

Theories of cognition in CSCW

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Abstract. There are many theories useful for framing CSCW research and they may in principle be irreducible to a single theory. CSCW research explores questions involving numerous distinct—though interacting—phenomena at multiple levels of description. The useful approach may be to clearly distinguish levels such as individual, small-group and community units of analysis, and to differentiate terminology for discussing these different levels. Theory in general has evolved dramatically over the ages, with a trend to extend the unit of cognition beyond the single idea or even the individual mind. Seminal theoretical works influential within CSCW suggest a post-cognitive approach to group cognition as a complement to analyzing cognition of individuals and of communities of practice.

Introduction

There is no one theory for CSCW. Research in CSCW is guided by and contributes to a diverse collection of theories. Even the word *theory* means different things to different CSCW researchers and plays various distinct roles within CSCW work. The reading of the history of theory presented here is itself reflective of one theoretical stance among many held, implicitly or explicitly, by CSCW researchers.

The nature and uses of theory have changed over history and continue to evolve. The theories most relevant to CSCW—in the view developed in this paper—concern the nature of cognition, specifically cognition in cooperating groups. Through history, the analysis of cognition has broadened, from a focus on single concepts (Platonic ideas) or isolated responses to stimuli (behaviorism),

to a concern with mental models (cognitivism) and representational artifacts (post-cognitivism). More recent theories encompass cognition distributed across people and tools, situated in contexts, spanning small groups, involved in larger activities and across communities of practice. For CSCW, theory must take into account interaction in online environments, knowledge building in small groups and cognition at multiple units of analysis.

A brief history of theory

CSCW is multi-disciplinary by its nature and because of its origins. Consider the name, *Computer-supported Cooperative Work*: it combines concerns with *computer* technology, *cooperative* social interaction and *work*—very different sorts of scientific domains. CSCW grew out of research in fields like sociology, anthropology, informatics, artificial intelligence, cognitive science and social psychology—domains that are themselves each fundamentally multidisciplinary. Theory in these fields may take the form of predictive mathematical *laws*, like Shannon's (1949) mathematical theory of information or Turing's (1937) theory of computation; of *models* of memory and cognition; or of *conceptions* of group interaction and social practice. They may have very different implications for research: favoring either laboratory experiments that establish statistical regularities or engaged case studies that contribute to an understanding of situated behaviors.

In the European tradition, theory begins with the ancient Greeks—especially Socrates, Plato and Aristotle—and continues through the 2,500-year-long discourse of philosophy. In recent times, theory has veered into unexpected directions as it has morphed into sciences based more on empirical research than on intellectual reflection. For instance, the work of Freud, Darwin and Marx replaced traditional philosophic assumptions about fixed natures of minds, organisms and societies with much more dynamic views. Theory always transcended the opinions of common sense—so-called *folk theories* based on the everyday experience of individuals—to synthesize broader views. But folk theories have also changed over time as they adopt popularized pieces of past theories; thus, a trained ear can hear echoes of previous theories in the assumptions of common-sense perspectives, including in current CSCW research literature.

After the dogmatic centuries of the medieval period, philosophy took some significant turns: the rationalism of Descartes, the empiricism of Hume, the Copernican revolution of Kant, the dialectical development of Hegel, the social situating of Marx, the existential grounding of Heidegger and the linguistic turn of Wittgenstein. These all eventually led to important influences on theory in CSCW and the disciplines that contributed to it.

influences largely through several seminal texts: *Mind in Society* (Vygotsky, 1930/1978), *Situated Learning* (Lave & Wenger, 1991), *Lectures on Conversation* (Sacks, 1962/1995) and *Understanding Computers and Cognition* (Winograd & Flores, 1986).

Mind in Society is an edited compilation of Vygotsky's writings from the early 1930s in post-revolutionary Russia, which has been influential in the West since it appeared in English in 1978. Critiquing the prevailing psychology as practiced by behaviorists, Gestaltists and Piaget, Vygotsky did not try to fit psychology superficially into the dogmatic principles of Soviet Marxism, but rather radically rethought the nature of human psychological capabilities from the developmental approach proposed by Hegel and Marx. He showed how human perception, attention, memory, thought, play and learning (the so-called mental faculties) were products of developmental processes—in terms of both maturation of individuals and the social history of cultures. He proposed a dynamic vision of the human mind in society, as opposed to a fixed and isolated function. The Hegelian term, *mediation*, was important for Vygotsky, as it is for CSCW. Even in his early years still talking about stimulus and response, he asked how one stimulus could mediate the memory of, attention toward or word retrieval about another stimulus (Vygotsky, 1930/1978, p. iii). In Hegelian terms, this is a matter of mediating (with the first stimulus) the relation (memory, attention, retrieval) of a subject to an object (the second stimulus). This is central to CSCW because there the work is mediated by technological networking as well as by cooperative interaction, so analysis of cognition has to include the mediating technology and the cooperating partners.

Situated Learning went beyond Vygotsky in expanding the unit of analysis for learning. For Vygotsky and his followers, analysis must include the mediating artifact (tool or word) and the peer or group. For Lave & Wenger, the unit of analysis is a larger community of practice. Adopting the theoretical and analytical centrality of social practices in Marx, they focused on learning as the development of processes and relationships within the community in which individuals participated. Learning was viewed on the model of apprenticeship, in which an individual gradually—and primarily tacitly—adopts the practices that are established within the community in which the individual is becoming a member. Within CSCW, this approach can be seen in the idea that cognition is an aspect of social practices as developed by and engaged in by a community.

Lectures on Conversation laid the cornerstone of Conversation Analysis (CA), which studies the linguistic practices of communities. It was based on the ethnomethodological (Garfinkel, 1967) perspective, grounded in both Wittgenstein's linguistic analysis and Heidegger's (1927/1996) and Husserl's (1936/1989) phenomenological approach. Like Wittgenstein, CA analyzed language at a unit larger than the isolated word or speech act. CA focuses on *adjacency pairs* used in conversation (see Schegloff, 2007 for a systematic

Theories of individual cognition in CSCW

Many research questions within CSCW involve individual cognition. CSCW research is often treated as a sub-discipline of social-psychological research, oriented to the mind of the individual participant, within group contexts. Such research can follow traditional scientific research paradigms based on pre-Kantian empiricism (Hume) and/or rationalism (Locke). CSCW research often adopts a constructivist approach, based on the Kantian principle that the individual constructs his or her own understanding of reality. Such constructivist theory is cognitivist, in that it involves assumptions about cognitive processes in the mind of the individual underlying their observed behaviors.

Work within CSCW certainly acknowledges the importance of the larger social, historical and cultural context. However, it often treats this context as a set of environmental variables that may influence the outcomes of individual cognition, but are separable from that cognition. In this way, cognition is still treated as a function of an individual mind. This approach may be called *socio-cognitive*. It acknowledges social influences, but tries to isolate the individual mind as a cognitive unit of analysis by controlling for these external influences.

Followers of Vygotsky, by contrast, are considered *socio-cultural*. They recognize that cognition is mediated by cultural factors. Yet, they still generally focus on the individual as the unit of analysis. They investigate how individual cognition is affected by cultural mediations, such as representational artifacts or even by cooperative interactions. Vygotsky himself—who was after all a psychologist—generally discussed the individual subject. For instance, his concept of the zone of proximal development measured an individual's ability when working in a group, not the group's ability as such. Vygotsky was trying to demonstrate that individual cognition was derivative of social or intersubjective experiences of the individual, and so his focus was on the individual rather than explicitly on the social or intersubjective processes in which the individual was involved.

In this sense, much CSCW research investigates individual cognition in settings of cooperation. If one looks closely at most studies—e.g., in social psychology or management—that claim to be about small-group interaction, one finds that they adopt this kind of focus on the individual within a group setting and treat the group interaction as an external influence on the individual.

An example of a theory of individual cognition is psycho-linguistic contribution theory (Clark & Brennan, 1991). This particular paper is often cited in CSCW literature. Although the paper claims to be in the Conversation Analysis tradition, it translates the adjacency-pair structure of grounding shared understanding into the contributions of the individuals. It analyzes the individual contributions as expressions of their mental representations or personal beliefs and treats the resultant *shared understanding* as a matter of similar mental

theory addresses the study of teams in the most detail in Chapter 6 of (Engeström, 2008), it is mostly concerned with the group's situation in the larger industrial and historic context; rather than analyzing how an analyzed group interactionally builds knowledge it paraphrases how the group deals politically with organizational management issues.

There is something of this avoidance of the small group as the scientific focus in other theories popular in CSCW as well, for instance even in distributed cognition. In defining statements of post-cognitivist theory, Hutchins has indeed explicitly pointed to group-cognitive phenomena:

- “Cognitive processes may be distributed across the members of a social group” (Hollan, Hutchins & Kirsh, 2000, p. 176).
- “The cognitive properties of groups are produced by interaction between structures internal to individuals and structures external to individuals” (Hutchins, 1996, p. 262).
- “The group performing the cognitive task may have cognitive properties that differ from the cognitive properties of any individual” (Hutchins, 1996, p.176).

However, rather than focusing on these group phenomena in detail, he prefers to analyze socio-technical systems and the cognitive role of highly developed artifacts (e.g., airplane cockpits, ship navigation tools). Certainly, these artifacts have encapsulated past cultural knowledge (community cognition), and Hutchins' discussions of this are insightful. But in focusing on what is really the community level—characteristically for a cultural anthropologist—he does not generally analyze the cognitive meaning making of the group itself (but see his analysis of group or organizational learning in Chapter 8 of Hutchins, 1996, for an impressive exception).

Even ethnomethodology (Garfinkel, 1967; 2006) and conversation analysis (Sacks, 1962/1995; Sacks, Schegloff & Jefferson, 1974; Schegloff, 2007) consider themselves social sciences, versions of sociology or communication studies, but not sciences of the small-group unit of analysis. They aim to analyze social practices, defined across a whole society or linguistic community. This may be a quibble over words, for they do in fact define many important processes at the group unit, although they call them *social*. Vygotsky, too, used the term *social* in an ambiguous way when he said that learning takes place socially first and then later individually. *Socially* can refer to two people talking as well as to transformations of whole societies. But for the sake of distinguishing levels of description or units of analysis in CSCW, it seems important to make clear distinctions. Table 1 suggests sets of different terms for referring to phenomena at the individual, small-group and societal levels. The distinction of these three levels is argued for by (Rogoff, 1995), (Dillenbourg et al., 1996), (Stahl, 2006) and others in CSCW and CSCL. We start with these three levels, which seem particularly central to much of CSCW work, although other levels might also usefully be distinguished, such as “collective intelligence” or “collective

Theories of small-group cognition in CSCW

As suggested above, the CSCW-related literature on small groups and on post-cognitive phenomena provide some nice studies of the pivotal role of small groups, but they rarely account for this level of description theoretically. They are almost always in the final analysis based on either a psychological view of mental processes at the individual level or a sociological view of rules at the community level. They generally lack a foundational conception of small groups as a distinct level of analysis and description. They often confuse analysis at the small-group level and at the societal level, and lack a developed account of the relationships among the individual, small group and community of practice.

It seems obvious that the small-group level should be considered particularly central to CSCW theory, because CSCW is explicitly concerned with supporting cooperative work. There are few other domains in which cooperative work, knowledge building or group cognition necessarily play such a central role. However, CSCW theoreticians have often tried to avoid the implications. We have seen this, for instance, in the case of activity theory—which could profitably be used to investigate group processes—where Engeström (2008) argued against a focus on group cognition because workplace teams tend to come and go quickly, forming changing *knots* of co-workers around ephemeral tasks. This argument echoed the attitude of Schmidt & Bannon (1992) in their programmatic opening article of the inaugural issue of the CSCW journal. In rejecting the use of the term “group” as a defining concept for CSCW, they reduced the theoretical perspective to one focused on individuals “articulating” (i.e., coordinating) their “distributed individual activities” (p. 15). They made this move despite claiming that their concept of “cooperative work” was congruent with Marx’ (1867) definition of cooperative work as “multiple individuals working together in a conscious way in the same production process.” Marx was analyzing in detail the historic shift of the unit of production from the individual to the group, but Schmidt & Bannon insist on still focusing on the individual. They complain that the units of cooperative workers are not well-formed, clearly defined, persisting groups. But that is beside the point. The theoretical point is that they accomplish work tasks and associated cognitive tasks (including articulation tasks and power struggles) through group interaction processes and that these should be analyzed as such, not simply as sums of individual actions and reactions or as effects of societal forces. In particular, as cooperative work shifts from the manual factory production of Marx’s time to knowledge building and other forms of intellectual production in the information age, group cognition phenomena call for analysis at the small-group unit.

There are distinct phenomena and processes at the individual, small-group and community-of-practice levels, and analyses at these different levels of description can reveal different insights. As Grudin (1994) put it,

well as due to the mediation of representational artifacts and media used by the group.

The theory of group cognition absorbs many ideas from the theories discussed above, including that of a shared dynamic dialogical space. Despite some scattered case studies by the authors already mentioned and their colleagues, there is not yet much documentation and analysis of empirical instances of effective group cognition. The analysis of group cognition needs not only specially focused methods to track its occurrence, but even prior to that it needs appropriate CSCW technologies and group methods to structure and support groups to effectively build knowledge that can be shown to be a group product not reducible to individual mental representations. The Virtual Math Teams Project was launched to generate a data corpus that would allow for the analysis of group cognition. This project and some analyses by a number of researchers are documented in (Stahl, 2009). Group-cognition theory focuses on the sequential team interaction within case studies of small-group collaboration. This takes place within an interaction *space* or a *world* in the Heideggerian sense, which opens up to allow the production of group-cognitive accomplishments. The interaction that takes place within such a world—whether face-to-face or online—is subject to a variety of constraints, as pictured in Figure 2.

Note that Figure 2 is not intended to be a model of objects and processes. Rather it tries to present some of the complex constraints on the discourse through which group cognition might be achieved. Neither the physical individuals nor their group are represented here as such; the dialogical (Bakhtinian) voices of the individuals enter into the sequential team interaction and respond to it. Over time, the sequential team interaction forms the central shared-dynamic-dialogic space within which the group-cognitive constraints interact. Behind the individual voices that enter into this interaction space are not so much minds containing mental representations, as a fluid background of past experiences and developed resources for action, which surface based on relevance to the interaction. The team discourse is situated in: the shared dialogical context generated by the ongoing interaction itself; the culture and history associated with the group's community of practice; and the socio-technical environment including the media of communication. The interaction is goal-oriented toward the task—as given externally but as enacted by the group—and mediated by a variety of kinds of artifacts, including codifications of knowledge products previously generated by the group. These artifacts might end up among the team outcomes, in relation to the guiding task. Of course, other constraints and influences are possible as well, coming for instance from the guidance of a manager or the motivations of a reward system. The point is that one can picture the whole system producing cognitive accomplishments without having to postulate mental representations in individual minds, let alone to reduce the whole system either to rational mental decisions or to regulation by social institutions.

the kind of network that he would endorse for picking apart and then reassembling instances of group cognition.

A multiplicity of theories in CSCW

In general, CSCW raises many fundamental questions for traditional theories, oriented as CSCW is to small groups and to online interaction. The accustomed characteristics of the physical world, in which colleagues and interlocutors are embodied and visible to each other, are often missing in CSCW settings, and that brings into question numerous assumptions of folk theories and traditional approaches. The group itself has no identity as a physical body and has no brain to possess its knowledge; it relies on external memories, which differ essentially from personal memories (Donald, 1991). The online world—shared dialogical space—has no location or extension. Team members can come from around the world and do not necessarily share local connections and culture. CSCW involves workers in qualitatively different social relations of production, modes of being in the world or forms of life; even Marx, Heidegger and Wittgenstein's foundational philosophies of post-cognitive theory need to be rethought for virtual groups. Concepts of causality, world, knowledge, cognition, intersubjectivity, interaction and presence need to be reconceptualized for theories in CSCW.

There are many avenues for developing theories in CSCW, as reviewed in this article. Although there are some similarities among these alternatives—often in terms of their critiques of earlier theories—there are strong differences of position and perspective. This is not necessarily a problem. There is a huge assortment of processes taking place in successful CSCW events: at multiple time scales and involving different aspects of interaction. It is possible to raise innumerable research questions, each requiring possibly different methods of investigation at various levels of analysis. It is likely that CSCW requires multiple theories, which are not reducible to one grand unifying theory and which even seem incommensurate with each other. This goes essentially beyond the common notion of *mixed methods*, in which two or more methods of analysis are used to triangulate a single phenomenon from different angles. There are distinct phenomena at different levels of description—and they interact with each other in complex ways in CSCW settings.

CSCW is the study of cooperative work, from a design perspective. Cooperative work often involves large communities, such as a company or a community of practice spread across companies. On the other hand, much of the actual work comes down to tasks done by individuals. But much of the coordination, decision making, articulation, brainstorming, discovery and knowledge building is accomplished by small groups. Community accomplishments are thereby mediated by small groups, which carry out the necessary activities and involve the individuals. Cooperative work involves a

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