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ORIGINAL ARTICLE

Development and Evaluation of a New Questionnaire for Rating of Cognitive Failures at Work

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ABSTRACT

Cognitive-based human errors have major contribution to performance and safety in working environment. This study designed to develop a measurement tool in order to evaluate this type of errors in the occupational settings. An Occupational Cognitive Failure Questionnaire (OCFQ) was developed. Content validity of the OCFQ was performed using a quantitative approach. Reliability of questionnaire was assessed by internal consistency and test-retest methods. A preliminary list of 35-items was prepared as a starting point. After evaluation of validity, five items were rejected. The new measurement instrument with 30-items was finally developed. The content validity index (CVI) for the final OCFQ was found acceptable (CVI=0.7). Results show that final OCFQ was internally consistent (α=96) and intraclass correlation coefficients (ICC) was 0.99. Measurement of cognitive failure in the workplace requires a valid and reliable tool. In respect to probable outcomes of cognitive failures occurrence at work, the present study suggested that OCFQ would be a useful instrument for measurement of cognitive failure in the working environment.

Keywords: *Cognitive failure, Questionnaire, OCFQ, Workplace*

INTRODUCTION

Cognitive errors play an important role in accidents and safety behavior [1, 2]. Cognitive failure is defined by Martin (1983) as a "cognitively based error that occurs during the performance of a task that the person is normally successful in executing" [3]. Cognitive failure was named as such to encompass numerous types of execution lapses: 1) lapses in attention (i.e., failures in perception), 2) memory (i.e., failures related to information retrieval), and 3) motor function (i.e., the performance of unintended actions, or action slips [2]. Cognitive failure is defined by Wallace, Kass, and Stanny (2002) as a mistake or failure in the performance of an action that the person is normally capable of completing. They additionally noted that the ability to complete the task is present, but rather something else interferes with the successful completion of the task. Wallace and colleagues stated that interference stems from one of three categories: memory, distractibility, and physical blunders [4].

To date, only one measure has been developed to investigate explicitly one's proneness for committing a cognitive failure: the Cognitive Failure Questionnaire [1]. This measure was developed to assess everyday

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failures in perception, memory, and motor function. Following the work of Broadbent et al. (1982), Wallace et al. proposed the meaning of cognitive failures at work and developed the first tools for rating this type of errors: Workplace cognitive failure scale (WCFS) [5]. However, such as other human performance measures, cognitive failures requires further studies and different measurement tools for specific domains. Thus, it is necessary that recent researches focus on role of cognitive failures in the industrial workplace accidents.

The present study was designed to develop a new measurement tool in order to evaluate cognitive failures in the industrial workplaces.

MATERIAL AND METHODS

Questionnaire development

Identifying the content domain of the questionnaire

First, content domains of the questionnaire were identified. Lawshe (1975) has suggested that the content domains must firstly be identified before the steps to determine content and construct reliability and validity can be applied [6]. A review of the literature such as Broadbent et al. (1982) and Wallace (2004) [1, 7] was performed in order to define the content domain of questionnaire (i.e., cognitive failure).

Identifying specific categories of content domain

Cognitive failures are defined as failures in perception, memory, and motor functioning, in which the action does not match the intention [1]. Thus, cognitive failures include numerous types of execution lapses: lapses in attention (i.e., failure in perception), memory (i.e., failures related to information retrieval), and motor function (i.e., the performance of unintended actions, or action slips) [12]. Based on this definition, the four factors determined as content domain of new questionnaire as Memory, Attention, Action, and estimation (such as depth, distance, and weight). In this step, Chadwick's guideline (1984) was followed in the analysis of content domain and extraction of some items [8].

Modifying items and developing a preliminary questionnaire

A panel was comprised of participants in the Iranian South Pars Gas Company industrial field. Ten experts who represented operator workers, service workers, foreman, supervisors, safety experts and researchers were identified and invited to participate. In this step, in order to development more items, one item related to any factor was presented to panel members. Then they were asked to write the similar cases that occur during their tasks and working environment. Consequently, draft of the questionnaire was constructed as it met the following requirements:

1) Include all the most important of the cognitive failures that was identified in step 2.1.2, 2) All developed items cluster into intended categories, and 3) All developed items match with occupational cognitive failures.

Developed effectiveness of the draft questionnaire

Whereas the items developed by limit and specific members, regarding the importance of co-operation likelihood and enhancement of effective responses, Leedy and Ormrod's (2001) Guideline and Henerson's et al. (1987) suggestions were used as well [9, 10].

Determining the content validity model

Holsti (1969) describes content analysis any technique used for the purpose of making inferences by objectively and systematically identifying specific characteristics of message [11]. In this study, in order to determination of content validity, Lawshe (1975) and Chadwick et al. (1948) approaches were chosen. In the Lawshe model, a questionnaire was developed and structured to guide and allow panelists to indicate clearly their judgments on the essentiality of the inclusion of different items in a model. Participant experts were then requested to write the corresponding code in the spaces provided next to each item under the "judgment" block the different responses and codes were: E- Essential, U- Useful but not essential and N- Not necessary [7].

Model modification

In the present study, Lawshe model was chosen. For preventing different misunderstanding related to Lowshe's codes as noted by Henerson and improving response process, a different 5- point likert scale (i.e., 1= strongly disagree; 5= strongly agree) as used by Leedy and Ormrod's (2001) guideline [9] was chosen. This scale for larger range and clear phrases was better one.

Identifying experts willing to act as panelists to validate the draft questionnaire

A content evaluation panel will normally comprise of the identified domains, or a domain universe in which the judgments are to be made. The panel was therefore selected in accordance with objective criteria dictated by the nature of and required outcomes of the research. Although the Lawshe Method of content validation only requires a minimum of four panelists, it was decided to include as many experts in the panel as practically possible. This further enhanced the value of the model by ensuring that it will be difficult to find many other researchers and practitioners with the credentials or authority to challenge the purported content validity of the model [6]. The specialist nature of the research necessitated that experts dedicate at least one hour to consider the model and complete the questionnaire. Due to practical difficulties in involving a large number of experts in such study, it was decided that a minimum of eight and a maximum of sixteen expert panelists would be participated in the judging process. A relatively small group of eight expert panelists needs to display a relatively high consensus on the validity of the model

Table 1. Composition of panel of experts

Expert type	Number
Cognition Science Specialist	3
Safety Specialist	1
Ergonomist	2
Psychologist	2
Total	8

and their consensus needs to reflected in a Content Validity Rate (CVR) value higher than 0.62. This value could also be loosely related to the opinion of Chadwick et al. (1984), who proposed that a reliability coefficient of 0.6 or above for a content analysis would be regard as acceptable [6, 9]. The maximum of sixteen panelists were decided on by doubling the minimum number of panelists, with a view to making provision for an eventuality where a number of panelists failed to complete or return questionnaires. The validity of the model could also be judged more effectively if more than ten panelists were to return questionnaires. Twenty experts who represented safety expert, cognition expert, ergonomic expert, and psychologist were subsequently identified and telephonically invited to participate. Panelists were deemed to be experts for proposes of this research if they possessed at least a PhD, or equivalent. Prior learning was also recognized for purposes of determining the value of a qualification. An expert must have been actively involved cognitive failure issues in the period between 2000 and 2009 and preferably for longer than ten years in total. All panelists must also have been willing to dedicate approximately one hour of their free time to complete the questionnaire. Of the twenty experts who were initially approached, sixteen agreed to participate in the research. Eight experts returned a correctly completed questionnaire. This amounted to a return rate of fifty percent. The panelist expert field presented in Table1.

Capturing data and performing mathematical and statistical analysis

The judgments of the panelists were captured on a personal computer. Microsoft Access and Microsoft Excel were used for this purpose. Statistical and mathematical calculations were performed on a personal computer using Microsoft Excel.

Quantifying of consensus among panelists

The consensus among penelists on the necessity to include a specific component can be quantified by determining the content validity ratio (CVR) [6]. The following formula was used for this purpose:

Eq. 1: $CVR= (n_e-n/2)/ (n/2)$

n_e is the number of panelists indicating ”essential” (This variable may be replaced by another eg.”n_n = the number of panelists indicating unnecessary” or other variables under investigation). n/2 is the number of panelists divided by two. CVR is a direct liner transformation from the panelists saying” essential”

Table 2. Minimum values of CVR and CVRt for different numbers of panelists: One Tailed Test, P-Value=0.05 (6)

Numbers of panelists	Minimum acceptable CVR value
5	0.99
6	0.99
7	0.99
8	0.75
9	0.78
10	0.62
11	0.59
12	0.56
13	0.54
14	0.51
15	0.49
20	0.42
25	0.37
30	0.33
35	0.31
40	0.29

The utility of the CVR can be derived from the following characteristic:

- When fewer than half say” essential”, the CVR is negative.
- When half say ”essential” and half do not , The CVR is zero
- When all say ”essential” the CVR is computed to be 1.00.(It is adjusted to 0.99 for ease of manipulation)
- When the number saying” essential” is more than half, but less than all, the CVR is somewhere between zero and 0.99 [6].

Interpretation of the CVR value of judgments on components is given in Table 2.

The following asseumptions can be made when interpreting the CVR according to Lowshe (1975):

1- When all panelists disagree on the essentiality of an item is not truly essential.

2- When all panelists fully agree that an item is essential, they could be either all wrong or all right. Since they are viewed as experts, it must be concluded that not all of them can be wrong and the item can be considered essential.

3- In doubtful cases the following two assumptions, which are consistent with established psychophysical principles, can be made:

- Any item or performance, which is perceived to be”essential” by more than half of the panelists, has some degree of content validity.
- The more panelists (beyond 50%) who perceive the item as”essential” the greater the extent or degree of its content validity.

4-It might sometimes be necessary to weight the CVR computed for different items. Lawshe (1975) cautions that the rating concept, or weighting, is not compatible with the content validity analysis method as described above, since the rationale in the content validity method rests on both logical considerations and empirical evidence. Authors have identified several

Table 3. Means and CVR values of the respective judgments and acceptation or rejection results

Item no.	CVR	Mean	Accept/Reject
1- Did you forget frequently called phone numbers of your workplace departments?	0.5	1.5	Accept
2- Did you find you couldn't remember the steps or sequences of daily work procedures?	0.75	1.7	Accept
3- Did you go to one place or department of your workplace and forget why you went?	1	2	Accept
4- Did you forget where put your tools or equipment?	1	2	Accept
5- After you started working, did you realize that you were not using personal protective equipment?	0.5	1.5	Accept
6- Did you ask your colleagues to remember you take some notes of what you do?	1	2	Accept
7- Did you forget the names of equipment/tools?	0.75	1.7	Accept
8- After a meeting, did you realize that you never discussed the main topic for which you called the meeting?	0.75	1.7	Accept
9- Did you have to return home or workplace because you forgot something?	0.75	1.7	Accept
10- Did you forget to pass along a message to somebody?	0.75	1.7	Accept
11- Did you feel as though you have forgotten to turn off a light or lock the door when leaving your office?	0.75	1.7	Accept
12-Did you fail to pay attention to alarms, voice messages, displays?	0.75	1.8	Accept
13- Did you stare (or zone out) when you should be listening to something?	0	1.3	Reject
14- Did you lose your attention to work because of irregular noise or colleagues passing?	0.5	1.5	Accept
15-Did you fail to realize the time while you were looking at clock at once?	0.5	1.7	Accept
16- Did you ask for the same information twice (such as times, names, or dates) twice date during the same conversation because you forgot the answer?	1	2	Accept
17- Did you lose your concentration after starting a task because of day dream?	0.5	1.5	Accept
18 -Did you distract during studying a manual because of noises?	0.75	1.8	Accept
19 -Did you couldn't to do simple physical tasks during speaking with phone?	0.5	1.5	Accept
20 - Did you lose your focus during doing several simple works simultaneously?	-0.75	1.1	Reject
21- Did you delay starting your work because you lost focus?	0.5	1.6	Accept
22- Did you forget words that already have told or a task that you have already completed?	0.5	1.6	Accept
23- Did you fail to find where you placed an object for work?	0.5	1.5	Accept
24 -Did you slip on the street or at your workplace?	-0.75	1	Reject
25 -Did you accidentally drop your tools or equipment suddenly?	0.5	1.6	Accept
26- Did you accidentally throw away tools or parts?	0	1.3	Reject
27- Did you press the wrong button or controls on a computer or piece of equipment?	1	2	Accept
28- Did you go to wrong department for handling a specific task?	0.5	1.6	Accept
29 -Did you put a tool in the wrong place?	0.75	1.7	Accept
30- Did you find you chose the wrong method for a task that you have frequently performed in the past?	0.5	1.6	Accept
31 -Did you turn on or turn off a device incorrectly?	0.75	1.8	Accept
32-Did you leave your keys or mobile phone in the lock or desk?	1	2	Accept
33- Did you hit something or somebody accidentally?	0.75	1.8	Accept
34- Did you have difficulty in estimating weight, distance or depth?	0.5	1.5	Accept
35 - Did you find you confuse right and left when giving directions	0.25	1.3	Reject

criteria that may be used to establish assigned to CVRS. Some of these criteria are relevance, importance, usefulness and time spent [6].

Calculation of the respective judgments means

For purpose of computing the mean for each item, the following conversion was done for the values reflected in the questionnaire:

Strongly Agree or Agree - was replaced by 2

No idea - was replaced by 1

Strongly Disagree or Disagree - was replaced by 0

Only those components and links with CVR values and meeting the minimum values were retained in the final model.

Determination of acceptation or rejection criteria

To select items of final questionnaire, the following criteria were applied:

1. Accept unconditionally if CVR is equal to or larger than 0.75. This value applies to 8 panelists in accordance with table 2 of CVR values.

2. Accept if CVR is between 0 and 0.75 and the mean of judgments is higher than 1.5. A value of higher than 1.5 would indicate that the mean of judgments is closer to the value of "Strongly Agree or Agree" judgments than to the value of "No idea" judgments. A CVR value of 0 indicates that the panel has undecided and that not less than fifty percent of the panel believed that the item is "Strongly Agree or Agree".

3. Reject if CVR is less than 0 and the mean is lowers than 1.5. This means that it will be impossible to include any item that was not judged to be essential by at least half of the panel, or any item possessing a mean of judgments that is closer to "Strongly Disagree or Disagree" than to "Strongly Agree or Agree".

Quantifying and interpretation of the content validity of the final questionnaire

The content validity index (CVI) is simply a mean of the CVR values of items retained in the validated procedure, model, test, or format. It presents the commonality of judgments regarding the validity, or applicability of the final procedure, model, test, or format being researched. The overall content validity will be higher if the value of the CVI is closer to 0.99 and vice versa [6].

Eq. 2

$$CVI = \frac{\sum_n^1 CVR}{Retained\ numbers}$$

Internal consistency and Repeatability of the final questionnaire

Internal consistency

In the present study, an occupational sample consisting of fulltime employee (n=260) staffed in the Iranian South Pars Gas Company was chosen randomly and they were requested to complete the final questionnaire. Internal consistency was evaluated with Cronbach's alpha coefficient.

Repeatability

Repeatability or test-retest reliability was evaluated by the Pearson correlation coefficient.

RESULTS

Draft OCFQ

As described in the previous section, a draft 35-item questionnaire was created as shown in Table 3.

Means and CVR values of the respective judgments and acceptation or rejection results

The means and individual CVR values of the judgments were calculated and the results were compared with the corresponding criteria. For every item, means and CVR values and acceptation or rejection results are given in Table 3.

CVI results and introduction of final OCFQ

In this study, after evaluation of validity, five items were rejected. The new measuring instrument with 30-items was developed. The CVI for this new measuring instrument was calculated by Eq. 2:

$$CVI = \frac{\sum CVR}{retained\ numbers} = \frac{20.75}{30} = 0.70$$

Finally, the CVI for the final OCFQ was found to be 0.7 in the present study.

Internal consistency

As noted previously, the internal consistency of the measuring instrument was evaluated by the Cronbach's alpha. Results show that final OCFQ was internally consistent in the present study (α=96).

Repeatability

To determine test-retest reliability, intraclass correlation coefficients (ICC) were used; values of 0.50 and higher indicate reasonable reliability. Results show that the ICC was 0.99.

DISCUSSION

Serious lapses and failures are common in working life. For preventing, probable outcomes of these types of errors, we need a valid measure. The present study designed to develop the specific questionnaire for occupational cognitive failure evaluation and its validity and reliability. In order to improving reliability, a combined panel consisted of both the field study experts and the industrial practitioners were invited, while the majority of previous research conducted on student participants, which may have interferences in validation process of occupational cognitive failure measures [1, 4]. Additionally, for improving the response process, the Likert scale was used [9] because we believe that there are many misunderstanding related to lawshe's codes.

In the present study, one of the famous content validity approaches (CVR) was conducted and the results showed that the final OCFQ was a valid and reliable instrument that could be used in measurement and predicting safety performance of working population. However, future research should attempt to evaluate construct validity of this version. While the present study examined internal consistency and repeatability in industrial workplace, more specific workplaces and participants may be required. On the other hand, whereas the OCFQ can be used to identification of latent failures in the long chains of accident, future research is needed to examine which cognitive failures actually predict safety behavior and accidents in organizations.

CONCLUSION

Measurement of cognitive failure in the occupational settings requires a valid and reliable instrument. Occupational Cognitive failure questionnaire (OCFQ), which showed an acceptable validity and reliability, can be regarded a useful, valid and reliable tool for this mean.

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