Cognitive Failure at Work: Factorial Structure of a New Questionnaire

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ABSTRACT
Motivation – To estimate cognitive failure and preceding conditions at work with a new questionnaire, and to describe its factorial structure and subscales.

Research approach – An explorative survey approach was used with a questionnaire consisting of three parts: Workplace Cognitive Failure Scale (WCFS), a new scale on cognitive failures, and a questionnaire on work conditions.

Findings/Design – The results replicate the factorial structure of the original WCFS, with its memory, attention, and action subscales. With additional items of cognitive failure we found four subscales detailing perception of relevant information, forgetting work tasks, multitasking, and acting in the environment. Seven subscales were found for work-related factors that are likely to impair cognitive functioning.

Research limitations/Implications – Only employees of one company and one occupation participated in the preliminary study, which limits generalisation of the findings.

Originality/Value – The research makes a contribution to defining and detailing cognitive failure at work and identifying work-related conditions that may induce human error and accidents in occupations that are not safety-critical, but nevertheless prone to accidents.

Take away message – Improving safety at conventional workplaces requires means to recognise central latent causes of human error. We developed a cost-effective method to identify types of cognitive failure and work conditions that may induce error at work.

Keywords
Human error, Cognitive failure, WCFS, Safety, Occupational Accident, Logistics

INTRODUCTION
Human error and error-causing conditions are common at workplaces, and are key factors underlying accidents in different occupations. Human errors are involved in the majority of occupational accidents; for instance, in as many as 80-90% of fatal and serious occupational accidents in a Finnish study (Salminen & Tallberg, 1996). Although many occupations are prone to occupational accidents, recognising and managing human error is not a common activity within conventional workplaces, for instance, in the fields of maintenance and logistics. In contrast, human error models and methods are commonly used in safety-critical occupations (Salmon, Lenné, Stanton, Jenkins, and Walker, 2010).

The demands of conventional jobs are in many aspects different than those of high-demand safety-critical jobs (see e.g. Sluiter, 2006). Most conventional jobs employ people that do not come from selected populations, and special cognitive capacity and skills are not required, nor does working presume long training periods or high level of expertise.

Still, the cognitive demands of the tasks and work environments in conventional jobs can be high, e.g. working in varying conditions, doing multiple tasks at a time, or having a lot of noise or interruptions at work. These conditions disrupt cognitive function, and may thus lead to cognitive failure, human error, and accidents at work.

Together, these three conditions – substantial number of occupational accidents, unselected population, and error inducing cognitive demands of the work environment – create a need for efficient methods to reduce human error and enhance occupational safety in conventional occupations. The aim of our study is to develop a method to define the nature of cognitive failure and related work conditions. We utilise the findings of cognitive psychology and the human error research of safety-critical and high-demand jobs with specific job demands, in order to develop a new questionnaire on cognitive failure and work conditions.

Decreasing Human Error at Work
In occupational safety research, the focus is traditionally on the safety and health of the employees, and on accidents and hazards that occur at work. Human error is often seen as a central reason for occupational accidents, which implies a person-oriented approach (e.g. Rasmussen, 1986). This approach has been criticised for leading to individualistic blame cultures, in which the true reasons for human error can not be recognised (Reason, 2000).

The newer view, called the systems perspective approach, considers the role of system-wide conditions in the errors people make (Dekker, 2002; Reason, 2000) and, in occupational safety research, the preconditions of occupational error and accidents (for a meta-analyses see Christian, Bradley, Wallace, and Burke, 2009). In our study, we focus both on human error, specifically cognitive failure, and on the work conditions that may lead to failure and error.

Cognitive failures are lapses in cognitive functioning, e.g. attention, memory, and motor functions (Broadbent, Fitzgerald, and Parkes, 1982; Wallace and Chen, 2005). There are also typical cognitive limitations in the human ability to perceive, to maintain and process information in working memory, and to store and retrieve information from long-term memory (Lindsay & Norman, 1997). Our first aim is to identify and
detail the various types of cognitive failure and other impairment of cognitive functioning in non-safety-critical occupations.

Our second aim is to recognize the conditions that are likely to impair cognitive performance and lead to cognitive failure, as well as to actual human errors and accidents at work. We focus on those conditions at maintenance and stock logistic workplaces that directly affect the human ability to process information, e.g., interruptions, noise, and multitasking, which have been shown to induce cognitive failure in other occupations (e.g., Elfering, Grebner, & Dudan, 2011).

The SUJUVA Study

Our on-going study “Better work flow, less error: Decreasing human error at work (SUJUVA)” is a 3-year project that started in June 2011. In the beginning of the project, we familiarised ourselves with four large Finnish organisations, especially their maintenance and stock logistic work, their work conditions, and the nature of their occupational accidents.

In the first part of the study, we constructed a questionnaire on cognitive failure and related work conditions. In the second part of the study, beginning in 2013, we will develop a new occupational accident investigation and analysis method. It will allow better scrutiny of the nature and conditions of human error than the methods that are typically used in work places that are not safety-critical but prone to occupational accidents.

In this short paper, we’ll present the extended questionnaire on cognitive failure and their preconditions, and the results on the factorial structure and subscales of the three sections of the questionnaire.

METHOD

Participants

The participants of the SUJUVA-study are employees from four Finnish organisations who work in maintenance and stock logistics. The data gathering is still ongoing, and we present here the preliminary results of 953 participants (855 males) working in logistics.

The New Questionnaire on Cognitive Failure

We constructed a questionnaire on cognitive failure, human error, and accidents at work based on previous studies and methods of human error, occupational accident, and cognition research. The questionnaire is also based on careful inspection of the job characteristics and working conditions in the four participating organisations. In the development of the questionnaire, we aimed at statements that concern concrete examples and activities at work, avoiding abstract items that require other information than one’s own tasks and work behaviour.

The questionnaire consists of three sections: the Finnish version of the Workplace Cognitive Failure Scale (Wallace & Chen, 2005), additional subscales on cognitive function, and subscales on work related conditions that disrupt cognitive performance. We also presented background questions, e.g., gender, age, and type of work, and questions on experience and attitudes about occupational accidents. These items are not reported in this paper.

The first versions of the questionnaire were tested in small groups in the organisations in order to ensure relevance and clarity of the questions.

Workplace Cognitive Failure Scale

The Workplace Cognitive Failure Scale (WCFS, Wallace and Chen, 2005) is a 15-item questionnaire that has been developed from the Broadbent, Fitzgerald, and Parkes (1982) Cognitive Failures Questionnaire. It consists of three subscales: Memory (e.g. "Fail to recall work procedures"), Attention (e.g. "Easily distracted by co-workers"), and Action (e.g. "Unintentionally press control switches on machines"), and replies are on a 5-point Likert-type scale, "never" to "very often". The original WCFS was translated from English to Finnish and Swedish (the two official languages in Finland), and back-translated to English, checking for and correcting discrepancies, to ensure fidelity to the original version.

New Items on Cognitive Failure

We constructed 15 new items to get more detailed information on perception of relevant information (e.g. "I have misinterpreted a message"), forgetting work tasks (e.g. "I have forgotten what has been agreed upon"), multitasking ("If I have several tasks, I have trouble deciding which is the most important to complete") and acting in the environment ("I start to move in the wrong direction or I am in a different place than I thought"). These statements were replied to with a 5-point scale: "every day", "every week", "every month", "every year or less", and "never".

Scale on Work Conditions

The Work Condition scale consisted of 35 items and 6 topics. They were Know-how (e.g. "The guidelines given are too difficult"), Communication (e.g. "There are too many notices and there is too little time to read them"), Physical working environment (e.g. "There is visual and auditory noise in the working environment"), Smoothness and planning (e.g. "There are a lot of interruptions at work"), Work load (e.g. "No time to take mandatory breaks"), Machines and equipment (e.g. "The system is out of order"). These statements were also replied to with the scale: "daily", "weekly", "monthly", "every year or more seldom", and "never".

RESULTS

We performed a confirmatory factor analysis on the 15-item WCFS to test whether the 3-factor model of Wallace and Chen (2005) study was supported. We also performed two separate exploratory factor analyses for the 15 new items on cognitive failure and for the 35 items on work conditions in order to find possible new subscales. Since the items of the new sections of the questionnaire were not based on a single theory but on several theoretical approaches and findings, there was no single theoretical motivation to find certain subscales. Therefore, exploratory factor analysis was chosen in order to discover a factorial structure that is both statistically, theoretically, and practically justifiable.

Factorial structure of the Finnish WCFS

The confirmatory factor analysis that tested the 3-factor model showed that the fit of the model in our data using the Finnish version of WCFS and the fit of the model in the original (Wallace and Chen, 2005) data were very similar: $\chi^2(87, N = 951) = 700.9, p < .001$, RMSEA = 0.09, CFI = .94; $\chi^2(87, N = 323) = 332.2, p < .05$, RMSEA = 0.06, CFI = .92, respectively. There were only minor differences between our study and the Wallace and Chen (2005) study in the loadings of individual items on the relevant factors (Table 1).

Factorial Structure of the New Items of Cognitive Failure and Work Conditions

Exploratory factor analysis using the maximum likelihood method with oblique rotation resulted in a good fit and meaningful interpretation for a 4-factor model of the 15 new items on cognitive failure. Seven subscales were found for the 35 items of work-related factors that may impair cognitive functioning and thus induce cognitive failure at work. The reliability of all scales and their subscales are presented in Table 2.
Table 1. Standardized loadings in our sample, with Wallace and Chen (2005, study 2) loadings in parentheses

<table>
<thead>
<tr>
<th>Item in WCFS</th>
<th>Memory 1</th>
<th>Attention 1</th>
<th>Action 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>.74 (.60)</td>
<td>.51 (.51)</td>
<td>.61 (.47)</td>
</tr>
<tr>
<td>Memory 2</td>
<td>.74 (.54)</td>
<td>.82 (.87)</td>
<td>.79 (.62)</td>
</tr>
<tr>
<td>Memory 3</td>
<td>.69 (.79)</td>
<td>.84 (.84)</td>
<td>.69 (.53)</td>
</tr>
<tr>
<td>Memory 4</td>
<td>.83 (.61)</td>
<td>.80 (.70)</td>
<td>.71 (.63)</td>
</tr>
<tr>
<td>Memory 5</td>
<td>.78 (.50)</td>
<td></td>
<td>.77 (.81)</td>
</tr>
</tbody>
</table>

DISCUSSION

The aim of our study was to develop an approach and method that is suitable for conventional occupations, in contrast to high-demand and safety-critical jobs with specific job demands. We focused on cognitive failure, including several aspects of cognition that are reflected in concrete behaviours and failures of employees at work. We also focused on work-related conditions that are likely to impair cognitive functioning and may thus lead to human error and occupational accidents.

We developed a questionnaire on cognitive failure and their preconditions that is suitable for conventional organisations, in contrast to high-demand and safety-critical jobs with specific job demands. The results showed similarity of 3-factor model of the Wallace and Chen (2005) WCFS and its Finnish version. Furthermore, the four extended subscales on 15 new items of cognitive failure, and the seven subscales on the 35 items of work conditions were meaningful and had high reliability scores. To sum up, the new questionnaire is promising and it is likely to provide a practical and cost-effective method to recognize the types of cognitive failure and everyday working conditions that may induce error and accidents in maintenance and stock logistics.

Future Studies

In our ongoing project, the next step will be to study correlations between the 7 work condition subscales and the 7 cognitive failure subscales. Furthermore, we’ll analyse whether these variables correlate with the actual level of occupational accidents in the four organisations and the divisions that participate in the SUJUVA study. In the second part of the study, we will use these results to develop a new method that allows recognising the types of human error involved in a specific occupational accident. We will also explore preconditions that lead to human error at work, in the spirit of cognitive ergonomics and new human error research (e.g. Dekker, 2002; Hollnagel, Nemeth, and Dekker, 2008).
Table 2. Internal consistencies (Cronbach's alpha based on standardised items) for the WCFS, the new subscales on cognitive failure, and the subscales of work conditions.

<table>
<thead>
<tr>
<th>Subscales</th>
<th>No. of items</th>
<th>n</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>WCFS: Total</td>
<td>15</td>
<td>896</td>
<td>.89</td>
</tr>
<tr>
<td>WCFS: Memory</td>
<td>5</td>
<td>929</td>
<td>.80</td>
</tr>
<tr>
<td>WCFS: Attention</td>
<td>5</td>
<td>925</td>
<td>.82</td>
</tr>
<tr>
<td>WCFS: Action</td>
<td>5</td>
<td>936</td>
<td>.78</td>
</tr>
<tr>
<td>New Cognitive Failure: Total</td>
<td>15</td>
<td>888</td>
<td>.91</td>
</tr>
<tr>
<td>New Cognitive Failure: Perception of relevant information</td>
<td>4</td>
<td>925</td>
<td>.82</td>
</tr>
<tr>
<td>New Cognitive Failure: Forgetting tasks</td>
<td>3</td>
<td>928</td>
<td>.85</td>
</tr>
<tr>
<td>New Cognitive Failure: Multitasking</td>
<td>2</td>
<td>926</td>
<td>.78</td>
</tr>
<tr>
<td>New Cognitive Failure: Acting in the environment</td>
<td>5</td>
<td>925</td>
<td>.81</td>
</tr>
<tr>
<td>Work Conditions: Total</td>
<td>34*</td>
<td>843</td>
<td>.93</td>
</tr>
<tr>
<td>Work Conditions: Knowledge and communication</td>
<td>9</td>
<td>911</td>
<td>.86</td>
</tr>
<tr>
<td>Work Conditions: Warning signs</td>
<td>3</td>
<td>930</td>
<td>.82</td>
</tr>
<tr>
<td>Work Conditions: Poor perception conditions</td>
<td>4</td>
<td>927</td>
<td>.74</td>
</tr>
<tr>
<td>Work Conditions: Taxing environment or work</td>
<td>3</td>
<td>932</td>
<td>.72</td>
</tr>
<tr>
<td>Work Conditions: Work flow and interruptions</td>
<td>4</td>
<td>929</td>
<td>.82</td>
</tr>
<tr>
<td>Work Conditions: Work load</td>
<td>6</td>
<td>924</td>
<td>.84</td>
</tr>
<tr>
<td>Work Conditions: Working methods</td>
<td>5</td>
<td>918</td>
<td>.77</td>
</tr>
</tbody>
</table>

* The Work Condition Scale only includes 34 items instead of the 35 in the questionnaire, since one item did not load significantly on any of the factors.

REFERENCES


