Simulate the Job: Predicting Accidents Using a Work Sample

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This study examined the construct and criterion-related validity of a psychomotor work sample in predicting safety incidents in addition to job performance for entry-level manufacturing jobs. Results shed light to the underlying constructs measured in the work sample and demonstrated usefulness of a pre-employment work sample in improving workplace safety.

In almost any work-related environment that involves physical activity, safety is routinely rated as the single most important factor by subject matter experts. No other aspect of work is more important than ensuring the health and well-being of oneself and others. While there are many factors that contribute to accidents, it is clear that some individuals are more likely to engage in high risk, unsafe behaviors than others. For instance, a study by Knipling and his colleagues found that 20 percent of drivers account for almost 80 percent of all driving accidents (Knipling et al., 2004).

In addition to the health and welfare of the individuals involved, accidents are costly to the organization in terms of insurance, equipment, and goods. According to the Occupational Safety and Health Administration (OSHA), for every $1 a company spends on medical expenses for a worker's compensation claim they also incur $4 in indirect workers compensation costs. For every $1 of disability (lost time) expenses paid for a worker's compensation claim OSHA estimates that the employer also incurs between $2 and $10 in indirect workers compensation costs. Considering that in 2007 the average workers' compensation claim was $46,800, the indirect cost would be over $200,000.

Workplace injuries are both more ubiquitous and serious than is commonly thought. According to a recent study by the U.S. Bureau of Labor Statistics, slightly more than one-half of the 3.3 million private industry injury and illness cases reported nationally in 2009 were of a more serious nature that involved days away from work, job transfer, or restriction – commonly referred to as DART cases. In 2009 these occurred at a rate of 1.8 cases per 100 workers (U.S. Department of Labor, Bureau of Labor Statistics, *News Release, October 21, 2010*. USDL-10-1452). Therefore, nearly 50% of all injuries are severe enough to lead to loss of work, restricted duty upon return and/or transferring out of the original job.

IMPROVING SAFETY

Safety incidents, accidents, and various forms of safety-related behaviors are influenced by a range of factors. A recent meta-analysis evaluated two broad categories, person factors and situation factors in predicting workplace safety (Christian, Bradley, Wallace, & Burke, 2009).

Situational Factors

On the one hand there are Situational Factors that play a key role in predicting safety behavior. One of the primary and most important of these factors is the Safety Climate of the organization. *Safety climate* can be defined as the shared perceptions of individuals in the work environment related to safety-related policies, practices, and procedures pertaining to safety matters that affect personal well being (James, James, & Ashe 1990). It is impacted by factors such as management's commitment to safety practice, perceived organizational support, safety systems that are put in place, and training provided about safe practices and procedures, as well as the leadership style of the direct supervisor. With regard to leadership, the level of leader member exchange (LMX), or the degree to which employees feel free and willing to raise safety concerns to their supervisor is a critical determinant of safety climate (Hofmann & Morgeson, 1999). Research consistently shows that there is a strong, significant relationship between safety climate and safety behavior (Clarke, 2006).

Personal Factors

In addition to situational factors there are individual factors that relate to safety behavior which then result in safety outcomes. In other words, two individuals, placed in the same job and the same environment, will not necessarily engage in similar levels of safety behaviors. One will be more or less likely to act safely, follow procedures and protocols, and avoid unnecessary risks than the other. Each individual brings characteristics, ways of processing information, and behaviors that are unique to them.

Many individual difference variables have been shown to relate to safety outcomes. Conscientiousness is consistently related to safety performance and safety compliance as well as accidents and injuries (c.f. Christian et al., 2009; Clarke & Robertson, 2005; Wallace & Vodanovich, 2003). Thrill seeking and recklessness have long been associated with unsafe behaviors (c.f. Zuckerman & Link, 1968). Individuals who are more thrill-seeking are more likely to drive fast, accelerate through yellow lights, take dangerous shortcuts, and drive while intoxicated (Arnett, Offer, & Fine, 1997; Ashton, 1998; Kilgore, Vo, Castro, & Hoge, 2006; Paul & Maiti, 2007). Risk taking has also been shown to be significantly related to accidents and injuries (Christian et al., 2009). Across a variety of occupations locus of control has been found to predict accident risk, number of reported accidents, and accident severity (Wuebker, 1986). In addition, individuals with an external locus of control had average accident-related medical costs 2.6 times higher than their internally-oriented counterparts (Jones & Wuebker, 1993). Emotional stability has long been shown to be related to accidents among professional drivers (Roy & Choudhary, 1985), motorists (Mayer & Treat, 1977), and within industrial settings (Hansen, 1989).

In general, these studies have addressed the types of individual difference variables that predict safety outcomes. Most of these studies used non-interactive assessment methodologies, such as personality and biodata inventories and cognitive ability tests for capturing these individual factors. Indeed, even a variable such as cognitive failure, which has also shown to be related to safety outcomes, is typically evaluated using self-report response scales (c.f. Broadbent, Cooper, Fitzgerald, & Parkes, 1982; Wallace & Chen, 2006; Wallace & Vodanovich, 2003).

The purpose of the current paper is to describe the development of an interactive psychomotor work sample simulation and evaluate how effectively that was able to predict safety behavior in applied manufacturing setting. In addition, the construct validity of that simulation was evaluated to determine the individual differences variables that comprise that simulation. One of the criticisms of past research on safety and safety outcomes is that many studies suffer from a common method and perhaps more critically, a common rater bias. For instance, of the 113 criteria listed in Christian et al.'s (2009) meta-analysis, 72 of them (64%) relied on self-reports of safety criteria. In addition, of the 111 predictor variables in that study, 93 of them (84%) relied on self-report measures such as personality scales, job attitudes, climate measures, etc. While a number of studies have shown that there is a strong relationship between self-reports and supervisor ratings of accidents (c.f. Wallace & Vodanovich, 2003), the over reliance on self-reports of both predictor and criteria are concerning. In the current study, the predictor is based on actual physical performance in a job-relevant simulation and the criterion consists of supervisor ratings of safety incidents.

Work Sample Testing and Previous Research

Work sample testing is a form of assessment involving the use of hands-on performance measures, whereby an applicant or incumbent performs a given task or set of tasks under conditions comparable to those found on the position in question (Callinan & Robertson, 2000). The primary philosophy behind this approach to assessment lies in the theoretical foundation set forth in the seminal works of both Wernimont and Campbell (1968) and Asher and Sciarrino (1974). Although addressing the concept of validity more broadly, Wernimont and Campbell (1968) encouraged a general shift from the traditional focus on traits and predispositions to a greater emphasis on observable forms of behavior.

A large body of research has provided evidence for the high validity of work sample measures, compared to traditional paper-and-pencil tests (e.g., Campion 1972; Mount, Munchinsky, & Hanser,1977), and similar conclusions have been reached in meta-analyses and reviews (Schmitt, Gooding, Noe, & Kirsch, 1984; Roberton & Kandola, 1982; Roth, Bobko, & McFarland, 2005; Schmidt & Hunter, 1998). Schmidt and Hunter (1998) noted that, across all predictor measures, work samples produced the highest validity for overall job performance (.54), higher than that of general cognitive ability (.51), Conscientiousness (.31), and biodata (.35). Roth et al. (2005) also reported a moderate relationship between work sample test and general cognitive ability (.32). However, specific research examining validity of work sample measures in relation to safety criteria was scarce, if not nonexistent.

HYPOTHESES

The hypotheses for this study are broken into two different categories. The first set relates to the construct validity of the work simulation. These hypotheses are evaluated using a large applicant dataset. The second set of hypotheses relates to the predictive validity of the work simulation in predicting not only job performance, but more specifically, to the prediction of safety outcomes.

In the first set of hypotheses, the work sample test is evaluated against a web-based multi-scale and multi-measurement assessment battery, described below, that has been shown to be related to performance as well as related to other measures of the constructs in question. There are a number of competency areas that should logically be related to performance on the work sample and many that should not.

> *Hypothesis 1. The work sample simulation will be unrelated to Positive Attitude (1a), Conscientiousness (1b), Locus of Control (1c), and Teamwork (1d) as measured in the web-based assessment. The work sample simulation will be positively related to Attention to Detail (1e), Multitasking (1f), Work Pace (1g), and Cognitive Ability (1h) as measured in the web-based assessment.*

The second set of hypotheses focuses on the predictive validity of the work sample in predicting job performance and safety outcomes using the smaller validation sample.

> *Hypothesis 2. The work simulation will be positively and significantly related to Task Performance (2a), Contextual Performance (2b), and occurrence of safety incidents (2c) as rated by supervisors.*

METHOD

Applicant Sample and Procedure

The applicant dataset came from 5,849 applicants to production team member positions at a large auto manufacturer in Canada who successfully completed two of the four phases of the selection process. The first two phases of the process included an online application and then a proctored administration of the Select Assessment for Manufacturing, a web-based multi-assessment battery, described below. Applicants needed to successfully complete the first two phases in order to be invited to the work sample simulation. The original applicant sample size for the first phase in the process was 37,538, and 26,116 for the second phase in the process. Due to legal environment in privacy laws, it is less common to collect demographic information in Canada during the pre-employment selection process. Therefore, racioethnic and gender information were not available.

The validation sample consisted of 130 production employees who had been hired using the above referenced selection process and who had been employed for at least one year and with their immediate supervisor for at least six months.

Measures

Test Battery

The content of the web-based multi-assessment battery, the Select Assessment® for Manufacturing, has been described and appeared elsewhere in the literature (O'Connell, Kung, & Tristan, 2011; Hattrup, O'Connell, & Labrador, 2005; O'Connell, Hartman, McDaniel, Grubb, III, & Lawrence, A., 2007). The assessment consists of four major types of assessment methods: self-report personality scales, situational judgment items, applied problem solving/cognitive ability items and interactive information processing simulations. These measures are combined within the program using a proprietary weighting methodology and resulting in a set of competencies, which include: attention to detail, positive attitude, process monitoring (multitasking), personal responsibility (locus of control), problem solving (cognitive ability), teamwork, conscientiousness and work pace. A recent meta-analysis of this assessment showed that across 27 studies and 3,926 individuals all of these competencies were significantly related to performance with corrected correlations ranging from .23 for positive attitude to .37 for work tempo (O'Connell & Reeder, 2008). For the purposes of this study, results are presented at the competency level because those provide the most reliable and accurate measure of the variable in question.

Work Sample

The wok sample simulation was designed using information gathered from detailed observations and job analyses at four separate manufacturing sites for the manufacturer in question. This simulation has been described elsewhere in the literature (O'Connell et al., 2011). The exercise simulated an essential set of physical tasks that are required in manufacturing positions at all facilities in the organization. There were four primary stations that candidates rotated through during the course of the exercise: spot weld, bolt mount, wire harness, and weight mount. The work sample lasted approximately four hours. Most of the scores for the simulation were calculated automatically via computers connected to each station. Collapsed across the four stations, three major scores emerged from the simulation: Attention to Detail (accuracy), Fine Motor Skills, and Work Pace (speed). In addition, a trained proctor observed groups of six individuals who completed the exercise and completed a structured rating form associated with the number of "safety violations." Violations were operationalized as instances where candidates did not follow procedures or failed to wear the appropriate personal protection equipment. An overall rating was made at the end of the simulation and entered into the system.

Criterion Measure

For the validation sample, a 21-item performance rating form was administered to the incumbents' immediate supervisors. Responses to each item are indicated on a 7-point Likert-type scale. Data collected from this rating form was used to compute two primary performance scales: Task performance and Contextual performance. Task performance (8-item) relates to activities involved in direct-line job responsibilities, while Contextual performance (8-item) is associated with activities that benefit the organization and the work group but are not necessarily associated with direct-line behavior. Internal consistency for Task and Contextual performance in the present sample were .89 and .84, respectively. In addition, a separate rating was made regarding the number of safety related incidents the individual was involved in over the past six months.

RESULTS

The first set of analyses focused on the construct validity of the work sample simulation using an applicant sample. Table 1 presents descriptive statistics and correlations for the variables in question.

Because the sample size for the applicant sample is so large, even very small correlations such as r=.03 are statistically significant at p<.05. For purposes of this study we used a cutoff of p<.001 to test the hypotheses in question. Using this standard we evaluated the first set of hypotheses as follows.

Hypotheses *1a – 1d* were all supported. The correlations between the work sample and positive attitude, conscientiousness, locus of control and teamwork were all either insignificant or in the negative direction, although below the .001 threshold. Hypotheses *1e - 1f*, regarding a positive, significant correlation between the work sample and attention to detail, multitasking, work pace, and cognitive ability were also supported.

TABLE 1
DESCRIPTIVE STATISTICS AND INTERCORRELATIONS BASED ON APPLICANT SAMPLE (n=5,849)

	M	SD	1	2	3	4	5	6	7	8	9	10	11
1. SAM: Attention to Detail	7.13	1.06	--										
2. SAM: Positive Attitude	7.21	1.53	.24†	--									
3. SAM: Multi-Tasking	7.40	1.80	.44†	-.11**	--								
4. SAM: Locus of Control	7.15	1.75	.30†	.40†	-.11**	--							
5. SAM: Teamwork	6.91	1.47	.05**	.15†	-.03**	.15†	--						
6. SAM: Conscientiousness	7.14	1.56	.27†	.52†	-.13†	.40†	.04**	--					
7. SAM: Work Pace	7.60	1.21	.41†	.07**	.72†	.03*	.01	.20†	--				
8. SAM: Cognitive Ability	7.50	1.42	.15**	-.01	.19**	.07**	.39**	-.11**	.16**	--			
9. WS: Attention to Detail	5.93	1.78	.13†	-.02	.19†	-.03*	.01	-.06**	.17†	.21**	--		
10. WS: Fine Motor Skills	5.89	1.78	.17†	-.06**	.30†	-.05**	-.04**	-.03**	.28†	.16**	.43†	--	
11. WS: Work Pace	6.02	1.88	.14†	-.07**	.27†	-.05**	-.07**	-.04**	.26†	.11**	.15†	.86†	--
12. WS: Safety	7.36	2.70	.08**	-.05**	.14†	.03*	.00	-.04**	.10**	.09**	.20†	.19†	.17†

Notes: * p < .05, ** p < .01, † p <.001

The second set of hypotheses focused on the criterion-related validity of the work samples. Table 2 below presents descriptive statistics and correlations for the variables in question. There was extreme range restriction on the validation sample. A sample of 37,538 applicants was screened down to less than 3,000 individuals eligible for job offers. Of the group hired, only those individuals who were still on the job after one year were eligible for inclusion in the validation sample. For that reason, the second set of hypotheses were evaluated using the corrected correlations and the associated significance tests described by Raju and Brand (2003) for determining significance of correlations corrected for unreliability and range restriction.

Hypothesis *2a* was supported across the board. The three measures that came directly from the work sample, i.e. attention to detail, fine motor skills, and work pace, as well as the safety ratings by proctors were all significantly related to task performance as rated by supervisors. Hypothesis *2b* was mostly supported. The three measures that came directly from the work simulation were all significantly related to contextual performance as rated by supervisors. However, the safety rating by proctors was not. The results for Hypothesis *2c* were also largely but not fully supported. Fine motor skills, work pace, and safety ratings were all significantly related to safety incidents whereas attention to detail was not.

TABLE 2
DESCRIPTIVE STATISTICS AND INTERCORRELATIONS BASED ON VALIDATION SAMPLE (n=130)

	M	SD	1	2	3	4	5	6
1. Criteria: Task Perf.	5.76	0.80	--					
2. Criteria: Contextual Perf.	5.40	0.82	.84†	--				
3. Criteria: Safety Incidents	0.16	0.55	-.19**	-.22**	--			
4. WS: Attention to Detail	6.83	1.59	.16 (.38†)	.12 (.29†)	.00 (.06)	--		
5. WS: Fine Motor Skills	6.85	1.40	.21*(.48†)	.15 (.35†)	-.22*(-.52†)	.25**	--	
6. WS: Work Pace	7.28	1.53	.19*(.44†)	.15 (.35†)	-.27**(-.61†)	-.03	.86**	--
7. WS: Safety	8.19	1.83	.15 (.37†)	.03 (.08)	-.15(-.39†)	.16	.24**	.19*

Notes: * $p < .05$, ** $p < .01$, † $p < .001$. Correlations in parentheses represent corrected correlations for range restriction and criterion unreliability.

DISCUSSION

The purpose of the current study was twofold. The first was to evaluate the accuracy of a work sample simulation in predicting safety incidents and job performance. The second was to gain a better understanding of the constructs that were being measured by the work sample.

Increasingly, organizations that employ individuals in physically demanding work environments are searching for ways to improve safety behavior, reduce exposure to dangerous situations, and, ultimately, to reduce accidents and injuries (c.f. Bell, O'Connell, Reeder, & Nigel, 2008; O'Connell & Delgado, 2011). As noted earlier, one of the criticisms with safety research to date is that it suffers from a common method, common rater bias. The vast majority of safety research has used self report measures of personality or biodata correlated with self reports of safety incidents (c.f. Christian et al., 2009; Clarke & Robertson, 2005). This study adds to the safety literature by evaluating how well a job relevant work sample relates to independent ratings of safety incidents. While supervisor ratings of the number of safety incidents are not necessarily "objective" criteria, they are certainly more objective than self ratings of safety incidents and are provided by a different source. The results were very clear and positive. Three of the four assessment scores from the work sample simulation were significantly and strongly related to independent ratings of safety incidents. It was interesting that the attention to detail measure from the work sample was unrelated to safety incidents, although it was related to both task and contextual performance.

The current study contributes to the understanding of how a work sample measure can broadly cover the criterion domain by not only differentiating task from contextual performance, but also by predicting a separate and largely independent rating of safety. Given the multidimensional nature of the performance construct (Borman & Motowidlo, 1993), the validity of any predictor will be at least partially dependent upon how the criterion domain is conceptualized. Our results support this notion; the magnitude of the relationship for all four measures that emerged from the work sample measure was higher for task performance than for contextual performance. Three of the four work sample scores were also more strongly related to safety incidents than contextual performance. This is as expected because the work sample measure is essentially an assessment of task related performance compared with contextual performance. Future research should continue to investigate how various assessment methods, including work samples, combine to predict other organizationally-relevant criterion variables, including safety violations, injury and accident occurrence, and turnover.

The second major purpose of this study was to better understand the constructs associated with performance in the work sample simulation. As expected, performance on the work sample was largely unrelated to measures of positive attitude, locus of control, teamwork, and conscientiousness. The work sample was related, however, to measures of attention to detail, multitasking, work pace, and cognitive ability. Clearly, there is a strong cognitive component to the work sample simulation used in this study, consistent with prior research (Roth et al., 2005), even though it was largely a physical activity. Significant correlations were also observed between the work sample and safety incidents. Overall these results provided useful construct validity findings for the work sample.

The cognitive component found in the work sample measures likely reflects the learning curve associated with a new activity. While it was not evaluated in the current study, it is likely that the cognitive nature of performance in the work sample would diminish as the simulation continued, with the highest relationship being at the start of the simulation. The measures of attention to detail, multitasking, and work pace in the web-based simulation were all partially derived from interactive, information processing simulations which all clearly have a cognitive component (Kinney, Reeder, & O'Connell, 2008, 2009). These measures all correlated with the work sample which itself predicted safety incident ratings. Together these findings build on previous evidence demonstrating that information processing based measures are strong predictors of safety behavior and accidents (c.f. Arthur, Barrett, & Doverspike, 1990). Furthermore, these findings suggest that individual differences other than personality might be important personal factors associated with safety behaviors and outcomes as well as a fruitful area for safety research.

As stated earlier, situational factors plays an important role in workplace safety. Future research could incorporate safety climate and LMX in examining relationship between work sample simulation and safety outcomes. In summary, the current study illustrates that psychomotor work samples, when designed to replicate various aspects of a physically demanding job, can significantly predict work related incidents and accidents, in addition to task and contextual performance. From a construct validity perspective, our findings suggest that these types of work samples will correlate with cognitive ability while showing little relationships with personality traits. Given the importance of reducing accidents and safety incidents in the workplace, future research on work samples in physically demanding job settings would be beneficial to both researchers and practitioners.

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