Collective intelligence in a computer mediated environment

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ABSTRACT

The role of computer in the emergence of collective intelligence is most of the time underestimated. Outside the fact that it allows the collaboration between individuals, we will also see that it modifies the interactions and memorizes the traces of the activity. These specific features lead to that computer services become full actors of the interaction with their own influence like individuals. The resulting symbiosis effect boosts significantly the outcome of the human collaboration. Thus, the objective of this chapter is to deepen our understanding of these mechanisms in order to improve the management of collective intelligence.

INTRODUCTION

Collective intelligence is far from being a new concept. More than two thousands years ago, Aristotle (350 B.C.E) already states that :

«.The principle that the multitude ought to be supreme rather than the few best is one that is maintained.....For the many, of whom each individual is but an ordinary person, when they meet together may very likely be better than the few good...For each individual among the many has a share of virtue and prudence, and when they meet together, they become in a manner one man, who has many feet, and hands, and senses; that is a figure of their mind and disposition. ».

Actually, not only collective intelligence is not new, but it is evoked in a wide variety of fields ranging from theoretical issues to applied domains. Thus, why adding a new chapter to the huge amount of literature available? From our point-of-view, there are two major answers to this question.

First, because even if this topic has been widely evoked, we still know very little about this emerging phenomenon. Looking at the behavior of social animals (bees, ants, ..) or human collectivities we have, for a long time, observed the leverage effect of the group commonly described as providing more than the sum of individual contributions. This observation set apart, we don't know the precise conditions of this emergence and why a small cause can, sometimes, generates mass consequences. What are the factors that increase the group cooperation and is it possible to artificially enhance or forecast these conditions? We may also ask why a collective behavior can provide positive outcomes (knowledge, mutual assistance,..) or suddenly leads to uncontrollable results such as herd effect. Even if social sciences give valuable enlightenments to these issues, we think that the intake of computer sciences has to be reconsidered in a new perspective. Not only can it give complementary answers, at the image of what is being done in other scientific fields such as in biology (genome research) or in physics, but also because the role and the influence of computer devices in human interactions are now almost unavoidable. But, what is this role more precisely ?

The answer to this question is actually the main topic of this chapter and constitutes a change of point of view in front of a purely human-centered scientific posture. In our investigation, the computer is not seen as a passive device, but as an actor to full-fledged of the collective activity.

If it is obvious that the spreading of interconnected computer environments offers new opportunities for the cooperation between individuals, the understanding of the underlaying cooperation mechanisms is still limited. This contribution can seem evident when having in mind initiatives such as open projects like *Wikipedia.org*. We can also cite the popularity of opinion polls on a large scale such as those operated by *Change.org*. The surveys launched by an individual or a small group aspire to mobilize large numbers of citizens lobbying for a wide range of causes. In some cases, such initiatives may even influence governments policy. These results of the collective intelligence are favorable to the decision-making and generate structured knowledges or high value softwares. But here, the computer is seen as a service support, outside this added value, its own influence is not addressed.

Actually, another role sometime underestimated is that computer environments modify the interactions features and consequently their potential outcomes. A basic example of such changes appears if we remember that the non verbal interaction is often lost in computer communications such as in e-mail. It was shown that this loss of information can have unexpected consequences in human relations. Let's imagine that a small joke can be misinterpreted and can be felt as an affront without a smile or the adequate voice tone. Another example is that of the interactions delays reduction favored by the computers. It is no more necessary to move or to wait, a lot of things can be done from a smart-phone. The drawback is that such "time compression" gives more weight to impulsive behaviors, sometimes irreversible compared to those in the “real life”. These phenomena are particularly sensitive to certain forms of mediated interactions such as those observed in on-line share trading. Given that collective phenomena can be sensitive to small variations, as amplified by snowball effect (see chaos theory), it seems necessary to seek to deepen the role of the computer in human interactions.

A third role, that we can evoke, starts from the observation that the interconnected computer environments such as Internet are actually a huge memory that keeps the traces of users activities and interactions. In theory, this large amount of data as well as in the general field of experimental sciences, can provide clues explaining complex emerging phenomena. In this way, traces analysis can be a useful addition to psychosocial assessment in the understanding of collective intelligence. For example, we will see in this chapter that the coherence of the group structure, measured from interaction traces can be a useful indicator for monitoring the group dynamics. However, traces analysis is not a trivial exercise. Beyond scientific difficulties related to the data interpretation, also appears the technical problem of data collection. Another challenge is the use of these indicators to make adaptable services based on a feedback loop such as collaborative filtering or recommendation systems. With these services, the group directly benefits from the collaboration of its members, trough a reduced cognitive load.

Thus, as we will see, the computer offers new keys for exploring and enhance collective intelligence with considerable challenges for social organization and governance. It is also important to evoke ethical and legal issues. Indeed, the recent debates concerning the individual right to control personal data seems to oppose itself to the use of traces. But ultimately, may be that the most important issue of our society is to offer the best compromise between the preservation of human rights and the technological contribution.

BACKGROUND

In short, the concept of collective intelligence often carries two main ideas, the leverage effect of the group action and the delegation of the individual control capacity. The leverage effect is sometimes expressed saying that the action of a group is more efficient than that of the sum of the individual's actions. The delegation effect involves that a group acquires a form of autonomy by the inheritance of

a part of the power of its members. This means that somewhere, the group becomes an identity and that his action escapes, more or less, to the will of its members. An example of such unconscious delegation process can be observed in herd phenomena such as panic effects in the financial crachs. Evidently and contrary to the common idea, the collective intelligence does not always have positive consequences. Thus, most of the thinkers of the nineteen century had a poor idea of the collective action like Nietzsche (1886) who said that madness is rare in individuals, but in groups, parties or nations it is the rule.

The expression "collective intelligence" appears in a wide series of scientific fields even if the understanding of the background concept is far from being shared by all. It probably began being mentioned after having been observed in the nature. The organized behavior of social animals such as ants or bees has been extensively studied. For Bonabeau who studied what is called swarm intelligence, the collective intelligence allows to solve problems that cannot be solved by individuals acting separately (Bonabeau, Theraulaz & Dorigo, 1999). This basic definition is interesting because it links together the group action and the most shared view of the intelligence that involves adaptation and problems solving capacity. But for some researchers, collective intelligence can be developed only by humans, to build and share high level constructions such as artifacts or culture (Levy, 1999). Thus, definitions for human collective intelligence often put ahead, emotions, opinions or creativity. These two extreme views involving either a low or a high level of individual cognitive capacity have also been simulated in computer science with artificial agents. Finally, we can sum up the different views saying that collective intelligence involves interactions between individuals, collective consequences and a form of coordination between the local and the global level.

Regarding the fundamentals at the basics of this functioning, the debates in computer sciences reflect those in philosophy and psychology between the cognitivism and the models that focus on interaction (connexionism, constructivism, ..). In his book J.B. Smith evoked a series of formal models showing how individual and collective cognition can be used in computers (Smith, 1994). In short, formal models aim at describing how a computer has to perform tasks depending on rules. This strategy has been applied historically in artificial intelligence. Our posture is different in the sense that we do not seek to replace the human by the computer. We try to describe the natural interactions between humans and computers and use the corresponding descriptors in order to enhance the collaboration between individuals. In this sense, we are more inspired by socio-constructionist theories than by cognitivist models .

In what follows, we situate ourselves, as an observer of real contexts where humans interact in more or less structured organizations. The governance of these organizations largely depends on the stream of influences between individuals and the group.

From individual interactions to collective behaviors.

The form of collaboration between individuals may largely differ, but we may split it in two modes depending on that the collaboration is explicit or not. In explicit collaboration all individuals are aware participating to a common task. At a limited scale, this can be a brainstorming group in a factory, to a world wide project such as the open initiatives (e.g. *Linux*, *Sourceforge.net* or the *Wikipedia* project). In all cases, the motivation or the degree of contribution of individuals may vary, but all are conscious to collaborate to a common goal. Conversely, the implicit cooperation implies that actors are not always mindful of cooperating or do not realize the extent or the ultimate goal of their cooperation. A basic example of this kind of process is the page-rank algorithm that is used in recent search engines. This process, that puts ahead the best popular research results on the basis of the indirect cooperation, is very similar to which operates in opinion polls. In implicit collaboration, individuals are first of all motivated by a personal strategy, but their actions can finally result, more or

less unwittingly, in a collective performance (Lancieri, 2004). They watch films or give their opinion on the web because they want to do so. Their first motivation is not to provide data that will be used for statistics or to enhance a search engine. Anyway, such collective opinion is more and more used to forecast events such as in financial markets, elections or sports.

Johnson (1999) used the same principle, with artificial agents, to explore the underlaying mechanisms of these collective performances. In his experiment, the agents are programmed to act individually in order to find the shortest path in a maze. Then, Johnson looks at all the individual paths and for each node of the maze, computes the decision took by the majority of the agents. For all the steps, he obtains the collective solution which appears to be the shortest possible path. This experience shows several conditions to exploit the capacity of the group. The first one is the need of an equilibrium between the diversity and the homogeneity of individual contributions. Indeed, if each agent takes the same path, the added value of the group is useless. The diversity of opinions allows to minimize the possible individual errors and bring new opportunities or ideas. To paraphrase the words of Bateson (1972) we must remember that knowledge arises from the difference. But conversely, if all the agents' paths are different, here again, no group solution (consensus) is possible. So, the key is the equilibrium in the various dimensions of the solving process. Even if most of the time the diversity is understood in term of variety of domain of expertise, but curiously the variety of capacity seems also to be a good thing. Several works show that even individuals with few social interconnections or with a low personal capacity are necessary to enhance the group ability (Granovetter, 1983; Page, 2008). The emotional diversity is also fundamental as was evidenced by Woolley et *al* (2010) who showed the role of womens in the performance of a group. With his colleagues, she used a general collective intelligence factor (c-factor), comparable to the individual IQ, that explains a group's performance. We may imagine that, for educational reasons, "intelligent" people tend to have a similar way of thinking that reduce the diversity of the group. In a certain way, the collective intelligence is not always compatible with the "intelligence" of all individuals of the group.

This equilibrium lack can come from exogenous conditions or from the influence of the group itself. Organizational pressures can occur, as in a factory where the manager want to setup a brainstorming group with the best experts of a domain. This seems to be a wise decision but in some situations, the added value of such association can be limited in comparison with a multidisciplinary group. The individual influences that lead to a lack of diversity are also often linked to the trend to mimic others. This phenomenon occurs in a context of uncertainty and is particularly sensitive to initial conditions. The same mechanisms appear in social norms or in fashions. In such situations, the imitation behavior limits the cognitive load of individuals and makes easy the taking of usual decisions. In this case, the weight of the first idea, even if it is under optimal, is followed sequentially and reinforces itself as a snow ball in what the economists call information cascades (Bikhchandani, Hirshleifer, & Welch, 1992; Hung & Plot, 2001). Then, the choice of the majority appears as reassuring, which helps to reinforce its credibility. At the end, the majority has accepted a possible wrong option without remembering why.

Fortunately, it appears that the cost of the decision perceived by individuals may limit the effect of information cascades (Boyd & Richerson, 2005). This cost is not the same for someone who can undergo the direct consequence of his decision such as an entrepreneur compared to a civil servant for whom the risks of a bad decision are more limited. The cost-gain equation can also be evoked considering the selfishness of individuals who in some occasions, keep and hide the information instead of cooperate, in order to gain power over others. But, strangely, the common wealth can start with a form of selfishness. In the every day life, one can cite many chains of complex activities that requires coordinations between actors that first take care to their own advantages before to participate to a collective profit (e.g agriculture which feeds distributive trades which feeds restaurants,..). The

games theory contains a large quantity of examples showing the influence of personal interests on the motivation to collaborate. The well known prisoners dilemma has allowed to study the equilibrium between the selfishness and the generosity in groups.

Relation between the local and the global level

The group behavior can be operated in two extreme modes of organization either purely centralized or decentralized. Both paradigms have been studied and even used in some real large scale situations. The centralized governance, by definition, is few favorable to collective intelligence. As in the caricature of the army model, individuals' initiatives are not allowed. In order to make the collective behavior controllable and foreseeable, all individuals should obey to a unique source of directives. This model seeks more the collective power (addition of individual forces) than the collective intelligence. In the decentralized model, the governance is delegated to individuals who have the freedom of action and of interactions with other individuals. The collective intelligence is more likely to emerge in such context.

Some authors have pointed out that, in decentralized organizations, the phenomena of emergence are marked by a paradox between differentiation and standardization. For example, in the emergence of fashions, that we have previously evoked, the motivation to follow the tendency starts from a will to be different. However, the final result is the standardization because the mass finally tends to follow the tendency. Wanier *et al* speak about a phenomenon of “identical differentiation” (Wamier & Lecocq, 2004). This process is characteristic of relations between collectives and individualities. Indeed, when a fashion evolves to the point where it is shared by all, another fashion emerges, making it possible for individuals to be different again. These more or less slow and interdependent mechanisms are difficult to forecast in the short term, but are clearly visible on long-term cycles. The well known dilemma of the El Farol bar, based on a real story, is a model showing such cycles of influences in a group (Arthur, 1994). It begin from the observation that people are not motivated to come in a bar when it is empty or crowded, but progressively in an increasing and decreasing way depending on its level of attendance. Whether at large or at more limited scale, we can observe two mechanisms linking the local and the global level: the informational aggregation and the feedback loop capacity.

Due to the informational aggregation effect, individuals make their decisions from a synthesis of what they perceive of the group behavior. In other words, each individual computes a kind of global trend instead of looking at the behavior of each other individuals. In relative terms, this process was also observed in the experiment of Johnson when he computes the group solution from the choice of the majority. Aggregation is a centralized process, sometimes mechanical, with no judgment or pressure. It collects, synthesizes and dispatches local information among the group. In a session of face-to-face brainstorming, the mechanism of aggregation is operated by the animator and with a device (white-board). The animator has not a directive role, but rather makes a smooth coordination that ensure a cool and equitable participation. The white-board as a media is essential, it ensures the mechanisms of memorization and forgetting that allow to make emerge the most essential of the discussion. The remarkable point here is that the aggregation process involve a loss of information comparable to the forgetting effect in the human memory.

Secondly, the informational feedback loop provides to each individual the collective aggregated perception. But, by the way, from where does come this perception ? In front of a bar, the situation or the ambiance is perceived by the view and ear and the decision to come in or not is taken immediately. But, for a long term process such as a fashion, things go differently. The modern speed of the emergence or the change of fashions cannot be explained by the direct perception of the real world. Only the relay of media (magazines, television, Internet) can provide enough memory for this,

at more long term, aggregation process. We will see that the control of this loop is a necessary step to manage collective intelligence.

The relative simplicity of this process is a fundamental opportunity for intelligent service automation if we compare it to the difficulty to substitute the human intelligence for the computers. From the era when was born the artificial intelligence with its hopes and disillusions, the future probably tends towards the automated management of the synergy between the human intelligences. This new form of governance is implicit, but it doesn't exclude, rather complements, the formal delegation of power to a management team. In all cases, the media is changing the mode of management of groups or of organizations.

THE MEDIA AND THE ENVIRONMENT MORE THAN BASIC MEDIATORS

Depending on contexts, the term "media" may have different definitions. In a strict sense, it refers to impersonal means of information dissemination, used to communicate and normally, without the possibility of customization. In a more open vision, this word has the meaning of an intermediate and correspond to components (hardware, software, content) used for the interaction between individuals. The tools associated with the Internet such as email or web servers are media and as such, are naturally involved in a complex and mutual influence within the interaction between individuals.

Indeed, first, the media influence the interaction insofar they alter the perception of the reality and change the individual behavior. Actually, the media create a new equilibrium adding, but also removing functionalities. The communication becomes, almost independent from the time and space and has the capacity of memorization data for future use. This leads to the situation in which tools like short messages systems, forums or even the basic e-mail have changed the use of writing at the expense of the use of snail mail. But, the media also remove some elements of the communication. A basic example is the non verbal communication such as the smile or the gesture that are missing with the telephone or the mail. This loss of information about the intentions allied with the spontaneity offered by the media leads to unexpected consequences. Sociologists have shown, for example, that the lower the loss of information induced by the media is limited, the more relationships of trust settle and contribute positively to resolve conflicts. This was observed comparing chat and phone with face-to-face communications (Doise, 2003).

On the other hand, and even if it seems less obvious at first glance, the reciprocal relationship is also true insofar the interaction has an influence on the functionality and the performance of the media. This is particularly observable in file-sharing networks that use a peer-to-peer technology where the popularity of a film increases de-facto the amount of sources and consequently the file download speed. Thus, the popularity of a content leads to more comfort of use. Similarly, this effect is also observable in some forums where users can gain the status of expert from the community. A rank of expertise then appears as a star mark automatically added in the user interface when a new post comes in the forum. Thus, the group behavior tends to modify the user interface which in return will modify the behavior or the choices of the group. Sometimes, this causality loop induces not wished effects. In such forums, sometime simply because of lack of time, the users tend to read only the posts from the designed experts which consequently tend to exclude new contributors.

The media are thus potentially context-sensitive in the sense that they are influenced by their use at a given time, in a given place and with a given intention. Pushing this logic to its limits, the environment becomes a full part of the media. In pervasive computing that supports ambient intelligence, the processing, storage and communication capabilities are scattered and distributed to the extreme (clothing, connected objects, infrastructure ..). The environment allows the continuity in

the activity even in movement, and inherits of the features and the behavior of the media. This vision is also consistent with the theory of activity that gives to the media an extended role in the interactions (Engeström, 1999). To clarify ideas, let us consider an user in vacation who could receive spontaneously on his smart-phone a message stating that the monument he has in front of him has a story out of the ordinary. The time and place of the transmission of this information make sense. In this case, not only the context framework is extended integrating the time, space and the memory of the activity, but also it is supported by functions merged into the environment. These functions are for example, the wireless network that enables mobile communication and can deliver geo-localization capacities among others. This illustration is not futuristic. One example is the museum of the city of Strasbourg (France) where the visitor uses a device that allows to receive throughout his visit an audio explanation directly and precisely in relation with the area of the museum where he is located (see also Apple IBeacon device). Beyond confined places, today's technology allows these services to be extended to large areas such as in future smart cities.

With its new status of media, the environment also inherits of its properties and in particular that linked to the mutual influence. In this sense, the mediated environment amplify and accelerate what already exists in face-to-face relations. Initially, individuals choose locations and times of activity depending on their inner characteristics (proximity, pleasant, functional, ...) and because other people have made the same choice. It is what happens when we go at 10 o clock to the meeting room because all the members of our team are available for a working session. These choices affect the constraints and the functionality of the environment which retro-act on the choices of individuals. Because the meeting room appears to be convenient, it was decided to enhance its features with video-conference capacities. As a consequence, the room becomes less available and often needs an early booking. Through this game of continue mutual influences, media and environments become adaptable, active and play a symbiotic role with individuals.

If we try to isolate the both sides of this symbiotic relation, we can put ahead a model of generalized media that results from the merge of various basic elements that are the time, the space of exchanges and the structure of interactions. The time corresponds, not only, to the interaction duration, but also to the level of its synchronization or the reaction time between the cause and the consequence of an exchange. The spontaneity or the frequency at which take place an interaction can lead to a great difference in the final results. Axelrod (1984) shows, for example, that the trust or the behavior in a relation comes after repeated interactions because of the anticipation that the relation will last. The space of exchange represents the framework of the interaction. This structuring element which is the extent or the degree of inking in the physical world will allow to deploy a capacity of memorization that will be a fertile ground for the emergence of collective properties. The depth of the shared memory, the level of visibility of individuals activities, the level of fusion between physical space and informational space are constituent elements of this property. Finally, the structure of interactions is an organizational measure extending what we can observe in well known media such as forum boards (many to many) or as web-site (one to many). This measure will be described with more details in the next section.

Even if, of course, the comparison between the human and the media has its limits, several common features lead us to consider it as a full actor of the interaction. Probably the most important is it capacity to anticipate. We will see that, in the same way the individual activity is socially and culturally influenced, proportionately speaking, a recommendation system, for example, gives advices on the basis of other users activity. This model is dynamic and reflexive in that each contributors in the interaction, whether a human or a machine including the environment has a vision of the interaction (a feedback link) and has the ability to adapt itself to it. This collective symbiosis through computers is largely dependent from traces of activity.

ANALYSIS OF TRACES, THE MEANING FROM DATA

We saw that media are important to be considered for 3 reasons. First, because it can efficiently support the collective activity, secondly it modifies the interactions between individuals and finally, because it stores traces that are as much of memory pieces witnessing the activity and interactions. In a broad view, the concept of trace can cover any form of information generated subsequently to the activity of individuals. Thus, a basic web server log file as well as the content of an email are among others, examples of traces that can contain thematic, chronological, or even geographical clues, describing the activity. These data can be used to compute purely quantitative indicators such as the number of users accessing to a resource, but also to analyze words of documents and other elements related to the semantic of the interaction. Incidentally, even quantitative data can be interpreted from a qualitative point-of-view and can describe difficultly observable or hidden behaviors. Not only these indicators can help us to better understand the functioning of groups, but they also can be used to build adaptable services that enhance the collective performances as by a form of self-management.

The measure problem

The research in this domain could be divided into two main categories, according to whether the phenomena are observed or simulated. Observation can be done directly or by the mean of surveys either experimentally or in operational situations. The major problem of the observation strategy is the incapacity to perceive all the aspects of a complex behavior. The variation of influences or of consensus among a large number of actors produces emergent properties that, sometimes, appear after a delay difficult to forecast, or on a short duration (percolation effect) and thus are difficultly observable. Even at a small scale, the experiments are hard to setup and thus, they introduce a distance that can be temporal or contextual with the reality. Another problem is the observation bias where the observed situation is influenced by the observer. Nowadays, observing social phenomena can be compared with the situation of the chemistry or the biology 200 years ago, before the invention of the microscope. Global effects can be observed, but it was difficult to understand underlaying mechanisms. An important step appears with the evolution of computers allowing the simulation of collective behaviors. The difficulty is that the simulation requires a prior programmable model of the individual behavior as well as a model of interaction between agents (Smith, 1994). These models are far from being known due to the human complexity. The strategy is then to make hypothesis on basics models and to verify if the simulated behavior corresponds to what is known from the reality. Even if the simulation is essential to the test of hypothesis, it has limits inherent to the necessity to have accurate models. A new path is then to find the way to collect and analyze data in the current of the real activity in order to understand the behaviors.

The individual

Let us first consider the case of the user's thematic profile, a set of data describing the user's topics of interest frequently used for personalization purposes. With the proliferation of the on-line information and services, personalization and adaptability become a real challenge. The keywords contained in the profile are either provided directly by the user through an on-line form or collected from his traces, for example, from the consulted web pages. Due to its contextual and temporal variability, building an accurate user's profile is far from being obvious. Yet, despite this complexity, methodologies of profiles validation are rarely addressed by the researchers. But the good news is that although simplistic, the implementation of metrics applicable to intangible items such as the user's profile is possible with reasonable results in term of probability. Thus, in an experiment, we shows that the similarity between two users' profiles composed of several hundreds of words corresponds to a similarity of their activity of 70 % (Lancieri, 2005). Outside the words contained in a web document, its structure of hyper-links is also very informative and can be used to built a statistical indicator of the user level of expertise. This measurement starts from the observation that statistically, the complex

web documents that are highly technical and somewhat popularized like the European constitution have few hyper-links. Conversely, a summarized or a vulgarized web page will tend to have more hyper-links, allowing to deepen the main content. Thus, following this theory, a scientist, for example, will consult more probably a higher fraction of web documents with few links compared to an average user. Beyond describing the individual activity, this philosophy can be applied to better understand the collective behavior.

The collective

The main drawback of the user profile is its static nature since, like a picture, it represents a view of an individual at a given time. But, the web documents can also be analyzed in a dynamic perspective and, in relation with an adaptable period of time including the future activity of users (Davison, 2002). Thus, we observe that 47% of pages visited by an average user correspond to links contained in one of the two previously visited pages. In observing things differently, we see that pages already visited has 25% of probability to be accessed again. If now, instead of considering the activity of an individual, we observe a group, this value grows to 50%. One might wonder about the meaning of this figure and on its evolution factors. A group, of course, consults more pages than an isolated user but, the rate of redundancy of activity being based itself on the total number of pages viewed, one might expect that this ratio remains stable, whatever the number of users considered. In reality, the fact that a group creates more redundancy of consultation comes from the effect of sharing and synergy own to groups. That is to say that the more there are individuals, the more increases the likelihood that one of them would be interested in others reading, hence increasing the redundancy of consultations. This observation led us to propose the redundancy of activity, easy to compute, as a measure of group consistency. This refers to the diversity within groups that we mentioned at the beginning of our discussion. A group of people with a large variety of interests is likely to have a low level of redundancy rate compared to a group where people are interested in a narrowest range of topics. This relationship, relatively intuitive, has been experimentally verified (Lancieri, 2005). Another interest of this approach is that it allows to evaluate the synergy of a group before to form it, which can be considered as a management method.

In a comparable way, Kapur et *al* (2006) studied the mechanisms of convergences in newsgroups oriented to problems solving. They developed a measurement of the group activity convergence by computing the number of interactions going in the same direction (Np) and against (Nn) the objective laid down for the group. The convergence ratio (Cr=Np-Nn)/(Np+Nn)) was computed at each stage of a problem resolution. The authors observed that phenomena of emergence appeared very early, in the first 30 to 40% of the time of the group discussion. In addition, statistical tests showed that the convergence ratio, easy to compute, was a very good guide to the level of performance of the group (see also IQ from Woolley *et al,* 2010).

These examples show how to compute indicators that synthesize the group conduct, but it could be instructive to evaluate the individual behavior in comparison of that of the group, during a period of time. This gives a view of extreme or conformist attitudes. Starting from the profile vector of each user, the idea is to replace each vectors by a single numerical value representing at each time slot (e.g one week) the euclidean distance between the vector of an individual and the aggregated vectors of the group (comparable to the gravity center). Thus, in the following figure, the succession of the Ei values (E1, E2, ..) represents the evolution of one user behavior (symbolized by the upper dotted plot) compared to that of the group (symbolized by the lower dotted plot).

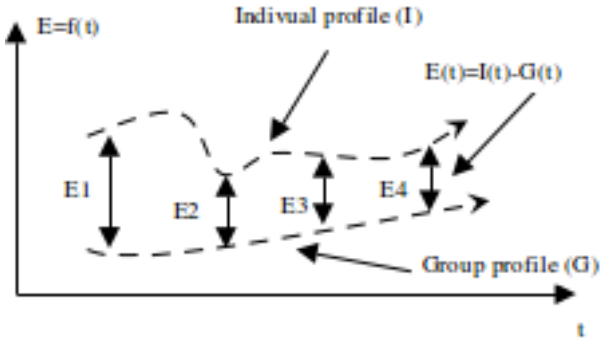

Figure 1: Compared evolution of users behaviors

Let us note that the inertia of the group profile is very high because it combines and smooths the individual behaviors variations. Compared to the group inertia that appears as a benchmark for its stability, a user profile will vary more significantly. By analogy to physic, this approach is similar to the measure of difference of potentials. The chronological plot of the Ei values can be automatically computed and used for monitoring purposes. In order to show an example of use of such method, let us imagine a fictive situation with one hundred people. Each one has a more or less independent work that requires surfing the web for collecting information. In this case, it is possible to monitor the evolution of users' thematic profile and form a brainstorming group depending on criteria of thematic homogeneity. The goal could be to put together individuals with different topics of interest (i.e. Ei values plot far from the zero level).

The structure

A convenient model of group interactions is that of the network that can be analyzed through the graph theory. One can refer to the article of Barabási that provides an extended state of the art in this domain (Barabási, 2007). What is interesting with the network model is that it allows to describe properties of the whole group starting from local characteristics more “easy” to obtain. Moreover, such model is generalizable in wide variety of domains and forms of interactions. In the following example, we present a way to measure the structure of interactions in the physical world involving users' moves in a research lab building (Benayoune & Lancieri, 2005). The localization data were obtained through traces of users' crossovers between 17 WIFI hot-spots distributed over the site. These data are commonly available on most wireless routers and allow to have a statistical view of the activity of each of these hot-spots. A synthesis is shown in the following figure where the thickness of the lines (figure 2a) represent a path between the hot-spots more or less traveled by users. This intensity is reported in the histogram of the figure 2b where the bars correspond to the level of hot-spots activity ordered in a decreasing order. A hot-spot with a large activity means that the corresponding area is often crossed by users. The logarithmic transformation on both axes of this histogram provides a straight line (figure 2c). This linearity refers to the concept of internal similarity (Long tail, fractal, ..) own to power law distributions (eg Pareto, Zipf law, ...). It is interesting to note that the slope of this curve is a synthetic indicator of the structure of spaces occupancy. A slope near the horizontal imply a more homogeneous dispersion of the occupancy in all areas. Conversely, a slope that tends toward the vertical would be the sign of over-occupation of some places compared to others (for more details, see Lancieri, 2007).

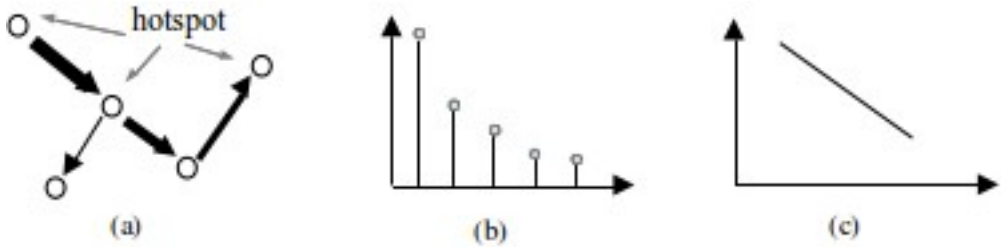

Figure 2: Modeling of the structure of spaces occupancy

The same strategy has been applied to model interactions in social networks. We showed that on-line forums on open source technologies have a characteristic slope more horizontal than those linked to corporations products (Lancieri, 2000). This finally appears quite logical since the distribution of the contribution (posts) is expected to be more equitable in open-source compared to the industry world where the communication is canalized and maintained by a minority of the company representatives.

Whether in on-line contexts or in the physical word, these methods can be used to provide contextualized mediated services. We can imagine a situation where once identified the main areas of activity, these spaces can be enhanced with public services or commerces adapted to the moment of the day (more or less attendance).

THE STRENGTH OF MEDIATED SERVICES

It may seem obvious that a shared memory is mandatory when it comes of collective intelligence. Even in the more basic situation of a face-to-face discussion, the common view is shared in the memory of each interlocutor. In most of the mediated services such as wiki, forums or the web itself, the shared memory is present. A common view is extracted thanks to the informational aggregation process previously evoked. In addition, the indicators or other form of knowledge extracted from the users activity, whatever its accuracy, can be used to provide value-added services based on the necessity of a shared knowledge or a consensus. This need appears especially in recommendation services that help decision making in a context of information overload by extracting the main choices from a critical mass of people. First, let us say that the trust that a user may have in recommendations may vary depending on the way a recommendation is done. A Nielsen survey shows that 70 % of the consumers tend to trust the opinion of other consumers posted on-line, but only 24 % trust in advertising received on their mobile phone. In comparison, 90% trust the advices coming from known people, 62 % from TV, and 37 % from on-line banners among others (Nielsen, 2009)

In some occasions, the user makes directly his own opinion on a product after having browsed the evaluations made by other buyers. Plenty of web sites contains such evaluation (*epinion.com, booking .com*, …). In this case, the web site provides a part of the information aggregation in the sense that all opinions are visible and that a consensus rating is computed. In an extended approach, such strategies have been used as automatic polls in order to forecast the result of elections or sport competitions. A more automated process is that of collaborative filtering systems such as that used by *Amazon.com*. This merchant advises a book to a customer because its recommendation system has observed the similarity between his browsing history and that of other users. This forecasting service can be found for any kind of items such as films and represents a high commercial challenge. As evidence, in 2009, the Netflix competition has awarded a prize of US$1,000,000 to the winner of the best collaborative filtering algorithm. In this case, the user has almost nothing to do, the advices are automatically aggregated starting from the activity of other users and spontaneously provided through a

personalization of the user interface. Here, the trust in the advice largely depends in the trust the user has on the merchant. According to Swearingen, users tend to buy 20% of the items recommended by Amazon (Swearingen & Sinha, 2002).

A last example showing how a decision can be made more easy thanks to the mediated collaboration is that of the on-line brainstorming (Lancieri, Lavallard & Mason, 2005) (Veilleroy, Eurin, Hoogstoel & Lancieri, 2013). The Qlim platform was designed to support the on-line group creativity, on the basis of a feedback mechanism, as it occurs in a brainstorming session (see also Delphi method). In short, the process starts as an on-line questionnaire with few questions and answer choices. Participants are invited by e-mail to answer these questions, add new questions and new answer choices. The user interface allows these changes in “one click”. Then, users are automatically notified by e-mail for all new contributions occurred during the day. They can go back to modify their answers at any time or make new propositions for questions or answers choices, and so on. This system was tested with a dozen of asynchronous brainstorming sessions, each involving an average of 20 students. As for face-to-face sessions, Qlim allows to take benefit from the collective thinking, but with several enhancements. First, the mode of expression based on questions allows participants not only to give ideas, but also to partly solve the problem. Indeed, as said Charles Kettering, a problem well stated is a problem half solved. Second, the participations can be made from any place, at any time, asynchronously and anonymously without the pressure of the group look. Third, it integrates a graphic monitoring the consensus evolution and the interactions. It enables, for example, to make a link between the changes of opinions and the leadership in groups.

The influence of the group on individual decisions has been evoked by social sciences, but it is difficult to observe. In web recommendation systems, traces allows a better evaluation of such influence, but this remains approximative. With Qlim, this process of influence can be studied more accurately with all traced interactions because the process converge pretty rapidly. In all these examples, we saw that the media offer a key functionality that is the aggregation capacity of all the individual interactions in a collective intelligence (decision, consensus, advice, ..). First, it provides the computer framework necessary to support the collaboration (often through the web), keeps the traces of interactions, synthesizes the trends, computes the results. The aggregation capacity provided by the media combined to the human intelligence finally gives its real power to the collective intelligence. But even if the potential is substantial, it is not out of risks coming from the reuse of personal data.

ON THE ETHICAL AND LEGAL ASPECTS OF THE USE OF TRACES

By nature, the use of traces of activities is problematic from an ethical and a legal point-of-view. Indeed, each individual has the right to preserve his privacy and not to disclose the portion of his activity that he considers as personal. In legal terms, the laws of most democratic countries govern the practices as the "Data Protection Directive" in the European Union. The basic principle is ultimately quite logical in the sense that the user must be informed and accept for the use of his personal data. That said, the legislation may be inconsistent and the willingness of some countries may also be limited when the economic and political interests are at stake. Many examples have shown that traces have been used unbeknownst to users, sometimes with painful consequences. Without going into philosophical debates, we can make several observations on these issues.

Different types of risks

On the technology side, and before all other considerations, it is important to observe that most media have a natural ability to record the activity. At the origin, for checking the proper functioning of computer systems, these capabilities have also been used to make statistics and extended to CRM

(Customer Relationship Management). In some cases, the ignorance of the media functioning can also cause some misuses leading to any indiscretions with unexpected consequences. The newspapers cited a lot of examples of individuals that have been dismissed for having put on their blog some criticisms against their company or sometimes simply for having a philosophy of life judged out of the norm.

Outside personal indiscretions, the problem may come from the imprudence of others. Indeed, several social networks platforms exploit the ability to integrate directly contacts address books (eg. from Gmail). Except if we not use email, each of us may one day find his address on bad sites and be "watered " by spam simply because of some careless friends. The traces can also be used by pressure groups to orient the information, organize over-classification of certain links in the search engines or make abusive redirections. The case of "Google bombing" is typical of this risk that made headlines during the 2007 presidential campaign in France. On this occasion, any user making a search on the candidate name "Nicolas Sarkozy" saw himself redirected to a web site related to "Iznogood". Using a weakness in the page-rank technique, this method is very simple and virtually unstoppable. It was enough that was made a sufficient number of links between the name of the candidate and the address of the website Iznogood-the-film. As can be expected, other political figures, with more or less humor, have been targeted by this kind of manipulation. In the other side, the recent news concerning the mass hidden monitoring operated by the NSA have woken up the fears of big brother, as in the novel of Georges Orwell (Orwell, 1949). Even if all countries monitor a part of their populations for security reasons, the motivations are sometimes less clear. (Rusbridger, 2013)

But, at short term, the most important risk is probably related to malicious softwares. We should be conscious of our increasing dependence to computers systems ranging from banking services to energy power management. In such context a wide spread of computer viruses can cause real damages having an impact on the whole economy (loss of jobs, ..) and cause society disorganization. Without going so far, the spyware is one of the most common and the most current of these softwares associated with the risk of traces operation. Having said, this concept is blurred in the minds of individuals and is often mixed with a popular form of psychosis which distorts or multiplies the risk perception. An example of a real risk associated with Trojan spyware is that of keylogers that makes a distant capture of passwords or credit card numbers in order to misuse the user identity (e.g Chewbacca). The keyloger can take various forms, but usually a firewall, an anti-virus up to date and a little common sense allow to reduce the risk significantly. Moreover, introducing such processes on a user's machine is an offense clearly identified. These examples show that even if the risk associated with the use of traces exists and should not be underestimated, it is not always seen in its reality, sometimes overvalued or underestimated and not necessarily focused on the good actors.

Evolution of the risk perception

Historically, we can see that regarding the mediated activity, the vision of the borders of privacy have evolved over the time. At the beginning of the use of the phone, for example, users considered as an intrusion of having to pick up the handset. They perceived as a risk to have a caller with whom they not wanted to talk. So it was customary that a servant plays the role of mediator (Flichy, 2006). More recently, the example of British in term of sensitivity to individual freedoms has also evolved. First, the simple fact of having to present their identity card was considered as an infringement of their freedom, they accept now widely the security cameras scattered in English cities as in all modern countries (Porter, 2004).

The reasons for these changes of opinions come without doubt from the habituation and from a new equilibrium between the perceived benefits in terms of security compared to the risks in terms of loss of freedom. This remind us what we said above in relation with the establishment of trust (see

Axelrod statement). The regular usage of the technology have definitely changed the perceived nature of the problem, revealing that negative expectations may be overvalued. Regarding traces of on-line activities, the question may also be partially addressed in this way. The regular arrests of terrorists or of pedophiles by tracking their on-line traces are also likely to change public opinion. The evolution of the perception of the balance between risks and benefits could also be measured remembering that the use of credit cards in e-commerce was not built in a day, even with a lot of guaranties. It gained the trust after a long era of suspicions and fears. With the practice and the awareness that the risk was small compared to the benefits, the acceptance has evolved gradually.

Under another perspective, a decade ago, some users have seen a resurgence of the hegemonic will of Microsoft when it proposed a control software with the new versions of Windows operating system. Over the course of time, even if these fears are not completely allayed, we see that this software also enables to protect, relatively reliably, the computers by automatically installing updates that secure the system significantly. The question of the perception of the balance between risks and benefits is the same here. Even if we can not underestimate the commercial ulterior motives of Microsoft (which may seem normal for an industrial), is this risk higher than the benefit of avoiding security holes in our computer? A recent enlightenment to this question was given by the results of the 2014 Cisco security report that states that 99% of all mobile malwares in 2013 was aimed at Android, that is an open-source operating system !

Beyond the individual perception, the influence of the group is also a factor since many individuals are determined by what does or feels the majority. The perception of risk is also affected by these phenomena. The ethologists show, for example, that the organization of animal groups (shoal of fish, ...) is partly motivated by the fact that the perception of the risk of being the victim of a predator is lower in a group. This fact can be observed in the case of illegal downloading (peer to peer) where the argument of the mass is more or less consciously seen as a protection. Anyway, as we consider the individual or the group, issues of acceptability are essential when we are trying to implement a tool or a service. This situation therefore also arises regarding the use of traces.

CONCLUSION

At the moment where the compression of time and space allowed by computers tends to expand our vision of knowledge, the use of media is at the heart of a lot of debates and research works. Apart from methodological issues, we can put forward several points in relation with governance that we believe worth to investigate.

First, let us cite the need for governments to obtain a feedback from the population. The relation between the public opinion and the wealth of the democracy has often been evoked (Fishkin, 1992). At the beginning, this question was largely ignored since governments, often totalitarian, did not saw the necessity to consult the people under their administration. After several revolutions, every one (should) have understand that a good governance requires rules approved by the majority. Thus, it is not rare to observe the organization of polls in order to see if the public opinion is mature for some sensitive decisions. For some politicians, having this feedback is only necessary to avoid the risk of people dissatisfaction but for others, the collective opinion is a real added value for governance. For example, the theory of public choice (Nobel price JM Buchanan) try to adapt the collective insight of the market laws to the politic administration. In such view, the motivation of individuals in front of the collective benefits is a key issue.

In some countries, official public “votations” are frequently organized on the direct push of citizens. This is the case in Switzerland where the law dictates that any petition garnering 100,000 signatures

must be put to a nationwide vote. Recently, the majority in favor of immigration restriction make the buzz. This trend to vote from public initiatives is accelerated with media such as tweeter where the public opinion can be evaluated immediately on almost every topic. Researchers have designed automatic systems that compute the opinion ratio that can be interpreted as an indirect vote. The methods we evoked in this chapter are possibly usable at large scale, but also in local context as in factory as we seen with the e-brainstorming Qlim tool.

Another contribution of such "social monitoring" is to better understand the trend of the society. We can observe that the media capacity allows a new form of direct organization between people. This is a clue showing that central institutions related to education or commerces lose a part of their power. Indeed, it is not rare to note people acting together when they want to buy something or if they want to defend their rights more effectively (class action). Other initiatives such as micro business or crowd-funding already functioning show this trend to people empowerment. In the educational context the development of MOOCs (Massive On-line Open Courses) is also a clear sign of this tendency. In some case, the diploma, the age limit, the location or the inscription fees is no more an issue. Whatever the topic, courses can be found freely on the web for all people who are ready to make efforts.

Of course, this presentation should not make forget the side effects. The lack of control and of guaranty can be a real drawback but in the other side, the fall in the Orwell word is also a risk. Furthermore, whereas the diversity is positive regarding the emergence of collective intelligence, the overload of information is rather a break. Thus, the major concern could be to identify the right mode of control in order to take the better profit of the collective intelligence. The actual answers are still basic. By making an analogy with the wind, which can be used only when it appears, since, if the phenomenon is well known, it is not possible to control it. It is a little bit the same with collective intelligence, the possibility of control seems still a dream. Yet, as we have seen, in a certain way, such management is possible. Human driven adaptable services such as recommendations systems could be the key to reach the equilibrium between constraints and benefits. But what are the conditions, the benefits and the limit of such strategy ? Even if we gave some partial answers to these questions it remains a lot of works to do. In this sense, this still emerging field of research is a real challenge.

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