupations	48	13.87%
Protective Service Occupations	11	3.18%
Sales and Related Occupations	31	8.96%
Transportation and Material Moving Occupations	20	5.78%

Table 2. Zero-order correlations demographics, personality, and study variables included in the final model.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1. Sex	--														
2. Ethnicity	-.05	--													
3. Minority Status	.02	-.10	--												
4. Work Hours	**.14**	.02	**-.02**	--											
5. Age	.01	**.12**	-.08	.04	--										
6. Openness	-.04	**-.19**	.05	.01	-.08	(.84)									
7. Conscientiousness	-.04	-.07	.05	.07	.10	**.24**	(.87)								
8. Extraversion	.08	-.03	.02	.13	.05	**.24**	**.18**	(.91)							
9. Agreeableness	**-.18**	.00	-.01	.01	**.14**	**.33**	**.28**	**.37**	(.90)						
10. Emo. Stability	**.18**	-.08	.02	.10	.10	**.12**	**.48**	**.37**	**.26**	(.93)					
11. Subjective Job Experience	.07	-.08	.09	.21	**.13**	**.15**	**.24**	**.22**	.04	**.12**	(.90)				
12. Tenure	-.01	.08	.03	**.16**	**.33**	-.02	**.12**	.02	.06	**.13**	**.13**	(.92)			
13. ICAR Total Score	**.13**	.02	**-.13**	**-.07**	-.06	.03	-.10	**-.17**	-.10	-.04	-.06	-.01	(.79)		
14. Overall SA	-.02	-.08	-.07	.08	**.15**	**.41**	**.45**	**.22**	**.37**	**.40**	**.19**	.02	.06	(.87)	
15. Safety Performance	-.09	-.10	-.01	.07	**.13**	**.38**	**.41**	**.28**	**.40**	**.31**	**.26**	.04	.01	**.67**	(.89)
Mean	0.56	0.94	0.20	38.72	37.28	28.80	29.55	19.40	28.57	25.93	20.55	0.00	7.54	38.33	19.27
SD	0.50	0.23	0.40	8.49	10.60	6.43	6.76	9.07	7.63	9.33	5.14	0.93	3.57	6.92	4.14

Note: Sample size for correlations range from 344 to 349 due to missing data; coefficient alpha reported along the diagonal; gender is coded as female = 0, male = 1; minority status is coded as 0 = non-minority, 1 = minority.

As previously mentioned, a work context code reflecting an employee's typical use of safety equipment within a particular occupation was also generated for each participant based on their SOC code. The average for this sample was 61.40 (*SD* = 33.35), which was quite low considering a score of 75 reflects "once a week or more but not every day"; however, participants' comments suggested idiosyncrasies of their work are not necessarily reflected by the O*NET classification. For example, one participant noted he/she worked as a payroll clerk (context code = 3), but the position required the him/her to interact with employees in a hardhat area, necessitating the use of safety equipment. Given these idiosyncrasies, participants were not excluded from further analysis based on this code.

Validation of the Job Experience Measure

The job experience measure comprised nine items that were hypothesized to load on single job experience factor. Because the three tenure items used a different response format than the others, all item responses were transformed into z-scores for further analysis. Although reliability for the 9-item measure was fairly high (α = .84), inspection of confirmatory factor analysis (CFA) results suggested that a single factor model did not fit the data well. As shown in Table 3, Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) were .924 and .898, respectively), below the .95 rule of thumb for good fit (Hu & Bentler, 1999), and Root Mean Square Error of Approximation (RMSEA) was well above the .05 cutoff (Browne & Cudeck, 1993).

Due to concerns about the fit of a one-factor CFA model, an alternative two-factor model was proposed with the three continuous tenure items loading on one factor (Tenure) and the six Likert-type items loading on another factor (Subjective Job Experience). Because the job experience nine items were no longer forced to load on one factor, raw data were used for this

analysis rather than z-scores. The CFA results indicated that the two-factor model fit the data fairly well. Although the RMSEA was above the recommended threshold, the CFI and TLI were both .99 indicating good fit. Both the subjective job experience and tenure items were internally consistent, with $\alpha = .92$ and $\alpha = .90$, respectively. The two factors were only modestly correlated, $\phi = .13$. As shown in Table 2, subjective job experience tended to correlate with personality variables, overall SA, and safety performance. Tenure was correlated with conscientiousness and emotional stability, but was not significantly correlated with SA or safety performance.

Validation of the Context General Self-Report SA Measure

Confirmatory Factor Analysis. As mentioned previously, Sætrevik (2013) found item 7 problematic as it had a factor loading close to zero on the factor it purported to measure; thus, this item was excluded from all analyses in this study. Internal consistency according to coefficient alpha was acceptable for both the perception and comprehension subscales ($\alpha = .76$ and .85, respectively), but was low for the projection subscale ($\alpha = .60$). All three subscales significantly correlated with age, all five personality factors, and subjective job experience. Most importantly, the three SA factors also correlated significantly with safety performance and its subdimensions. These correlations are reported in Table 7 in Appendix A.

Next, the three-factor SA model described by Sætrevik was tested using confirmatory factor analysis. The global fit indices suggested adequate fit for the model; as shown in Table 3, the CFI and TLI are within acceptable ranges, but the RMSEA was above the recommended cutoff (Hu & Bentler, 1999; Browne & Cudeck, 1993). Although the model demonstrated adequate fit, a warning message suggested a linear dependency among two of the latent factors. Specifically, the comprehension and projection SA factors were so highly correlated they were

indistinguishable (ϕ =.99, SE =.02). Additionally, the correlation between the perception and comprehension SA factors was also high (ϕ = .93, SE =.01), and perception and projection SA were also highly correlated, but to a lesser degree (ϕ = .83, SE =.03). Thus, the warning and factor intercorrelations suggested these results were not trustworthy. Importantly, these results suggested it would be problematic to proceed with testing the mediation tenets of Endsley's model as originally conceived. Instead, the relationships between SA and other variables would need to be explored using one of the proposed alternative models that treat SA as a unidimensional construct.

The last row of Table 3 presents the CFA results for a one-factor SA model, with the perception, comprehension, and projection items all loading on a single factor. The fit of this model was adequate. As before the RMSEA was above the traditionally recommended value, but the CFI and TLI results indicated good fit (Hu & Bentler, 1999; Browne & Cudeck, 1993). Most importantly, however, this collapsing of dimensions resolved the linear dependency among the factors. The correlations of the overall SA factor with external criteria resembled the pattern demonstrated by the components (shown in Table 7 in Appendix A). The results presented in Table 2 show overall SA significantly correlated with age, the Big Five personality factors, subjective job experience, and safety performance. Therefore, the unidimensional SA model was retained for subsequent SEM testing described later in this presentation.

Table 3. Confirmatory Factor Analysis (CFA) Global Fit Indices for Scale Validation (N = 344)

Experience Scale Validation	**χ^2 (df)**	***p***	**CFI**	**TLI**	**RMSEA [90%CI]**
1-Factor	1251.82 (27)	< .001	.924	.898	.361 [.344,.378]
2-Factor	146.63 (26)	< .001	.992	.990	.115 [.098,.134]
SA Scale Validation	**χ^2 (df)**	***p***	**CFI**	**TLI**	**RMSEA [90%CI]**
3-Factor SA	548.46 (51)	< .001	.963	.952	.136 [.124,.149]
1-Factor SA	447.45 (54)	< .001	.956	.946	.144 [.132,.157]

Predictors of SA and their Relative Importance. Next, the overlap of overall SA with the other individual difference predictors of safety performance was examined using multiple regression and relative weights analyses. As mentioned previously, relative weights analysis decomposes the explained variance and establishes the proportion explained by each of the predictors as a percentage of R^2. Although the CFA failed to reproduce the three component model of SA, for the sake of thorough reporting, the regression and relative weights analyses were conducted for the perception, comprehension, and projection components, as well as overall SA. The results, presented in Table 4, are discussed below in this order.

As shown in Table 4, the manifold of personality, cognitive ability, and experience variables accounted for 30% of the variance in perception SA scores, and this model was statistically significant. Of this variance accounted for, emotional stability explained the most (38.38%), followed by conscientiousness (24.10%), agreeableness (17.82%), openness (10.94%), extraversion (5.27%), subjective job experience (1.43%), cognitive ability (1.12%), and tenure (0.94%). In sum, the individual difference predictors accounted for a significant amount of variance in perception SA, the majority of which was predicted by emotional stability and conscientiousness.

The same predictors accounted for 34% of the variance in comprehension SA, although the rank-order relative importance of predictors differed from that of perception SA. Openness accounted for the most (34.92%), followed by conscientiousness (27.11%), emotional stability (13.65%), agreeableness (13.45%), subjective job experience (4.57%), cognitive ability (4.14%), extraversion (2.00%), and tenure (0.15%). Overall, the predictors explained a statistically

significant proportion of variance in comprehension SA, with openness and conscientiousness accounting for the majority of explained variance.

Fully 26% of the variance in projection SA was explained by the individual differences in the model, and this result was statistically significant. As with perception and comprehension SA, most of the explained variance was accounted for by personality variables. The pattern of relative weights closely resembled that of comprehension SA, and the rank order was largely the same. Again, openness accounted for the majority of explained variance (38.21%), followed by conscientiousness (20.68%), agreeableness (16.69%), emotional stability (10.99%), subjective job experience (10.53%), extraversion (2.05%), cognitive ability (0.68%), and tenure (0.18%). In sum, the manifold of predictors accounted for a significant amount of variance in projection SA, the majority of which was attributable to personality variables.

Finally, these analyses were repeated for overall SA, as shown in the final column of Table 4. Reflecting the results described for the individual components, the combination of individual differences again accounted for a statistically significant proportion of variance in overall SA (38%). According to the relative weights analysis, openness accounted for the most variance in SA (26.17%), followed closely by conscientiousness (25.80%), and emotional stability (21.84%). Agreeableness (16.54%), subjective job experience (4.21%), extraversion (3.09%), cognitive ability (2.08%), and tenure (0.26%) accounted for the remainder. Thus, the predictors accounted for a statistically significant proportion of variance in overall SA, personality variables again dominated the variance accounted for, and the most important predictors of the individual SA components (namely, openness, conscientiousness, and emotional stability) were also the most important predictors for overall SA.

Table 4. Summary of Regression for Predictors of SA Dimensions and Total Score and their Relative Importance (N = 344)

	Perception SA			Comprehension SA			Projection SA			Overall SA		
Variable	*B(SE)*	*β*	*% Var*	*B(SE)*	*β*	*% Var*	*B(SE)*	*β*	*% Var*	*B(SE)*	*β*	*% Var*
Constant	3.26 (1.00)			4.83 (0.97)			3.06 (0.62)			11.15 (2.16)		
Openness	0.06 (0.02)	0.12	10.94%	0.14 (0.02)	0.30	34.92%	0.08 (0.01)	0.28	38.21%	0.28 (0.05)	0.26	26.17%
Conscientiousness	0.08 (0.02)	0.17	24.10%	0.11 (0.02)	0.24	27.11%	0.04 (0.02)	0.16	20.68%	0.23 (0.05)	0.23	25.80%
Extraversion	0.00 (0.02)	0.00	5.27%	-0.01 (0.02)	-0.04	2.00%	-0.01 (0.01)	-0.05	2.05%	-0.02 (0.04)	-0.03	3.09%
Agreeableness	0.07 (0.02)	0.17	17.82%	0.06 (0.02)	0.14	13.45%	0.04 (0.01)	0.15	16.69%	0.16 (0.05)	0.18	16.54%
Emotional Stability	0.10 (0.02)	0.30	38.38%	0.05 (0.02)	0.15	13.65%	0.02 (0.01)	0.12	10.99%	0.17 (0.04)	0.23	21.84%
ICAR total score	0.06 (0.04)	0.07	1.12%	0.11 (0.04)	0.13	4.14%	0.02 (0.02)	0.05	0.68%	0.19 (0.09)	0.10	2.08%
Subjective Job Experience	0.02 (0.03)	0.03	1.43%	0.05 (0.03)	0.08	4.57%	0.05 (0.02)	0.14	10.53%	0.11 (0.06)	0.08	4.21%
Tenure	-0.25 (0.15)	-0.08	0.94%	-0.08 (0.15)	-0.02	0.15%	-0.03 (0.09)	-0.01	0.18%	-0.35 (0.33)	-0.05	0.26%
Multiple R		0.54			0.59			0.51			0.61	
R^2		0.30			0.34			0.26			0.38	
F-test		17.45			21.76			14.51			25.04	
p-value		< .001			< .001			< .001			< .001	

Note: % Var represents the percentage of variance accounted for according to the rescaled relative weight.

Incremental Validity of SA for Predicting Safety Performance

As shown in Table 5, hierarchical regression analysis was conducted to test whether SA contributed uniquely to the prediction of safety performance. Cognitive ability, job experience, and Big Five personality variables were entered as predictors in Model 1, and overall SA was added to Model 2. The manifold of predictors in Model 1 accounted for 33% of the variance in safety performance, and this result was statistically significant. Adding overall SA as a predictor in Model 2 increased the variance accounted for by a statistically significant 17%. Thus, overall SA provided significant incremental validity in the prediction of safety performance.

Next the unique contribution of each predictor was examined using relative weights analysis. In Model 1 (Table 5), the rank order of each of the predictors of safety performance was as follows: conscientiousness (23.58%), openness (23.05%), agreeableness (22.83%), emotional stability (11.18%), subjective job experience (11.12%), extraversion (7.38%), cognitive ability (0.71%), and tenure (0.16%). In Model 2, overall SA accounted for the preponderance of explained variance (51.49%). The remaining variance was distributed among the other predictors according to the following rank order: agreeableness (11.23%), conscientiousness (11.06%), openness (10.28%), subjective job experience (5.96%), emotional stability (5.13%), extraversion (4.55%), cognitive ability (0.25%), and tenure (0.08%). In sum, when overall SA was included in the model, it accounted for more than 50% of the explained variance in safety performance.

Table 5. Summary of Hierarchical Regression for Predictors of Safety Performance (N = 344)

	Model 1			Model 2		
Variable	*B(SE)*	*β*	*% Var*	*B(SE)*	*β*	*% Var*
Constant	3.49 (1.33)			0.06 (1.20)		
Openness	0.13 (0.03)	.21	23.05%	0.05 (0.03)	.07	10.28%
Conscientiousness	0.13 (0.03)	.21	23.58%	0.06 (0.03)	.10	11.06%
Extraversion	0.02 (0.02)	.05	7.38%	0.03 (0.02)	.07	4.55%
Agreeableness	0.12 (0.03)	.22	22.83%	0.07 (0.02)	.13	11.23%
Emotional Stability	0.04 (0.02)	.10	11.18%	-0.01 (0.02)	-.02	5.13%
ICAR total score	0.08 (0.05)	.07	0.71%	0.02 (0.05)	.02	0.25%
Subjective Job Experience	0.12 (0.04)	.15	11.12%	0.09 (0.03)	.11	5.92%
Tenure	-0.12 (0.20)	-.03	0.16%	-0.01 (0.18)	.00	0.08%
Overall SA				0.31 (0.03)	.52	51.49%
Multiple R		0.58			0.71	
R^2		0.33			0.50	
F-test		20.85			110.27	
p-value		< .001			< .001	
ΔR^2					0.17	
F for ΔR^2					36.85	
p-value					< .001	

SEM Analysis of the Proposed Model Relating SA to Safety Performance

SEM analyses were conducted to compare the fit of four models: specifically, the three proposed models, and an additional model, which separated job experience into subjective work experience and tenure factors. *Table 6* presents global fit statistics for all of these models, but *parameter estimates are reported only for the fourth model, which conceptualized SA as a unidimensional construct* in accordance with the earlier CFA findings. As can be seen in Table 6, the global fit statistics for all proposed models are within the conventional range of acceptability.

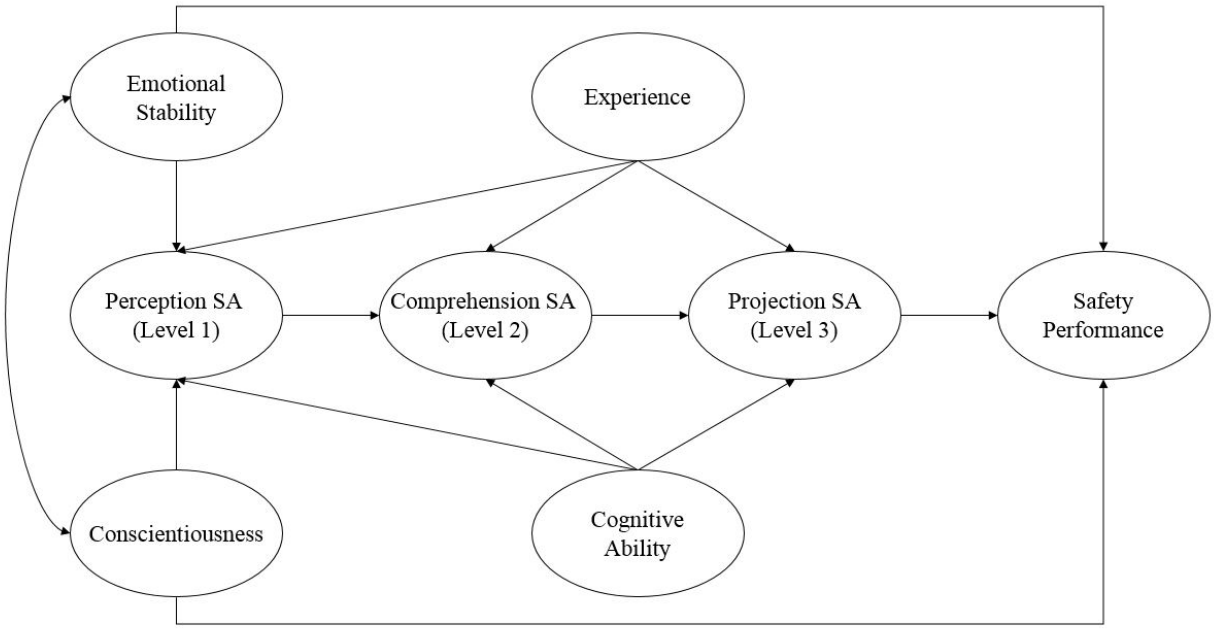

Figure 1. Model 1 - Proposed Structural Equation Model

Model 1 (Figure 1) embodied the strongest theoretical assumptions: specifically, the mediation among each of the SA components, the effects of conscientiousness and emotional stability partially mediated by SA, and the effects of experience and cognitive ability fully mediated by the SA components. The model converged without error and the global fit indices suggested good fit, with the CFI (.940), TLI (.937), and RMSEA (.054) at or near the

recommended levels of .95, .95, and .05 respectively (e.g., Browne & Cudeck, 1993, Hu & Bentler, 1999).

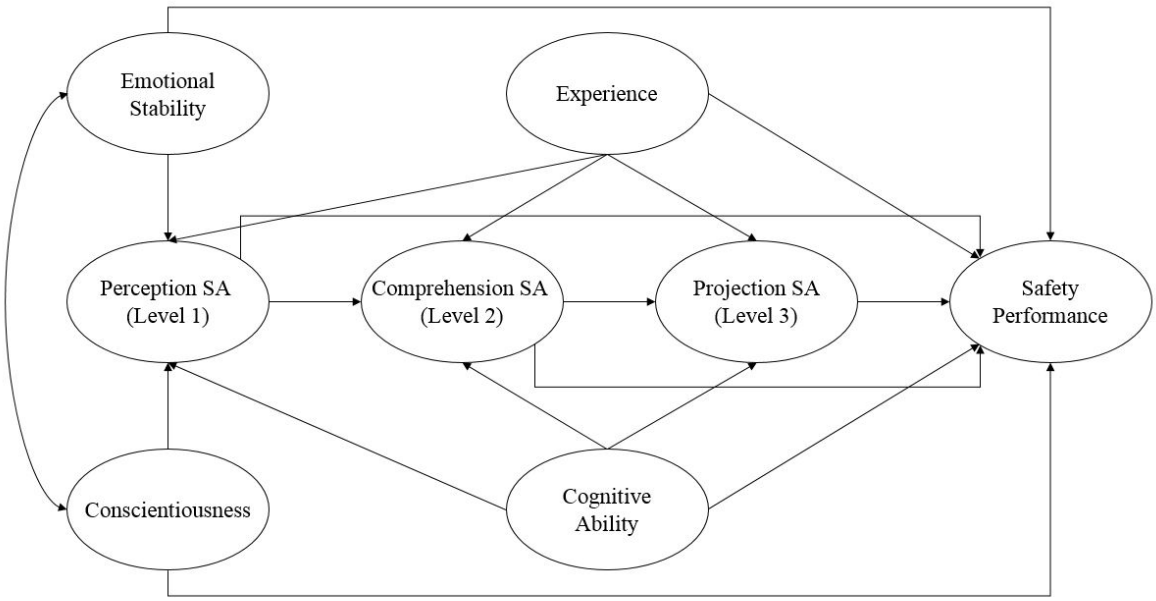

Figure 2. Model 2 - Proposed First Alternative Structural Equation Model

Model 2 (Figure 2) retained the three component model of SA, but direct paths were added from perception SA, comprehension SA, cognitive ability and job experience to safety performance to allow partial, rather than full, mediation. This model converged without error and fit the data similarly to Model 1. χ^2 was significant (χ^2 (1873) = 3786.20, $p < .001$) but the CFI (.940) and TLI (.937) both approached the .95 criterion for good fit (Hu & Bentler, 1999) and the RMSEA point estimate (.054) and 90% confidence interval (.052,.057) were close to the .05 criterion for excellent fit (Browne & Cudeck, 1993).

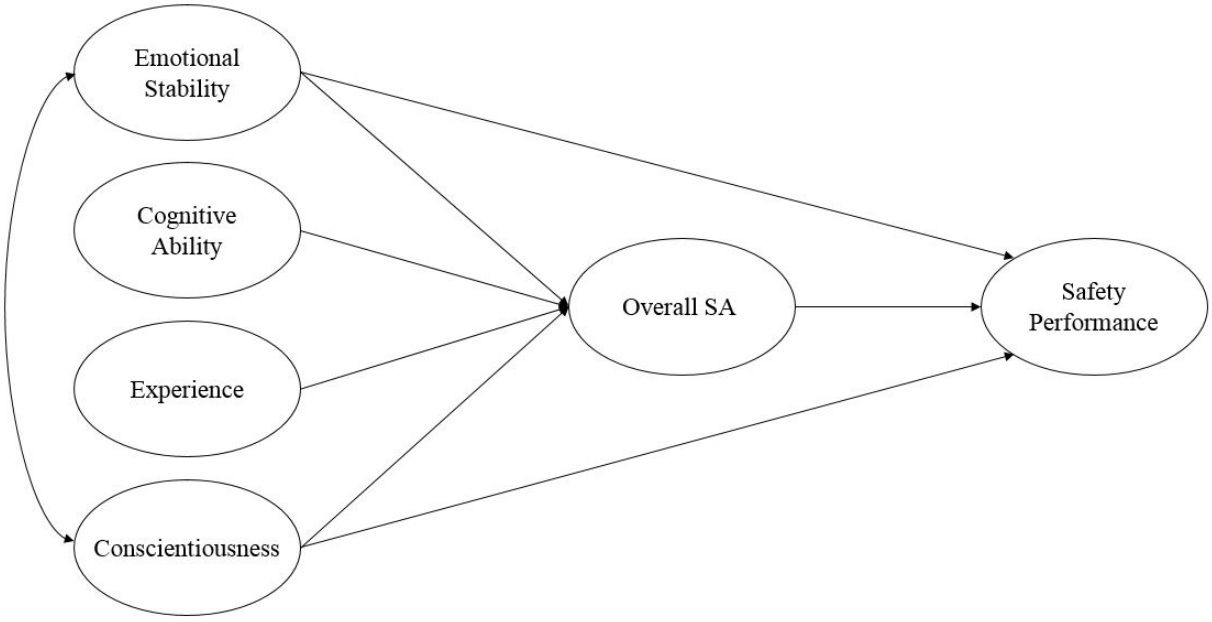

Figure 3. Model 3 - Proposed Second Alternative Structural Equation Model

Unlike Models 1 and 2, Model 3 (Figure 3) conceptualized SA as a unidimensional construct in accordance with the previously presented CFA findings. This model posited that overall SA fully mediates the relationships between cognitive ability and job experience and safety performance, but only partially mediates the relationships between personality variables and safety performance. The fit statistics for this model were very similar to the previous two: χ^2 was significant (χ^2 (1881) = 3904.31, $p < .001$), CFI = .936, TLI = .934, and RMSEA = .056 with a 90% confidence interval of (.053, .058) suggesting overall good fit. Note, however, that in light of the CFA results supporting a two-factor model of job experience, an additional model was examined with job experience split into subjective job experience and tenure factors.

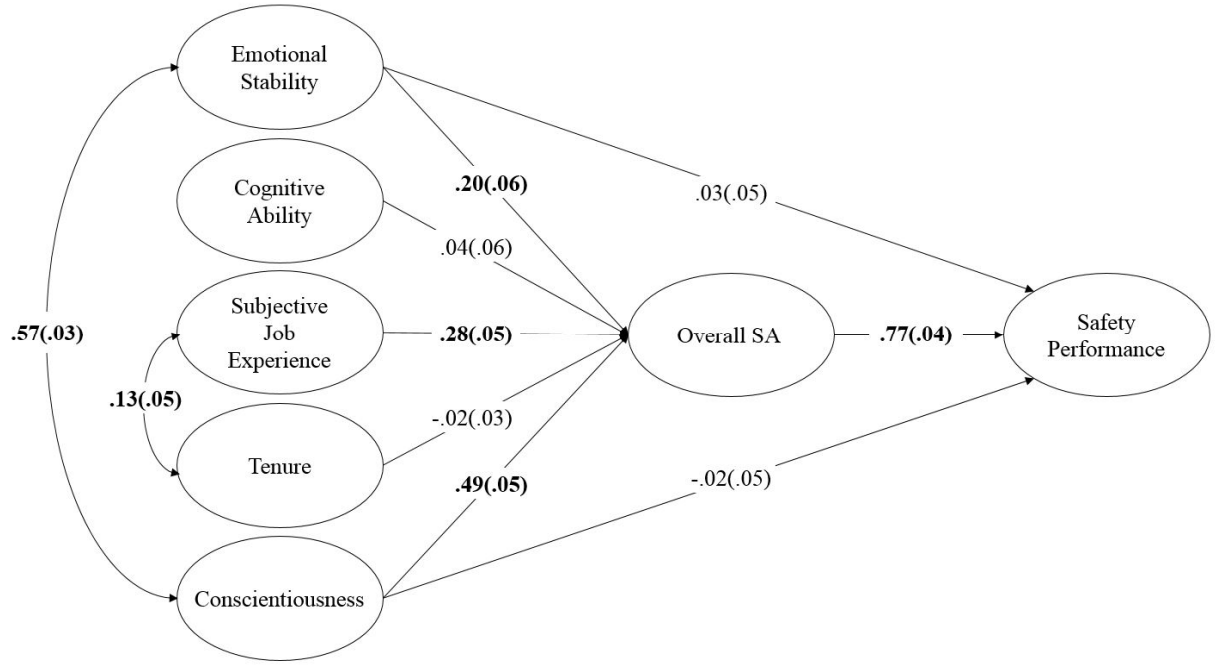

Figure 4. Model 4 - Final SEM Model (Standardized Parameter Estimates Shown)

Model 4 (Figure 4) was the final model examined and is the model for which parameter estimates are reported. Model 4 retains all of the characteristics of Model 3, except job experience was split into subjective job experience and tenure factor in accordance with the earlier CFA results. Although the overall χ^2 was still significant (χ^2 (1879) = 3146.40, $p < .001$), the CFI (.960) and TLI (.959) were both above the recommended .95 threshold for good fit (Hu & Bentler, 1999), and the RMSEA point estimate (.044) and its 90% confidence interval (.041, .047) indicated excellent fit (Browne & Cudeck, 1993). The implications of the parameter estimates for the proposed hypotheses are described below.

Hypothesis 2 posited that projection SA has a direct effect on safety performance. However, that hypothesis could not be tested as originally planned because the CFA of the self-report SA measure did not support the purported three-factor structure. Instead, the CFA findings supported a unidimensional SA model, so overall SA was substituted. As shown in Figure 4, the standardized path coefficient from overall SA to safety performance was statistically significant

(β = .77, SE = .04, p < .001) in accordance with expectations, which suggests at least partial support for hypothesis 2.

Several hypotheses regarding the interaction of personality, SA, and safety performance were also supported. As shown in Figure 4, the paths from conscientiousness (γ = .49, SE = .05, p < .001) and emotional stability (γ = .20, SE = .06, p < .001) to overall SA were both statistically significant, and represented strong and modest effects, respectively. Additionally, when overall SA was included in the model, the direct paths from conscientiousness to safety performance (γ = .03, SE = .05, p = .57) and from emotional stability to safety performance (γ = -.02, SE = .05, p = .69) were not statistically significant. Therefore, it seems the effects of the personality variables were mediated by overall SA, thus providing partial support for hypotheses 3 and 4. Additionally, the emotional stability and conscientiousness factors correlated as expected (ϕ = .57, SE = .03, p < .001), which supports hypothesis 5.

The final hypotheses concerned the relationships between cognitive ability and SA and job experience and SA. In contrast to hypothesis 6, the Model 4 SEM results indicate that cognitive ability did not significantly predict overall SA (γ = .04, SE = .05, p = .54), although it remains unknown whether some SA components might have been better predicted than others. In contrast, job experience was predictive of overall SA. Specifically, the subjective job experience factor had a statistically significant effect on overall SA (γ = .28, SE = .05, p < .001), but the tenure factor did not (γ = -.02, SE = .03, p = .61). The correlation between the two experience factors was statistically significant but small (ϕ = .13, SE = .05, p = .01). Thus, quality of job experience, rather than quantity of job experience, predicted overall SA, partially supporting hypothesis 7.

Table 6. Structural Equation Modeling (SEM) Global Fit Indices for Proposed and Retained Models (N = 344)

Models	χ^2 (df)	*p*	CFI	TLI	RMSEA [90%CI]
Model 1 - Proposed Model	3787.79 (1877)	< .001	.940	.937	.054 [.052,.056]
Model 2 - 1st Alternative	3786.20 (1873)	< .001	.940	.937	.054 [.052,.057]
Model 3 - 2nd Alternative	3904.31 (1881)	< .001	.936	.934	.056 [.053,.058]
Model 4 - Modified 2nd Alternative	3146.40 (1879)	< .001	.960	.959	.044 [.041,.047]

Chapter Four
Discussion

Recent research suggests that SA may mediate the relationship between a variety of individual difference variables and safety performance. The intent of this study was to examine some of these relationships while testing the basic tenets of Endsley's (1995b) three-component SA model (Endsley, 1995b). To widen the range of occupations that could be examined, this study used a newly developed self-report SA measure by Saetrivik (2013), which would allow tests of the mediation hypotheses implied by Endsley's representation. Unfortunately, CFA revealed a collinearity problem with the three-factor solution, which necessitated a simpler unidimensional representation. Thus, relationships between SA antecedents and outcomes were examined using an overall SA measure formed by combining the items representing the perception, projection, and comprehension factors.

Regression and relative weights analyses indicated that SA exhibited statistically significant and practically important incremental validity in predicting safety performance, above the Big Five personality dimensions, cognitive ability, subjective job experience, and tenure. It added fully 17% more explained variance to the model. Additionally, when SA was included in the regression model, it accounted for more variance in safety performance than all other predictors combined. Subsequent SEM analyses also supported the efficacy of SA as a predictor of safety performance, as illustrated by the sizable standardized path coefficient β=.77 in the final model. Collectively, these results demonstrate the utility of overall SA as a proximal predictor of safety performance.

In addition to the predictive validity of overall SA alone, the construct also mediated the relationships of several predictors of safety performance. Specifically, overall SA fully mediated the relationships between emotional stability and conscientiousness with safety performance; when SA was included in the model, the direct paths from conscientiousness and emotional stability to safety performance were not statistically significant. These results are interesting because previous research indicates that these two personality factors are among the best predictors of safety performance (Christian et al.'s, 2009; Hogan & Foster, 2013). In sum, the overall SA factor fully mediated the relationship between the personality dimensions included in the model and safety performance.

To evaluate the impact of job experience in this conceptual framework, a scale differentiating between quantity and quality of job experience was developed. It was hypothesized that the items would load on a single general factor, but CFA showed that the subjective job experience and tenure components were only slightly correlated. Subsequent SEM results indicated that subjective job experience predicted overall SA, but tenure did not. Thus, it appears the quality of one's job experience is more predictive of overall SA than the quantity.

Most surprisingly, this research found no significant relationship between cognitive ability and overall SA. This finding is in contrast to previous studies, which suggest SA is driven by working memory, fluid intelligence, and other specific cognitive ability constructs (e.g., Durso, Bleckly, & Dattel, 2006). The most likely explanation is that the relationship between cognitive ability and SA was greatly attenuated in this study by using a self-report SA measure, which asked participants to make judgments about their typical environmental awareness, rather than requiring them to perceive, comprehend, and project outcomes concerning stimuli under maximum performance simulation scenarios (e.g., SAGAT). The high correlations among the

self-report component scores suggest an alternative measurement approach is needed to gainfully assess SA and test Endsley's mediation assumptions in a wide array of occupations.

Limitations and Future Research

While this is the first empirical test of this assumed mediation, there are several alternative explanations which preclude strong interpretation of this result. As previously mentioned, the study relied on a SA measure which may reflect typical SA rather than maximal SA. Additionally, the SA items were administered in a single setting, whereas the commonly used SAGAT-like measures rely on individual probes to assess perception SA, comprehension SA, and projection SA separately. Further, the current study used a self-report measure of SA whereas the majority of SA studies tend to use simulation-based techniques. Thus, the three separable factors may only be present only under maximal performance conditions, when probes for each of the components are separate, or when simulation-based methods are used. Therefore, future research should compare different forms of SA assessment, focusing on the distinction between typical and maximal SA and how this distinction may influence the relationships between SA and other constructs. Specifically, given the influential nature of openness, conscientiousness, and emotional stability in predicting SA, future research should investigate how SA might mediate the relationship between these personality domains and general job performance.

Another limitation is that participants were incentivized to answer cognitive ability items using a reward for each item answered correctly. Although the bonus was relatively small compared to the amount paid for simply completing the study, the observed scores could reflect participant motivation to complete the cognitive ability items rather than their trait ability level. Further, the mean number of correct responses waned for latter cognitive ability items,

specifically, the three dimensional rotation items, in comparison to earlier items, specifically, the verbal reasoning and letter and number combination items; however, several participants noted their enthusiasm for completing the three dimensional rotation items in their open-ended comments. Thus, it still unclear if participants' scores truly reflect their ability or their motivation. Future research investigating the relationship between cognitive ability and SA should conduct testing under more robust testing settings.

The results are also limited by the experience scale developed within the study. Although the items were developed based on the findings of the job experience literature, the items may reflect confidence in one's job experience rather than the quality of one's job experience. Additionally, the participants were told to answer the items with a referent peer of similar experience within their organization, but the choice of the referent may skew the results; for example, if the participant chose a highly motivated, achievement-oriented peer, they may be engaging in upward social comparison and reflect on their job experience unfavorably. Similarly, if a participant chose a slothful, unengaged referent other of similar tenure may engage in downward social comparison. Future research should investigate how different choices of referent peers influence the results and should seek to refine such self-report measures.

Implications

The results of this study provide contradictory evidence to the tripartite model of SA, suggesting the SA construct may be better explained by a general, overall awareness factor rather than three distinct components. For SA measurement, assessments of the seemingly separable perception, comprehension, and projection SA may result in longer assessments than necessary. A brief, overall SA assessment may offer the same information but could be less costly and time

consuming. This interpretation is made with caution, however, as the current study may have assessed typical rather than maximal SA, as is most often assessed in the SA literature.

Despite the need for additional theory development, SA was an excellent predictor of safety performance. For the purposes of selection, SA offers additional predictive validity beyond other individual differences typically assessed during the selection process. For especially safety conscious occupations (e.g., line production, construction, food preparation) who must predict whether or not applicants will adhere to safety rules and regulations, the addition of a brief, public-domain, 13-item self-report measure of SA may allow them to meet this need.

References

Arthur, W., Jr., & Graziano, W. G. (1996). The five-factor model, conscientiousness, and driving accident involvesment. *J Pers, 64*(3), 593-618.

Benavides, F. G., Benach, J., Muntaner, C., Delclos, G. L., Catot, N., & Amable, M. (2006). Associations between temporary employment and occupational injury: what are the mechanisms? *Occupational and environmental medicine, 63*(6), 416-421.

Borman, W. C., & Motowidlo, S. (1993). Expanding the criterion domain to include elements of contextual performance. *Personnel selection in organizations; San Francisco: Jossey-Bass*, 71.

Broadbent, D. E., Cooper, P. F., FitzGerald, P., & Parkes, K. R. (1982). The cognitive failures questionnaire (CFQ) and its correlates. *British Journal of Clinical Psychology*, *21*(1), 1-16.

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), Testing structural equation models (pp. 136- 162). Newbury Park, CA: Sage.

Breslin, F. C., & Smith, P. (2006). Trial by fire: a multivariate examination of the relation between job tenure and work injuries. *Occupational and Environmental Medicine, 63*(1), 27-32. doi: DOI 10.1136/oem.2005.021006

Bureau of Labor Statistics, U.S. Department of Labor. (2010). Standard Occupational Classification. Retrieved August 12, 2015 from http://www.bls.gov/soc/soc_structure_2010.xls

Bureau of Labor Statistics, U.S. Department of Labor. (2013). Census of Fatal Occupational Injuries. Retrieved July 27, 2015 from http://www.bls.gov/iif/oshwc/cfoi/cftb0277.pdf

Carretta, T. R., & Ree, M. J. (1994). Pilot-candidate selection method: sources of validity. *The International Journal of Aviation Psychology*, *4*(2), 103-117.

Carretta, T. R., Perry, D. C., Jr., & Ree, M. J. (1996). Prediction of situational awareness in F-15 pilots. *Int J Aviat Psychol, 6*(1), 21-41. doi: 10.1207/s15327108ijap0601_2

Cattell, R. B., Eber, H. W., & Tatsuoka, M. M. (1970). *Handbook for the sixteen personality factor questionnaire (16 PF): In clinical, educational, industrial, and research psychology, for use with all forms of the test*. Institute for Personality and Ability Testing.

Christian, M. S., Bradley, J. C., Wallace, J. C., & Burke, M. J. (2009). Workplace safety: a meta-analysis of the roles of person and situation factors. *J Appl Psychol, 94*(5), 1103-1127. doi: 10.1037/a0016172

Condon, D. M., & Revelle, W. (2014). The international cognitive ability resource: Development and initial validation of a public-domain measure. *Intelligence, 43*, 52-64. doi: DOI 10.1016/j.intell.2014.01.004

Costa, P. T., & McCrae, R. R. (1985). *The NEO personality inventory*. Psychological Assessment Resources.

Costa, P. T., & McCrae, R. R. (1992). NEO PI-R professional manual: Odessa, FL: Psychological assessment resources.

DuBois, D., & McKee, A. S. (1994). Facets of work experience. In *9th Annual Conference of the Society for Industrial and Organizational Psychology, Nashville, TN*.

Durso, F. T., Bleckley, M. K., & Dattel, A. R. (2006). Does situation awareness add to the validity of cognitive tests?. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *48*(4), 721-733.

Endsley, M. R. (1988). *Situation awareness global assessment technique (SAGAT).* Paper presented at the Aerospace and Electronics Conference, 1988. NAECON 1988., Proceedings of the IEEE 1988 National.

Endsley, M. R. (1990). *Predictive utility of an objective measure of situation awareness.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.

Endsley, M. R. (1995a). A taxonomy of situation awareness errors. *Human factors in aviation operations*, 287-292.

Endsley, M. R. (1995b). Toward a theory of situation awareness in dynamic systems. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 37*(1), 32-64.

Endsley, M. R. (2000a). Direct measurement of situation awareness: Validity and use of SAGAT. *Situation awareness analysis and measurement, 10*.

Endsley, M. R. (2000b). Theoretical underpinnings of situation awareness: A critical review. *Situation awareness analysis and measurement*, 3-32.

Fracker, M. L. (1991). Measures of situation awareness: an experimental evaluation: DTIC Document.

Goldberg, L. R. (1992). The development of markers for the Big-Five factor structure. *Psychological assessment, 4*(1), 26.

Gugerty, L. J. (1997). Situation awareness during driving: Explicit and implicit knowledge in dynamic spatial memory. *Journal of Experimental Psychology: Applied, 3*(1), 42.

Hogan, J., & Foster, J. (2013). Multifaceted Personality Predictors of Workplace Safety Performance: More Than Conscientiousness. *Human Performance, 26*(1), 20-43.

Houston, J. S., Borman, W. C., Farmer, W. L., & Bearden, R. M. (2005). *Development of the enlisted computer adaptive personality scales (ENCAPS), renamed Navy Computer Adaptive Personality Scales (NCAPS)* (No. 502). Technical Report.

Hu, L. T., & Bentler, P. M. (1999). Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives. *Structural Equation Modeling-a Multidisciplinary Journal, 6*(1), 1-55. doi: Doi 10.1080/10705519909540118

Johnson, J. W. (2000). A heuristic method for estimating the relative weight of predictor variables in multiple regression. *Multivariate Behavioral Research*, *35*(1), 1-19.

Johnson, J. W. (2001). The relative importance of task and contextual performance dimensions to supervisor judgments of overall performance. *Journal of Applied Psychology*, *86*(5), 984 - 996.

Judge, T. A., Jackson, C. L., Shaw, J. C., Scott, B. A., & Rich, B. L. (2007). Self-efficacy and work-related performance: the integral role of individual differences. *Journal of Applied Psychology, 92*(1), 107.

Kaplan, S., & Tetrick, L. E. (2011). *Workplace safety and accidents: An industrial and organizational psychology perspective*.

Kass, S. J., Cole, K. S., & Stanny, C. J. (2007). Effects of distraction and experience on situation awareness and simulated driving. *Transportation Research Part F: Traffic Psychology and Behaviour*, *10*(4), 321-329.

Muthén, L. K., & Muthén, B. O. (2002). How to use a Monte Carlo study to decide on sample size and determine power. *Structural Equation Modeling, 9*(4), 599-620.

Nahrgang, J. D., Morgeson, F. P., & Hofmann, D. A. (2007). *Predicting safety performance: a meta-analysis of safety and organizational constructs.* Paper presented at the 22nd annual conference of the society for industrial and organizational psychology.

National Safety Council. (2014). *Injury Facts®, 2014 Edition*. Itasca, IL: Author. Library of Congress Catalog Card Number: 99-74142

Neal, A., & Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal of Applied Psychology, 91*(4), 946-953. doi: Doi 10.1037/0021-9010.91.4.946

Neal, A., Griffin, M. A., & Hart, P. M. (2000). The impact of organizational climate on safety climate and individual behavior. *Safety Science, 34*(1-3), 99-109. doi: Doi 10.1016/S0925-7535(00)00008-4

Ng, T. W. H., & Feldman, D. C. (2010). Organizational Tenure and Job Performance. *Journal of Management, 36*(5), 1220-1250. doi: Doi 10.1177/0149206309359809

Paul, P., & Maiti, J. (2007). The role of behavioral factors on safety management in underground mines. *Safety Science, 45*(4), 449-471.

Postlethwaite, B., Robbins, S., Rickerson, J., & McKinniss, T. (2009). The moderation of conscientiousness by cognitive ability when predicting workplace safety behavior. *Personality and Individual Differences, 47*(7), 711-716. doi: DOI 10.1016/j.paid.2009.06.008

Raven, J., Raven, J.C., & Court, J.H. (1998). *Raven Manual: Sec. 4. Advanced Progressive Matrices (1998 ed.)*. Oxford, England: Oxford Psychologists Press.

Revisions to the Standards for the Classification of Federal Data on Race and Ethnicity, 62 Fed. Reg. 58789 (Oct. 30, 1997)

Sætrevik, B. (2013). Developing a context-general self-report approach to measure three-level situation awareness. *Int Marit Health, 64*(2), 66-71.

Saus, E. R., Johnsen, B. H., Eid, J., & Thayer, J. F. (2012). Who benefits from simulator training: Personality and heart rate variability in relation to situation awareness during navigation training. *Computers in Human Behavior, 28*(4), 1262-1268. doi: DOI 10.1016/j.chb.2012.02.009

Schmidt, F. L., & Hunter, J. E. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin, 124*(2), 262-274. doi: Doi 10.1037//0033-2909.124.2.262

Selcon, S. J., Taylor, R. M., & Koritsas, E. (1991). Workload or situational awareness?: TLX vs. SART for aerospace systems design evaluation. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 35, No. 2, pp. 62-66). SAGE Publications.

Smith, K., & Hancock, P. (1995). Situation awareness is adaptive, externally directed consciousness. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 37*(1), 137-148.

Sneddon, A., Mearns, K., & Flin, R. (2013). Stress, fatigue, situation awareness and safety in offshore drilling crews. *Safety Science, 56*, 80-88. doi: DOI 10.1016/j.ssci.2012.05.027

Sulistyawati, K., Wickens, C. D., & Chui, Y. P. (2011). Prediction in Situation Awareness: Confidence Bias and Underlying Cognitive Abilities. *International Journal of Aviation Psychology, 21*(2), 153-174. doi: Pii 935838094

Taylor, R. M. (1990). Situational Awareness Rating Technique(SART): The development of a tool for aircrew systems design. *AGARD, Situational Awareness in Aerospace Operations 17 p(SEE N 90-28972 23-53)*.

Quińones, M. A., Ford, J. K., & Teachout, M. S. (1995). The relationship between work experience and job performance: a conceptual and meta-analytic review. *Personnel Psychology*, *48*(4), 887-910.

Waag, W. L., & Houck, M. R. (1994). Tools for assessing situational awareness in an operational fighter environment. *Aviat Space Environ Med, 65*(5 Suppl), A13-19.

Wallace, J. C., & Vodanovich, S. J. (2003). Workplace safety performance: Conscientiousness, cognitive failure, and their interaction. *Journal of Occupational Health Psychology, 8*(4), 316.

Appendix A: Additional Tables

Table 7. Zero-order correlations between study measures (including subscale correlations) (N = 344-349).

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Demo.	1 Sex	--																											
	2 Ethnicity	-.05	--																										
	3 Minority	.02	-.10	--																									
	4 Work Hours	**.14**	.02	**-.02**	--																								
	5 Age	.01	**.12**	-.08	.04	--																							
IPIP	6 Openness	-.04	**-.19**	.05	.01	-.08	(.84)																						
	7 Conscien.	-.04	-.07	.05	.07	.10	**.24**	(.87)																					
	8 Extrav.	.08	-.03	.02	.13	.05	**.24**	**.18**	(.91)																				
	9 Agreeable.	**-.18**	.00	-.01	.01	**.14**	**.33**	**.28**	**.37**	(.90)																			
	10 Emo. Stabil.	**.18**	-.08	.02	.10	.10	**.12**	**.48**	**.37**	**.26**	(.93)																		
Exper.	11 Subjective	.07	-.08	.09	.21	**.13**	**.15**	**.24**	**.22**	.04	**.12**	(.90)																	
	12 Occupation	.01	.07	.00	.17	**.36**	-.05	**.11**	-.02	.05	**.11**	**.15**	--																
	13 Organization	.02	.08	.04	.18	**.30**	.00	**.14**	.06	.07	**.16**	**.15**	**.75**	--															
	14 Position	-.06	.07	.03	.11	**.27**	-.01	.08	.00	.05	**.11**	.06	**.83**	**.83**	--														
	15 Mean Tenure	-.01	.08	.03	**.16**	**.33**	-.02	**.12**	.02	.06	**.13**	**.13**	**.92**	**.92**	**.95**	(.92)													
	16 Total	.06	-.02	.09	.26	**.26**	**.12**	**.26**	**.20**	.07	**.17**	**.88**	**.56**	**.56**	**.50**	**.58**	(.84)												
ICAR	17 Verbal Reas.	**.17**	.02	**-.16**	**-.07**	-.08	.03	-.08	**-.16**	**-.12**	**-.12**	-.03	-.04	**-.12**	**-.12**	-.10	-.07	(.60)											
	18 Letter Num.	.05	-.05	-.10	-.04	-.04	.06	-.07	-.10	-.02	-.01	-.03	.01	.01	-.01	.00	-.02	**.47**	(.60)										
	19 Matrix Reas.	.10	.05	-.06	-.06	-.04	-.01	-.09	**-.15**	-.10	.01	-.07	.03	.06	.02	.04	-.03	**.38**	**.46**	(.53)									
	20 3-Dim. Rot.	.08	.09	-.06	-.07	.02	.00	-.06	**-.14**	**-.11**	.04	-.05	.05	.06	.03	.05	-.02	**.23**	**.34**	**.82**	(.63)								
	21 Total	**.13**	.02	**-.13**	**-.07**	-.06	.03	-.10	**-.17**	-.10	-.04	-.06	.01	.00	-.03	-.01	-.05	**.72**	**.78**	**.85**	**.66**	(.79)							
SA	22 Percep. SA	-.02	-.10	-.09	.08	**.13**	**.27**	**.39**	**.23**	**.34**	**.44**	**.12**	.00	.02	-.04	.00	.10	.04	.03	.01	.00	.03	(.76)						
	23 Comp. SA	-.01	-.04	-.06	.08	**.12**	**.43**	**.42**	**.18**	**.33**	**.32**	**.19**	.04	.07	-.01	.04	**.17**	.10	.07	.06	.02	.10	**.71**	(.85)					
	24 Proj. SA	-.03	-.06	.01	.05	**.15**	**.39**	**.34**	**.16**	**.31**	**.26**	**.22**	.04	.07	.00	.04	**.20**	.06	.01	-.01	-.03	.02	**.50**	**.68**	(.60)				
	25 Overall SA	-.02	-.08	-.07	.08	**.15**	**.41**	**.45**	**.22**	**.37**	**.40**	**.19**	.03	.06	-.02	.02	**.17**	.08	.05	.03	.00	.06	**.88**	**.93**	**.78**	(.87)			
Safety	26 Compliance	-.08	-.10	.02	.00	.10	**.38**	**.38**	**.17**	**.35**	**.27**	**.18**	-.02	.04	-.02	.00	**.15**	.04	.04	.01	-.02	.03	**.56**	**.62**	**.54**	**.66**	(.92)		
Perf.	27 Participation	-.08	-.08	-.03	.12	**.12**	**.31**	**.35**	**.31**	**.35**	**.28**	**.28**	.04	**.11**	.04	.07	**.26**	-.08	.01	.01	.03	-.02	**.44**	**.49**	**.51**	**.54**	**.57**	(.88)	
	28 Total	-.09	-.10	-.01	.07	**.13**	**.38**	**.41**	**.28**	**.40**	**.31**	**.26**	.01	.09	.01	.04	**.24**	-.03	.03	.01	.01	.01	**.56**	**.62**	**.59**	**.67**	**.86**	**.91**	(.89)
	Mean	0.56	0.94	0.20	38.72	37.28	28.80	29.55	19.40	28.57	25.93	20.55	0.00	0.00	0.00	0.00	0.01	2.91	2.19	2.44	0.84	7.54	12.54	16.58	9.21	38.33	10.23	9.04	19.27
	SD	0.50	0.23	0.40	8.49	10.60	6.43	6.76	9.07	7.63	9.33	5.14	1.00	1.00	1.00	0.93	5.93	1.19	1.34	1.97	1.11	3.57	3.04	3.04	1.82	6.92	2.08	2.60	4.14

Appendix B: Measures

Demographics

Response options are presented in brackets. Participant instructions are as follows: Please answer the following questions regarding your demographic background. If you are not comfortable answering any of these questions, you may leave them blank.

What is your age? [text entry restricted to numeric format]

What is your sex? [Male] [Female]

What is your ethnicity? [Hispanic or Latino] [Not Hispanic or Latino]

What is your race? Please select all that apply. [American Indian or Alaska Native] [Asian] [Black or African American] [Native Hawaiian or Other Pacific Islander] [White]

Please use the following drop down menus to find your occupational classification area and job title. A context code will appear, please select it.

Occupational Area [drop down]

Job title [drop down]

Context Code [drop down – automatically populated]

International Personality Item Pool (IPIP) 50-Item Five Factor Inventory (Goldberg, 1992)

Response options are on a 5-point (1 = Very Inaccurate, 5 = Very Accurate) scale. Reverse scored items are noted (R). Participant instructions are as follows: Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Indicate for each statement whether it is 1. Very Inaccurate, 2. Moderately Inaccurate, 3. Neither Accurate Nor Inaccurate, 4. Moderately Accurate, or 5. Very Accurate as a description of you.

Conscientiousness items:

- Am always prepared.
- Leave my belongings around. (R)
- Pay attention to details.
- Make a mess of things. (R)
- Get chores done right away.
- Often forget to put things back in their proper place. (R)
- Like order.
- Shirk my duties. (R)
- Follow a schedule.
- Am exacting in my work.

Emotional stability items:

- Get stressed out easily. (R)
- Am relaxed most of the time.
- Worry about things. (R)
- Seldom feel blue.
- Am easily disturbed. (R)
- Get upset easily. (R)
- Rarely get irritated.
- Change my mood a lot. (R)
- Have frequent mood swings. (R)
- Get irritated easily. (R)
- Often feel blue. (R)

Agreeableness items:

- Feel little concern for others. (R)
- Am interested in people.
- Insult people. (R)
- Sympathize with others' feelings.
- Am not interested in other people's problems. (R)
- Have a soft heart.
- Am not really interested in others. (R)
- Take time out for others.
- Feel others' emotions.
- Make people feel at ease.

Extraversion items

- Am the life of the party.
- Don't talk a lot. (R)
- Feel comfortable around people.
- Keep in the background. (R)
- Start conversations.
- Have little to say. (R)
- Talk to a lot of different people at parties.
- Don't like to draw attention to myself. (R)
- Don't mind being the center of attention.
- Am quiet around strangers. (R)

Openness items:

- Have a rich vocabulary.
- Have difficulty understanding abstract ideas. (R)
- Have a vivid imagination.
- Am not interested in abstract ideas. (R)
- Have excellent ideas.
- Do not have a good imagination. (R)
- Am quick to understand things.
- Use difficult words.
- Spend time reflecting on things.
- Am full of ideas.

International Cognitive Ability Resource (ICAR) 16-Item (Condon & Revelle, 2014)

Items omitted for test security. Please visit http://icar-project.org/ for item details.

Job Experience Measure

Response options are presented in brackets where applicable. All other questions are on a 5-point (1 = Strongly Disagree, 5 = Strongly Agree) Likert-type scale. Reverse scored items are noted (R). Scale instructions are as follows: Please answer the following questions regarding your **overall** job experience. Compare yourself to peers of similar age, positions, and educational backgrounds. Be as honest as possible.

Numeric response items:

How long have you been employed in your current **occupation** (e.g., Customer Service) **in months**? [text entry restricted to numeric format]

How long have you been employed in your current **organization** (e.g., Target) **in months**? [text entry restricted to numeric format]

How long have you been employed in your current **position** (e.g., Manager) **in months**? [text entry restricted to numeric format]

Likert-type items:

I have been exposed to more experience building situations than my peers

I have more experience than my peers

I have had more opportunities to learn on the job than my peers

I have had more opportunities to apply my job related knowledge than my peers

I have had more opportunities to apply my job related skills than my peers

I am less experienced than my peers (R)

Context General Self-Report SA Measure (Sætrevik, 2013)

Response options are on a 5-point (1 = Completely Disagree, 5 = Completely Agree) scale. Reverse scored items are noted (R). Instructions are as follows: Relate the following questions to what thoughts you usually or typically have in your work.

Perception SA items:

I sometimes lose track of information relevant for maintaining safety in my work (R)
I sometimes lose track of safety due to receiving too much information at the same time (R)
Some of the information I need to assess safety is presented in a way that makes it difficult to understand (R)
The information I need to assess safety is easily available

Comprehension SA items:

It's hard to know which consequences my actions have for safety (R)
I know which information is relevant for safety and which information is not relevant for safety
I know how to act to maintain safety
I feel confident that I know how to deal with the various adverse incidents that may arise
I know which situations in my work involves higher risk than others

Projection SA items:

I notice when an unsafe situation is about to arise at my workplace
I plan ahead in order to handle various adverse incident that may arise
It is impossible to predict what will happen during an adverse incident (R)
I usually know what's going to happen next with regards to safety

Safety Performance (Neal & Griffin, 2006)

Response options are on a 5-point (1 = Strongly Disagree, 5 = Strongly Agree) scale. Instructions are as follows: Relate the following questions to what thoughts you usually or typically have in your work.

Safety compliance items:

I use all the necessary safety equipment to do my job
I use the correct safety procedures for carrying out my job
I ensure the highest levels of safety when I carry out my job

Safety participation items:

I promote the safety program within the organization
I put in extra effort improve the safety of the workplace
I voluntarily carry our tasks or activities that help to improve workplace safety

Appendix C: IRB Approval Letter

USF
UNIVERSITY OF
SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

October 5, 2015

Andrew Thurston
Psychology
11275 53rd Ave N
Saint Petersburg, FL 33708

RE: **Exempt Certification**
IRB#: Pro00023791
Title: A Model of Situation Awareness as a Predictor of Safety Performance

Dear Mr. Thurston:

On 10/4/2015, the Institutional Review Board (IRB) determined that your research meets criteria for exemption from the federal regulations as outlined by 45CFR46.101(b):

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Approved Items:

SA Study Protocol- Thurston.docx

SA Informed Consent - Thurston.docx

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF HRPP policies and procedures.

Please note, as per USF HRPP Policy, once the Exempt determination is made, the application is closed in ARC. Any proposed or anticipated changes to the study design that was previously declared exempt from IRB review must be submitted to the IRB as a new study prior to initiation of the change. However, administrative changes, including changes in research personnel, do not warrant an amendment or new application.

Given the determination of exemption, this application is being closed in ARC. This does not limit your ability to conduct your research project.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

John Schinka, Ph.D., Chairperson
USF Institutional Review Board