Detection and Characterization of Tacit Occupational Knowledge through Speech and Behavior Analysis

Philippe Fauquet-Alekhine and Frédéric Daviet

***Abstract*—The industrial society facing a "skills drain" with a massive renewal of staffs these years, improving the training of newcomers in the companies has become a key point. More specifically, being able to integrate tacit knowledge as input data of occupational training programs is a significant issue. On the basis of recent work, we developed a protocol helping us, through replay interview of subjective video recordings of activities and additional experiments, to detect and characterize tacit occupational knowledge through speech and behavior analysis. The application case used to illustrate the benefit of the method is the profession of nuclear reactor pilot. Identification and characterization of a tacit knowledge was done and questions raised for further discussion and integration in the training process.**

***Index Terms*—Behavior, metaphor, simulator, tacit knowledge.**

I. Introduction

Most long established west European firms such as Electricité De France (EDF) are subject to a high renewal of employees [1], [2]. For a plant such the Nuclear Power Plant of Chinon (EDF, France) which has 1200 employees (all professions included), this "exodus" is considered by some Human Resource analysts as a "skills drain": it appears that in the next ten-fifteen years, 33% of population will be renewed and, currently, young employees represent 13% of the staff. Other analysis suggests that 50% of the staff will be renewed in the next 5 years.

In such a socio-technical context, improving the training of newcomers in the companies is a crucial point [1]. This is achieved, among other means and methods, through the characterization, understanding and formalization of knowledge, know-how and competencies of experienced workers in order to enhance the quality of the input data of the occupational training programs.

Knowledge, know-how and competencies include both declarative knowledge (explicit factual knowledge) including theory and concepts, and tacit knowledge resulting from the experience [3]–[7]. Among these, tacit knowledge is particularly difficult to identify and therefore to characterize, understand and formalize in order to include it within a training program.

Furthermore, a key question is to decide whether or not it must be taught: sometimes, it may be better to let the tacit knowledge develop naturally through the professional curriculum. Hence, innovative techniques and analyses are welcome to investigate and study occupational tacit knowledge and related items.

On the basis of recent work [8] aiming at understanding and characterizing, from field data, the nature of the transmission and the formalization of knowledge (both explicit and implicit) underlying the execution of professional gestures as part of a given work activity, we developed a protocol helping us, through replay interview of subjective video recordings of activities and additional experiments, to detect and characterize tacit occupational knowledge through speech and behavior analysis.

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II. Material and Method

The protocol we developed is based on a recent work [8] aiming at retrieving the expert knowledge in individual work situations focusing on professional gestures and leading to the realization of pedagogical tools for transfer of knowledge. It consisted of digital capture of the gesture through subjective and external recordings associated with a goal-oriented verbalization in situations (self-confrontation interviews and reconstruction) in the theoretical framework of the Subjective Evidence-Based Ethnography (SEBE) elaborated by Lahlou [9].

The protocol we developed was structured in four phases:

1) preparation phase,
2) audio-video capture phase,
3) analysis phase,
4) additional interviews and experiments.

The preparation phase was to identify the experimental field (location and type of work activity), contact the participants and schedule the experiment and analysis.

The audio-video capture phase involved a briefing with participants (the subject whose activity is analyzed and co-workers), equipping the subject, recording by means of a subcam (presented thereafter), and a short feedback of the researchers to the participants.

The analysis phase was structured in three steps: i)Pre-viewing of recordings without the subject; ii)Replay interview with the subject; iii)Post-analysis of the replay interviews by the researcher.

The additional interviews contributed to validate the findings of the post-analysis. The additional experiments

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helped to enhance characterization of identified tacit knowledge. They consisted of statistical video analysis of subjective recordings.

The replay interview step of the analysis phase applied subjective re-situ interview techniques [10] combining self-confrontation [11] and explicitation interview [12] in the frame of a goal-oriented verbalization applying Activity Theory concepts [13]–[15] and an extended model of competencies in action [16], [17]. It aimed at explaining the subject's activity based on the video recording of the activity according to a subjective situational point of view. Confronting the subject to the subjective video replay captured whilst performing the activity (capture phase), the interview favored the setting in the foreground of the subject, shedded light on what the subject had to do (or not), knew to do (or not), wanted to do (or not), was able to do (or not).

The post-analysis step of the analysis phase provided detection and first characterization of tacit occupational knowledge through the subject's speech analysis (including comparative analysis of verbal elements of speech) whilst explaining the behavior during the activity.

The equipment used for audio-video capture (Fig. 1) was composed of i) a micro audio digital recorder DVR-500-HD2 (Active Media Concept) providing HD video recording up to 1280 x 960 pixels at 25 frames per second, integrated touch 3" color display, SDHC memory expandable up to 32 GB, USB connection, ii) a 4 mm diameter - 40 mm length miniaturized subcam mounted on safety glasses, 480 lines color, iii) an additional lavaliere microphone.

The occupational context chosen for the study was an activity performed by the nuclear reactor pilot in the control room on the French Nuclear Power Plant of Chinon. The activity chosen was common to any pilots' work: in French "le tour de bloc" which may be translated as "block watch-around". This consists in watching and checking operating parameters in the control room. This activity lasts usually from 10 to 30 min. and assumes a replay interview about 1h in the shorter case.

Ten pilots have been involved in these experiments among them six novices. The differentiation between novice and experienced was done according to the criterion of the research department "Risk Management" of the company. They carried out in 2003 a research aiming at characterizing deviation from the expected result in work activities. This is since applied in the company for deviations characterization. Among the parameters selected for the features of the deviation's actor was the time spent in the position; this was divided in three intervals: less than 2 years, between 2 and 5 years, more than 5 years. A worker was identified as novice until 2 years spent in the position and experienced after 5 years. We here decided two differentiate novice from experienced worker at the intermediate level, i.e. 3.5 years.

III. Results and Discussion

A. Audio-Video Capture and Analysis Phase

The "block watch-around" in the control-room was analyzed for each subject. From the researcher's external point of view observing in live the activity, the task was performed in a very similar way for all of them. Yet through individual replay interviews based on the subjective video breaking down through a cooperative analysis (subject/researcher) the behavior and associated mental representations of actions and goals, a significant difference was pointed out: while the novice said "I am checking the value of the steam generator pressure here", the experienced pilot said "I am looking whether or not the steam generator pressure goes straight". This kind of metaphorical expressions in experienced subjects' speech was generalized.

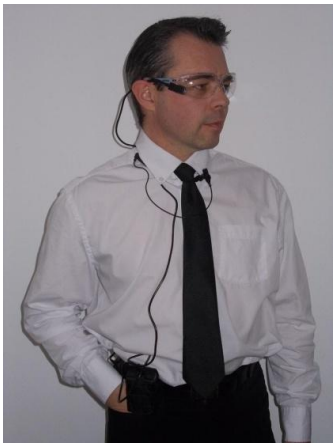

Fig. 1. Example of subjective camera device (subcam): Mini camera on glasses, lavaliere microphone, mini-camcorder in belt holster equipping a subject.

Further exchanges with the experienced pilots during the individual replay interviews showed that in fact they were not reading the value of the parameter but looking at the shape of the curve for this parameter. All replay interviews confirmed these trends, illustrating that, after a while, pilots could have developed a faster but reliable way to read information in the control room based on visual clues rather than on reading values. Discussions showed that yet, according to the subjects, this was never taught, even not shared explicitly between workers.

The comparative post-analysis of interviews confronting answers obtained from the questioning of the extended model of competencies in action on one hand, and from the subjective re-situ interview on the other hand, suggested this difference of professional practice between novices and experienced workers was of tacit knowledge type.

B. Additional Interviews

Interviews with representatives of three other professions involved in watching and checking operating parameters in the control room of the nuclear plant confirmed the previous findings. An expert engineer, a shift operating team manager, and a trainer (all experienced workers) confirmed in individual interviews that they often checked "values going straight" rather than reading formally the value.

Again, discussions showed that, according to the subjects, this was never taught, even not shared explicitly between workers.

C. Additional Experiments

Therefore, a statistical analysis in depth of the subjective recordings appeared relevant in the aim at finding indications

regarding the way pilots were catching information. A parameter emerged at once: the time spent by the pilot watching a part of the panel without moving. We called these intervals "stop-vision". We thus counted for each subject the number of stop-visions and calculated the associated rate in occurrence per minute (occ/min), measured the length of each stop-vision and performed a modal analysis of the data per intervals of 1 second. Hence, for novices on one hand and for experienced on the other hand, we obtained a distribution cumulating at rank 1 the number of stop-visions encountered by subjects included in the range [0; 1s], at rank 2 the number of stop-visions encountered by subjects included in the range [1; 2s], and so on until rank 7 cumulating all stop-visions greater than 6 s. For comparison purpose from one subject to another, the absolute cumulative values were normalized for each subject by the total number of stop-visions. Fig. 2 draws the distribution of the proportion of stop-visions per rank for novices and experienced pilots. A Kolmogorov-Smirnov test confirmed the differentiation of the two distributions with $p<0.05$. It appeared clearly that experienced pilots spent less time to catch information, with an extreme value of the density equal to 43% and centered at a duration a bit less than 2s. prolonged by a trend to zero towards higher values, while the novices presented an extreme value of the density equal to 29% and centered at a duration a bit higher than 2s. prolonged by a trend significantly not null towards higher values.

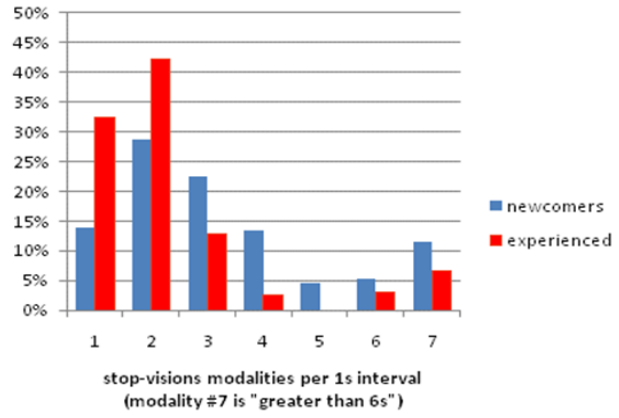

Fig. 2. Modal analysis of the stop-visions for pilots ranked per intervals of 1 second.

As said above, the fact that after a few years, pilots could develop this kind of know-how while, according to the subjects, not taught and even not shared explicitly between peers, suggested that this kind of tacit know-how had to develop spontaneously. Two questions then rose: after how much time this kind of know-how may be effective and must this kind of know-how be taught early in the training for the trainees to be efficient faster?

An indication for the first question was found in the analysis of the stop-vision rate. Plotting the stop-vision rates versus time spent in the position (Fig. 3) for all types of pilots showed arrangements of points that could break into two parts, each fitted by a linear line which intersection matched the abscise 2.5. This suggested therefore a hypothesis: this kind of know-how could likely be integrated by the pilots after spending about 2.5 years in the position. This value, lower than the criterion selected to differentiate novice and experienced pilot, suggested that this kind of how-how was developed before the worker being considered experienced according to former analysis of the research department "Risk Management" of the company.

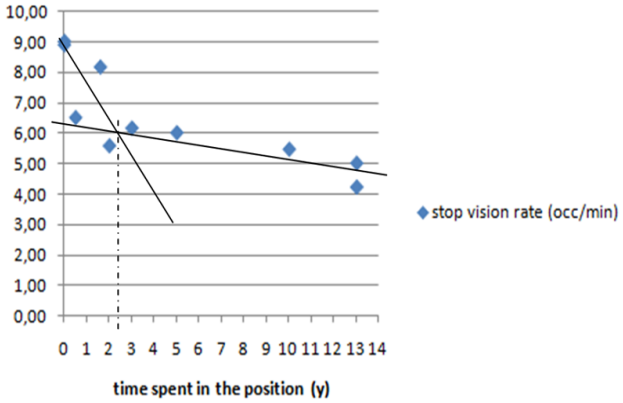

Fig. 3. Stop-vision rates versus time spent in the position of pilot for each subject.

Regarding the second question about the fact that this kind of know-how might be taught early in the training curriculum for the trainees to be efficient faster, a first assumption was made that if this is applied after such a long period, perhaps it needs time to be integrated by the subject to be efficient from a cognitive standpoint. The contribution of the companionship to this process may be analyzed in future studies. Further investigations are needed to answer correctly the question.

One could object that stop-visions are not reliable as a differentiating indicator about the way a pilot takes information from the control panel, arguing that one may move the eyes without moving the head and thus a given fixed visual field may correspond for one subject to the acquisition of one or two pieces of information while for another subject this is related to more than ten. In order to assess the potential bias induced by this consideration, comparative analyses are planned in collaboration with the Nuclear Training Center of Tricastin (France) and the University of Aix-en-Provence (France) which undertook similar experiments with eyes-tracking systems mounted on glasses.

A final point needs discussion here regarding the fact that subjects often checked "values going straight" rather than reading formally the value and that, according to the subjects, this was never taught, even not shared explicitly between workers. As written here and all along the present paper, this practice was never taught, even not shared explicitly between workers according to the subjects.

Yet, undertaking interviews, the metaphorical expression "values going straight" spontaneously appeared in the subjects' speech to explain their behavior whilst checking parameters. We therefore may assume that, in the daily operating work in the control room, they also use this metaphorical expression. This might mean for example that when an experienced worker asks a novice to check a parameter or gives information to the novice, this metaphorical expression is included non consciously in the exchange. "Non consciously" would explain first that

according to the subjects the related practice is never taught nor shared between peers. This could suggest secondly that even if not taught nor shared, the novices try to make sense for this expression when earring it, and simultaneously develop and integrate this practice in their own professional style: the verbal exchanges including this metaphorical expression could infer the related professional practice and therefore contribute to its elaboration for the novices. This reminds socialization process in the SECI model of Nonaka & Takeuchi [18], [19] for knowledge transfer and conversion. The model distinguishes four knowledge conversion processes: Socialization, Externalization, Combination, Internalization (SECI). Socialization allows the passage of tacit to explicit to promote transmission from the experienced worker to the novice. Socialization enables the sharing of experience and mental models; it is the case through companionship.

IV. Conclusion

The study aimed at applying a protocol helping work analysts, through replay interview of subjective video recordings of activities and additional experiments, to detect and characterize tacit occupational knowledge through speech and behavior analysis. This was achieved by implementing, during the replay interview, subjective re-situ interview techniques combining self-confrontation and explicitation interview in the frame of a goal-oriented verbalization applying Activity Theory concepts and an extended model of competencies in action.

The results and analysis showed that the comparative post-analysis of interviews confronting answers obtained from the questioning of the extended model of competencies in action on one hand, and from the subjective re-situ interview on the other hand, could help analysts to detect and give first characterization of professional practices of tacit knowledge type.

The main concluding assumption of this study is that there are tacit know-how that are elaborated with time and therefore with experience, differentiating novices from experienced workers, know-how that perhaps must not be taught on simulators while acquired by oneself or taught through companionship according to a process that remains unclear for the moment.

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