



Risk Assessment for Subjective Evidence-Based Ethnography Applied in High Risk Environment

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Subjective Evidence-Based Ethnography (SEBE) is a family of methods developed for investigation in social science based on subjective audio-video recordings with a miniature video-camera usually worn at eye-level (eye-tracking techniques are included). Despite its application to the analysis of high risk professions (e.g. anesthetists, aircraft pilots, nuclear reactor pilots) and the potential additional risks it induces, no suggestions regarding these concerns and no solutions helping researchers to anticipate this kind of risks are available in the literature. Aiming at filling this gap, we undertook a study of SEBE equipment applied to the analysis of workers' activities on a nuclear power plant. The method was divided in three phases: i) observations and discussions on full scale simulators of activities undertaken by one or two workers ($N=42$) to characterize the consequences of the SEBE equipment, ii) bibliographic research combined with results of first phase to elaborate a risk assessment protocol, iii) analysis of its application in real operating situations ($N=17$). The elaborated protocol gave satisfactory results in terms of risk prevention and time application: No incident or accident occurred and the risk assessment took less than five minutes. The observations highlighted however a risk of side-effect (using SEBE equipment to justify subjects' mistake or

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failure) giving greater importance to the necessity of this sort of risk assessment protocol. To date, the protocol needs to be tested in other industrial contexts in order to be improved and/or to confirm its robustness.

Keywords: Activity analysis; eye tracking; high risk industry; risk assessment; miniaturized camera; video.

1. INTRODUCTION

Using video recordings allows the researcher to access to the reality of work activities which is one of the major concerns of work analysts. The use of video has almost become a necessity because it pushes the limits of the classic observation paper / pencil: Even with the help of analysis grids, the researcher's writing speed is often much slower than the performance of the task by observed workers. In addition, taking notes entails the risk of not watching the scene for a while and so to miss important elements of activity. This could be corrected by replaying the activity but in the world of work, it is generally inappropriate to ask to redo several times the activity observed while video allows for multiple visualizations retrospectively, very useful in the case of complex situations. When the work analyst applies self-confrontation, the video recording is a main tool: observed subjects seeing themselves in action can learn about themselves and thus correct or improve themselves. Thus, the video is both a source and a support: a data source for the researcher and a support of expression (body, speech), of mediation, which participates in the emergence of meaning of the activities and of the co-production of knowledge through the triangle operator-image-researcher [1].

As noticed by others, video analysis may help researchers "to reveal how activities are produced with respect to the contingencies and circumstances of the participants within organizational settings, and examine how the technologies available in these domains are utilized" [2].

Amongst all the possible devices available for such video recording of activities, the first person approach or subjective approach presents the particularity to use a recording device embedded on the subject in action. The point of view of the camera is then that of the subject: this characterizes the first person or subjective point of view. This kind of approach was conceptualized by Lahlou [3,4] under the name of Subjective Evidence-Based Ethnography

(SEBE). The SEBE is thus a family of methods developed for investigation in social science based on subjective audio-video recordings with a miniature video-camera most of the time worn at eye-level (the subcam), then confrontation of subjects with these subjective recordings to collect their subjective experience, and finally discussion of findings and final interpretations between researchers and subjects. The use of a subjective perspective brought interesting series of improvements on the quality of the explanation by the subject's intentions when rendering in self-confrontation interview with the subjective videos [5].

The recent progress regarding miniaturized cameras and camcorders helps new researchers to reach a deeper layer of analysis. For example, the consumers' behavior analysis through subjective recordings avoiding disturbance due to heavy and bulky equipment was obtained [6,7]. Gobbo [8] applied the SEBE approach to shoes consumption (videos are available on line: ethnoshoes.com). Fauquet-Alekhine et al. [9] analyzed consumers' behavior shopping wines in stores for marketing concerns. Similarly, these devices allow researchers to access relevant data regarding work activity: examples of application are available for nuclear industry [10-12].

SEBE also includes eye-tracking systems (see the reviews [13,14]). Researchers have used this kind of devices to analyze and improve training [15-17], to analyze consumers' behavior [18-20], to study high risk professions such as anesthetists [21], aircraft pilots [22-24], flight fighters [25], air traffic controllers [26], nuclear reactor pilots [27].

The use of SEBE metrology equipment does not present any special risks for the subjects themselves. Conversely, SEBE equipment applied to the analysis of high risk professions might induce problems due for example to the interaction between the SEBE equipment and the work environment (cables may be trapped in the industrial equipment) or due to a disturbance of subjects' actions (SEBE glasses might change

the subjects' vision). Despite these potential additional risks induced by SEBE equipment, the literature is void of suggestion regarding these concerns and of solutions helping researchers to anticipate subsequent problems.

This paper aims at providing a devoted risk assessment for SEBE application for high risk professions.

2. MATERIALS AND METHODS

2.1 Design

The high risk professions chosen to undertake this study was the professionals of nuclear industry at the nuclear power plant (NPP) of Chinon (Electricité de France). The analysis frame was bounded by the analysis of their work activity (see for example [12]).

A first phase (first observations and discussions) was undertaken on simulators to observe and discuss with workers ($N=42$) the consequences of the SEBE equipment used. Three kinds of professions were observed: Reactor pilot, operating field worker, and maintenance technician.

A second phase (risk assessment elaboration) was related to a bibliographic research regarding possible risk assessment protocol in high risk industries and to the development of the SEBE risk assessment.

A third and final phase (application) consisted in applying the elaborated risk assessment of phase 2 in real operating situations. Professions concerned were the same as for phase 1 but subjects ($N=17$) were other persons.

All studied situations involved one or two subjects at the same time in a given work activity. These situations were real operating situations therefore exposing subjects to interactions with the industrial environment in operation and to interpersonal contacts with colleagues including all constraints induced by their job and by interactions with other jobs.

2.2 Subjects

For phase 1, reactor pilots were observed and then interviewed in the simulated control room. $N=30$ subjects (age: 25 to 45 yo.; professional experience: several months to 13 years) were equipped with SEBE equipment whilst evaluating

safety (individual activity) or dealing with periodical tests of the process (collective activity). Operating field workers were observed and then interviewed in the field simulator. $N=10$ subjects (age: 25 to 45 yo.; professional experience: several months to 15 years) were equipped with SEBE equipment whilst configuring hydraulic circuit (individual or collective activity). Maintenance workers were observed and then interviewed in one of the tap and valve simulators. $N=2$ subjects (age: 45 yo.; professional experience: 20 years) were equipped with SEBE equipment whilst working with valves and related actuator devices. All these activities lasted from several minutes to 2 hours. All simulators were located at the Training Center of the NPP of Chinon.

For phase 3, reactor pilots were observed and then interviewed in one of the control rooms. $N=5$ subjects (age: 25 to 45 yo.; professional experience: several months to 10 years) were equipped with SEBE equipment whilst evaluating safety (individual activity) or dealing with periodical tests of the process (collective activity). Operating field workers were observed and then interviewed in the field. $N=10$ subjects (age: 25 to 35 yo.; professional experience: 1 to 7 years) were equipped with SEBE equipment whilst configuring electric or hydraulic circuits (individual or collaborative activity). Maintenance workers were observed and then interviewed in one of the electric premises. $N=2$ subjects (age: 28 and 40 yo.; professional experience: 5 and 15 years resp.) were equipped with SEBE equipment whilst undertaking the test of a part of the control system of the installation. All these activities lasted from several minutes to 3 hours and took place at the NPP of Chinon.

As the aim was to develop a SEBE risk assessment for anyone of the staff, gender, age and experience were not considered as variables to be analyzed, yet subjects were chosen so that a large range of age and work experience could be represented by the sample.

2.3 Apparatus

All simulators were of full scale type, reproducing with a high degree of fidelity the real operating material and environment of a NPP, as well as the real kinetic of physical parameters.

The SEBE equipment was made up of three parts linked with cables: i) a micro audio digital recorder DVR-500-HD2 self powered by internal

batteries, ii) a 4 mm diameter - 40 mm length miniaturized subcam mounted on safety glasses, iii) a lavalier microphone. This SEBE equipment was purchased at Active Media Concept.

Reactor pilots were dressed with their own civil garments. Other professionals wore individual safety equipment including overalls, helmet, shoes and gloves if needed.

2.4 Procedure

Phases 1 (first observations and discussions) and 3 (application) required a prior discussion with the management of the teams (operating and training) in order to present the study, negotiate hierarchical agreement, and identify the possible subjects and activities. Then a preparation was undertaken with the subject(s) in order to explain the aim of the research, discuss of agreement and sign the ethical form. Only for phase 3, the preparation included the application of the SEBE risk assessment protocol elaborated in phase 2. After equipping the subject(s), work activity was engaged by the subjects and / researchers began making observations using pencil and paper. No particular instruction was given to subjects: They just had to perform their task as usual. Observations focused on interactions of the SEBE equipment with the environment and subjects. Immediately after the end of the time planned for the experimentation, a semi-structured interview was carried out by the researchers with the subject(s). Questions were asked regarding subjects' perception of their own safety and comfort whilst wearing SEBE equipment, their ability to act, to perform the task, constrains induced by the SEBE equipment on their activity, the interaction between the SEBE equipment and their garments or the industrial equipment. A final open question left place for additional comments. The difference between phase 1 and phase 2 lied in the final interview: for phase 1, the goal was to explore the risks, for the phase 2, the goal was to complement the protocol.

Phase 2 (risk assessment elaboration) began with a list of potential risks due to the SEBE equipment elaborated from the material obtained in phase 1, also fostered by feedback from others studies [3,11,28,29]. These risks were then categorized in order to identify families of potential risks. It was here assumed that risks of a given family could be identified by the same set of questions. In these conditions, it would make the risk assessment more concise.

In parallel, a bibliographic research was undertaken to explore the risk assessment in high risk industries. Four industries were considered: Nuclear, aerospace, airline, and medicine. The investigation focused on available approaches, methods and protocols of risk assessment of work activity in order to adapt it in the case of the SEBE use.

3. RESULTS

3.1 Results of Observations, Interviewers (Phase 1) and Additional Feedback

The first observations from the researchers as well as the first remarks from the subjects concerned the interaction of the SEBE equipment with their body and with their worn equipment: these resulted in comments (positive or negative) regarding the SEBE glasses over their own glasses, the way they had to adjust their own glasses whilst working (one of the pilot was used to pushing back his glasses on the nose (a tic) and another was used to pushing his glasses up on his front when reading certain indicators of the control panel). This led us to consider other possible interactions with prostheses (hearing aid, lenses) and to question the relevancy and the adjustment of the positioning of the SEBE equipment on the subjects.

The operating field workers were wearing overalls with a lot of pockets and a lot of things inside. These led us to question the possible interaction between these objects and SEBE equipment, especially with the cables. As a consequence, the reliability of their movements, of their actions, as well as of their speed of action was questioned. Observations pointed out possible interactions between the SEBE equipment (especially the cables) and the industrial equipment in the case of operating field worker and maintenance worker.

Finally, it appeared important to remind to the subjects that the most important was to perform their work activity and that, in case of discomfort due to the SEBE equipment, this latter had to be taken away at once.

3.2 Results of the Risk Assessment Elaboration (Phase 2)

The results of phase 1 led to a questionnaire for risk assessment divided in 5 categories addressing a specific field of the experiment for work activity:

- Usual biotechnical constraints (including concerns about individual's safety and comfort),
- Biotechnical constraints of the activity,
- Performance constraints,
- Equipment safety,
- Induced biotechnical constraints (including concerns about individual's safety and comfort).

Each category was then broken down into several questions:

1-Usual biotechnical constraints

- 1.1-Do you wear a hearing aid?
- 1.2-Do you wear lenses?
- 1.3-Do you wear glasses?
- 1.4-If Yes to any of the questions, is this resulting in particular regular manipulations?

2-Biotechnical constraints of the activity

- 2.1-Do you wear equipment that may interact with the SEBE equipment? (e.g. belt metrology, helmet, ear plugs, prostheses)

3-Performance constraints

- 3.1-Can SEBE metrology reduce the reliability of your movements?
- 3.2-Can SEBE metrology reduce the speed of your movements?
- 3.3-Can SEBE metrology mechanically interact with your work environment, causing damage? (e.g. span, crawl, slip, climb)

4-Equipment safety

- 4.1-Could SEBE Metrology be damaged?
- 4.2-Could SEBE Metrology be infected, contaminated?

5-Induced biotechnical constraints (once SEBE metrology in place). Do you feel a particular discomfort for:

- 5.1-The field of vision?
- 5.2-Listening?
- 5.3-The weight of the glasses?
- 5.4-The placement of the camcorder?
- 5.5-The placement of cables?
- 5.6-The length of the cables?

A final reminder was added: The reminder was that the priority is the work activity carried out by the workers. In case of discomfort felt by workers due to SEBE equipment, workers must request its immediate withdrawal.

The bibliographic research undertaken to explore the risk assessment in four high risk industries

(§2.4) gave relevant results from nuclear and aerospace industries.

The Institute of Nuclear Power Operations (INPO) highlighted the necessity to have constant risk assessment: "Nuclear safety undergoes constant examination" is one of the 8 principles of a strong nuclear safety culture [30]. "Insights from probabilistic risk assessments are considered in daily work activities and change processes" [31] promoting constant examination. This means that risk assessment is more than one examination: the risk assessment must be undertaken every time performing the activities as the context and/or the actors are always new. For the SEBE, we applied this as the necessity to perform a systematic risk assessment before each application, even if we had the same subject and/or the same activity.

The International Atomic Energy Association (IAEA) provided a probabilistic approach of risks and promoted a method for risk assessment based on consequences and frequency (Fig. 1):

The process of quantified risk assessment is probabilistic in nature. It recognizes that accidents are rare and that possible events and risks cannot be entirely eliminated. Because major accidents may or may not occur over the entire life of a plant or a process, it is not appropriate to base the assessment process on the consequences of accidents in isolation. The probability of this kind of accidents actually occurring should be taken into account. [32].

To operate this approach concretely, we applied the risk assessment matrix of the National Aeronautics and Space Administration (NASA) [33], in full agreement with the recommendations of IAEA, simple and quite clear. In this approach, coherent with most of those applied in high risk industries since the work of Farmer [34], gravity is evaluated in terms of consequences. The matrix approach is a cross assessment of the probability and consequences which are both rated on a five step scale:

Very low, low, moderate, high, very high

The definition of the steps is given in the Tables 1 and 2. They are presented according to four domains: Safety, technical, cost, schedule.

For example, in Table 1, it is suggested that a given space program may be concerned by very

high risks if an identified risk has a probability to occur during the program greater than 10^{-1} (safety domain) or if the probability not to meet the expected performance is greater than 50% (technical domain) or if the probability of an over cost is greater than 75%.

Regarding the safety concern, as done by Probabilistic Risk Assessment (PRA) for high risks industries, we considered probability as a frequency related to the experiment. Yet, the PRA of NASA as well as of INPO considered the probability of occurrence related to a whole space mission or a whole industrial unit operation of which scale of assessment may be several hours, weeks, months or years [32]. Regarding our experiment, we were interested in the impact of wearing the SEBE equipment. This was a permanent situation and we considered that the

appropriate scale of assessment was the second. This led to the following association in Table 3.

Risks were then assessed in the 5x5 matrix according to Fig. 2.

The global aim of a risk assessment is to identify risks for the activity and then implement remedial measures to reduce risks and return all of them in the green area (bottom left corner) of the 5x5 matrix if possible.

On Fig. 2, we adopted a nomenclature to designate:

- probability: p (in subscript on Fig. 2)
- consequence: c (in subscript on Fig. 2)
- very low, low, moderate, high, very high: VL, L, M, H, VH

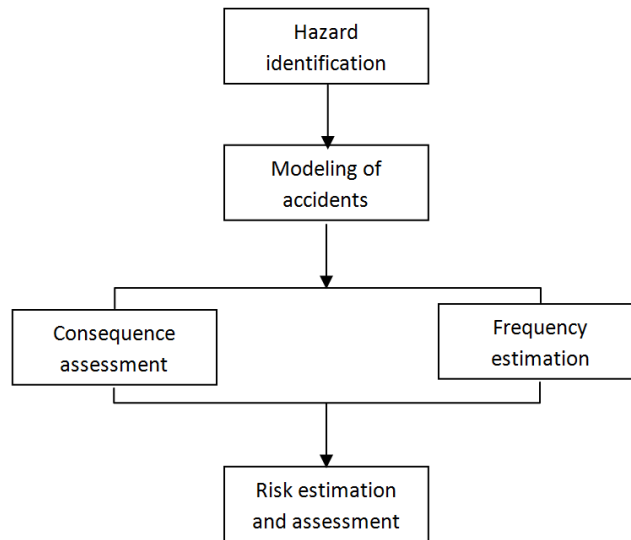


Fig. 1. Overview of quantitative risk assessment procedure. Adapted from IAEA [32]

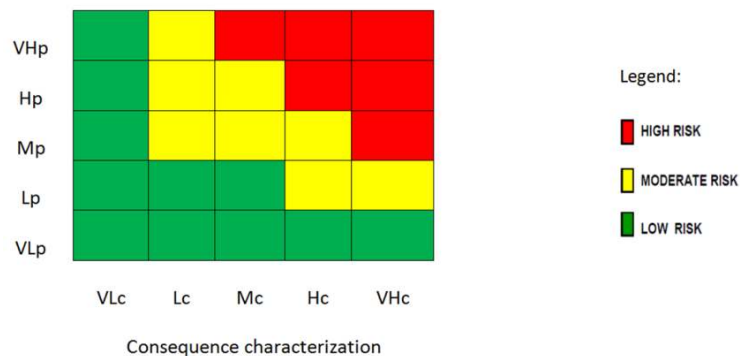


Fig. 2. Risk assessment in the 5x5 matrix Probability vs Consequence characterization

Table 1. Definition of the five steps scale for probability. Adapted from Alcom et al. [33]

| Probability | Safety (estimated probability of safety event occurrence) | Technical (estimated probability of not meeting performance) | Cost/Schedule (estimated probability of not meeting cost or schedule commitment) |
|---------------|---|--|--|
| VH: Very High | $p_s > 10^{-1}$ | $p_T > 50\%$ | $p_{CS} > 75\%$ |
| H: High | $10^{-2} < p_s \leq 10^{-1}$ | $25\% < p_T \leq 50\%$ | $50\% < p_{CS} \leq 75\%$ |
| M: Moderate | $10^{-3} < p_s \leq 10^{-2}$ | $15\% < p_T \leq 25\%$ | $25\% < p_{CS} \leq 50\%$ |
| L: Low | $10^{-6} < p_s \leq 10^{-3}$ | $2\% < p_T \leq 15\%$ | $10\% < p_{CS} \leq 25\%$ |
| VL: Very Low | $p_s \leq 10^{-6}$ | $0.1\% < p_T \leq 2\%$ | $p_{CS} \leq 10\%$ |

Table 2. Definition of the five steps scale for consequences. Adapted from Alcom et al. [33]

| Risk | VL: Very Low | L: Low | M: Moderate | H: High | VH: Very High |
|-----------|---|--|---|--|---|
| Safety | Negligible or No impact. | Could cause the need for only minor first aid treatment. | May cause minor injury or occupational illness or minor property damage. | May cause severe injury or occupational illness or major property damage. | May cause death or permanently disabling injury or destruction of property. |
| Technical | No impact to full mission success criteria. | Minor impact to full mission success criteria. | Moderate impact to full mission success criteria. Minimum mission success criteria is achievable with margin. | Major impact to full mission success criteria. Minimum mission success criteria is achievable. | Minimum mission success criteria is not achievable. |
| Schedule | Negligible or no schedule impact. | Minor impact to schedule milestones; accommodates within reserves; no impact to critical path. | Impact to schedule milestones; accommodates within reserves; moderate impact. to critical path. | Major impact to schedule milestones; major impact to critical path. | Cannot meet schedule and program milestones. |
| Cost | <2% increase over allocated and negligible impact on reserve. | Between 2% and 5% increase over allocated and can handle with reserve. | Between 5% and 7% increase over allocated and cannot handle with reserve. | Between 7% and 10% increase over allocated, and/or exceeds proper reserves. | >10% increase over allocated, and/or can't handle with reserves. |

The definition of the steps is given Tables 1 and 2. They are presented according to four domains: Safety, technical, cost, schedule. Regarding the SEBE method, cost and schedule are not impacted domains provided that the SEBE equipment is not destroyed. This issue is addressed through the technical domain. Hence, the protocol we elaborated below examined

points from the safety and technical standpoints only. Therefore, each question related to the five categories of risks listed in section 3.2 gave rise to an assessment according to safety and performance domain, concretely achieved through an assessment form presented in Figs. 3 and 4 as an example for question 1.1 of the SEBE risk assessment protocol.

These forms (Figs. 3 and 4) were completed at the beginning of the document by an introduction sheet explaining briefly how to apply the document and by three summarizing grids at the end of the document, each one related to the type of risks (red in upper right corner, green in bottom left corner, yellow in the middle, in the matrix Fig. 1).

Table 3. Appropriate scale of assessment for safety probability or likelihood

| Probability | Frequency |
|------------------|-----------|
| 10 ⁻¹ | 1/10 sec |
| 10 ⁻² | ½ min |
| 10 ⁻³ | 1/15 min |
| 10 ⁻⁶ | 1/10 j |

The introduction sheet reminds the user the color code associated to the risk level and what is an acceptable risk according to the matrix. It also presents a Table on which the designation of the activity studied and the names of the performers must be written by the analyst as well as the date of the risk assessment and the participants' names, complemented by the time and date of the activity performance and the performers' names. This information is important because it helps the analyst to prove that people performing the task were involved in the risk assessment. The Table also offers the possibility to write down the number of conclusions identified during the risk assessment. This information is relevant as it helps analysts and workers to know whether or not they have something to do to minimize the risks by a quick look in case of activity realized later than the time of the risk assessment: If the number of conclusions is "0", no significant risk was identified; otherwise the summarizing grids at the end of the document must be read. On these grids, the analyst writes the number of the questions concerned by a risk identified, for which domain (safety and/or technical) and what must be done.

3.3 Application of the SEBE Risk Assessment in Real Operating Situations (Phase 3)

The whole document obtained was thus made up of thirty-four pages (available for free on line at <http://www.hayka-kultura.org/larsen.html>). Using this document for SEBE risk assessment implies beginning by filling the Table on the introduction sheet. This was achieved during the preparation phase with the subject(s) just before performing

the work activity. Then, turning the page, the first question 1.1 (Fig. 3) was asked to the subject(s) regarding safety domain and in case of answer "YES", consequence was identified clearly and written in the box "1" under "consequence", then characterized and probability evaluated. In case of several consequences, box "2" and "3" could be used. The pairs (characterization; probability) were then drawn on the matrix writing "1" for consequence #1 and so on. In case of ticking inside the yellow or red area, remedial had to be written in the next box. Then the next page was considered (Fig. 4), asking the same question 1.1 from the performance standpoint, and a similar analysis was carried out. This was then done for the next questions. In case of answer "NO", the page was turned without any comment.

At the end of the document, all identified consequences were summarized in the last three summarizing grids and the total number of consequences identified and reported in the grids was noted on the introduction sheet. Doing so, it was easy to consult the document later and know how many risks and remedial were identified and not forget any of them.

Application of the SEBE risk assessment document with workers in real operating situation was indeed easy and quick. Most of the answers to the questions were negative and the protocol was applied in less than five minutes.

There was a recurrent positive answer to question #3.3: "Can SEBE metrology mechanically interact with your work environment, causing damage?" for the operating field workers and maintenance workers. The systematic remedial action was to run the SEBE metrology cables inside the overalls.

There were no cases of subjects equipped with a hearing aid. No case of possible infection or contamination of the SEBE metrology equipment was encountered.

Only one case of discomfort was reported (questions of category #5) not during the risk assessment but during the interview after performing the activity. The subject was a reactor pilot.

No case led to withdrawing the SEBE metrology equipment.

No incident or accident was observed or reported.

| | | |
|--|--------------|--|
| 1- Usual biotechnical constraints | answer (Y/N) | 1.4-If Yes, is this resulting in particular regular manipulations? (Y/N) |
| 1.1- Do you wear a hearing aid? | | |

Safety impact analysis:

If yes in 1.4, describe the possible consequence(s) and encircle:

| consequences | consequence: encircle the corresponding characterization | | | | | occurrence probability p : encircle the corresponding p | | | | |
|--------------|--|---|---|--|---|---|-----------------------|--------------------------|--------------------------|----------------|
| | Negligible or No impact (VL) | Could cause the need for only minor first aid treatment (L) | May cause minor injury or occupational illness or minor property damage (M) | May cause severe injury or occupational illness or major property damage (H) | May cause death or permanently disabling injury or destruction of property (VH) | 1/10j<p (VL) | 1/10j<p & p<15min (L) | 1/15min<p & p<1/2min (M) | 1/2min<p & p<1/10sec (H) | p>1/10sec (VH) |
| 1- | VLc | Lc | Mc | Hc | VHc | VLp | Lp | Mp | Hp | VHp |
| 2- | VLc | Lc | Mc | Hc | VHc | VLp | Lp | Mp | Hp | VHp |
| 3- | VLc | Lc | Mc | Hc | VHc | VLp | Lp | Mp | Hp | VHp |

For each consequence, position its probability vs its characterization in the matrix by reporting its number on a corresponding box, then describe the remedial implemented:

| | | | | | |
|-------------|------------------|----|----|----|--|
| Probability | VHp | | | | consequences : describe the remedial implemented to move a risk in the acceptable zone (green) or to watch a moderate risk (yellow): |
| | Hp | | | | |
| | Mp | | | | |
| | Lp | | | | |
| | VLc | Lc | Mc | Hc | VHc |
| | Characterization | | | | |

NB: acceptable risk consequences (green zone) does not need any remedial.

Fig. 3. SEBE risk assessment form for question 1.1 related to safety domain

| | | |
|--|--------------|--|
| 1- Usual biotechnical constraints | answer (Y/N) | 1.4-If Yes, is this resulting in particular regular manipulations? (Y/N) |
| 1.1- Do you wear a hearing aid? | | |

Technical impact analysis:

If yes in 1.4, describe the possible consequence(s) and encircle:

| consequences | consequence: encircle the corresponding characterization for success | | | | | probability: x% of the objectives of the activity are concerned | | | | |
|--------------|--|------------------|---|--|---|---|--------------|---------------|---------------|------------|
| | No impact (VL) | Minor impact (L) | Moderate impact: Minimum mission success criteria is achievable with margin (M) | Major impact: Minimum mission success criteria is achievable (H) | Minimum mission success criteria is not achievable (VH) | x<2% (VL) | 2< x <15 (L) | 15< x <25 (M) | 25< x <50 (H) | x>50% (VH) |
| 1- | VLc | Lc | Mc | Hc | VHc | VLp | Lp | Mp | Hp | VHp |
| 2- | VLc | Lc | Mc | Hc | VHc | VLp | Lp | Mp | Hp | VHp |
| 3- | VLc | Lc | Mc | Hc | VHc | VLp | Lp | Mp | Hp | VHp |

For each consequence, position its probability vs its characterization in the matrix by reporting its number on a corresponding box, then describe the remedial implemented:

| | | | | | |
|-------------|------------------|----|----|----|--|
| Probability | VHp | | | | consequences : describe the remedial implemented to move a risk in the acceptable zone (green) or to watch a moderate risk (yellow): |
| | Hp | | | | |
| | Mp | | | | |
| | Lp | | | | |
| | VLc | Lc | Mc | Hc | VHc |
| | Characterization | | | | |

NB: acceptable risk consequences (green zone) does not need any remedial.

Fig. 4. SEBE risk assessment form for question 1.1 related to performance domain characterization

4. DISCUSSION

4.1 Contribution

When obtaining the SEBE risk assessment protocol after phase 2, a worry came to our mind regarding the time which would be necessary to apply it: Usually, additional tasks are never welcome in the course of industrial activities because they reduce efficiency by increasing the time of work. We were pleased to demonstrate finally that this did not take more than about 5 minutes.

The fact that no problem was encountered and just one complaint was reported by the subjects whilst applying the SEBE equipment with prior risk assessment in real operating situations is encouraging: It suggests that the developed protocol for SEBE risk assessment may be a relevant tool. Problem due to the dimensions of the device would perhaps have been different with a bigger camera, especially for field workers in narrow premises.

The complaint regarding SEBE equipment concerned just one case of discomfort reported during the interview after performing the activity (1 subject over 17 in the application phase 3). The subject was a student reactor pilot. However, observations led to the assumption that this person was using any reason to justify his difficulties in achieving the tasks (lack of competencies). Yet, due to ethical concerns, this point could not be discussed neither with his managers nor with his colleagues for confirmation or not. This highlighted a very important point: if an individual may attempt to hide a kind of lack of competencies by invoking the effect of the SEBE equipment, we may assume that, in case of accident occurring in situation, the SEBE equipment might be designated by the subjects as a main factor contributing to the accident even though it would not be really the case. This finding gives even greater importance to the necessity of this sort of risk assessment protocol. Indeed, in case of the occurrence of an accident whilst using the SEBE equipment with risk assessment beforehand, there are arguments to defend the absence of contribution of the SEBE equipment to the accident. Obviously, this does not prevent the workers to make by their side the risk analysis of their own activity.

This protocol may be applied to any kind of SEBE, including wireless devices or systems for

which the camcorder and/or the microphone are integrated inside the glasses: In these cases, the related questions are merely not applicable.

4.2 Quantitative Approach

Risk assessment addressing SEBE use is quite new and therefore suffers of a lack of experience feedback on the contrary of space programs or nuclear reactors operation. A long experience feedback helps analysts to make the risk assessment more accurate by fostering probability data with the frequency of event occurrences. For example, the repetitive failure of a given sensor m times over a ten year space program including M launches of a rocket equipped with this sensor helps analysts to adjust the probability of failure of this sensor to m/M . The SEBE unfortunately does not have any benefits of this kind as it has never been considered from such a standpoint until today. Nevertheless, from the $N=42$ cases used to elaborate the protocol and then from the $N=17$ cases for application, we may conclude that the thresholds suggested by the NASA to bound the technical levels (Table 1) and that the thresholds selected to bound the safety levels (Table 3) are appropriate: indeed, applications in working situations led us to implement remedial actions that avoided any problem in the considered industrial domain. For example, while the placement of the cables was not pointed out as inducing a possible difficulty for reactor pilots, this was not the case for field workers for whom keeping the cables inside the vest was recommended.

4.3 Limits

Despite the fact that results of the present study suggest that the developed protocol for SEBE risk assessment may be a relevant tool, the application as well as the exploratory phase preceding the elaboration of the protocol concerned only one industrial field. Furthermore, no particular biotechnical constraint was met except wearing glasses: it should be interesting to deal with subjects concerned by prostheses. The same for equipment safety with infection or contamination. It would be worth to test the application of the protocol in context of other high risk industries in order to submit it to other fields of constraints and test its robustness and learn whether or not the protocol needs improvement and complements.

5. CONCLUSION

A protocol for risk assessment regarding the application of SEBE metrology equipment was validated for work activities in nuclear power plant. This protocol was based on the recommendations and applications of the International Atomic Energy Association, the Institute of Nuclear Power Operations and the National Aeronautics and Space Administration.

The protocol gave satisfactory results in terms of risk prevention and time duration application. We found important to add a reminder in the protocol document for the subjects not to forget that the priority remains the work activity carried out by them. In case of feeling any discomfort due to SEBE equipment, they must request its immediate withdrawal. Furthermore, recommendations of INPO (§ 3.2) led us to highlight the necessity to perform a systematic risk assessment before each application, even if we had the same subject and/or the same activity.

The observations highlighted however a risk of side-effect: Workers who are not at ease in their job due to lack of skills might say that the SEBE equipment was disturbing them to justify a problem and not to accept their own responsibilities; moreover, in case of an accident, SEBE metrology equipment could be accused as disturbing workers even though it was not the case. These findings gave greater importance to the necessity of this sort of risk assessment protocol.

This protocol may be applied to any kind of SEBE, including wireless devices or systems with integrated camcorder and/or the microphone inside the glasses. Yet, the protocol needs to be tested in other industrial contexts in order to be improved and/or to confirm its robustness. Despite that, the SEBE risk assessment protocol we obtained clearly fills a gap with efficiency for researchers and analysts using SEBE techniques.

CONSENT

The author declares that written informed consent was obtained from subjects for publication of this paper.

ETHICAL APPROVAL

This study received ethical approval of the Ethics Committee of the Dept. of Social Psychology

(LSE, London, UK) and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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COMPETING INTERESTS

The author has declared that no competing interests exist.

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