# Fatal attraction

## Interaction and crisis management in socio-technical systems

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Interaction seems to be responsible in manifold ways for accidents and disasters (e.g., Perrow 2008; Vaughan 1999; Mattewman 2012). We intend to delineate some peculiar ways in which this can be true. *Interaction is a fatal attraction*. Everyone knows how frustrating it is to be caught up in an undesired interaction. Nonetheless, we try to find a proper way out, we do not simply walk away from our interlocutor. We prefer to maintain and sustain interpersonal interaction, we are attracted to it. In the realm of Socio-Technical Systems (STS), which entails other relevant elements besides the interacting subjects, such as specific ends to achieve and avoid, the fact that interaction calls for further interaction could have fatal consequences.

The present contribution —result of an interdisciplinary effort (sociology, philosophy, AI)— is mainly theoretical, yet some empirical cases, stemming both from fieldwork and documentary analysis, are taken into consideration. They mainly serve as examples of application of our approach. The paper reflects on interpersonal interaction, its force of attraction, and the Recognized Epistemic Field (REF) that is simultaneously its by-product and its requirement; and considers the role they all play in STSs' crisis management.

We shall propose a socio-ontological analysis of interaction, its potential entrainments as well as impasses. We shall then turn to STSs' crisis management and try to single out which extra-ordinary modality, or "style", of action-in-interaction is more suited for dealing with critical situations in complex organizational contexts. In the concluding sections we shall finally propose some indications for improving crisis management in STSs on the basis of the interactionist approach to critical situations —which, on the other hand, is a view from the dark side on interaction— that we will have previously illustrated. Such guidelines will refer both to human agents' possible education, and to artificial agents' design.

*Caught in interpersonal interaction*

When people *are* together, they *keep on doing* a lot of things to *keep on being* together. This is what we call "the attraction of interaction", that is, the tendency to avoid *true* impasses, situations where coordination is totally lost and there is no way to recover it. A *true* impasse is a limit case. It can be considered the extreme boundary of interaction, after this boundary interaction[1] ceases to be, in the strongest sense. These cases are obviously limited: we usually *close* (Schegloff, Sacks 1973) our interaction in a cooperative way; nonetheless, true impasse could be useful to describe our living together.

There are many ways to justify the claim that we are attracted towards interaction with others. The classical one relies on the cooperative trait that characterizes the so called "human nature", and can be traced back to Aristotle's *zoon politikon*. Cognitive sciences and neurosciences have only recently focused on these issues (Cacioppo *et al* 2012). We could interpret these studies by saying that we are attracted to interaction, we want to display that we are available to cooperate with our conspecifics. This is a trait that can be found also in other primates, but with relevant differences related to the specific *institutional* dimension of

[1] Here we are primarily concerned with interpersonal interaction.

humans, a realm where there seems to be a basic commitment towards (inter)acting together, where empathy with others seems to have a crucial role. It is not by chance that the closings, that is the ways we normally "take leave in interaction", are highlighted in these kinds of studies too. As the cognitive scientist Michael Tomasello puts it:

> Suppose you and I agree to walk to the store together. Along the way, I suddenly, without warning, veer off and go my own way, leaving you standing there alone. You are not only surprised, but miffed (or maybe worried about me), so that when you return home you will tell your friends about the incident. "We" were walking to the store together, and I broke that "we" unilaterally, due to either my selfishness or my derangement. Interestingly, I could have avoided the whole incident by simply "taking leave," saying that I just remembered something important I had to do, asking permission, as it were, to break our "we." (Tomasello, 2009: pp. 57-58)

The break up of interaction can also be linked to violence. Violence is perhaps not a usual consequence for a missing closing move in the dull context of the store. Stronger motivations are necessary, and they are obviously varied The point is that we tend to avoid breakups, and this is perhaps more evident in the case of violence, since it is one of the strongest threats to intentional sharedness:

> Humans are hard-wired for interactional entrainment and solidarity; and this is what makes violence so difficult. Confrontational tension and fear [...] is not merely an individual's selfish fear of bodily harm; it is a tension that directly contravenes the tendency for entrainment in each other's emotions when there is a common focus of attention. (Collins, 2008: 27)

In philosophy, claims on the attraction of interaction could be supported also by appealing to a utilitarian position: we cooperate because we adopt a strategy that maximizes our utility function. This explanation is not necessarily in contrast with those mentioned above, if we consider that it could be possible to identify somehow the good with the pleasure of being and (inter)acting with others. Another way to explain such attraction could be by identifying a normative justification, according to which we tend to keep on interacting because we *ought* to do so, and this is in some way irreducible to any other explanation that uses the notion of good or pleasure. Here we neither want to provide an overview of the debate on cooperation, nor to take a specific position among the many that can be discerned throughout the history of thought. Instead, we would like to add a, so to speak, "orthogonal", consideration, more linked with the inner structure of interaction, and that, as we shall see, will give us some relevant hints on how to manage critical situations. This justification of the attraction of interaction is based on the importance of *rhythm*, that is, the idea that people are *caught in the rhythm* of interpersonal interaction. But before going into that, it is necessary to give at least a general picture of some of the relevant traits of interaction according to our approach.

Interaction is of at least two orders: the first order interaction (FOI) is the interaction itself, an end *per se*, no matter how it is pursued: by talking, moving, gesturing or towards more complex interactional units (IUs), like playing football, going to a restaurant or walking together[2]. The second order interaction (SOI) is constituted by such IUs. Dan is standing in line waiting for his turn at the cash register; when he approaches the cashier, Alex, he starts complaining, while Alex is scanning his items. She then utters the price he has to pay. Dan gives her money and says goodbye. They start when Dan approaches the counter and go through the following (subsequent and co-occurrent) IUs: "the check out", "the complaining", "the goodbye". It is not possible to experience any interaction without having a unit *for*

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2 Cf. also the notion of frame in Goffman (1974) and Minsky (1974).

interacting: we interact by doing specific things together. Therefore, a SOI can be composed by different units and, in order to have a FOI, it is necessary to have a SOI, via at least one IU.

A SOI could be seen as a *bundle of units*; when all the units that are active at a certain time fall into a *local* impasse, also the FOI does, *i.e.*, interaction ceases to exist. Here a global, *true* impasse occurs. If we want to keep two things together, we need some kind of connector; in interpersonal interaction, we could use the metaphor of a rope. The connection itself represents the FOI, the rope is the SOI, the braided plies IUs; if all plies are cut, then the two things fall apart. Obviously, interaction is more complicated: there is more than dyadic in interaction; IUs can be tied together in such a way that the impasse on one of them can have cascade effects on the others; etc. The tendency to avoid impasses is, at different degrees, therefore, the tendency to avoid to break IUs in such a way that interaction is not possible anymore.

Each of these IUs are made of turns and then moves. IUs, by means of turns and conversational as well as bodily moves, are *rhythmic*:

> [...] humans have evolved to have particularly high sensitivities to the micro-interactional signals given off by other humans. Humans are hard-wired to get caught in a mutual focus of intersubjective attention, and to resonate emotions from one body to another in common rhythms. This is an evolved biological propensity; humans get situationally caught up in the momentary nuances of each other's nervous and endocrinological systems in a way that makes them prone to create interaction rituals and thus to keep up face-to-face solidarity. I am making more than the banal point that humans have evolved with large brains and a capacity for learning culture. We have evolved to be hyper-attuned to each other emotionally, and hence to be especially susceptible to the dynamics of interactional situations. (Collins, 2008: 27)

It is far from easy to give a formal account of what rhythm is. Rhythm is not simply a sequence of events with some periodicity. Appealing to its etymology, it has been often highlighted that rhythm is *flow*, a dynamical entity grounded on human movement. For example, according to Andy Hamilton (2012), rhythm is rooted deeply in human activity and its perception is dependent on human, but not necessarily intentional, recognition. This means that in order to perceive rhythm one must *project* it onto regular successions. This projection is often not even conscious, but involves mutual awareness, as in the relevant case of rhythmic synchrony. Systematic studies are nowadays conducted on rhythmic synchrony in interaction. Satinder P. Gill has recently (2012) proposed an embodied account of rhythmic synchrony, starting from a massive interdisciplinary work based on music psychology, psycholinguistics and social psychology, neuroscience, kinesics, gesture, and interaction analysis.

According to Gill (2012) in interpersonal and situated interaction we are connected via rhythmic events that range from moment-by-moment timed syllables to bodily movements in synchrony. It seems also that the very sense of sharedness is connected to synchrony and it is linked with empathy and well being among interactants. This is explained via the notion of *entrainment*.

Entrainment, in general, is an interactive process in which two or more rhythmic processes adapt to each other and get synchronized. As illustrated by Clayton and colleagues (2005) this notion, nowadays considered in many domains such as mathematics, physics and biology, can be traced back to the beginnings of modern physics. Huygens called it ‘the sympathy of the clocks’. Two pendulum clocks, mounted on the same support, after some time would synchronize (or anti-synchronize) their motion, independently of their respective starting motion. In social interaction people entrain by aligning the timing of their actions, sounds and so on. This phenomenon appears to be ubiquitous (Chartrand & Bargh 1999; Oullier et al. 2008; Richardson et al. 2005) and it fosters cooperation and social rapport

(Lakens and Stel 2011), this amounts also to a sense of well being while the interactants are locked in phase (Gill 2012).

We enjoy interaction as we enjoy and get caught together in rhythm, and this, as Durkheim (1912) noted through the bodily-grounded notion of collective effervescence during rituals, is one of the bases of sociality and social institutions. This "coordination of temporally structured events through interaction" (Clayton et al. 2005) is perhaps the best way to illustrate our point of a situated interaction made of bodily movements and voice that then creates our IUs, which *gravitate* interactants in keeping on interacting. Entrainment is not simply pleasurable, but also difficult to resist. In a study by Neta Spiro and Tommi Himberg (2012) it emerged that people in tapping tasks to a metronome are drifted away in keeping tempo by each other's beat and they often do not realize their drift.

These kinds of studies are important since they give us a justification for the attraction of interaction, that is the fact that we tend not to break the flow of interaction because, as stated at the beginning of this section, it is an end *per se* and also because it is pleasurable and somehow difficult to resist, and, finally, because rhythm is one of the necessary conditions for sense making in humans. In philosophy, especially in the analytic tradition, this dimension of meaning has not been so far extensively studied[3], instead, in interaction studies the potent effect of being together and understanding each others given by rhythm is nowadays being explored:

> The voice and body of caretaker and child move together. It has been suggested that this capacity to rhythmically synchronize is developed before birth whilst in the womb […]. As adults, we have developed the ability to move in time with others and to express pragmatic meaning in time with others, where we seek

[3] One among the fews relevant exception is perhaps given by the work of Patrick Suppes (2009), who nevertheless did not focus specifically on the interactive dimension of rhythm in meaning construction.

> information, clarity about what the other might mean, clarifying to the other our meaning, agreeing with the other, and expressing understanding. (Gill 2012: 118)

To take into account sense making is important, since our point is to show how, in joint actions towards a common goal, we run the risk to make common agreements that are more influenced by our willingness to keep on being in the flow of interaction, rather than being determined by relevant cues in the environment, that are necessary to achieve this common goal. This is what we mean by *fatal* attraction of interaction, that is, the possibility that the "distractive effect" of interaction creates a potentially harmful consequence on the coordination among interactants *and* environment. Thus, in the next section we will consider how interactional co-construction of meaning has an *objectifying* character, namely, the fact that we tend to consider objective what we appearently agreed upon, even if this objectivity is far from being actual. This also means to take Schutz's (1962) notion of the idealization of the congruency of systems of relevance, and move a small step ahead towards the detailed analysis of *how* that is co-constructed in situated interaction.

### *Presupposed objectivity of the Recognized Epistemic Field*

In our account, situated and co-constructed sense making, has, among its basic elements, reference points (RP). Dan's putting an item on the counter *and* Alex picking it up and scanning creates an RP in their interaction. With this RP in force, it would be awkward, for instance, if Alex, right after, ran away instead of doing the checking out[4]. Such RPs contribute to build an entire *Recognized Epistemic Field* (REF), as it is called *en passant* by Zizek (1988). Here we intend to further characterize such notion. Interpersonal interaction is a

[4] She could have done so *before* picking up an item (or after a colleague calling for her help, for instance), but not after that reply move (Goffman 1981).

process involving *subjects*. Conceiving subjects entails, for us, considering them as having an Epistemic Field (EF), *i.e.*, an ensemble of *attitudes*: intending to go to the movies, believing that it is raining, etc. When subjects are interacting, they regard the other participants (as well as themselves) as having an EF too and this is what, in a sense, allows interaction itself. That is, we are *higher-order* intentional systems, since we are capable of *ascribing* to others and to ourselves intentional states (Dennett 1987).

According to Robert Brandom (1994) this amounts to say that we are *interpreting* intentional systems, and this means that in interaction there is a dimension of normativity and commitment that is difficult not to consider[5]. This also contributes to the fact that, among interactants, to have an EF is both a presupposition and a requirement. Thus, each subject, once exposed to actions-in-interaction (Schegloff *et al.* 1984), has, as part of her/his EF, projections of the content of the other interactants' EFs. Perceiving someone as making an interactional move triggers projections of: what the other means by such move, the implicatures (Grice 1967; Goffman 1981) of that move, the inferences (Brandom 1994) one can possibly draw from it, *and* the considerations regarding his/her own moves about what is going on in interaction. All (counter)moves make *scores* (*Ibid.*:181 ss.), *i.e.*, RP.

Among projections, there are some devoted to those moves that are considered relevant by participants with respect to the ongoing interaction and are regarded as having been mutually recognized: this amounts to say that situatedness and sequentiality plays a crucial role. Dan opens a conversation with Alex by saying "Hallo". His turn —potentially— is the first part of an adjacency pair, a greeting sequence. Alex interprets as such Dan's move and produces the second half of the pair: "Hi". Dan takes again the turn and begins another sequence. This means that: a) Dan interprets Alex's move as the completion of the greetings sequence and that, by now, b) he knows that his first move has been interpreted by Alex as a

5 As we said, we believe that at least the orthogonal dimension of rhythm and entrainment should be added into the picture, because these phenomena allow or facilitate the flow of information among interactants.

greeting, since she replied with a greeting; on the other hand, c) Alex knows that her interpretation of Dan's first move was correct, since he has accepted her move as appropriate as a follower of his own and has prosecuted with interaction. By now, Dan and Alex are both convinced that they have just finished a greeting pair and are going to continue their interaction, and that the other shares the same conviction. They marked an RP and the latter has entered the REF.

When people create an RP by mutually recognizing it through moves and reply moves, they mark that point in the REF. That is, they have reached an "interpersonally valid definition of the situation" (Garfinkel 2008). By an ongoing confirmation through recognition, REF emerges as an interactional co-construction and achievement. With this, we construct the *boundaries*[6] of the events[7] we are participating to, that is, IUs. Finally, we "import"—and thus make "valid"— in an actual interaction frame/work, rules, practices... that were not necessarily readily available. In this way we identify different events as playing football, etc: "what makes a group — a group for the moment— is that its members are committed to the same constitutive expectations or, loosely speaking, 'playing the same game'" (Rawls 2008: 707).

Conceiving a REF entails considering the sub-part of an interactant's EF that has to do with the actual interaction and its *score*, together with the sub-part of the other interactant's EF *as* projected by the former (and viceversa). Whenever these sub-parts are regarded as isomorphic by participants, a process of "unification" is triggered. If an interactant displays moves that allow the other to infer that their "gameboards" are isomorphic, he/she tends to reify, on the basis of this inference, a unique field, a unique gameboard. Such "unification mechanism", furthermore, creates an *objectifying tendency*, but this does not mean that there

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6 On boundaries of events, cf. Varzi, Smith (2000). On the cognitive aspects related to this notion, such as the mechanism of identification of events and actions see Goldman (2007).

7 Ontologically speaking, FOIs, SOIs and IUs are *events*, things that happen in time, like today's raining. For an overview on the notion of event see Casati and Varzi (1996).

is, necessarily, an absolute objectivity in the REF. Another element that contributes in objectifying the REF is given by the very structure of interaction itself:

> The reflexive relationship between turns at talk constitutes an ordered sequential backbone to conversation. In all types of action, sequential ordering is what gives objectivity and concreteness to social things and creates information as a social object. (Ralws 2008: 722)

We claim that this happens also because of entrainment: we tend to avoid to put forward those points that can threaten our sense of flow in interaction, for the reasons expressed in the previous section. This amounts, for the agents involved, to generate a sense of being together, that can be mistaken for an actual and effective understanding of the situation at stake.

From all these considerations follows that, in situated interaction, there is a *perceived as objective* common and public agreement. As we said, this does not mean that this agreement is objective. According to Brandom (1994) and inferential role semanticists in general, meaning of expressions is dependent on "subjects to be disposed to make, or to treat as proper, certain inferential transitions involving that expression" (Whiting 2008). In this sense, inferential role semantics is considered to have an holistic position on meaning, being it dependent on the inferential relations any given expression possesses to other expressions. But if the meaning of each expression is the set of all the possible conditions and consequences that can be drawn from them, then hardly two people, with a limited and situated body of knowledge and beliefs, can attribute the same meaning to the same expression.

This can be seen as quite problematic. Roughly, Brandom tries to face this issue by recurring to what the other interlocutor is actually pointing at; understanding is in some way to put ourselves in others' shoes, that is: "if you want to understand what I say, you have to be able to associate with it a sentence that in your mouth expresses the same claim as the

sentence uttered in mine" (Brandom 1994: 509-10 cit. in Whiting 2008: 580). This position has been criticized (see Whiting 2008 for details). For us, instead, this theoretical difficulty — that is, the fact that the number of possible consequences that can be drawn from an expression is vast and it is difficult to give a criterion to asses which are those that are relevant in order to communicate the same meaning— reinforces our hypothesis that the objectivity of the REF has to be weakened. Moreover, we believe that there is a role played by the environment, that allows us to have, if not the same meaning resulting from an interaction, a sort of coordination with it: "what we mean depends on how things actually are, whether we know how they are or not" (Brandom 1994: 647, cit. in Whiting 2008: 581). Finally, it is the very nature of us as intentional systems that makes the objectivity of the result of our interaction somehow fragile. The dependence of social entities on agents' minds, rules and their application —as we tried to show in one of our previous works (Bottazzi and Ferrario 2012)— makes things less objective than one could think, and leaves room for misunderstandings or lack of proper knowledge of what is going on in the system itself.

Objectivity is more a requirement than a feature of interaction, like in the tale "The emperor's new clothes", where the Emperor goes on, naked, in the procession without, seemingly, caring about it, being driven by the thought that 'the procession must go on'. Simultaneously, the Emperor's situation is perceived by the crowd as awkward because we "triangulate"[8]: we coordinate our interpersonal interaction with the *relevant* elements of the surrounding environment. This allows us to check and change the REF, and contributes in strengthening the criterion of its objectivity as a requirement[9].

It goes without saying that the environment is neither just a background in our processes of interaction, nor solely the source of the indexical nature of social action, nor, finally, the affordance for constructing "objective" REFs. It is also fundamental in those

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8 Cf. Davidson (1982).

9 This is related to accountability (Garfinkel 2008).

contexts and situations in which we interact having ends that go beyond the *per se* end of interacting (*i.e.*, the attraction of interaction). Take, for instance, the case of toasting: the material the glasses are made of —say crystal or plastic— is relevant with respect to the local end, and interactants should take that into consideration —e.g. by putting more or less strength in the gesture— if they want to properly coordinate to such an end. In other cases, "triangulation" is crucial with more complex elements, such as airplanes or airports' runaways. Whenever subordinating our action-in-interaction to some end/s in the socio-technical world, triangulation with the relevant elements of the environment is crucial. In our approach, this means that the content of the REF must be well coordinated among the interactants and the environment, since breaking in —or just letting fray, in a manner of speaking— one of the sides of the triangle might lead, as we shall shortly see, to accidents and catastrophes.

It is worth noticing, indeed, that the notion of end is double: having and end means achieving something while trying to avoid something else. Since we have adopted here a view from the dark side by considering how important, in the understanding of the nature of socio-technicality, are critical situations, we can say that the negative ends play a crucial role. It is true that our positive ends guide us in a way, but it is also true that the negative ones (like breaking glasses or spilling wine when toasting) must be taken into account. To have a good triangulation is important, since it can help avoiding what is undesired —*i.e.*, our negative ends.

Furthermore, interpersonal coordination and triangulation are strongly related to prediction, via the accountability dimension of action-in-interaction (e.g. Bottazzi *et al.* 2012; Garfinkel 1967; Goodwin and Goodwin, 1996; Heath and Luff 2000; Suchman, 1996). The REF-based interactants' coordination and rhythm-based "attuning" with one another, and with the relevant element of the environment as well, enhances prediction and thus coordination. Such attuning, however, should be equally distributed, so to speak, especially when we inter/act in the socio-technical realm. This means that the implicit perils of progressive entrainment

with one (or some) elements of the system over the others should be avoided, as well as those coming from the absence of any form of entrainment and coordination. If one recalls what previously said on rhythm about the example of the metronome, it seems that, similarly, being caught in the rhythm of interaction has an unrecognized effect on triangulation: to get locked in interpersonal interaction can create also *unaware* misalignment with the environment.

*Interaction in STSs: some empirical examples*

We shall now consider some empirical examples, starting from a brief analysis —based on the previously illustrated approach to interaction— of the case of an actual catastrophe: on June 1st, 2009, an AirFrance Airbus crashed into the Atlantic. We shall focus on the following "moments" of the story.[10]

Excerpt #1

| | | |
|---|---|---|
| 02:08:03 | R: | *You can possibly pull it a little to the left.* |
| 02:08:05 | B: | *Sorry, what?* |
| 02:08:07 | R: | *You can possibly pull it a little to the left. We're agreed that we're in manual, yeah?* |
| 02:08:19 | B: | *What I call in manual er, no we're in computed.* |

Excerpt #2

| | | |
|---|---|---|
| 02:10:10 | | The stall warning sounds. |
| 02:10:11 | R: | *What's this?* |

Excerpt #3

| | | |
|---|---|---|
| 02:10:51 | | The stall alarm begins to sound: **"Stall, stall" + cricket** continuously. |
| 02:10:55 | R: | *Damn it!* |
| 02:10:56 | B: | *TOGA.* |

[10] Elaborated from Otelli (2011) and BEA (2012).

| | | |
|---|---|---|
| 02:11:00 | R: | *Above all try to touch the lateral controls as little as possible eh.* |
| 02:11:03 | B: | *I'm in TOGA, eh?* |
| 02:11:06 | R: | *(3.00) Damn it, is he coming or not?* |
| 02:11:07 | | Plane reaches maximum altitude. With engines at full power, the nose pitched upward, it moves horizontally for an instant and then begins to sink back toward the ocean. |

Excerpt #1 is illustrative of a successful doublechecking of the REF. After interacting with the radar map, Robert (R), one of the two copilots, suggests to the other one, Bonin (B), to do a maneuver. B does not understand, signals it —even if it is a "dis-preferred" (Pomerantz 1977) move, thus potentially harmful for interaction *per se*[11] —, but does not further specify the nature of the problem: is it non-reception, asking for repetition, or misunderstanding, requiring, depending on the case, further explanations, clarifications, justifications, negotiations, etc.? R's turn contains, indeed, two moves: the first one, a repetition, is directed toward a possible non-reception, while the second one towards, precisely, checking the REF's state, its uniqueness —i.e., sharedness— and "objectivity". The second move is that to which B replies in his following turn, and this eventually allows REF's "realignment", also with respect to the artifact "plane" —which is in computed mode, and both copilots know that by now. This is a good example of how a partial interactional impasse could provide with the opportunity for checking and, in case, revising the REF.

Less than two minutes later, the stall warning sounds for the first time. In the meanwhile, for various reasons, the flight mode has automatically passed to manual, and B is now in control. By his utterance in excerpt #2, R asks him some sort of explanation, and this shall trigger a ri-triangulation sequence between R, B and the relevant (with respect to the local ends) elements of the environment that last about 30 seconds (02:10:12 - 02:10:40), and ends with the warning returning silent. This ri-triangulation, furthermore, is such that those

[11] We could also say that B resisted the attraction of interaction, taking a risk with respect to the FOI.

environmental elements are treated as subjects – *i.e.*, they are involved in the co-construction of the REF. Consider, for instance, the following turn of the sequence (cf. Otelli 2011):

> It says we're going up, so descend. [02:10:33]

Shortly after, however, the stall alarm begins to sound again (excerpt #3). B replies by doing, and declaring to do, a TOGA[12]. The latter is not simply improper for a stall situation; even apart from this, it is inappropriate with respect to the state of some relevant elements of the environment, like altitude. This has two effects: B's maneuver does not produce the desired result (i.e., climbing); R, apparently unable to conceive a TOGA at that altitude and somehow disconnected from interaction, suggests to do something that, on the other hand, is unconceivable for B —being the suggestion in contradiction with the maneuver that B was convinced they both marked in the REF. B then tries to mark it again, more committed to doublecheck the REF for achieving coordination. R, however, remains disconnected with respect to both the colleague and the environment, and "self-talks" about the Captain (whom he called back in the cockpit after the first stall warning had stopped).

Contemporarily, the plane reaches the point of no return. R seems to wake up, but, even now, both he and B appear unable to recognize —not to mention mutually recognize and coordinate about it— the stall itself. R makes explicit that he does not understand what is happening [02:11:21]. He no more understands either the colleague's actions, or the (relevant) elements of the environment. The stall warning as well, in fact, was probably not understandable for the two copilots, given that they thought to be in the normal flight control law (that prevents aircrafts from stall) whilst being in the alternate one. This, moreover, was something that the on-board computer had communicated, but it had done so immediately after having given another information (*i.e.*, the passage from computed to manual mode), so

[12] Taking Off Going Around. It is a maneuver used in taking off or aborting landing, thus usually undertaken at sea level, not at 37,500 feet, like in the present case.

that the former —like the stall itself, and the TOGA maneuver of one of the two copilots— has not entered the REF.

From this point of view, we believe that considering the stall alarm as another interactant would have increased the probability to take into account the actual possibility of a stall. On the one hand, in fact, the on-board computer as an agent would have probably checked, eventually, the actual reception of the communicated information; on the contrary, what happened is that it did not repeat, for instance, the message of change from control to alternate flight law once aware —by being copresent to others' action and participating to the interaction— that the other participants had not received the information. On the other hand, we are quite convinced that, if rather than the on-board computer's voice uttering something, there would have been a screaming person entering the cockpit, the stall alarm would have been treated differently.

In this sense, furthermore, it could be worth noticing that, although it is well know that the (group of) user(s) and the context of use come first, so to speak (e.g. Suchman 1987, Bassetti 2012), we should probably start to acknowledge the existence of a sort of indifference and overruling attitude towards technological artifacts. Consider, as another empirical example, the following fieldnotes excerpt, concerning the ethnographic research that one of the author (Chiara) has recently begun conducting in an Italian International Airport.

> [The ENAC[13] local Director], [the Police local Chief], [the security guards' Technical Director] and I go to see the new wireless palmtop for boarding passes' check. "It comes out green if everthing's ok" and presents instead two different messages if the boarding pass is not ok - [the Technical Director] explains. The palmtop is used by the security guard at the outlet of the line for accessing security check area. That of the boarding pass is "one to one" check - that is, "100% as control percentage"
> [...] At some point, while we are talking a little bit aside, the security guard calls [the

[13] National Authority for Civil Aviation.

> Technical Director] attention to a boarding pass that the palmtop indicates as not valid. "Try one more time", he suggests. "I did it twice already", replies the guard. They repeat together for the third time: the palmtop keeps giving the same message, "passenger already entered". They repeat the reading twice again, with the same result. [The Technical Director] briefly interacts with the device, a brief gesture to the passenger and she passes by. Facing the questioning expression of the others and mine, he explains what he has just done: "I simulated a check off for exit, and then I cleared for entrance". [The ENAC Director] notes that doubt still exists about whether the device gave such a message. [The Technical Director] evades the issue with "Eh, well yes... sometimes..." coupled with a slight head shaking, and looks away. [Fieldnotes, 22th April 2013]

A similar case happened in the Chernobyl disaster in 1986: being very expert, the team was overconfident, and its members were operating not analytically but rather "intuitively" (Dorner 1997). This overruling attitude, indeed, seems to have emerged some time ago – perhaps having its roots in scientific culture, like the Chernobyl case would suggest –, yet it appears to be increasingly spreading in everyday social and organizational life. We might talk of a culture of the human countermand raising in Western societies around technology, and we might attribute that, perhaps naively, to the increasing presence, and material as well as discursive visibility of technological artifacts. The hypothesis, in short, is that with the larger and larger diffusion of technology in everyday life, the attitude that was peculiar of scientists with their work instruments (sometimes, instruments of their own invention or production) is becoming an element of common sense culture, and, therefore, of organizational culture/s too —with potentially critical, if not fatal, effects. Another element in this process —one, at least, that we cannot exclude— consists of the (less and less marginal) hacker, first, and then open source / free software culture.

We stated, moreover, that interactional entrainment is both one of the backbones of social interaction itself and a potentially lethal obstacle to effective coordination and triangulation in STSs, especially in critical situations. In the empirical case presented at first, the problem was the malfunctioning of such a backbone itself, the lack of entrainment and

coordination as for the copilots' (inter)actions. However, the main point we want to raise on this regard —in line with Collins' (2008) claims concerning violence— consists in the need of distancing from ordinary interaction, its fatal attraction, and its usual entrainment whenever interacting within an STS. Of interest, from this point of view, is the case of another accident: the incursion that occurred in 2001 on Milan Linate Airport's runaways.

> At 8.05 the Cessna Citation was instructed by ATCOs to taxi from the western apron along the northern taxiway (taxiway R5), and then via the northern apron to the main taxiway which runs parallel to the main runway, a route that would have kept it clear of the main runway. [...]
>
> *GND: «DeltaVictorXray taxi North, via Romeo 5, QNH 1013, call me back at the stop bar of the main runway extension.»*
>
> *D-IEVX: «Roger via Romeo 5 and 1013, and call you back before reaching main runway.»*
>
> The read-back of the pilot was clearly imperfect. There were several omissions that would then become crucial in the accident dynamics: north, stop bar, runway extension. However, the air traffic controller did not take account of them. [...]
>
> At the crossroads between the taxilines R5 and R6, the pilot instead of turning to the left and taxing to the North on R5, turned to the right and taxied along the southern taxi route (taxiway R6) that crossed the main runway. [...]
>
> During the taxi along R6 the flight met a S4 signal, that was not on the map. It was an old signal, present only in R6, and belonging to a set of signals that were operationally dismissed in 1998 but not actually removed from the airport. Both pilots and controller were not aware of them and of their meaning.
>
> The pilot reported the position. [...]
>
> *D-IEVX: «DeltaIndiaEchoVictorXray is approaching Sierra 4.»*
>
> *GND: «DeltaIndiaEchoVictorXray, confirm your position?»*
>
> *D-IEVX: «Approaching the runway, Sierra 4.»*
>
> *GND: «DeltaVictorXray, Roger, maintain the stop bar, I'll call you back.»*

> *D-IEVX: «Roger, hold position.»*
>
> Thus the air traffic controller intended to instruct the flight to proceed to the North, along what he expected to be R5. In the controller's opinion the flight was leaving the apron on R5. Actually the pilot had taxied the aircraft in the opposite direction along the R6, towards the main runway. The air traffic controller did not take into account the fact that the pilot, while confirming the position, reported to be approaching the runway.
>
> In the meantime a Scandinavian Airlines Flight [...] carrying 110 people [...] was given clearance by a different controller to take off from runway 36R. Fifty-three seconds later, the [... aircraft] collided with the Cessna that was crossing the runway.[14]

Among the various intertwined causes of this severe accident— from the lack of a stop bar at the intersection between taxiway R6 and runway, to the bad conditions of signalling systems on the taxiway and runway —a crucial one consists in the fact that the air traffic controller did not check whether the pilot had correctly understood the clearance in the first instance. Even more crucially, when the pilot reported to be at S4 (old sign) and approaching the runway, the ground controller, unaware of one of the elements of the environment, that is the old sign, assumed that the position report was wrong —maybe due to low visibility, condition of which he was aware instead (it was a very foggy morning)— and that the plane was actually at the crossroad between R5 and R6. "Assuming" is the keyword here. The ground controller first assumes that his communication has been fully and effectively understood without searching for confirmation (or, actually, in front of some omissions)— the same problem that has not been foreseen by the designers of the AirFrance Airbus' computer, who did not established a confirmation mode in response to the information on the changing flight law— and then assumes to possess the correct information, even if the latter seems incongruent with respect to the information provided by the other interactant *as* in relation with the environment. In other words, REF "unique objectivity" is assumed, and ("preferred")

[14] From the final release of the deliverable D3.1 "Repository of cases" of the ALIAS project, by ALIAS Consortium for EUROCONTROL.

agreement is taken-for-granted —like in everyday mundane interaction. Lack of knowledge about the work environment, that limits triangulation, coupled with absent doublecheck of the REF, due to what we called the attraction of interaction, brought to the catastrophe.

*Implications and suggestions for STSs' crisis prevention and management*

To us, the most important level of analysis in STSs' crisis management is that of interaction, which should be contrasted with mundane interpersonal interaction. In STSs and, more generally, organizations, indeed, we are not exactly dealing with "all practical purposes" (Schutz 1962, cf. also Garfinkel 1967: viii), but rather with some specific purposes. The REF, as an ongoing interactional accomplishment situated in a local environment, therefore, acquires even greater relevance, since it is fundamental for coordination and triangulation, that are in turn crucial in complex socio-technical contexts. REF's boundaries are the boundaries of coordinated action-in-interaction. What is not marked in the REF does not exist, so to speak, with respect to the —positive and negative— ends of the STS: it is not available as a means for reaching such ends through situated interaction. This brings to three interrelated possible guidelines, on which we elaborate in this section, that could be implemented in a STS by specific training of the subjects involved. However, also other solutions can be foreseen, and we shall explore them in the following and last section.

First, even if at the detriment of interpersonal interaction per se, though not to the point of misfiring interaction, REF needs to be periodically doublechecked by participants in a STS's work context. They should thus resist the attraction of interaction, increase "dis-preferred" interactional moves and, in some sense, search for impasses —that is, they should neither take agreement for granted, nor get caught too deeply in the interactional entrainment that characterizes most of human-to-human behavior.

Monitoring the REF and its supposed-but-shared objectivity —at least with respect to those aspects that are most relevant both in systemic terms, such as organizational (positive) goals and (negative) ends, and at the situated level of the material environment and its artifacts — is crucial, especially in critical situations. Such an extra-ordinary control over reciprocal perspective requires an equally extra-ordinary interaction. An interaction in a certain sense more "frail" than the ordinary one; less oriented towards agreement, as well as interactional continuity and stability. One prone to dis-preferred moves and local impasses for the sake of the (trans-boundary) goals of the STS; neither much concerned with FOI, nor with single, local IUs in themselves, but rather with SOI as a whole. One able to the resist the fatal attraction of interaction and the "mermaids" of reciprocal attuning and entrainment through the enactment of dis-preferred, sometimes even unpleasant ways, or "styles", of coordinated (inter)action.

As the aircraft disasters cases that we presented were supposed to illustrate, indeed, in critical situations and especially in actual crises, mundane "styles" of action-in-interaction may lead to catastrophe. Most accidents, actually, can be ultimately described and even explained by the following line: They thought they both agree(d) that… This is not an astonishing result, of course. However, we maintain that the approach to interaction presented in the paper constitutes both a fruitful lens to analyze critical situations in complex systems, and a potential tool, if used in professionals' education and training, for preventing and managing crisis. On the one hand, our approach allows for instance to "translate" the above mentioned line with the following: They preferred to display agreement/understanding than to actually check for it. On the other hand, be he the soldier who has to kill another one on the battlefield (cf. Collins 2008), the policeman in patrol who has to exert suspects over his fellow human beings and invade their privacy (cf. Sacks 1972), or the airport security guard who has to put her hands on passengers' belongings and their very bodies, in fact, the agent in the STS should – and should be trained to – enact interactional practices that contravene, at least in part, ordinary social norms in order to reach specific, other-than-interactional goals.

Secondarily, not only mutual coordination, but also the triangulation with the environmental elements that are relevant to the STS's ends is fundamental. In fact, good triangulation enhances the REF, enlarges its boundaries, and thus enlarges the boundaries of coordinated action. Given that we are dealing with the whole system, we need each relevant element to be able to contribute to the construction of a mutually recognized, "valid" definition of the situation. Taking (collectively) into account the incongruence constituted by the old S4 sign on Linate runaways, or the data displayed by the Air France Airbus' on-board computer (e.g. on flight laws or altitude) and, particularly, its vocal and voiced stall alarm, would have probably resulted in the avoidance of the disasters. Failing to consider them has certainly resulted in diminished power of prediction and, therefore, coordinated action.

Sometimes, and we reach the third and last issue, considering artifacts as subjects equipped with EFs and thus able to contribute to the REF may be helpful. It is not by chance that, in the case of the Air France Airbus crash, the interactional sequence of re-triangulation and realignment which got closest to solve the crisis and prevent the tragedy contained, as already mentioned, the following turn: "It says we're going up, so descend" (02:10:33). Unfortunately, however, it seems that a cultural tendency towards technology and technological artifacts is emerging that goes in the opposite direction —that is, indifference and/or overruling. This, moreover, appears to pertain not only to common sense culture, but also professional, expert and organizational ones. Furthermore, we have the impression —yet clearly in need of further inquiry— that such an attitude with respect to technologies is increasingly becoming socially regarded, and thus interactionally displayed, as a mark of professional competence, that distinguishes the expert professional from the amateur. Consider, as a final example, the following fieldnotes excerpt.

> During the exam at the x-ray machine, the policeman asks the security guard "What does the machine see?". Then, without leaving her the time to answer, he continues, after a

> quick – self-satisfied – look at me, "The machine doesn't see anything! The guard sees on the basis of what the machine filters" [Fieldnotes, 24th April 2013]

Yet one would at least have to pay attention to the machine-filtered images and, perhaps more importantly, the machine-specific "style" of communication.

*Interaction: among human interactants, among artificial agents, in socio-technical systems*

In the analysis that we have conducted so far, we have mainly focused on the interaction among human agents, even when we have looked at them happening in socio-technical systems, as in the examples of Air France and Linate. In such examples, human agents surely interact in a technologically dense environment, in which artificial devices surely play a role, but not properly as "first class citizens" in the interaction realm.

Take for instance the case of the Air France flight: we could fairly say that at the beginning, while the aircraft is flying in computed mode, the airplane's computer can be seen as a genuine agent, as it can autonomously "decide" which maneuvers to perform. Nonetheless, at this stage we cannot say that it is interacting with other agents; some sort of interaction starts when the computed mode is turned off and the aircraft is set on manual mode. But at this point, its role in interaction appears as very limited, as it is confined to the emission of a warning sound that, in the specific case, goes largely unnoticed in the most crucial part of the interaction. In this very example we could hypothesize that, had the airplane's computer had a more active role in the interaction, maybe the catastrophe could have been pre-empted.

Why did the co-pilots ignore the warning that was being proposed again and again? Because, whereas the computer was signaling the stall, they could not recognize the situation they were in as a stall and, not being able to really interact with the on-board computer in the

same way as they were interacting one with the other (asking explanations or confirmations, providing the reasons of their sayings or doings), they just decided to ignore it. They had understood that the computer was giving a warning alarm, they had understood that the computer was warning them *because* it "believed" they were in stall, but they could not understand *why* the computer "believed" it, and the computer could not explain why, as it lacked most of the capabilities that could have made it a real interactant. But if ascribing a more active role to artificial agents in the interactions that are most relevant for socio-technical systems is among the solutions to be taken in serious consideration, we have to at least indicate a direction to follow in order for this to be possible.

The topic of artificial agents' interaction is obviously central for the community of MultiAgent Systems, that has inquired various aspects of such interaction, ranging from agent communication languages[15] (ACLs), to communication and interaction protocols, to coordination mechanisms[16], to forms of organizations of artificial agents and so on.

Although many of the topics studied in these works are undeniably very relevant for our endeavour, most of them share an assumption that results in a vision which is not the one we are trying to propose here. Namely, that the interaction that has to be studied is the one among artificial agents and the system within which they act is inhabited only by artificial agents: humans are either absent (artificial agents are designed to perform tasks autonomously from the human), or only indirectly present (artificial agents are "representatives" of human users, who only instruct them on which goals they want to be satisfied). But this is not the case in most socio-technical systems, where artificial agents must be able to interact not only among themselves, but also with human agents (and vice versa).

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[15] Many works on the integration of agent communication languages with social attitudes are available, among them Colombetti *et al.* (2004), Gaudou *et al.* (2006), and Singh (2000).

[16] Pirjanian (1999) lists a series of coordination mechanisms for artificial agents, while Excelente-Toledo and Jennings (2004) illustrates techniques to enable agents to dynamically select them on the fly.

Thus, it is necessary to develop languages that allow artificial agents to communicate among themselves and it is necessary that their interaction is regulated by norms that constrain their behavior in such a way that their acts are made interpretable by other artificial agents, so that they can coordinate and form different kinds of organizations/coalitions/ societies, etc. But all this is not sufficient to obtain artificial agents that may play an active role in an interaction in which also human agents are involved. We need artificial agents to be able to represent, reason and communicate about: the socio-technical system as a whole and in its components, the environment in which the system is immersed, and most of all --and this is the point we would like to make in the present paper-- the interaction itself. The latter point includes many aspects, such as the rules of the particular kind of interaction, the roles that various agents play in the interaction, the dynamics of interaction, the mental attitudes of the interactants (as they can be inferred by their behavior), their EFs and the REF that is reached at various stages of the interaction.

To capture these aspects of interaction in socio-technical systems is for sure not an easy task, but a last claim we would like to make is that *applied ontology*, intended as a technique in Knowledge Representation in AI, could have here a key role. In AI an *ontology* is a specific (theoretical or computational) artifact expressing the intended meaning of a vocabulary, in terms of primitive categories and relations describing the nature and structure of a domain of discourse (Guarino *et al.* 2009). Making explicit as many implicit assumptions as possible, thanks to a well founded ontology, enhances the possibility, for the interactants and the system itself, represent and communicate about the system, the interactions going on within it and to identify critical issues[1]. By having a clear and formal model of what is going on in the system and interactants' EFs and REFs, we gain a powerful tool to recognize and react to critical situations.

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[1] A work still in progress, cf. Guarino *et al.* (2012).

Even though in the literature both works on engineering approaches on STSs (Baxter, Sommerville 2011) and on ontology of organization (Boella, van der Torre 2006) may be found, as far as we know still there are no significant efforts directed at including the dimension of systems' crises in the models. The present contribution is meant to be a preliminary step in such direction.

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