

# The structuring effects of tools in risky industrial work activity: failures and solutions

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## Abstract

Professional training for risky professions involves procedures and guidelines requirements. The use of the tools derived of this need sometimes have a so strong structuring effect that the user is unable to do otherwise than going to the failure.

Experiments have been conducted in order to determine if, within an industrial working population ( $N=57$ ), whether there could be a profession or an academic training making the subject less weak concerning the structuring effect of the tools.

Results have shown that the solution does remain neither in the profession nor in the academic training, and that tools must integrate this possible weakness of the intervener. Further experiments are planned to assess the effect of confidence and of global control.

## 1. Introduction

Exploitation of risky industrial plants implies a high level of safety and of work activity reliability. The production division of EDF always tries to find organizational solutions in order to reinforce those lines (see for example: Le Bot, 2004; Fauquet, 2007, 2008). Since several years, a Human Performance Program has involved all the nuclear power plants of EDF, within one topic concerning the management in the field dealing with organizational problems (Fauquet-Alekhine, 2012). Nevertheless, with all constrains under which workers and managers are submitted, due to diverse fields such as safety requirements (Buessard & Fauquet, 2009), production, economical competition, skills drain due to aging workers and renewal staff... work activities analysis show that, in given working situation, workers can be involved in a structuring effect of the tool used to perform the task. Observations have shown that sometimes workers could be involved in a human error or a deviation leading to a major (or significant) event even when they were updated regarding the task, were experienced, were well informed about the activity,

knew all about the job, were not too much self-confident. Indeed, nothing could explain the result except making the assumption that the tools used to perform the task under time pressure could have led them to the event. We thus thought the need that the tools used by workers and its potential structuring effect on the activity realization had to be investigated. We made the assumption perhaps a given category of workers, or a given category of academic background, could reduce the structuring effect of the tools.

The Macmillan dictionary suggests that a tool may be a piece of equipment, usually one that you hold in your hand, that is designed to do a particular type of work, or something that you use in order to perform a job or to achieve an aim (for example, speech is a tool of communication), or someone who is used by another person or group, especially to do a difficult or dishonest job.

Making the list of possible tools, we concluded that it could be the physical objet that extends the subject to transform the environment (e.g. carpenter's hammer), but also a method that helps the subject to transform the social world, the organization, the attitude, the behavior (e.g. the professor's books for teaching, the psychologist's protocol, Human Performance tools for the field worker). A tool may be thus external to the subject and to the object or internal to the subject. The essence of the tool can be physical (a hammer) or psycho-social (a method, a protocol, a procedure,...) or cognitive (a way of thinking) but can anyway be materialized as a physical tool by being written on paper (procedure, book). The transformation produced can be physical (making a roof) or psycho-social (obtaining new behavior, new organization, new consumption habits).

The tool being an important mean of the work activity in industrial context, and the potential structuring effect of tools leading to major event being observed, we decided to conduct experiments in order to determine whether or not a given category of workers, or a given category of academic background, could reduce the structuring effect of the tool. The assumption that some professions or academic background could have such an outcome was made after specific training sessions involving groups of workers taking psycho-technical tests: it appeared for example that some professions were more successful taking a test involving the Stroop effect than others.

## 2-Materials & Methods

The study has been conducted with subjects ( $N=57$ ) working on the nuclear power plant of Chinon. Different categories of jobs have been chosen in order to:

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- determine how the tools used to perform a work activity can be structuring and lead to the error,
- determine whether a socio-professional class or academic training can question the structuring effect of tools,
- understand palliative measures to the structuring effect of the tools and at what levels (within the tools, external to tools or activity or intervener).

We are thus studying how to avoid deleterious focus-structuring of tools (including modus operandi) in work activity.

The professional categories chosen were:

- executive manager,
- charter engineer manager,
- ex-technician manager,
- nuclear reactor pilot,
- technician,
- department assistant,
- service sector job.

A last category was added, external to the industrial context:

- student (9 to 14 yo.).

It has been added in order to appreciate the possible influence of the formatting effect of the academic training or of the professional training.

The test is called "Letter-test". It consists of a work activity done in a minimum of time. In fact, less than 5 minutes is necessary. Objective of the activity is to count up on five boards with three rows of letters each, the number of letters which the size (height) is less or equal to 5mm (Fig. 1 a). To do this, two different tools are proposed: a flat ruler (triple classic transparent decimeter) or a mask preformatted for the size of the boards (Fig. 1 b), with an opaque black area pierced with three rows of eight windows each. The mask is presented as developed especially for the work activity with a calibration of the height of windows said equal to 5mm: if a letter is seen entirely in a window, it must be recorded.



Fig. 1 a & b. Letter-boards and mask used for the test relative to the structuring effect of the tools.

The boards are seen one by one; whenever the board n+1 is given to the subject, the board n is taken by the experimenter.

The subject is informed that the Letter-test is timed (time pressure), and s/he must choose one of the two tools

proposed initially knowing that s/he can come back on this selection as much as s/he wants. All dialogues of the experimenters are written so that they give the same information as much as possible with the same words, same expressions for each subject.

For each analysis of a board, the results must be deferred on the supplied grid (Table I).

Table I. Results grid for subjects taking the Letter-test.

Board →	1	2	3	4	5
Line 1					
Line 2					
Line 3					

The specificity of the Letter-test lies in the fact that all the boards have a similar structure (3 lines and 8 letters per line, all positioned at the same place on a board) except the last board: the board #5 has 9 letters per line, the eight first letters positioned as on the four previous boards. But the mask is sized to 8 letters per lines: so it blanks the letter #9 of each of the lines of the board #5.

Ethics: all of the data collected is treated statistically. No personal data is collected or recorded. Subjects do not broadcast on their side any information concerning the test. Only socio-demographic data, results and observations are recorded.

### 3-Results

The gender is not mentioned because each profession induces this proportion. For example, the "department assistant" category is female 100%, and the "executive manager" category is male 100%.

Age and experience have been represented as large as possible: it is not expected here a representative sample of the population of the site in terms of respect of proportions, but in terms of different profiles.

This sample is to identify whether or not a population stands another in dealing with the three lines of the board #5 letter #9, i.e. by implementing a particular approach, by deploying a special reflection.

Analysis of the data shows that, among the adult population of the sample working on NPP, no population is pointed out, neither by the profession, nor by training. Indeed:

- only 6 people over 57 deal with the letter #9, that is 11%,
- among these 6 people, there are 3 students, which gives 3 people out of 50 over the adult population, which is 6%.

Professional profiles dealing with the letter #9 are:

- engineer - manager (1),
- operator (1),
- technician (1),
- student (3)

Academic profiles dealing with the letter #9 are:

- doctor (1),

- charter technician (BEP degree) (1),
- university charter technician (DUT degree) (1),
- student (3).

On observables, we see that:

- 39% of subjects spontaneously implement a Pre-job Briefing (PjB) by questioning and reformulation of what is to be done, all categories combined,
- 33% perform initial review of the conditions of the work activity in action; the control concerns especially the adequacy of the mask with the objective of the task; however it is implemented at the beginning of the activity only,
- 23% applies a specific method by removing such as vertical boards in rising or raising regularly the mask.
- 12% choose the ruler at the beginning of the activity and not the mask, different percentage of those dealing with the letter #9 because some of them change tool during the task performance,
- 11% have treated the letter #9,
- none was aware of the presence of an additional letter by line on board #5.

These results are represented in proportion of the sample on Fig. 2.

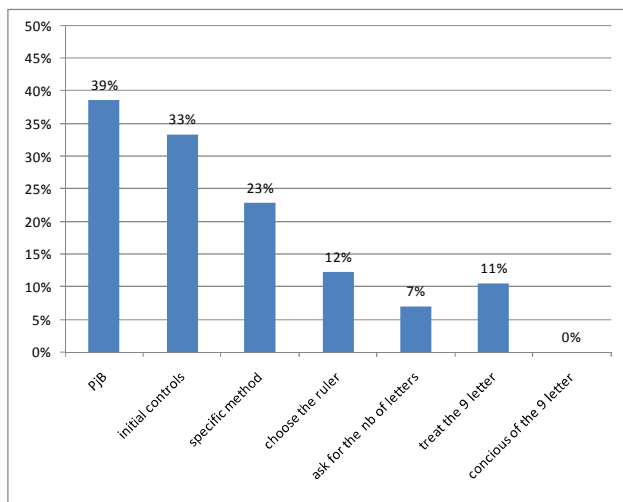


Fig. 2. Proportion of subjects having a specific behavior whilst taking the Letter-test.

The correlative analysis between results and observables indicates that:

- 100% of the people who have chosen rule deal with the letter #9, and 100% of those opting for the mask do not,
- 100% of people who have dealt with the letter #9 are not aware of the presence of an additional letter by line on board #5.
- 83% of people who have treated the letter #9 performed a PjB.
- 50% of the people who treated the letter #9 initiated prior checking to the realization of the task. But 100% of adults who have dealt with the letter #9 performed prior checking to the achievement of the task.

These combined behaviors are presented on Fig. 3.

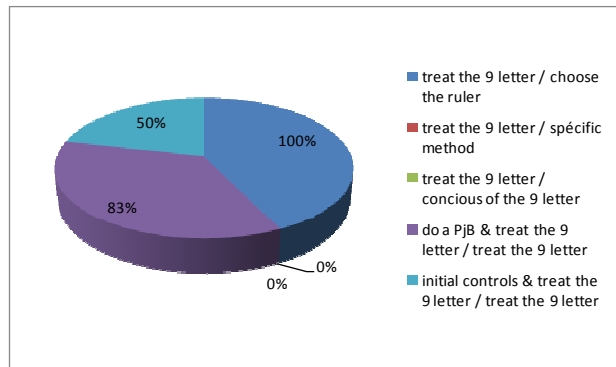


Fig. 3. Proportion of subjects having combined specific behaviors whilst taking the test.

To these data are added findings coming from observations when carrying out the activity and interviews in debriefing with the subjects. In particular, it appeared a priori confidence in most cases between the subject and the experimenter, which was not involving the subject to doubt about the quality of the mask, and therefore did not engaged to carry out or to deepen the initial control of the mask.

Observations in phase of realization of activity showed how the tool is structuring and focuses attention on specific informative clues, helping to achieve the goal, shadowing the peripheral indices. Thus, some subjects have implemented methods that might have revealed the presence of the letter #9, but did not see it while they had it in front of the eyes:

-Example 1: Some subjects (less than 10 cases) fit the mask for all the boards by raising the mask several times to see the letters under the mask. Most of them are looking for the letters matching within the windows. They do not note letter #9 while visible.

-Example 2: The subject comes to the board #5, put the mask on, counts letters, and has a doubt concerning the last letter that appears right of the line #1. It is a 'b'. He removes the mask, takes the ruler and measures letter #9 which is a 'o', puts back the mask on, recounts the letters and does not notice that the last window of the line #1 gives a 'b' and not a 'o'. (EMT01)

- Example 3: The subject has chosen to align the mask not on the upper cross of the board, but on the right column of the lines: for each board, s/he puts the mask by adjusting right windows on the right column of the letters, column #8. Comes to the board #5: he does the same, and aligns the right windows of the mask on the right column of letters, here column #9. This produces a visible shift for the experimenter-observer both for the crosses and the format paper. But the subject notes nothing and therefore deals with letter #9 but not letter #1 (in statistics, this case is registered as having not dealt the letter #9). (EMT04) (Fig. 4)



Fig. 4. Example of shift of the mask put on the board #5: we can see in the upper left corner the shift of the mask cross compared to the board one. We can also see the shift of the transparent mask over the white paper of the board.

-Example 4: Some subjects (4 cases) performed an initial control which led to accept the mask using only the middle line windows. Their goal is to work with a dedicated tool (which works fast) but reliable: considering then that the top and the bottom window lines of the mask are too big, they apply the mask on the boards shifting the middle window line on each line of the board. Doing so and arriving at board #5, they make visible letter #9 of lines #3 and #1 in offset from the windows of the mask (CEM09, P02, P04, TP08 (line 1)) (Fig. 5 a & b).

-Example 5: A subject takes the Letter-test in a room, facing a window, and decides stalling the mask maintaining the boards vertical. A posteriori, it is verified that letter #9 of the board #5 are slightly visible. But the subject does not see them.



Fig. 5 b & c. Examples of shifting of the mask when using only the middle line.

#### 4-Discussion

Interviews with adults indicate that time pressure induced by the announcement of the activity timing expected as short as possible lead them to choose the mask. They think that this "tool developed especially for this activity" will save time, which is true since the mean time of realization using the mask is about 3 min. while about 6 min. with the ruler. They therefore prefer the speed.

Subjects dismissing the mask for the ruler have all made a prior control of the mask and concluded that it was not reliable.

However, students have another approach. Their rejection of the mask is not due a qualification examination of the mask, according to their explanations in debriefing and the observed facts: none of the students has done such initial examination. What they prefer is to control the situation rather than the speed. The rejection

of the mask is induced by the inability to see what is hidden, the choice of ruler is induced by the familiarization with this tool while the mask will be used for the first time. Thus, the time constraint is not the same value for this population covering the age 9-14 years.

#### 5-Conclusion

The findings are the following:

- No population of NPP professionals stands another in dealing with the letter #9, i.e. by implementing an approach, deploying a special reflection.
- The proportion of professionals of NPP dealing with the letter #9 is very low (6%), compared to that of students (43%).
- The population distinguished is therefore the students (9-14 years). They favor control of the situation rather than gain of time: they want to be efficacious rather than efficient. However students have not yet been confronted with the imperatives of the world of work and productivity: the adults are and have learned, were formatted to become efficient (efficient in a minimum of time and resource). However, any non-professionals of NPP population can do better than a professional, because to work on NPP (as in any industry), there is a need to professionalize the newcomer, who therefore becomes, whilst learning to be efficient, very sensitive to time-control assessment.

Not having identified any industrial population distinguished from another, and not identifying any particular method related to the profession or the academic training, it must be sought a solution to cope with focus-structuring effect by the tools. For the moment, it is clear that the solution lies in the reconstruction of the tools: it must be the elements that will allow the person conducting the work activity of awareness of this possible focus. However, the solution cannot always be intrinsic to the tools: indeed, a hammer will be a hammer while a procedure can be adjusted, a working method can be adapted. In particular, an overall control at the end of work activity can be achieved, which was not allowed in the proposed test. To assess the effect of such control, other samples of subject will be met.

In addition, in the tests, encountered subjects showed relative confidence in the experimenter. A sample of subjects for which the confidence will be reduced will be also met.

Thus, we will see if one of these opportunities helps to improve the results.

#### References

- Buessard, MJ.; Fauquet, Ph. (2002) Impact de la prescription sur les activités de travail en centrale nucléaire. *Proceeding of the 37th SELF Congress*, Aix-en-Provence, France. 326-335
- Fauquet, Ph. (2007) Développement des pratiques de fiabilisation sur simulateur de pilotage de réacteur nucléaire. *Colloque de l'Ass. Int. des Sociologues de*

*Langue Française: Risques industriels majeurs*,  
Toulouse, France, 129-135

Fauquet, Ph. (2008) Analyzing training activity on simulators: the complementarity of clinical approach and regulations approach. *Symp. Activity2008 - Activity analyses for developing work*. Helsinki, Finland, 32

Fauquet-Alekhine, Ph. (2012) Industrial safety and experience feedback: the case of French nuclear power plants. *In* Fauquet-Alekhine, Ph. (eds) *Socio-*

*Organizational Factors for Safe Nuclear Operation*,  
Montagret: Larsen Science Ed., 1, 19-24

Le Bot, P. (2004). Human reliability data, human error and accident models—illustration through the Three Mile Island accident analysis. *Reliability Engineering & System Safety*. 83, (2), 153-167