Reconsidering Clark's Theory in CSCW

Nicolas Nova, Mirweis Sangin and Pierre Dillenbourg[1]

[1] School of Computer Sciences and Communication, Ecole Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland.
nicolas.nova@gmail.ch, mirweis.sangin@epfl.ch, pierre.dillenbourg@epfl.ch

Abstract. The use of Herbert Clark's work as a theoretical framework in the Computer Supported Collaborative Work domain is often dismissed or judged as "cooked" and led to a large body of controversy. This article intends to reconsider his contribution and re-examined the criticisms he received. The main critics addressed to Clark are that his notion of Common Ground is far too mentalist and lacks "situatedness". We argue that most of these criticisms stem from the verbal conversational aspects of Clark's theory. We sustain here the idea that his broader model of the "joint action" provides a fruitful ground for research in CSCW. Through one case study of our research, we indeed show how what Clark defines as "Common Ground "could be interpreted in a situated context. The discussion also addresses how this model can serve as a design framework.

Keywords: CSCW, theory, Intersubjectivity, Clark, Common Ground, Grounding.

1 Introduction

From the beginning of the CSCW field, theories have played an important role for the examination of collaborative practices as well as the design of efficient multi-user applications. Different theories such as Malone and Crowston's Coordination Theory [1], Distributed Cognition [2], Activity Theory [3] [4] or Situated Action [5] have been drawn from other disciplines and have been applied to make sense of collective activities. What is interesting with this small sample of theories commonly transferred to CSCW is its relative heterogeneity in terms of disciplines of origin. While Distributed Cognition emanated from the Anthropology tradition, Coordination Theory came from the Organizational Sciences. Apart from them, other frameworks that operate at a finer-grained level have also been employed. This is obviously the case of the work from Herbert Clark in psycholinguistics [6][7][8][9][10][11]. Originally a psychologist, Clark's work about the cognitive and social processes of language use has received lots of interest in CSCW. Various researchers [12][13][14][15][16][17][18] employed it for its relevance as a framework to understand how collaboration can be influenced by information technologies. However it is noteworthy that these researchers have mainly focused on the verbal interaction of Herbert Clark's Model and less on its importance to describe

coordination or joint activities. That said, Clark's theoretical framework has received more and more criticisms in the last decade. CSCW researchers have indeed raised doubts concerning its validity both for linguistics reasons and issues intrinsically linked to the field.

The goal of this article is twofold. First of all, we aim at providing answers to some of these criticisms. Second, we will argue that Clark's broader model of "joint activity" can provide a fruitful ground for research in CSCW. For this purpose, we first give a summary of Herbert Clark's model, introducing the notion of joint action, coordination devices and common ground and how they have been employed in CSCW. Thereupon, we describe and debunk the main critiques this theoretical work as received by linguists and researchers from our domain. The third part of our paper presents empirical evidence to support a more situated reading of Clark's work. Finally, we discuss the implications of this stance, showing both the importance of theory and why it matters for groupware design.

2 Theoretical considerations

2.1 Clark's theory

Herbert Clark's work in psycholinguistics first appealed to CSCW researchers because it provided a comprehensive framework and vocabulary to describe concepts of interest for designing collaborative applications. This included intersubjectivity [9][11][6], coordination [7] or how certain technologies affect these collaboration practices [8]. According to him and his colleagues, language, be it verbal or non verbal, is used when a group of people has to perform joint activities that require coordination with each other. In each joint action, participants face what Schelling [19] called coordination problems whenever they have common interests, or goals, and each person's actions depend on the actions of the others. In Clark's terms, the problem for the participants in a joint activity is thus to infer what individual actions they can expect from each other so that they can pursue the public goal of their joint activity. To solve the aforementioned coordination problems, participants rely on what Clark called after Stalnaker [20] the "common ground" (CG henceforth): the knowledge, beliefs and suppositions participants share about the activity, and that accumulate over the course of actions. He also described how this CG is constituted of "coordination devices": a rationale for mutual expectations that make partners believe that they will converge on the same joint action.

Of all the coordination devices, the most important are certainly explicit agreements, which are occurrences of dialogues in which parties explicitly communicate their own intentions. When two persons want to meet at a certain place, they often solve that problem by talking to each other and agreeing on the place and the time.

Another important type of coordination device is the convention; which Lewis [21] describes as the community's solution to a recurrent coordination problem.

Conventions or conventional procedures range from rules and regulations to less formal codes of appropriate conduct. They are not habits or practices but rules such as stopping at the red traffic light or placing knives on the right. Conventions can also be more "local" and less bound to the community; for instance three persons who want to meet for lunch every Tuesday (a joint action) can agree on meeting at a certain place at 12:15. They then each go there at that time every Tuesday (their participatory action). In this case, going to the meeting place is not a habit but a convention that has been set by participants of the joint activity. According to Clark, this is because "that is what they mutually expect each other to do based on the regularity in their recent behavior" [7]. As we see in this example, an explicit agreement can evolve into a convention if it is established as the agreed solution to a recurrent problem.

In addition, people ordinarily solve coordination problems using non-conventional coordination devices. Clark identifies two types of devices: precedent and manifest. Precedent applies to norms and expectations developed within the on-going experience of the join activity. If I remember that my friend Paul was at the local pub on Friday afternoon of last week, I may expect him to be there this week. Unlike the convention of meeting every Tuesday at 12:15, precedents do not depend on mutual agreement about an action, they are only expectations based on the previous experiences of participants. Malle [22] also coined the term "causal history explanation" to refer to expectations based on knowledge of previous behavior of that concept because the factors that predict a possible behavior lay in childhood experiences, past behavior or the agent's traits.

The second type of non-conventional coordination device is manifest elements from the environment. Clark also called this "perceptual salience": it refers to situations in which the environment (or the available information) makes the next move apparent within the many moves that could conceivably be chosen. During surgery, for example, pointing a certain element of anatomy can make it clear to all parties involved what to do next. Coordination by manifest elements or perceptual salience is thus produced by the very conduct of the joint activity itself.

These four coordination devices refer to mental representations (conventions, precedent), perceptual elements from the environment setting (manifestness) and communication (explicit agreement). The relationship between coordination and the common ground is twofold. On one hand, the process of coordination can be described as updating this common ground through the addition of new information (in the form of coordination devices). On the other hand, coordination devices are nothing more than a shared basis meant to enable the coordination of participatory action that would eventually contribute to joint actions.

The construction of mutual expectations about participatory actions is consequently both cognitive (i.e. expresses the need to access to mental representations) and situated, given the set of coordination devices people can rely on. Coordination devices thus produce mutual intelligibility between participants. By producing and perceiving those elements, people are actively enabling intersubjectivity with each other. Nevertheless, this exchange does not mean that coordination is an explicit and permanent process in which participants constantly monitor and interpret the devices that are available or that has been produced. Coordination should rather be seen as a mutual alignment process during which people takes advantage of the available elements.

Interestingly, this framework has been employed more as a model of discourse and communication than a model of coordination (see for example [12][14][15]). [23] for instance used the CG model as a theoretical framework to study remote problem solving mediated by synchronous textual interaction and whiteboards. Susan Fussell and her colleagues [13] intensively used Clark's theory in their studies of collaborative physical tasks (e.g. bicycle repair task, toy-robot building task or online jigsaw puzzle) and manipulated features of technology that a pair of students could employ to complete the task (e.g. [16][17]). In the same line of research, [18] referred to Clark and colleagues' work in a study of collaborative remote repair tasks using video-mediated communication. Wang and Rubart [24] recently applied Clark's theory on language use to hypermedia language in cooperative work settings and derived a conceptual framework aimed at informing the design and comparison of cooperative hypermedia systems and their use.

2.2 Critiques against Clark's theory

Although the previous section highlighted the success and relevance of Clark's model in the study of collaboration, two research communities criticized it: linguists from other schools of thoughts and CSCW researchers.

Linguists from the "pragmatic school" have issued two majors comments regarding the "Common Ground" theory and its various instances [25]. The first criticism concerns the representation of CG as most of them assumed that Clark claimed how CG was iterated through series of checks an individual should do to ground the mutual understanding (A should know that B knows X, B should know that A knows she knows X, and ad infinitum). Pragmatists such as Green [26], Schiffer [27] or Sperber and Wilson [28] hence criticize how overwhelming this would be from a cognitive point of view. Paradoxically, Clark fully agree with that, showing in his 1996 book how this kind of recursion is not possible and that the CG is rather shared: there is no need for these checks but that simply recognizing that a piece of knowledge is "shared" between the two conversants is sufficient. By pointing out this fundamental problem, Clark contenders had a partial reading of his work and dismissed the very notion of Common Ground leaving aside the notion of a shared representation. A second criticism of Clark's theory concerned the notion of uselessness of the CG. To researchers from the "inference school" such as Sperber and Wilson [28] what is important in communication is not the CG but the "mutual manifestness" of facts in the participants' environment. As these authors stated, conversants share the same "cognitive environment": a set of facts that are relevant to a person (i.e. that he or she can perceive and draw inferences upon it). However, these criticisms of Clark's theory have focused on earlier versions [9][11] since in the last version of Clark's theory, the notion of coordination devices exchanged during a joint activity is actually not far from the mutual cognitive environment.

More relevant to the discussion here is the fact that Clark's approach and theories also received a fair amount of disapproval from researchers in the CSCW field. For instance, Koschman & Lebaron [29] described how features of the material and social environment that people draw upon to make decisions were neglected in Clark's theory. They also complained about the difficulty they had to locate common ground

in the discourse utterances they studied in their research: to them, it could not be treated as an empirical fact, because it could not be observed, either directly or indirectly. For Koschmann and LeBaron problems arise when one consider CG as a possession of conversants such as a cooperatively constructed mental abstraction (i.e. a place to store and record things). The CG becomes "a place without place". Similarly, Arnseth and Ludvigsen [30] stated that according to Clark's view, communication was conceived as a process of coordinating knowledge that participants already possess. They rejected Clark because he presumably neglected that social interaction was the main "site" where participants' mental states were articulated, as if intersubjectivity was independent of the situation and the activity. Their criticism is thus that there would be too much mentalism in Clark's words.
What is very surprising is that those two criticisms dismissed Clark's work on the basis that the common ground was not situated, which is wrong and definitely based on an overly mentalist interpretation. These authors complain about the mentalism (the over-reliance on mental representation of the participants to coordinate among each others) as well as the difficulty of observing the CG. But they forget the elements that constitute it (i.e. coordination devices) are not all mental representations: explicit agreements and manifest elements from the situations are, by definition, situated and they are hence observable in the course of action.

The discussion about the situatedness of Clark's theory also refers to Suchman's discussion of plans and situated actions [5]. Suchman defined the notion of situated action in the context of human-computer interaction: she argued that human actions are not planned in a strong sense (as supposed by some cognitive scientists) but that they are linked to the current situation. She showed that actions are to a great extent linked to the specific situation at hand and are therefore hard to predict by using generic rules. To her, various kinds of information are available as "resources for action" and she describes how plans are such resources but that they must not be treated as control structures. Plans, to her, are local, situated and opportunistic: people only create a plan for local problems. This is actually not contradictory with Clark's theory, in his own terms, Suchman's plan can be considered as a "local convention" that is set by participants to solve "coordination problems". The plan can therefore establish a relevance hierarchy in the inference process by creating preferential coordination devices to solve the joint task. A plan is actually nothing more than the discussion of a local convention to solve a local problem. Finally, the way situated action describes human action is not contradictory with the coordination problem-driven theory of Clark: we underlined how coordination devices, as plans, are event-driven resources for action. The main difference is, however, that Clark accounts for some cognitive resources such as precedent or conventions.

McCarthy [31] asked the question of whether computer supported cooperation should be about the technical accomplishment of communication (as underlined in Clark's Model) or about the dialogical experience of collaborators. He stipulates that the limitations emerging from the use of Clark's model are that it forgets relational history (e.g. judgments of credibility, trustworthiness of information) and culture, which are preponderant in real situations. Here again "conventions" such as described by Clark [7] can be evocated as cultural coordination devices that can serve as theoretical model to frame research in technology mediated coordination.

Even though some criticisms cannot be dismissed, most of the comments that have been issued by CSCW and linguists can be countered by two arguments. The first one is that some critics only focused on early versions of Clark's work, not taking into account the recent contributions: the coordination devices. This aspect actually highlights the importance of cognitive, situated and social aspects of interactions, in the construction and the update of the common ground. As a second argument, these more recent elements about coordination devices counterbalance the very mentalist interpretations of Clark that dismissed his theory. To sum up, most of the criticisms addressed to Clark are on his consideration about the verbal interaction level. We sustain here the idea that the generalized model of "joint activity" during conversations proposed by Clark [7] can by effectively applied to the general problem of group coordination in CSCW. We agree with Klein and his colleagues [32] that "Joint activity" relies on coordination features such as interpredictability of the participants' attitudes and actions that are based on common ground. Furthermore, joint activity also relies on what the authors call "basic compact" – an often-tacit agreement to facilitate coordination and prevent its breakdown through commitment to align participants multiple goals (i.e. maintaining the common ground). Hence the Common Ground is the most important basis of inter-predictability. It is noteworthy that the CG in our view is not a state or a "space" [29] of "having the same knowledge, data and goals" [32]. One can rather refer to the CG as a process of building and maintaining a mutual understanding [7].

3 Empirical grounds

Now that we have described Clark's model, how it's criticized and what arguments we can oppose, let us complement our argumentation with our own research. Qualitative results from one of our studies offer an empirical basis to what we described above.

3.1 Field study procedure

A recent study we conducted addressed the socio-cognitive influence of location-awareness interfaces (see [33]) showing how knowing others' whereabouts has intricate relationship with group coordination. In this field experiment, we designed a pervasive game called Catchob! played by groups of 3 players who had to collaborate to find a virtual object ('Bob') located somewhere on our campus. Team-mates used TabletPCs on which they could access a map of the environment and different features represented on Figure 1. The interface features an individual proximity sensor, which indicates whether the user is close or far from the object through the number of red bars displayed at the top of the interface. The tool also enables synchronous communication through shared map annotations with the stylus (with a different color for each player). Annotations slowly fade out until they become completely invisible (after 4 minutes).

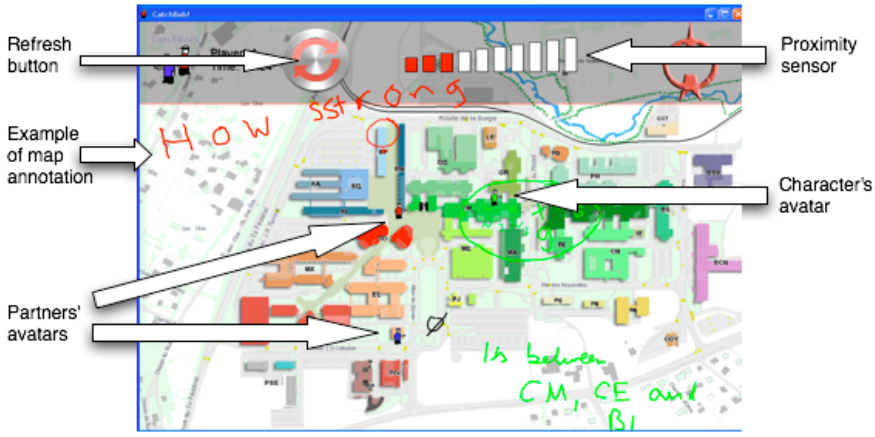

Fig. 1. Game interface as seen by one player. Location-awareness is the fact that 2 players avatars are displayed.

Moreover, an important feature of that interface was a location-awareness tool that enabled them to automatically get each of their own spatial location in real-time by clicking on a refresh button. Our precedent COOP paper in 2006 tackled the differences between the presence of this location-awareness tool and its absence, showing how self-disclosure can be more powerful because it allowed to convey intentionality. In order to deepen our understanding of the role of location-awareness in collaboration practices, we continued our investigation by how players coordinated and what information they relied on to figure out what their partners were doing.

10 groups of 3 students of our school participated in this field study. After being presented the game instructions at the lab, players were given 3 minutes to plan their strategy on a map (grounded plan), which was then left in the office. Players were then led to the common starting point at the centre of the campus. After completing the game (or reaching the 30 minutes limit), players were interviewed together using a replay of their activity (see more about this in [33]). The replay tool displayed in real time the position of each group member as well as their annotations. Those traces of the activity were presented to push players to explain what happened, an interview technique known as self-confrontation [34]. The player or the experimenter selected episodes of the game replay and asked one player to tell what happened then. In general, the player's answers triggered other comments by partners, turning the interview into a discussion about each of these moments. Conversations were recorded and for each episode, the experimenter also asked one player whether he/she knew what one of his/her partner was doing (and then thus partner was asked if the provided answer was right). This interview allowed us to collect evidence of the inferences performed by the participants.

3.2 Results

Post-game interviews, conducted along with a replay tool of the players' activity allowed to collect verbal comments about the activity matched with shared map annotations. This leads to the description of a typology of "coordination devices": the mutually recognized information that enables teammates to choose the right actions for collaboration. We observed five categories of coordination devices (the description below included excerpts from the post-game interview, all translated from French):

1) The plan that players set before starting the game was the most often cited coordination device. During these few minutes players discussed both the strategy they wanted to apply and the communication conventions they would use: "We decided that we would begin to send messages only when having some signal on the proximity sensor"; "We planned that the first who had some signal would send it to the other with the figure written on the map, before anybody should communicate anything".

2) Communication acts were the second most prominent coordination device cited by players. Even though communication was achieved through a narrow medium (map annotations on the TabletPC), important discussions about strategies discussion have been undertaken. The excerpts below provides examples of dialogues (as players recalled them): "I knew they were joining me because I drew a circle on the map where I thought Bob was, and they said ok we're coming"; "At that moment, I asked her what she was doing and she told me that she was backtracking". Dialogue occurrences like these were important for trajectory awareness and division of labor. However, most of the communication acts were not proper dialogues but announcements of proximity signal information ("I was telling them my readings, on a regular basis":), self-declared positions ("As soon as I got a reading I would put it and I would tell him where I was") or trajectories ("He drew an arrow, he marked the reading he was giving and the general direction where he was heading").

3) The location-awareness tool has been cited as an important coordinative device by players: "I saw that he was going in that direction, then I joined him", "I saw Sandra heading to the CE building so I thought we had to join her", "I knew they were arriving though the IN building because I saw their last positions".

4) Knowledge about the partners was also a powerful coordination device for some groups as explained by these two players: "I saw that Sandra was not moving, but I know her, she always moves and she's not lazy, so she was moving", "I saw he was coming from downstairs but I know him, I thought he would take the lift instead of the stairs". By knowing a partner's habit and behavior, players could infer some meaning about the course of action.

5) Knowledge about the environment was a key to coordination. Here are examples of how two players expressed this: "There is a bottleneck here between the CE and CM buildings, I knew he could only arrive from there", "I did not know he were joining me or go elsewhere but I knew there were a chance that I would meet him at La Coupole [center of the campus]".

This list of coordination devices actually fits with Clark's model of coordination that we presented in Section 2.1 as they correspond to his typology of devices. In Clark's terms, knowledge about partners and the environment would be "Precedent"

(when a precedent experience allows participants to form some expectations about others' behavior). Dialogue acts would be "Explicit Agreement" (when the participants explicitly acknowledge the information exchanged). The grounded plan discussed at the beginning is a set of "Conventions" (when conventional procedures are set by the participants). And finally, manifest elements from the environment; topology, network coverage, location-awareness information and non-acknowledged communication would be "Manifest elements".

4 Discussion and conclusions

In the present contribution, we argued that Herbert Clark's model of the joint activity in conversations can be broadened to the general notion of group coordination. For Clark [7], people enter in joint activities when they have to solve coordination problems (e.g. coordination in a collaborative treasure hunt). Coordination depends on the ability to predict more or less accurately the actions of others. This predictability relies on, the commitment made by each party to make its actions predictable (e.g. providing the partners with one's position), and the situation (e.g. the state of the problem; the time left; each partners positions etc.). Our empirical results have shown how coordination devices could allow this predictability. These features constitute what is called the common ground: the accumulation of "coordination devices" that can be considered as signaling mechanisms stemming from various sources such as verbal interaction among peers, the situation at hand, participants culture, etc. Clark proposed general categories of coordination devices (explicit agreements, conventions, precedents and perceptual salience) that can of course be deepened and more thoroughly described depending on the context at hand.

This paper did not aim at answering every critics addressed to Herbert Clark's theory. The present contribution was rather geared towards providing answers to the two main issues raised in the literature: the so-called mentalistic aspects of Clark's theory and its lack of situatedness. The aforementioned empirical evidences show how common ground could be interpreted in a situated context. It is also interesting to note how the process themselves, such Clark's grounding, are often more accepted by the research community than the substrate they manipulate (the common ground, the presence of mutual models). This situation is a bit paradoxical given that the existence of such process implies the notion of mental representation.

Furthermore, we believe the mentalistic view of the Clark model to be a side effect of the "crusade" against the cognitivist information processing model" (what was called by Cooper and Bowers [35], the "first wave HCI"), by authors of the "second wave HCI" pioneered by Winograd and Flores [36] and Suchman [5]. As sustained by Kaptelinin and Nardi [3], these approaches are mainly built upon "an unusually rebellious and antitheoretical branch of sociology known as ethnomethodology" [3]. Even though this second wave of HCI tradition broadly contributed to research and methodologies in CSCW, the antitheoretical stance may somehow weaken result generalizability. We agree with Kaptelinin and Nardi who emphasize on the importance of theoretical models for the purpose of comparability, abstraction and generalization. To paraphrase the authors, we need theoretical models in order to

move “forward, to know where to invest our energies […]. Otherwise we will always be going back to the square one of detailed renderings of particular cases” [3]. Clark’s general model of the “joint activity” is such a theoretical model that can help framing research in fields studying collaboration processes such as CSCW or CSCL.

Consequently, we sustain the idea that it is possible to have a more social and situated interpretation of Clark, which makes it still relevant to be employed as a framework in CSCW, fruitful not only for researchers but also for designers. On one hand, Clark’s “joint activity” model can serve as a theoretical framework (not to say “common ground”) for the process of hypothesis generation, abstraction generalization and result communication. On the other hand, Clark’s model can help the design of applications and services aiming at enhancing collaboration that involve the creation or the support of new coordination devices. Therefore, the early stage of the design of a groupware application requires to have a clear overview of how group members work but also employ coordination devices. Clark’s notions and typology is a representational framework to describe and predict team-mates behavior and thus propose appropriate solutions to support electronically the exchange of certain coordination devices.

References

1. Malone, T.W. & Crowston, K. (1994). The interdisciplinary study of coordination. Computing Surveys, 26 (1), 87-119.
2. Hutchins, E. (1995). Cognition in the Wild, MIT Press: Cambridge, MA.
3. Kaptelinin, V. and Nardi, B. Acting with Technology: Activity Theory and Interaction Design. MIT Press, 2006.
4. Kuuti, K. (1995). Activity Theory as a potential framework for human-computer interaction research framework. In B. Nardi (Ed.) Context and Consciousness: Activity Theory and Human (pp.17-44), Computer Interaction, Cambridge: MIT Press.
5. Suchman, L. A. (1987). Plans and situated actions: The problem of human-machine communication. Cambridge University Press: Cambridge.
6. Clark, H.H. (1992). Arenas of language use. University of Chicago Press.
7. Clark, H. H. (1996). Using language. Cambridge University Press.
8. Clark, H.H., & Brennan, S.E. (1991). Grounding in Communication. In L.B. Resnick, J.M. Levine & S.D. Teasley (Eds.) Perspectives on Socially Shared Cognition (pp.127-149). American Psychological Association: Washington DC.
9. Clark, H., H. & Marshall, C. E. (1981). Definite reference and mutual knowledge. In A. K. Joshi, B. L. Webber & I. A. Sag (Eds.) Elements of discourse understanding (pp.10-63), Cambridge University Press.
10. Clark, H. H., & Schaefer, E. F. (1989). Contributing to discourse. Cognitive Science, 13, 259-294.
11. Clark, H.H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. Cognition, 22, 1-39.
12. Dillenbourg, P. (1999). What do you mean by "collaborative learning"? In Dillenbourg, P. (Ed.) Collaborative learning: cognitive an computational approaches (pp.1-19). Elsevier, Oxford, UK.
13. Fussell, S., R., Kraut, R. E., & Siegel, J. (2000). Coordination of communication: Effects of shared visual context on collaborative work. In Proceedings of the 2000 ACM Conference on Computer Supported Cooperative Work, Philadelphia, PA, pp. 21-30.

14. Gutwin, C. & Greenberg, S. (2002). A Descriptive Framework of Workspace Awareness for Real-Time Groupware. Computer Supported Cooperative Work, 11(3), 411-446.
15. Monk, A. (2003). Common Ground in Electronically Mediated Communication: Clark's Theory of Language Use. In J. Carroll (Ed.): HCI models, theories and frameworks: towards a multidisciplinary science (pp.265-289), Morgan Kaufmann Publishers.
16. Fussell, S. R., Setlock, L. D., & Kraut, R. E. (2003). Effects of head-mounted and scene-oriented video systems on remote collaboration on physical tasks. Proceedings of the CHI 2003 Conference on Human Factors in Computing Systems, 513–520. New York: ACM.
17. Gergle, D., Kraut, R.E., and Fussell, S.R. (2004). Language Efficiency and Visual Technology: Minimizing Collaborative Effort with Visual Information. Journal of Language and Social Psychology, 23(4), pp. 491-517. Thousand Oaks, CA: Sage Publications.
18. Ranjan, A., Birnholtz, J. P., Balakrishnan, R. (2007). Dynamic Shared Visual Spaces: Experimenting with Automatic Camera Control in a Remote Repair Task in Proceedings of ACM CHI 2007.
19. Schelling, T. (1960). The Strategy of Conflict, Harvard University Press: Cambridge.
20. Stalnaker, R. (1978). Assertion. In P. Cole (Ed.) Syntax and Semantics vol. 9: Pragmatics. New York: Academic Press.
21. Lewis, D.K. (1969). Convention: a philosophical study, Cambridge, MA, HarvardUniversity Press.
22. Malle, B.F. (1999). How people explain behavior: A new theoretical framework. Personality and Social, Psychology Review, 3, 23-48.
23. Dillenbourg, P. and Traum, D. (2006) Sharing solutions: persistence and grounding in multi-modal collaborative problem solving. Journal of the Learning Sciences, 15(1), 121-151.
24. Wang, W., & Rubart, J. (2006).A cognitive and social framework for shared understanding in cooperative hypermedia authoring. Hypertext 2006: 53-56.
25. Smith, N. (1982). Mutual Knowledge. New York: Academic Press.
26. Green, G. M. (1987). Pragmatics and natural language understanding. New Jersey: Lawrence Erlbaum Associates.
27. Schiffer, S. (1972). Meaning, Clarendon Press, Oxford.
28. Sperber, D., & Wilson, D. (1986). Relevance: Communication and cognition, Blackwell, Oxford.
29. Koschmann, T., & LeBaron, C. (2003). Reconsidering common ground: Examining , Clark's Contribution Theory in the OR. In K. Kuutti, G. Karsten, P. Fitzpatrick, P. Dourish & K. , Schmidt (Eds.) ECSCW 2003: Proceedings of the Eighth European Conference on Computer-Supported Cooperative Work (pp. 81-98). Amsterdam: Kluwer Academic Publishing.
30. Arnseth A.C., Ludvigsen S., Mørch A., & Wasson B. (2004). Managing Intersubjectivity in Distributed Collaboration. PsychNology Journal, 2(2), 189-204.
31. McCarthy, J. (1998). Cooperation: Accomplishing Communication or Experiencing Relationships?, Working Notes of the COOP 98 Workshop on The Use of Herbert H. Clark's Models of Language Use for the Design of Cooperative Systems, Cannes, France, May, 1998.
32. Klein, G., Feltovich, P.J., Bradshaw, J.M., and Woods, D.D. Common Ground and Coordination in Joint Activity. In W.B. Rouse and K. R. Boff (Eds.), Organizational Simulation. John Wiley, 2004, 139-184.
33. Nova, N., Girardin, F., Molinari, G. & Dillenbourg, P. (2006): The Underwhelming Effects of Automatic Location-Awareness on Collaboration in a Pervasive Game, International Conference on the Design of Cooperative Systems (May 9-12, 2006, Carry-le-Rouet, Provence, France).
34. Theureau, J. (1992). Le cours d'action : analyse sémio-logique, Editions Peter Lang, Berne.

35. Cooper, G. & Bowers, J. (1995). Representing the user: notes on the disciplinary rhetoric of human-computer interaction. In. P. Thomas (ed.) The social and Interactional Dimensions of Human-Computer Interfaces, pp. 48-66. New York: Cambridge University Press.
36. Winograd, T., Flores, F. (1986). Understanding Computers and Cognition. Norwood, N.J.: Ablex