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Performance in Collaborative Activity: Contribution of Intersubjectivity Theory

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Abstract

Collaboration at work is a key component for activities in complex socio-technical systems. Reviewing the scientific literature showed that collaborative work activity has been well characterized, showing that perspective-taking is a crucial feature, but no study quantifies what makes the performance of collaborative activity. Analyzing performance during work activity inevitably refers to Cognitive Task Analysis paradigm (CTA). Based on digital ethnography and Intersubjectivity Theory, the study was undertaken in a nuclear power plant where cooperative activities were analyzed using a CTA process tracing method: whilst performing their activity, workers wore a miniature camera at the eye-level to record their activity from the first-person perspective and were then involved in a reflexive analysis of the activity. Results led to introduce the concept of "coherent perspective-taking" and demonstrated that it was the main variable explaining collaborative performance for cooperative activities. The related theoretical process is discussed and organizational factors favoring coherent perspective-taking are identified.

Keywords

collaborative activity, cognitive task analysis, digital ethnography, intersubjectivity, performance, perspective-taking

1. Introduction

Collaboration at work is a key component for activities, especially in complex socio-technical systems such as industrial plants or hospitals (Deutsch, 1949; Bratman, 1992; Bardram, 1998), where work activities are too complicated to be performed by a single individual. However, little investigation has

been undertaken to quantify what makes the efficiency of collaborative work activities despite the fact that it has been well characterized.

After clarifying what is "collaborative activity", we undertook a bibliographic research to identified what are the criteria that may make "collaborative activity" efficient and designed a field experiment to characterize and quantify the efficiency based on innovative use of theories.

The experimental field was chosen at the Operations department of a nuclear power plant. This complex socio-technical system was selected for the numerous possibilities offered in terms of collaborative activities to be analyzed. Moreover, an internal study had highlighted difficulties regarding collaborative activities. The management of the department had thus good reasons to provide means for the experiment.

1.1 The concept of "collaborative activity"

The Cambridge dictionary suggests that "collaborative working" is "the act of two or more people or organizations working together for a particular purpose". This definition leads back to the Latin roots: working together (in Latin: cum laborare: with/together work). Collaborative activity involves and implies task interdependency. It may concern different levels, such as workers (see for example Bratman, 1992 or Bardram, 1998) or institutions through workers (see for example Kaiser (2011) for interagency collaborative activities).

For Bratman (1992): collaboration may be cooperation (in Latin: *cum operare*: with/together operate) but collaboration is not systematically cooperation: competition (in Latin: *cum competere*: with/against compete) is also a form of collaboration. Deutsch (1949, 1962) differentiated cooperative situation from competitive situation by the relationships existing between the individuals' goals linked together through a positive (resp. negative) correlation between their goal attainments (Johnson & Johnson, 1974). For Bratman as for others (Clark, 1996; Deutsch, 2000; Klein et al., 2005), collaboration is a joint activity carried out by workers who intend to work together. According to Bratman (1992, p. 328), collaboration becomes cooperation when there is mutual responsiveness between co-workers (A needs B and B wants to respond and vice versa) and commitment to mutual support (A needs B and B can respond and vice versa) in addition to the commitment to the joint activity (statement of intent to work together). This is consistent with Activity Theory which highlights that a common goal (shared intention to reach a specific final state) is necessary for the success of joint activity (Leontiev, 1974; Nardi, 1995).

1.2 Theoretical approach of collaborative activity

Most of the authors adopted the Activity Theory approach for collaborative activity analysis. Bardram (1998) included cooperation as a form of collaborative activity and pointed out that "Activity Theory describes cooperation as a collaborative activity with one objective, but distributed onto several actors, each performing one or more actions according to the overall and shared objective of the work" (p. 91). He re-discussed the proposal of Engeström et al. (1997) who suggested a three-level structure of a

collaborative activity: co-ordinated, co-operative, and co-constructive collaborative activity; the levels are defined as follows from Engeström et al. (1997), Bardram (1998) and Omicini & Ossowski (2004, p. 3):

> *The co-ordinated aspect* of work captures the normal and routine flow of interaction. Participants follow their scripted roles, each focusing on the successful performance of their actions, either implicitly or explicitly assigned to them; they share and act upon a common object, but are not necessarily aware of this fact. The scripts coordinating participants' actions are not questioned or discussed, and need not be known and understood in all their complexity: in this stage, actors act as "wheels in the organizational machinery" and co-ordination ensures that an activity is working in harmony with surrounding activities.
>
> *The co-operative aspect* of work concerns the mode of interactions in which actors focus on a common object and thus share the objective of the activity; unlike previous cases, actors do not have scripts, actions or roles explicitly assigned to them: with regard to the common object, each actor has to balance his/her own actions with other agent actions, possibly influencing them to achieve the common task. So, co-operative activities assume that the object of the activity is stable and agreed upon, but the means for achieving the goal is to be defined and forged at this level.
>
> *The co-constructive aspect* of work concerns interactions in which actors focus on re-conceptualizing their own organization and interaction in relation to their shared objects. Neither the object of work, nor the means to achieve them are stable, so that they should be collectively constructed, i.e., co-constructed.

The authors emphasized that the co-ordinated level is characterized by stable means of work ("Such means are primarily the script revealing a distribution of the activity into several actions and actors, and the mediating artefacts", Bardram, 1998, p. 91), the co-operative level is characterized by stable object of work (it does not address one object then another; the object does not change even though it is transformed throughout the activity) and the co-constructive level is characterized by non-stable means and a non-stable object of work. Moving from one level to another implies stabilization or a reflection (destabilization) about means or object. Bardram (1998) warned that these three levels were "analytical distinctions of the same collaborative activity" but "an activity cannot be said to exist on one level alone" (p. 92). Similarly, Deutsch pointed out the interlaced nature of these levels by categorizing communication and coordination as positive characteristics of cooperative relationships. He also pointed out that this three-level structure excluded de facto the competitive form of collaboration otherwise it should take into account at least obstructed communication and inability to coordinate activities. "Means" and "object of work" suppose that they are included in and supported by an organizational system that provides shared rules or ways of practices: Heath & Luff (1991, p. 67) suggested that "collaboration necessitates a publicly available set of practices and reasoning which are

developed and warranted within a particular setting, and which systematically inform the work and interaction of various personnel" among which the way to communicate (see also Engeström et al., 1997; Bardram, 1998; Omicini & Ossowski, 2004).

Collaboration may also be considered in terms of action feedback. Deutsch (2011) underlined a possible (a)symmetric relationship between individuals involved in competitive activities depending on the effect possibly produced on the challengers: "suppose that what you do or what happens to you may have a considerable effect on me, but what I do or what happens to me may have little impact on you. I am more dependent on you than you are on me" (p. 25). Fauquet (2006), observing work activities in nuclear reactor control rooms, noticed that the action feedback could be immediate or deferred depending on the work context. Both authors pointed out the resulting influence on co-workers behaviors and on the performance of the activity.

1.3 Criteria for collaborative activity efficiency

The criteria characterizing collaborative activity elaborated from the literature review are listed in Table 1 (left column) with the associated sources (middle column). Criteria must be understood as mandatory properties for the activity to be collaborative. Then, activities may have facultative properties according to what was reported in the literature. The properties are listed in Table 2 for the cooperative form thus excluding other forms of collaboration as we shall not address them in the present study.

1.4 Perspective-taking or intersubjectivity: A neglected criterion as part of performance

In practice, in complex socio-technical systems, collaborative activities are often nested in a multi-tasking context. They verify properties pointed out by Rogers & Ellis (1994): collaborative activities "are fragmented by virtue of both their interwoven nature and the fact that they are situated within an intricate network of social interactions". This has an impact on the performance of collaborative activities depending on the form of the collaboration: in the domain of motor performance, it was found that cooperation led to higher performance than competitive or individual conditions (Johnson et al., 1981; Stanne et al., 1999; Peng & Hsieh, 2012; Plass et al., 2013). Similarly, Bardram (1998, p. 89) found that "when cooperation breaks down, changes over time" it may be "perceived differently by different actors involved" (p. 89). These remarks question the criteria given in Table 1 describing characteristics of collaborative activity, especially regarding mental representation sharing between co-workers and perspective-taking: if subjects' perspective-taking are opposed (e.g., subject A thinks subject B is involved in cooperation but subject B thinks subject A is not involved in cooperation) how do they elaborate the criteria "Subjects share the general mutual goal related to this task" and "Subjects coordinate their actions"? Moreover, since taking an opposed perspective might compromise the effectiveness of cooperation, we may assume that it has an impact on the efficiency of the activity when designed and thus expected to be cooperative by the organization: it deteriorates the mutual representation of the collective subject (Lahlou et al., 2004). Hoever et al. (2012) showed that perspective-taking could increase collaborative performance when co-workers are engaged in

perspective-taking conversely to the case where they are not instructed to take their team members' perspectives. For Klein et al. (2005), perspective-taking between co-workers relates to a "common ground" that includes beliefs and assumptions which are shared among the co-workers contributing to provide an interpredictability of co-workers' attitudes and actions. According to these authors, this interpredictability is a key factor in enhancing coordination performance and might be based on a shared mutual representation. Bratman (1998, p. 338) qualified perspective-taking as an essential attitude to cooperation. However, perspective-taking has never been studied as a key characteristic of cooperative activity in high-risk industry, perhaps due to the difficulty to objectify the effectiveness of this criterion. These considerations led us to add the criterion "perspective-taking" in Table 1.

Based on results obtained in a quite different domain, this of food industry (Fauquet-Alekhine & Fauquet-Alekhine-Pavlovskaia, 2016), Intersubjectivity Theory (Mead, 1912, 1913) appeared adapted to the objectivation of perspective-taking performance.

According to Rommetveit (1974), intersubjectivity may be understood as One's orientation to the orientation of Other. Ichheiser (1943) distinguishes three interactional-levels: the individual/group self-perception, the individual/group perception of Other, the perception of individual/group of the Other's perception of themselves. More recently, Gillespie (2007, p. 275) emphasized that these three levels may be considered to operate at two levels from the interlocutors' standpoint: "First, there is the level of a person's direct perception of Self or Other, and second there is the level of perception of the perspective of Other" which helps "to conceptualize how someone or a group might try to appear trustworthy. To appear trustworthy, they must orient to the criteria that they think Other is using in order to determine trustworthiness". The first level was conceptualized as the "direct perspective" by Laing et al. (1966), the second as "meta perspective", and the authors added as a logical possibility a third level, the meta-meta-perspective: the perception of individual/group of the Other's perception of their perception of themselves. On the basis of Laing and co-workers' studies, Gillespie (2007, p. 276) reformulated how these three levels of perspectives could be important and illustrated it by referring to the Cold War analyzed by the authors who argued that "the distrust between East and West operated at each of their three levels. Not only did East and West fear each other (direct perspectives), but they were each aware that the other feared them (meta-perspectives), and they each knew that the other was aware that they knew the other feared them (meta-meta-perspectives)". Gillespie (2007) thus suggested a model of intersubjective structure of trust and distrust articulated upon these three levels and pointed out that a context of trust or distrust was satisfied when the three levels were fulfilled according to this structure through intertwined properties as described hereafter. The intersubjective structure of trust and distrust was recently tested and validated when applied to the communicational process of food marketing by Fauquet-Alekhine and Fauquet-Alekhine-Pavlovskaia (2016) and the following presentation about intersubjectivity is excerpted from their article.

The entwined properties characterizing the intersubjective structure of trust and distrust may be easily depicted on a diagram. Let us consider two individuals involved in an intersubjective process; we call them "interactants". The two interactants are Self (S) and Other (O). The direct perspective (DP) assumes that S assigns an attribute (A) to O and vice versa. DP gives two statements. Statement (S)1="S thinks A about O" and Statement (O)1="O thinks A about S". The meta perspective (MP) considers that each of them knows these statements. Again MP yields two statements: Statement (S)2="S knows Statement (O)1" and Statement (O)2="O knows Statement (S)1". This means that "S knows O thinks A about S" and Statement (O)2="O knows S thinks A about O". Finally, the meta meta perspective (MMP) addresses an upper level of knowledge. MMP produces two statements: Statement (S)3="S knows Statement (O)2" and Statement (O)3="O knows Statement (S)2". The relationships drawn on Figure 1, when complying with the intersubjective structure as described here, give a strong consistency to the context. The way properties are entwined on Figure 1 implies that the relationships between S and O are bilateral and analogous.

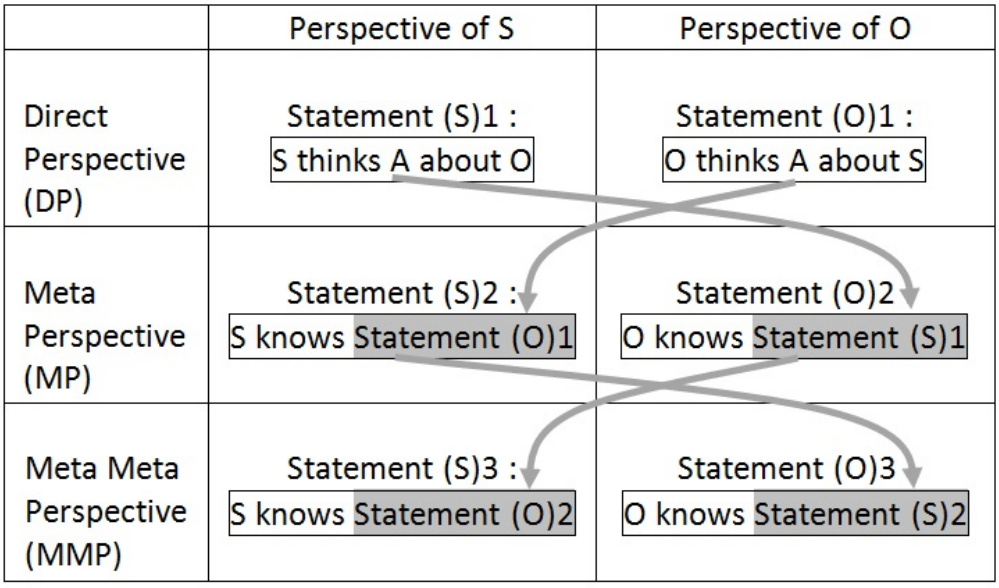

Figure 1. The intersubjective structure of trust and distrust between Self (S) and Other (O) each of them assigning to each other the same attribute (A)

When applied to collaborative activity, the intersubjective structure may be thought of in terms of collaboration rather than trust. The expression of the intersubjective structure of collaboration is then as follows: DP gives two statements. Statement (S)1="S thinks O works with him" and Statement (O)1="O thinks S works with him". MP yields two statements: Statement (S)2="S thinks Statement (O)1" and Statement (O)2="O knows Statement (S)1" and MMP produces two statements: Statement

(S)3="S knows Statement (O)2" and Statement (O)3="O knows Statement (S)2". In other words, when S thinks that O works with him, knows that O thinks S works with O and knows that O knows S works with O, and vice versa (the same inverting S and O) then there is a coherent perspective-taking within an intersubjective structure of collaboration that might contribute to the efficiency of the cooperative dimension of the activity: this is made possible when the following criteria are effective (from Table 1) "Subjects share the general mutual goal related to this task" and "Subjects coordinate their actions". Therefore, assessing the intersubjective structure during collaborative activity may help to better understand the collaborative process.

1.5 Overview of the research—experimental field

These considerations led to the following research questions and hypothesis:

> **General research question**: How performance of a collaborative activity of type cooperation may be explained in terms of the criteria in Table 1.
>
> **Focused research question**: To which extend perspective-taking may contribute to the performance of collaborative activity?
>
> **Hypothesis**: If workers are engaged in a collaborative activity supposed to be cooperative without perceiving themselves collaborating, then their performance is reduced as they probably do not use all the potentiality offered by the collaboration.

The aim of this study was thus to quantify the contribution of criteria and properties of cooperative activity to its performance, provided that workers' characteristics in terms of experience and technical skills would be considered too.

The experimental field chosen for this aim was this of cooperative activities on a French nuclear power plant (NPP). This choice was led by the postulate that such a complex socio-technical system would provide all the material needed for the study. Moreover, an internal study led by the Human Factors department of the NPP had pointed out a misunderstanding of what is "collaborative activity" among the Operations teams. Furthermore, a significant difference of perception of what "collaborative activity" is had been emphasized between the field workers on one hand and the management on the other hand (Fauquet-Alekhine, 2015). Details regarding the activities, the subjects performing the activities and the work contexts are presented in section 2 "Material & Method".

Table 1. Criteria describing collaborative activities elaborated from the literature review

x: systematic

/: sometimes

Criteria	Examples of scientific sources	collaborative	cooperative	co-constructive	competitive
Several subjects are involved.	General definition, Oxford dictionary Deutsch (1949, 1962) Johnson & Johnson (1974) Bratman (1992)	x	x	x	x
Subjects are related by organizational relations.	Heath & Luff (1991)	x	x	x	x
Subjects are related by timelines (defined by beginning and end).	Heath & Luff (1991) Deutsch (1949, 1962) Johnson & Johnson (1974)	x	x	x	x
Subjects share the general mutual goal related to this task	Deutsch (1949, 1962) Johnson & Johnson (1974) Lomov (1984) Nosulenko & Samoylenko (2009, 2011)	x	x	x	x
positive correlation between the individuals' goals	Deutsch (1949, 1962) Johnson & Johnson (1974)	x	x	x	
negative correlation between the individuals' goals	Deutsch (1949, 1962) Johnson & Johnson (1974)				x
subjects aim at performing together the same task (commitment to the joint activity)	General definition, Oxford dictionary Deutsch (1949, 1962) Johnson & Johnson (1974) Bratman (1992) Clark (1996) Bardram (1998) Engeström et al. (1997) Deutsch (2000) Omicini & Ossowski (2004)	x	x	x	x

	Klein et al. (2005)				
mutual responsiveness (A needs B and B wants to respond and vice versa)	Bratman (1992)	x	x		
commitment to mutual support (A needs B and B can respond and vice versa)	Bratman (1992)	x	x		
Subjects coordinate their actions	Bratman (1992) Bardram (1998) Engeström et al. (1997) Omicini & Ossowski (2004)		x	x	
Subjects communicate	Lomov (1984) Bardram 1998 Engeström et al. (1997) Omicini & Ossowski (2004)	x	x	x	/
Means are stable	Bardram (1998) Engeström et al. (1997) Omicini & Ossowski (2004)		if coordinated		/
Object of work is stable	Bardram (1998) Engeström et al. (1997) Omicini & Ossowski (2004)		x		/
A system providing the organizational relations can be identified	Heath & Luff (1991)	x	x	x	x
Subjects act within this system	Heath & Luff (1991)	x	x	x	x
Perspective taking	Bratman (1998) Klein et al. (2005) Hoever et al. (2012)	x	x	x	x

Table 2. Properties characterizing collaborative activities elaborated from the literature review

Identified properties	Examples of scientific sources
(A)synchronous real time	Le Bellu (2011) Luff, Heath, & Greatbatch (1992) Ellis & Gibbs (1989)
Task-load (a)symmetry	Le Bellu (2011)
Disturbance (a)symmetry	Rogers & Ellis (1994) Fauquet (2006)

Remote/Nearby activity	Luff, Heath, & Greatbatch (1992) Fauquet (2006)
Actions feedback immediate/deferral	Fauquet (2006)
Actions feedback (a)symmetry	Deutsch (2011)

2. Material & Method

2.1 Operations teams activities and participants

The analysis was applied at a French nuclear power plant: Operations shift teams were involved in Hydraulic Configuration, Lock & Tag activities and Periodical Tests. This was part of their daily work and was analyzed in real operating situations.

Hydraulic Configurations imply changes of equipment configuration used to carry fluids; they are carried out to adapt the industrial installation to safety or production requirements. Lock & Tag activities are safety procedures; their application ensures that equipment is properly shut off and not started up again prior to the completion of maintenance or servicing work; workers must affix a tag to the locked device indicating that it should not be turned on; removing the tag is named “unlocking”. Periodical Tests are sets of hydraulic and electric manipulations; they are periodically undertaken to test the reliability of the equipment when operating.

All these activities involve two workers: the pilot (in the control room) is in command of a set of equipment, but there are many other devices in the field that need visual control or direct manipulations such as valves, ventilators, electric racks; this is achieved by the field worker in the field. The pilot asks the field worker to take charge of the part of the work related to the field every time a procedure requires changes involving pieces of equipment that are not linked with the control room.

The study was undertaken over 8 weeks of shift. During this time, 21 situation cases were observed. Consecutive interviews were performed: firstly co-workers were met individually; secondly, they were met collectively in order to confront their point of view. Among the 21 situation cases, 6 were rejected: 2 cases because technical problems were encountered related to the industrial process (therefore non-standard), 2 cases because of organizational issues preventing the activity to be achieved during the shift by the pair of co-workers, 1 case because the activity was not collective despite what was planned, and 1 due to a participant-related problem (while performing the work activity, the pilot made a mistake when checking the state of a pump on a control panel; evidence of this was identified during the pre-analysis when viewing his subjective video; then, during the individual interview, incoherence appeared between his actions and his intentions; the field worker also confirmed this analysis during the individual interview. Yet, the pilot explained his action as if it had been intended, not as a mistake. This case of collaborative activity was thus rejected as not reliable).

Finally, 15 pairs of co-workers involved in $N_{situ/app/coll}=15$ different situation cases were kept for the analysis. Participation was voluntary: activities of interest were selected during the shift briefing,

workers assigned to these activities were suggested to participate. They always agreed. Participants' characteristics are given in Table 3. All of them were experienced workers.

Table 3. Subjects' characteristics for collaborative dimension analysis during the applicative test segment

	Field workers	Pilots
Gender (% male)	100	100
Age (y)	27.7	27.7
Experience (y)	6.1	1.8
Number of subjects	15	15

2.2 Data collection

Accessing what makes performance during work activity inevitably refers to work analysis and thus to the Cognitive Task Analysis paradigm (CTA). It regroups methods for the design and/or the analysis of activities. Two reviews provide an exhaustive state of the art (Tofel-Grehl & Feldon, 2013; Wei & Salvendy, 2004) and a categorization of the methods:

- Observations and interviews (very sensitive to the protocol adopted),
- Process tracing (capturing expertise during activity performance through audio and/or video recording).
- Conceptual techniques (indirect methods not applied in real operating situations).
- Formal models (computational models are developed to describe activities in context and are adjusted after comparison of the results with workers' feedback).

Applying Wei & Salvendy (2004)'s guidelines in selecting CTA methods according to the aim of the studies, a process tracing method was selected: data collection was based on Subjective Evidence-Based Ethnography approach (SEBE approach). A protocol was adapted from digital ethnography, based on Le Bellu and co-researchers' work (Le Bellu et al., 2010; Le Bellu, 2011; Lahlou, 2011; Nosulenko, 2008; Nosulenko & Samoylenko, 2009). The protocol, described in detail in Fauquet-Alekhine (2016), is based on the capture of the subjects' work activity through a first-person perspective video recording (subcam on Figure 2; see Lahlou, 1999) followed by a replay interview based on the Square of PErceived ACtion model (SPEAC model) described in Fauquet-Alekhine (2016) and Fauquet-Alekhine and Lahlou (2017). The SPEAC-based protocol implied a short preparation with the participants before undertaking the work activity, a capture phase of the activity to obtain a subjective recording of each worker's activity, then a "replay interview" (RIW) where participants comment their own first-person perspective recording to the researcher, followed by a post-analysis by the researcher. SEBE enables detailed introspection by the worker on his activity as the reviewing of first-person perspective recordings triggers episodic memory (Lahlou, 2011).

The SEBE equipment (Figure 2) used for first-person perspective video recording was made up of three parts linked with cables: i) a 12x12x8 mm camera (subcam) mounted on safety glasses,
ii) a micro audio digital recorder DVR-500-HD2 self-powered by internal batteries, touch screen, dimensions 80x52x22 mm, iii) a lavaliere microphone. This SEBE equipment was assembled from components produced at Active Media Concept (website: www.amc-tec.com). The advantages of this equipment were to avoid any electromagnetic interferences with the industrial control-command and to be adaptable to any kind of glasses (safety or vision).

Figure 2. SEBE equipment: subcam on glasses, microphone, camcorder and bag

Experiments were conducted by a Behavioral Psychologist researcher.
Before going onto the field to perform their activity, participants were individually equipped with this SEBE metrology. The schema of the protocol was the following:

- Workers were separately informed of the aim of the study. They undertook a risk assessment regarding the subcam used in real operating situation (Fauquet-Alekhine, 2016; Fauquet-Alekhine et al., 2018). They signed an informed consent. This lasted about 5 min. for each subject (preparation phase).
- Workers performed their activity (about 10 min. to several hours). At the same time, they recorded a subjective video of their activity (capture phase).
- At the end of the activity, workers gave the subcam equipment back to the researcher.
- After uploading the video files on a computer, subjects were met twice: first individually and then collectively to undertake the RIW (analysis phase). In order to respect the participants' workload, the management gave an agreement for interviews lasting not more than 1h. each. The RIW was based on self-confrontation (Von Cranach et al., 1982) and explicitation techniques (Theureau, 2002). In addition, the RIW was structured on the basis of the Square of PErcieved ACtion model (SPEAC method; see Fauquet-Alekhine, 2016, Fauquet-Alekhine & Lahlou, 2017). The post-analysis of the interviews (audio recorded) allowed the researchers to characterize the collaborative dimension of the

work activity.

2.4 Data analysis

2.4.1 Characteristics of the collaborative activity

Collaborative activities were analyzed in the light of the criteria and properties provided by the literature review and summarized in Tables 1 and 2.

In addition to these criteria and properties, the SPEAC method used to identify what makes competencies of workers provided by another study (Fauquet-Alekhine, 2017; see also Fauquet-Alekhine, 2016; Fauquet-Alekhine & Lahlou, 2017) suggested that, for workers with an equal level of competencies (experienced), certain non-technical professional practices might be source of performance for a collaborative activity of experienced workers. These findings provided additional properties:

- The workers structure their activity and also the sequence of reasoning and gestures.

This aspect was assessed through viewing the subfilms (video recorded with subcam). When structuration was effective, the subfilm showed that the worker did not look for what he had to do, his actions flowed smoothly, and his gestures were accurate. Conversely, when it was not effective, the worker was having many breaks to re-read the procedure, was coming back to an action already done or coming back to a place where he already had done what to be done. The structuration of the activity was assessed by the researcher based on the statement “the activity is structured” on a Likert scale coded from –2 (strongly disagree) to +2 (strongly agree). Observations showed that pilots always structure their activity; the dimensioning factor was thus on the side of the field worker.

This item was labelled “field worker structures his activity” in the following.

- The field worker undertakes an overall or final control of the activity or of an activity phase before moving onto another phase.

This aspect was assessed through viewing the subfilms. It was only assessed for the field worker as, for the types of collaborative activity observed, the pilot’s contribution on this aspect was difficult to assess with accuracy. The assessment by the researcher was coded 0 if not effective and 1 otherwise.

This item was labelled “field worker undertakes a final control” in the following.

- The workers share the same mental representation of the up-coming activity before performing the activity.

This aspect was assessed through viewing the subfilms (what information workers exchange) and through replay interviews (what they explained about what they did with the exchange). The assessment by the researcher was coded 0 if not effective and 1 otherwise.

This item was labelled “share the same mental representation of the up-coming activity” in the following. This item was considered as an assessment of the aforementioned characteristic “Subjects share the general mutual goal related to this task” (Table 1) according to the concept of “collective subject” in collaboration (see Lahlou et al. 2004).

- The workers share their forthcoming respective contributions before performing the activity.

This aspect was assessed through viewing the subfilms. It was easily objectified by the researcher: when workers exchanged with their colleague about what they intent to do, this aspect was considered effective. The assessment by the researcher was coded 0 if not effective and 1 otherwise.

This item was labelled “share their forthcoming respective contributions” in the following.

- Both workers have time to read the modus operandi (MO) before being involved in a co-preparation or a pre-job briefing with the pilot.

This aspect was assessed through viewing the subfilms and most often through replay interviews as workers did not think to switch on the recorder early enough. The assessment by the researcher was coded 0 if not effective and 1 otherwise.

This item was labelled “workers pre-read the MO” in the following.

- The workers undertake a co-preparation or a pre-job briefing (PjB) before performing the activity.

This aspect was assessed through viewing the subfilms and replay interviews. The assessment by the researcher was coded 0 if not effective, 1 in case of co-preparation or pre-job briefing and 2 in case of co-preparation and pre-job briefing.

This item was labelled “Co-preparation or PjB” in the following.

A last factor was noticed: the fact that the worker, although being experienced, might be novice regarding this specific activity (in French: “primo-intervenant”): even when experienced in the job, it could happen that the worker had never performed the activity. However, this parameter was assumed being not relevant as only 1 out of 30 workers (pilots and field workers) was concerned in our sample.

Two periods were investigated regarding the Operations shift teams activities: a period of standard workload without outage of nuclear units and a period of high workload during unit outages (three times more activities than the former).

Criteria and properties were assessed through viewing the subfilms (what participants did) and through replay interviews (what participants explained about what they did): the assessment by the Behavioral Psychologist researcher was coded 0 if the criterion was not effective and 1 otherwise. The intersubjective structure of collaboration was also assessed (next paragraph). These factors were correlated with job performance (section “Method”).

2.4.2 Perspective-taking and intersubjectivity

As mentioned in section “Introduction”, perspective-taking contribution to the performance of collaborative activity has never been objectified in the light of Intersubjectivity Theory.

Based on the statements exposed in section 1.4, the assessment of the intersubjective structure of collaboration was obtained through the analysis of the subjects’ feelings and beliefs whilst viewing collaborative sequences of their activity and being confronted to the subjective video recordings of their activity. This was undertaken through an interview led by the Behavioral Psychologist researcher.

To do so, during these sequences, specific moments were selected for both co-workers which took place at the same moment. For example, when 01:30 AM was visible on the field worker and the pilot's subfilm, subjects were asked about their perception of the collaborative dimension of their activity. This was done during their individual replay interview. These moments were selected during the preparation and debriefing phases of the activity by the Behavioral Psychologist researcher, and also during the realization phase. For the latter, moments were selected when co-workers were communicating (face-to-face or by phone) or not and/or working directly with the co-worker (e.g., the field worker closed a valve because the pilot had just asked him to do it on the phone) or not (e.g. the field worker was walking in the machine room towards the valves he had to handle so as to carry out the collaborative activity).

These impressions were obtained from the four questions asked and then discussed with the subjects during individual interviews whilst viewing the associated video sequence:

- Did you get the impression you were working together at this moment?
- Did you get the impression you were working as a pair?
- Did you get the impression your colleague thought you were working together at this moment?
- Did you get the impression your colleague thought you were working as a pair?

Such questions have clear operational implications, because if some answers are negative there is a possibility of misunderstanding or overlooking aspects that may be important for efficient collaboration.

These questions have been chosen because they addressed the direct and meta perspectives of the subjects according to the Intersubjective Theory. The meta-meta perspective was not questioned in order to avoid cognitive overload of the subjects as illustrated by these two examples:

- The first replay interviews showed that, after answering the two first questions, the subjects sometimes had difficulty understanding and answering the two questions that followed; this was not due to the subjects being limited intellectually but linked to the fact that they worked in shift teams: when you have to think about and answer these sorts of questions between 01 and 04 AM knowing your sleep pattern changes from one day or night to another and that you have been scrambling up and down and around the plant for several hours, it is clearly difficult to keep a clear mind when discussing concepts which you are not familiar with.
- The questions were repetitive: during one replay interview, the subject sometimes had to answer the same questions up to 8 times. Taking this point into account and also avoiding the subjects becoming bored, it was decided to avoid the meta-meta perspective; for example: Did you get the impression your colleague thought that you thought you were working together at that moment? Taking into account the fact that they would have also had to explain the answer, it was preferred to make them keep their energy to discuss and explain the SPEAC protocol questions.

Then, among the analyzed specifics moments, the proportion respecting the intersubjective structure of (non-)collaboration was calculated for each situation case. This proportion, on a continuous scale 0-100%, labelled "proportion of coherent perspective-taking" in the following, reflected the subjects' coherence in terms of direct and meta perspectives. It was taken as an indicator of the way subjects had developed an efficient perspective-taking.

2.4.3 Job performance

For the job performance assessment, a classical and simple scale commonly applied in the field of job performance assessment was used (see for example: Rynes et al., 2005; Helm et al. 2007; DCIPS, 2009; Smeets et al., 2013). This kind of scale presents the advantage to "be used for any type of job […] permit the assessor to factor in variables that are not under the employee's control but nevertheless influence performance […] allow a focus on whether results are achieved using acceptable means and behaviors […] generally carry less risk of measurement deficiency" (Rynes et al., 2005, p. 583; see also Wright et al., 1993; Arvey & Murphy 1998). Table 4 details these criteria and assigns for each a score between brackets.

Table 4. Criteria and scores for job performance assessment

criteria	**Unacceptable (1)**	**Minimally Successful (2)**	**Successful (3)**	**Excellent (4)**	**Outstanding (5)**
label	did not meet the expectations of the objective even though circumstances allowed for its achievement.	partially met the expectations of the objective; the result fell short of meeting the standards for quality, quantity, timeliness, and cost-effectiveness associated with the objective.	met fully with expectations of the objective; the result met the standards for quality, quantity, timeliness, and cost-effectiveness associated with the objective (e.g., met designated budget and/or timeframe) and was achieved with the appropriate level of guidance.	exceeded expectations of the objective; the results surpassed the standards for quality and quantity, and the timeframe associated with the objective (e.g., saved time or money).	greatly exceeded expectations of the objective; the result was exceptional and significantly surpassed the standards for quality, quantity, and timeframe associated with the objective (e.g., saved significant time or

money)

Doing so, the job performance was easy to assess without the need for a dedicated assessment grid per activity or an expert to judge the job results. Although they remained approximate, the pre-test of this scale assessment applied to activities at the nuclear power plant NPP showed that it gave satisfactory discrimination of job performance.

Each of the domains addressed through the scale (quality, quantity, timeliness and cost-effectiveness) were easy to assess in real operating situations. The standards for quality were usually commented by the subject during the replay interview or during the activity debriefing. The standards for quantity were not related to a quantity of pieces to be produced but to the fact that the final goal of the activity could be reached. Again, this was naturally commented upon by the subject during the replay interview or during the activity debriefing with their colleagues. The timeliness and the cost-effectiveness of the activity were easily rated when compared with the shift schedule for activities: the appropriateness between the schedule and the work done, corresponding to work done in time and without additional cost. This was discussed during shift briefing, during the activity debriefing or during the shift team debriefing.

For each of the domains addressed through the scale, a score was assigned respecting the aforementioned approach and a final score was given by calculating the average.

Job performance assessment was performed by the first author in charge of observations and based on the subfilms and replay interviews analyses. The researcher was considered competent to carry out this sort of assessment due to 4-year professional experience as an expert in safety followed by 10 years as a Human Factors Consultant, both periods in a French NPP. Job performance was assessed on a 1-5 scale, labelled “job performance” in the following.

2.4.5 Statistical analysis

Pearson correlation coefficients were calculated to assess relationship between variables (including criteria and properties of collaboration, workload and performance).

Multi linear regression analysis was undertaken in order to identify which criteria could explain performance of collaborative activities in the aim to quantify the contribution of relevant variables to cooperative collaboration.

Multi linear regression analysis was also undertaken in order to explain the proportion of coherent perspective-taking, a parameter of interest as innovative.

In both cases, residuals’ normal distribution was verified through a normal probability plot (correlation coefficient regarding the residual quantiles vs the expected quantiles).

Spearman’s rank correlation coefficient and Kendall’s rank correlation coefficient were calculated to assess how the relationship between job performance scores and proportion of coherent

perspective-taking could be described by a monotonic function. In other words, we assessed if subjects were ranked similarly for each variable.

3. Ethics

All participants signed an informed consent before undertaking experiments. This study received ethical approval (Code of Approval: DSP/RS/PFA-4) 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.

4. Results

4.1 Identification and selection of relevant variables

Collaborative dimension was assessed according to criteria and properties summarized in Tables 1 and 2.

Comparison between observations and criteria of Table 1 showed that all situation cases were of cooperative form and none of competitive form.

All the criteria in Tables 1 and 2 were assessed through viewing the subfilms (what workers exchange) and through replay interviews (what they explained about what they did with the exchange). The assessment by the researcher was binary and coded 0 if not effective and 1 otherwise. Criteria systematically observed (thus being equal to 1 or to 0 exclusively for all situation cases) could not be used for correlation calculation with others as they were equal for all situation cases (their variance being 0, the calculation of the correlation coefficient would imply dividing by 0). Therefore, only variable criteria were used for correlation analysis:

- Subjects share the general mutual goal related to this task,
- Means are stable.

Regarding the properties, only one item of interest for correlation calculation was identified: “Actions feedback immediate/deferred”. The others were systematically observed as present (which can be explained by the rigorous procedures in effect in NPP operation).

To summarize, the items being assessed and used for correlation calculations were:

- Subjects share the general mutual goal related to this task, done through the above item “share the same mental representation of the up-coming activity”,
- Means are stable,
- Actions feedback is immediate,
- field worker structures his activity,
- field worker undertakes a final control,
- share the same mental representation of the up-coming activity,
- share their forthcoming respective contributions,

- workers pre-read the procedure,
- Co-preparation or PjB.

Due to limited time for replay interviews, not all the specific moments regarding the analysis of the intersubjective structure of (non-)collaboration identified during the pre-analysis phases could be systematically discussed with subjects: N_{smom}=47 specific moments for the $N_{situ/app/coll}$=15 cases were discussed in replay interviews. Those which were discussed were distributed over the different phases of the activities as described in the second column of Table 5. The third column provides the proportion of moments with coherent DP-MP (Direct perspective vs Meta Perspective, as described in section "Introduction") between workers out of the number of specific moments per phase. The right column provides comments regarding the values obtained. Figure 3 gives an insight of what was a specific moment by placing side by side an excerpt of a pilot's subfilm (left) and an excerpt of a field worker's subfilm (right).

Overall, during the replay interviews, 188 DP or MP were investigated.

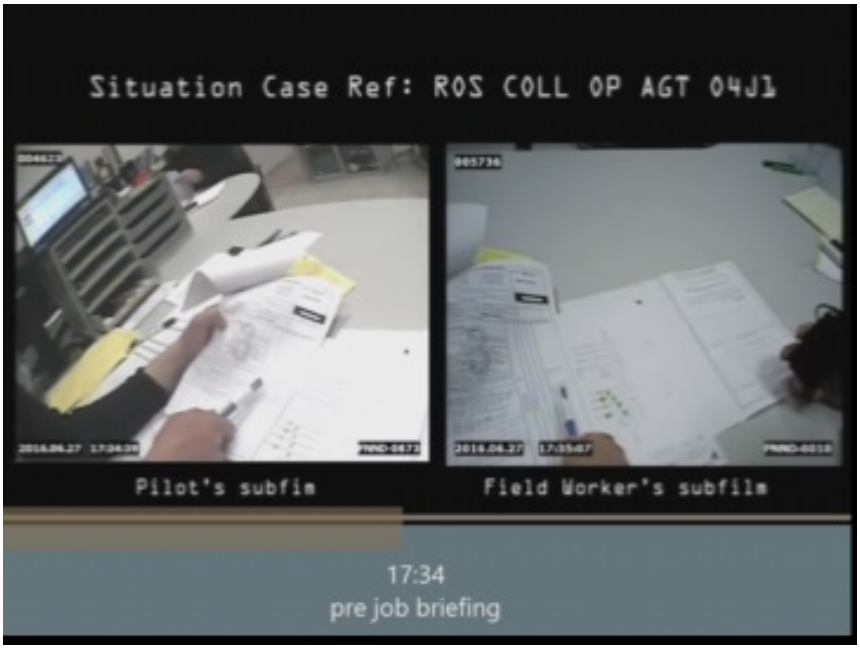

Figure 3. Insight of a specific moment placing side by side an excerpt of a pilot's subfilm (left) and an excerpt of a field worker's subfilm during the pre-job briefing phase of the activity at the same moment. This picture shows the subfilms with which DP and MP were discussed individually and collectively for time t=17h34 of the work activity, a moment when co-workers were exchanging information at the pilot's desk

Table 5. Distribution of the specific moments for intersubjective structure assessment over the activity phases

(*)N_{smom} is the total number of specific moments

Activity phase	% of specific moments of the phase compared to $N_{smom(*)}$	% of moments with coherent DP-MP within the number of specific moments of the phase	Comments
PjB or Preparation	29.8	64.3	This phase always summons co-workers in a face-to-face exchange.
Realization with face-to-face communication in progress	6.4	33.3	All situation cases were remote activities; the realization involved very few face-to-face moments.
Realization with remote communication in progress	34.0	75.0	
Realization without communication in progress	25.5	50.0	
Debriefing	4.3	100	This phase did not often happen or was difficult to discuss in replay interview due to time left per interview.

Correlations involving socio-demographic data were not relevant: no significant correlation was found between subjects' professional experience or subjects' ages and other factors.

Correlations involving workload versus other variables were not significant.

Variables are numbered as written in Table 6.

4.2 Modelling job performance of cooperative collaboration

Multiple linear regression analysis was used to develop a model for explaining job performance (dependent variable #1 in Table 6) from relevant independent variables. Variables without variation were not retained as not relevant. Variable #7 "novice" having a null correlation with job performance was not retained as not relevant. Variable #10 "Co-preparation or PjB" was linked with variables #5 "share their forthcoming respective contributions" and #9 "share the same mental representation of the up-coming activity": observations showed "Co-preparation or PjB" were times for co-workers that

favored sharing; this was confirmed by significant correlations between these variables. Variable #10 was thus rejected as not independent variable. Variable #11 “proportion of coherent perspective-taking” was also linked with variables #5 and #9 for the same reasons leading to the hypothesis that variable #11 could be explained by variables #5 and #9 (see next section). Variables #5 and #9 were thus rejected as not independent variable.

Table 6. Correlations r between parameters of interest regarding the collaborative dimension of activities during applicative test segment

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Job performance	1,00										
2. actions feedback immediate	0,15	1,00									
3. workers pre-read the MO	0,52**	0,00	1,00								
4. field worker undertakes a final control	0,59**	0,10	0,00	1,00							
5. share their forthcoming respective contributions	0,61***	-0,26	0,78***	0,19	1,00						
6. means are stable	0,83***	-0,19	0,53**	0,38	0,68***	1,00					
7. novice	0,00	0,19	0,13	0,19	0,11	0,07	1,00				
8. field worker structures his activity	0,78***	0,32	0,42*	0,48*	0,42*	0,73*	0,18	1,00			
9. share the same mental representation of the up-coming activity	0,83***	-0,19	0,53**	0,38	0,68***	1,00	0,07	0,73*	1,00		
10. Co-preparation or PjB	0,67***	-0,15	0,65**	0,30	0,61***	0,63**	0,23	0,64**	0,63**	1,00	
11. proportion of coherent perspective-taking	0,66***	0,02	0,40*	0,20	0,13	0,45*	-0,10	0,52**	0,45*	0,45*	1,00

Finally, the remaining relevant independent variables were #2, 3, 4, 6, 8 and 11. Multiple linear regression results are presented in Table 7.

Table 7. Multiple linear regression results for the six-variable model explaining job performance

	Coefficient β	**Error**	**t-test**	***p***
Constant	2.34	0.19	12.15	1,9E-06
11. proportion of coherent perspective-taking	0.22	0.09	2.27	0.05
4. field worker undertakes a final control	0.20	0,07	2,67	0.03
8. field worker structures his activity	0.15	0.07	1.99	0.08
3. workers pre-read the MO	0.12	0.09	1.29	0.23
6. means are stable	0.20	0.25	0.82	0.43
2. actions feedback immediate	-0.19	0.09	2.11	0.07

The results of the regression indicated the six-variable model accounted for 96% of the variance (R^2=0.96, F(5,78)=17.55, $p<10^{-10}$). Analysis of residuals' normal distribution was verified through a normal probability plot (correlation coefficient regarding the residual quantiles vs the expected quantiles was r(df=5)=0.92, p<.001 with F(1,8)=1.58, p>.23 implying that the null hypothesis of similarity for the distributions should not to be rejected and slope of the fit line was 1.20 showing a good agreement with the normal distribution).

It was found that four variables explained significantly job performance among which three positively, from the most influent to the less: "proportion of coherent perspective-taking", "field worker undertakes a final control" and "field worker structures his activity".

Spearman's rank correlation coefficient ρ was calculated between job performance scores and proportion of coherent perspective-taking: ρ(N=15)=0.73 (p<.002) illustrated a good match between ranking obtained on the two scales. In other words, job performance scores and the proportion of coherent perspective-taking statistically increased or decreased together. The results were confirmed with a Kendall's rank correlation coefficient: τ(N=15)=0.54 (p<.005).

4.3 Explaining proportion of coherent perspective-taking

Multiple linear regression analysis was used in the aim to explain proportion of coherent perspective-taking (independent variable #11 in Table 6) from relevant independent variables #5 "share their forthcoming respective contributions" and #9 "share the same mental representation of the up-coming activity". Multiple linear regression results are presented in Table 8.

Table 8. Multiple linear regression results for the two-variable model explaining proportion of coherent perspective-taking

	Coefficient β	**Error**	**t-test**	***p***
Constant	5.6E-16	0.36	1.5E-15	1
9. share the same mental representation of the up-coming activity	0.9	0,45	1,99	0.07
5. share their forthcoming respective contributions	-0.25	0.28	-0.90	0.38

The results of the regression indicated the two-variable model accounted for 50% of the variance (R^2=0.50, F(1,26)=2.00, p<.16). Analysis of residuals' normal distribution was verified through a normal probability plot (correlation coefficient regarding the residual quantiles vs the expected quantiles was r(df=5)=0.88, p<.001 with F(1,8)=1.51, p>.25 implying that the null hypothesis of similarity for the distributions should not to be rejected and slope of the fit line was 1.15 showing a good agreement with the normal distribution).

It was found that only one variable explained proportion of coherent perspective-taking significantly:

- share the same mental representation of the up-coming activity: β=0.9, p<.07.

5. Discussion

Surprisingly, Table 5 providing the proportion of coherent intersubjective structure between co-workers per activity phase indicated a low value for "Realization with face-to-face communication in progress" while it might be expected here the highest value. As mentioned in the right column of the table, all situation cases were remote activities; the realization involved very few face-to-face moments (6.4%) and the value is biased by an effect size. Conversely, and as expected, "Realization with remote communication in progress" clearly presented a higher percentage than "without communication".

Among all significant correlation coefficients for the item #11 "proportion of coherent perspective-taking", the highest was related to job performance: r=0.66 (p<.00001). This suggests that co-workers having the same direct and meta perspective regarding working together also reached the highest job performance. Considering similar direct and meta perspectives whatever they are positive or negative appeared to be the good choice: when considering similar positive (resp. negative) direct and meta perspectives only, i.e., co-workers think they work (resp. do not work) together and think their colleague thinks he works (resp. does not work) with them, the correlation coefficients with job performance were found quite lower and less significant: r=0.42, p=0.029 (resp. r=0.30, p=0.127). In addition, the proportion of coherent perspective-taking statistically increased or decreased together with job performance. This result came to invalidate the hypothesis presented in section "Introduction"; the hypothesis was: if workers are engaged in a collaborative activity supposed to be cooperative without

perceiving themselves collaborating, then their performance is reduced as they quite probably do not use all the potentiality offered by the collaboration. The results show that this hypothesis had to be rejected: when there is coherence for the intersubjective structure of collaboration and co-workers perceive identical moments of collaboration as well as of non-collaboration, the result is that workers are involved in collaboration of higher performance.

Variable #1 “job performance” was significantly correlated with all variables which address exchanges between co-workers (variables #5, 9, 10, 11). Multiple linear regression explained variable #1 by #11 “proportion of coherent perspective-taking” as a main factor, itself explained through multiple linear regression by #9 “share the same mental representation of the up-coming activity”. This latter was significantly correlated ($r=0.68$, $p<.001$) with #5 “share their forthcoming respective contributions” itself significantly correlated to #3 “workers pre-read the MO” ($r=0.78$, $p<.001$). Regardless the experienced workers’ level of technical skills assumed to be at least satisfactory in this study (see § Introduction), these results showed that the highest performance for cooperative activity was obtained when workers pre-read the MO followed by an exchange between co-workers. This could take the form of a co-preparation or a PjB which are key-moments during which co-workers elaborate shared mental representations of what is going to happen during the forthcoming activity. It contributes to performance and is reflected by a high proportion of coherent perspective-taking.

The relationship between #3 “workers pre-read the MO” and #10 “Co-preparation or PjB” could be interpreted in two ways: #3 favors #10 by engaging co-workers in #10 as the natural following of #3, or when workers have time for #3, they also have time for #10.

The role of #6 “means are stable”, presenting a high correlation coefficient with #1 “job performance”, was explained as follows on the basis of observations in real operating situations: as far as the organization and the resources are available as expected, it favors workers to have coherent perspective-taking and high performance; as soon as means becomes unstable (differing from expectations), what workers shared during the PjB becomes inadequate and the collective activity moves from the cooperative form to the co-constructive form.

Another point is worth to be discussed regarding the impact of influence on the efficiency of cooperative collaboration. It was found here that the workload did not have any influence neither on the performance nor on any other factors considered to describe the collaborate activity. However, this finding has to be weighted: when beginning studies with the shift teams, it was agreed with workers and managers that the subjects involved in the experiments would be experienced and volunteers; therefore the managers suggested collaborative activities according to these criteria; similarly, workers who accepted to participate agreed because they were not afraid to expose their (lack of) competencies to the researcher; the proposed and volunteer subjects were thus experienced (at ease with the job) and, it may be assumed, self-confident regarding their competencies; it follows that the workload might be a factor of influence regarding their performance, nevertheless at a lower level than for less experienced

workers. This means that, despite the fact that the workload was not a factor of influence for job performance, when replacing experienced workers by novices, we might have found that this factor had a significant influence.

To summarize, provided that workers have been trained to reach a satisfactory level of technical skills, what makes the performance of collaborative activities of cooperative form is:

- To undertake a co-preparation or a PjB between co-workers,
- During the co-preparation or PjB, to work sharing mental representations of the up-coming activity,
- To train field workers to structure their activity,
- To engage field workers to carry out a final control of their activity,
- To provide a stable work environment for workers in terms of means (organization and resources).

6. Limitations

The characterization of the collaborative dimension of the activities and the link with job performance was considered in the present study both from individual and collective standpoint but the subjects' psychological characteristics were not addressed. Recent studies undertaken within Professor Alexandrov's team (Apanovich et al., 2016) showed that performance in collaborative activity was sensitive to the holist or analytic character of subjects. Their conclusions suggested that not having taken into account this cognitive aspect might limit the generalization of the result of the present study. They also open the perspective of an extended research project analyzing the influence of the cognitive style on the occupational collaborative activity, its dimensions and its performance.

A more generic limitation is that, in spite of the diversity of the tasks studied, the population watched during the present study is specific: highly skilled professionals working in NPP. While these findings may probably apply to other high-risk and complex socio-technical systems (e.g., aerospace, medicine, transport, defense) one should be careful in generalizing these results: further research is needed.

7. Conclusions

7.1 Theoretical contributions

From the theoretical standpoint, the first contribution is that this study introduced the concept of "coherent perspective-taking" and characterized it as the main variable explaining performance in cooperative activity. This is an important point as, though perspective-taking was discussed in the literature, the property of coherence had never been specified and its contribution to performance has never been quantified.

The second contribution lies in the demonstration that performance of cooperative action begins very early: if an activity is divided in three phases (preparation, realization and operational feedback),

cooperation does not only begin during the realization phase but must be effective during the preparation phase in order not to lessen the performance.

The third contribution is that it demonstrates the applicability of the Intersubjectivity Theory for the study of collaborative activity through the characterization of perspective-taking. A protocol has been developed and successfully applied, easily replicable. This thus comes to fill the existing gap regarding understanding and characterizing the role of perspective-taking in cooperative activity.

The fourth contribution is the demonstration that Intersubjectivity Theory may work within another paradigm than this of trust: it was working within the paradigm of collaboration in the present study. As a research perspective, we might assume that other paradigms might successfully be tested too.

These contributions came to answer the research questions expose in section “Introduction”. In addition, it shedded light on the widespread preconceived thought that workers engaged in a cooperative activity without perceiving themselves collaborating results in poor performance; we have shown that performance rather comes from a coherent collaborators’ perception, when they feel themselves collaborating or not at the same time.

7.2 Practical contributions

From the practical standpoint, the main contribution of this study is to have depicted parameters that make the performance of collaborative activity when of cooperative form from the perspective of non-technical skills. This may help teams and managers or trainers to better focus on the factors that yield performance during a collaborative activity or when preparing it. Results showed that a main point to bear in mind is that preparation and pre-job briefing are crucial moments that favor the enhancement of variables making performance of collaborative activities, moments that the managers must reinforce in their teams.

We may finally suggest a definition for collaborative activity at work: an activity that involves several subjects related to each other by organizational relations and timelines, aiming at carrying out a given task together with mutual responsiveness, sharing the general mutual goal related to this task, within a system that provides the organizational relations and means and help to coordinating their actions.

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Competing interest statement

Dr. Ph. Fauquet-Alekhine is researcher at the SEBE-Lab, LSE, UK, and Scientific Director at the group INTRA robotics, former Human Factors Consultant and Chargé de Mission at Chinon Nuclear Power Plant, EDF (France).

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