Teamwork: collaborative activities of French fighter pilots in joint operations

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Abstract

In literature tending to Team Cognition (Salas & Fiore, 2004) and in Activity Theory studies (Caroly, 2010) the definition of "team" is quite variable (Patel, Pettitt, & Wilson, 2012; Wildman, Thayer, Rosen, Salas, Mathieu, & Rayne, 2012), but it is generally associated to already stable teams (working collective) whom members are used to work together in their actual activities (collective activities). Nevertheless, some of these teams are composed by individuals who don't know one another (knotworking), working on reaching a common goal in a disrupted spatiotemporal environment (e.g. aircraft collaboration in military joint operations). This kind of team activity is called collaborative activity (Montferrat, Poirier, & Coppin, 2009). Using both quantitative and qualitative methodology, this study distinguishes clearly different kinds of team, working collective and knotworking, and different team activities, collaborative activities and collective activities.

Theoretical literature and operational context

The aim of this study is to distinguish collective activities from collaborative activities (two kinds of team activities) thanks to the difference between working collective and knotworking (two kinds of team). First of all, these concepts will be defined, then a specific methodology will be exposed to test two hypotheses, and finally the results will be discussed before concluding.

Teams are usually identified after their different general contexts: e.g. sports (Bourbousson, Poizat, Saury, & Sève, 2011), military (Fiore & Salas, 2004), medical (Cuvelier, 2011). Patel, Pettitt and Wilson (2012) specify that no consensus have been established yet about what a team actually is. A team is usually already stable and trained when it is studied by the Team Cognition's literature. Its performance is due to multiple factors: shared mental models (Van den Bossche, Gijselaers, Segers, Woltjer, & Kirschner, 2011), team situational awareness (Rentsch & Woehr, 2004) and the quality of communications (Paris, Salas, & Cannon-Bower, 2000). However, Team Cognition apprehends the team concept only in its cognitive dimensions (Salas & Cannon-Bowers, 2000).

The Activity Theory proposes a definition of the concept of team that expands to its activity. De facto, Caroly (2010) names it collective activity when a shared and coordinated job (collective work), is operated by a working collective. The working collective is a team of individuals who trust one another, who share values, common language and goals, and who negotiate and adjust their professional and operating rules. This notion of working collective has to be kept in mind in order to identify the stable and trained teams.

The concept of knotworking comes as an opposition to the concept of working collective. Knotworking treats about more temporary and less stable teams. It is described by Engeström (2008) as "the active contribution of combined persons and artefacts in constant reorganization and operating according to wide temporary paths, and that are widely distributed in space. (...) This notion refers to the orchestration of a collaborative performance, distributed and partly improvised between actors or activity systems that are in other respects weakly connected to one another" (our translation). One of the knotworking's peculiar aspects is that it can be temporary when restricted to one single event, but it can be stabilised if its members get to work often together on the same situations' category.

The knotworking concept will be kept as a key to characterise occurring or emerging teams, as groups of individuals called up to joint operations for a common purpose: when they come from different countries or professions, individuals rarely share common mental models or situational awareness. Individuals also face difficulties to communicate intensively with their partners (restricted and secured communication medias). Likewise, they are barely able to talk about their action or professional rules, especially if they don't speak the same native language. Though they efficiently cope with strong technical and management constraints in network-centric warfare[4] and in interoperability. In particular, they deal with the spatiotemporal splitting of their actions (e.g. buddy lasing[5] between a fighter and an Unmanned Aircraft System, i.e. a drone). These activities cannot be anymore conceived or managed separately but necessarily jointly (individuals, teams, units, armies, nations). Riley, Endsley, Bolstad, and Cuevas (2006) indicate that controlling the military drills of planification process depends on a distributed team activity. This kind of activity is identified as a collaborative activity (Montferrat, Poirier, & Coppin, 2009). Collaborative activities call up teams that achieve their mission even though they don't have at their disposal the same advantages as the working collectives. Indeed, the working collective has specific advantages of reliability (De Terssac & Chabaud, 1990), for it is particularly able to deal with unexpected events (Grosjean, 2005). Unexpected events can be managed by means of:

- Enhancement of decisions by sharing information and insights (Cooke, Salas, Kiekel, & Bell, 2004; Patel et al., 2012)

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[4] Military doctrine or theory of war. It seeks to translate an information advantage, enabled in part by information technology, into a competitive advantage through the robust networking of well-informed geographically dispersed forces
[5] Coordination of two aircraft to treat a ground target: one of the aircraft is responsible for pointing a laser at the target to guide a weapon, while the other must deliver this weapon.

- Creation of action areas in- and outside the potential leeway (Caroly, 2010)
- Possibility to re-define the rules to reduce the goal conflicts (Caroly & Clot, 2004)
- Better capacities for adaptation and flexibility (Cooke et al., 2004).

Thus, reaching the set goals despite a knotworking configuration in collaborative activity empirically implies that to be effective, knotworking in collaborative activity uses different resources from those used by the working collective in collective activity. As a result, collective activity and collaborative activity appear to be two different kinds of team activities.

The literature (e.g., Caroly, 2010; Hsu, Chang, Klein, & Jiang, 2011; Wildman et al., 2012) allows to list a set of six constitutive dimensions to be accorded to any team activity. If collaborative activity and collective activity are two different kinds of team activity, these dimensions have to be differently rated. Individuals who work on collaborative activity will differently rate their satisfaction about these dimensions than individuals who work on collective activity. Those dimensions have been categorised from literature and six semi-structured interviews of French Air Force pilots who had worked with an Unmanned Aircraft System on a joint operation[6]:

- The "joint action" includes the constitutive elements of the live-activity when realised jointly, complementarily and articulated between team members. Also, there are elements linked to the interdependence of each one's part in the action, to the temporal and/or spatial (non) co localisation, to the simultaneous and updated knowledge of the state of the system, to the Team SA, and to the shared goals.
- "System and technical" supports include all the aspects linked to the characteristics of the organisational system (technical support included) communication excepted. This item concerns the awareness of the nominal functioning of the system, the constraints of the environment, the most frequent storylines, the decision-making chain, and finally the limits, errors and unexpected obstacles of the system.
- The "shared identity" concerns all the elements that impact the composition of the team: collective memory and knowledge sharing, systems of affiliation, tutorship or training, frequency of shared experiences, shared cultures and values, types of relationship.
- "Communication" refers to all the elements that allow communication within the team. It includes interfaces and means to get or transmit information, the interaction modes, the communication chain, the information delivery and flow (depending on the technical means at disposal), the existence of a shared language, the dedicated media.
- The "shared repository" covers all elements related to the prescribed rules (norms, procedures, rules of engagement) as well as the factual activity (daily violations, temporary uses). This dimension also includes every possibility of team regulations: leeway, hot and cold regulations, collective reflexive activities, rules' negotiation, etc.

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[6] Exploratory pre-study, realised in June 2012, unpublished

- "Knowing your partner" concerns aspects bond to the knowledge of the other partner, and to build a strong representation of his/her identity, cultures and values: his/her part, responsibilities, skills, attitudes, preferences, tendencies, hierarchy level, etc.

These six dimensions to be applied to any team activity are proposed in order to predict two points concerning the differences between *collaborative* and *collective activities*:

1. If collaborative and collective activities are two different kinds of team activity, satisfaction about those team activity's dimensions will be rated differently whether in collaborative activities or in collective activities.

Furthermore, Caroly (2010) precises that the emergence of a working collective is necessarily based on three factors: Negotiation of operational and professional rules, acknowledgement of skills, and mutual trust. These factors are respectively related to the dimensions "shared repository", "knowing your partner" and "shared identity".

2. Thus, differences between collective and collaborative activities will be found in the three pre mentioned dimensions linked with the working collective. They will be rated as more satisfying in collective activity.

Method

The study was set up on Nancy Ochey Airbase. Twenty-five fighter Pilots and Weapon System Officers (or WSO) answered this survey. Participants were confronted to six scenarios of team activity. If they already had lived the proposed scenarios, they had to evaluate their satisfaction about the six dimensions presented above. They also had to give an evaluation of the general satisfaction for each experienced scenario. These evaluations were marked on Visual Analogue Scales (Figure 1) from "totally satisfied" (grade 0) to "absolutely unsatisfied" (grade 10). In this example, the participant gives a 1.5 to the quality of communications in the activity.

Figure 1. Visual Analogue Scale evaluation of a dimension.

Six scenarios were proposed: collaboration with 1/ an American Unmanned Aircraft System Predator, 2/ a French Unmanned Aircraft System Harfang, 3/ a Forward Air Controller or FAC[7], 4/ Ground Troup 5/ a Fighter Patrol Force, and 6/ a C2[8] type structure. Amongst these six scenarios, only one (Fighter Patrol Force) concerned a collective activity that took place in a similar context of Joint Operations. This peculiar scenario was inserted in the survey in order to compare collective and collaborative activities. The other five scenarios complied with the characteristics of collaborative activities, and were gathered in order to guarantee that each participant had already been involved in one or more of the collaborative activities' scenarios. The survey was given to the participants during a briefing that started with clear instructions about the six dimensions. Twenty-five forms were collected out of the fifty ones that were distributed during the briefing. In addition, semi-structured individual interviews were performed with eight fighter pilots or WSO who had worked in Joint Operations. The point was to qualitatively strengthen the data from the surveys about specific collaborative activities, such as buddy lasing with Unmanned Aircraft System.

Results

The five collaborative activities scenarios (Predator, Harfang, Ground troup, FAC and C2) were aggregated (averaged) in order to get one "collaborative activity" category with six dimensions and a general assessment. In this way, each participant is related to one collaborative activity category with six dimensions and one general assessment. As a result one data table for the collaborative activity and one data table for the collective activity (Fighter Patrol Force) were created. Subsequently the ratings concerning the common dimensions of each category (collaborative vs. collective) were compared. For example, the average of "joint action" dimension in the collaborative activity category was compared to the average of the "joint action" in the collective activity category using Sudent's Test.

The results (Table 1) show a significant difference between collective activity (mean = 3.95, SD = 2.03) and collaborative activity (mean = 2.94, SD = 1.35) in the "joint action" dimension, $t(22) = -2.45$, $p < ,05$. This one is more positively rated in collaborative activity. The difference is statistically significant for the "shared identity", $t(22) = 2.61$, $p < ,05$, between collective activity (mean = 2.53, SD = 1.93) and collaborative activity (mean = 4.09, SD = 1.76). However, "shared identity" is rated as more satisfying in collective activity. As well, the difference is statistically significant for the "knowing your partner", $t(22) = 3.20$, $p < ,01$ between collective activity (mean = 2.98, SD = 2.31) and collaborative activity (mean = 4.38, SD = 1.72). "Knowing your partner" is more positively rated in collective activity. These results indicate that those dimensions ("joint action", "knowing your partner" and "shared identity") are rated differently by the individuals according they are set in a collaborative or in a collective activity.

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7 Man on ground, who guides Close Air Support mission
8 Command and control system within a military operation.

These results have to be connected to the general assessment of each activity that is significantly different, t(22)= -4.12, p< ,001, between collective activity (mean = 5.13, SD = 1.96) and collaborative activity (mean = 3.17, SD = 1.13). Four out of the seven rated dimensions show a significant difference between a *collective* and a *collaborative activity*.

Table 1. Compared averages of collective/collaborative activities.

		joint action	communication	shared identity	knowing your partner	shared repository	system and technical supports	general assessment
Collaborative activity	mean	2.94	4.44	4.38	4.08	2.72	3.54	3.17
	SD	1.35	3.91	1.72	1.76	1.2	1.64	1.13
Collective activity	mean	3.95	5.01	2.98	2.53	2.03	4.33	5.13
	SD	2.03	2.63	2.31	1.93	1.74	2.71	1.96
Student's T	t	-2.457	-0.629	3.204	2.61	1.6	-1.26	-4.12
	dl	22	22	22	22	22	22	22
	p	0.022	0.535	0.004	0.01	0.121	0.22	0.0004

In contrast, the dimensions: "communication" t(22)= -0.62, p ns, "shared repository" t(22)= 1.6, p ns, and "system and technical supports", t(22)= -1.26, p ns, are not rated as significantly different between collective and collaborative activities. The rate of satisfaction of these three dimensions (communication, shared repository, system and technical supports) cannot allow maintaining that there is a difference between collective and collaborative activity.

Among the different rated dimensions, three are linked to the existence of a working collective: "shared repository", "shared identity" and "knowing your partner". Two out of these dimensions, "shared identity" and "knowing your partner " are rated significantly different between collective and collaborative activity. Only "shared repository" is not significantly different.

- "Shared identity" *t*(22)=2.61, p< ,05 is rated more positively in a collective activity (mean = 2.53, SD = 1.93) than in a collaborative activity (mean = 4.09, SD = 1.76).

- "Knowing your partner" $t(22)=3.20$, $p< ,01$ is rated more positively in a collective activity (mean = 2.98, SD = 2.31) than in a collaborative activity (mean = 4.38, SD = 1.72) .
- "Shared repository" $t(22)= 1.6$; p ns is rated more positively in a collective activity (mean = 2,03, SD = 1,74) than in a collaborative activity (mean = 2,72, SD = 1,2).

These results indicate that a working collective is more built in collective activity than in collaborative activity, and implies a significant difference between the two kinds of team activities.

The qualitative analysis of the interview aimed to define more precisely which factors enhance or hinder collaborative activities of the fighter pilots and WSO in joint operations. Interviews were analysed by a classical content analysis (Krippendorff, 2004). After transcribing the eight interviews, transcripts were divided in meaning units: In all, two hundred and fifty-eight meaning units were identified and connected to different topics. In a quality aim, the defined encoding scheme consisted in an ecological split of the remarks. The selected categories were: communication in action, situation awareness (SA), complementarity of the missions between aircrafts, representation of the partner, technical capacities of the partner, to dispel a doubt, trainings, workload, opportunism missions, and information sharing between fighter crew. Each meaning unit could have been connected to several categories. According to its topics, each category were after that connected to the six dimensions of team activity already used in the survey. The results are presented from this final classification.

Concerning the meaning units about the "joint action", the participants mostly recall the technical complementarities of the aircrafts (for instance the drones' camera or the fighter's speed) for 12 out 258 statements, the complementarities of the shared SA (34/258 statements) and the issues of taking the leadership in low-normed situations or opportunistic missions (13/258).

"Communication" is revealed as a sine qua non condition for the feasibility and success of a collaborative activity. 98/258 statements in the interviews gave specifications about this process. These specifications concern the operative language and the spoken language, but also information sharing (40/258) in order to build a Team SA or to dispel a doubt (43/258).

The "shared identity" is hardly informed in the interviews. It is detected in the need of a shared operative language (7/258). This working collective item is rarely found in the collaborative activities participants were asked about.

Regarding the dimension "knowing your partner", interviews revealed that the pilots and WSO have a limited trust in their partners in collaborative activities (21/258). The skills of their partners are little known, called into question, and the participants even try to regulate those through their choice to arise their workload rather than sharing their tasks with their partners. All the meaning units associated to the dimension "knowing your partner" reveal quite a hesitation of the participants in

trusting their partners, especially due to the lack of knowledge of their training, of their profile, or of their geographical situation (for the Drone System Operators). This hesitation was declared to be due to the impossibility to clearly identify the partner's skills. Thus, two peculiar trends are to be held: on one hand, the dimension "knowing your partner" is closely related to the idea of trust ; on the other hand, this dimension is specific to the working collective and seems to be more limited in a collaborative activity.

Concerning the dimension "shared repository", negotiating the rules and regulations are revealed in collaborative activity but they only concern the operational rules and not the professional rules (48/258). Three different strategies of regulation were identified between the partners of a collaborative activity: the first one consists of setting up a common briefing stripped back to the essentials if necessary during the mission. The second strategy consists of misusing the technical capacities of an Unmanned Aircraft System and turning it into a radio relay in low covered areas. And the third one consists of to rely on the piloting skills of some Drone System Operators: indeed, the French ones are mostly former pilots and consequently have a real knowledge of the fighters they work with. So three strategies of regulation exist for only operational rules and not for professional rules. Regulations of professional rules are a proof of the existence of a working collective. The lack of professional rules regulation here indicates that there is no working collective in collaborative activity.

The dimension "system and technical support" is also a genuine worry (59/258). The categorised meaning units essentially concern the commanding process, or the limits of the available technical tools.

Discussion

The first hypothesis in the present study assumed difference between collective and collaborative activities. By comparing the averages from the survey of the collaborative and collective activities on each side, it was observed that these averages are significantly different for three out of the six dimensions and that they are different for the general evaluation of the perceived satisfaction in a collective or collaborative activity. These joined statistic index show a difference between both kinds of team activity, which tends to support our first hypothesis.

Furthermore, the results obtained with the survey as well as with the interviews, reveal the existence of a team that is more built or stable in a collective activity than in a collaborative activity. Moreover, a continuum of emergence seems to exist, that would allow an emerging team (a knotworking) to stabilizes itself in a collective working depending on the circumstances. The existence of this continuum seems to point out a major difference between both team activities. Since the working collective only emerges in collaborative activities as a knotworking, and as the estimated activities were all successfully achieved, then we can assume that the collaborative activities lay on other factors than the working collective to be efficient. Further studies will aim to identify these factors.

These further studies will attempt to strengthen the results. So the declarative data collection will be completed by more objective indexes of performance or workload, especially within the different populations (Rafale crew, A400M crew, etc). The next study's sampling will be operated on a similar quantity of collaborative and collective activities, which will enable us to focus on another factor that was often mentioned during the interviews: trust. And finally, since all the dimensions are not significantly rated different, it will be necessary to refine their classification.

The next study will investigate more intensively on the emerging processes of the working collective. It will bring elements of response to the question asked by Wildman and al. (2012) on the dynamic construction of the team knowledge through the evolution of the shared mental models.

As a conclusion, it seems necessary to split and consider differently these two kinds of team activities, in a purpose of activity analysing as well as in a typical Synthetic Task Environments of the Team cognition. Developing these concepts will enable eventually to guarantee the efficient and non-antagonistic articulation of individual, collective, and collaborative activities based on broken spatio-temporal span (e.g. an Unmanned Aircraft System flying in a COMposite Air Operation).

From an operational point of view, these results are the first step for the conception of an in situ evaluation tool. This will evaluate the quality of the collaborative context; during missions briefings for instance, this tool would anticipate and identify contextually the elements in favour and those more "fragile" for the up-coming collaborative activity. In the military aviation system for instance, this very tool would help for a better training of the operators for complexes and risky activities. In a long-term view, the trainings and tools dedicated to joint operations would take advantage of these results.

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