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Traces and activity: a case study of a joint writing process mediated by a digital environment

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The interdisciplinary research presented in this article is part of the study of collective human activities supported by technical devices. We begin by stating the objectives of the study and the type of activity observed, i.e. joint mediated writing. Then, we describe our procedure by (i) justifying our methodological choices, which are grounded in a psycho-ergonomic approach of ethnographical inspiration, (ii) detailing the setup of the study and (iii) describing the modes used to present the observables. Next, we present our analysis of a session, while revealing some intermediate results related to the properties of computer traces of interaction and their use in the course of the session. We end with a discussion of the results and limitations of the study followed by the conclusion, which opens up some pathways for designing 'tracing systems' capable of supporting joint mediated activities.

Keywords: interaction traces; appropriation; case study; collective cognitive activity; technical devices

1. Prolegomenon

The interdisciplinary research presented in this article is part of the study of collective human activities supported by technical devices. The Codisant group studies the joint production of artefacts, seen as a social, cognitive and instrumental activity. The Silex group works in the field of knowledge engineering, focusing mainly on the traces of interactions between the actors and how they are used in mediated learning contexts. The members of both teams adhere to the idea that the way technical devices are utilised by users, whether in individual or collective situations, is a key process for the scientific study of the roles and functions of these devices in the development of the activities that implement them. More specifically, our idea is not to stop at the utilisation of such computer systems, but to go further by tackling their appropriation by humans.

2. Introduction

In cases of collective work in a computer environment geared to human learning, interactions between actors can be 'observed' at two levels. First, human analysts can look directly at the communicational flow; secondly, they can make use of digital tools to obtain a written record of the sequence of events taking place on the computer hardware manipulated by the interacting partners (keyboard, screen, network, etc.). This dual approach makes it possible to trace the activity of the 'group', comprising individuals and material objects. Our hypothesis is that analysing data generated by both the lability of human behaviour and the perenniality of machine states is likely to 'bring us closer' to the mechanisms underlying the appropriation process we are examining.

Certain digital instrumentation systems automatically save computer traces of interactions that are tangible for humans and in more meaningful format than log files. The use of these traces for analysis purposes is common in the field of mediated activities. But, it is rare in situations where the observer him/herself is the one producing the traces. Thus, despite its great theoretical and practical implications in terms of knowledge of mediated activity and design of 'user-centred' environments, the 'reuse' of experience based on the viewing of interaction traces has hardly been explored. The study of how users put computer traces to use is the core research area of the Silex team. This team considers that being able to view computer traces of interactions between actors and digital environments can facilitate the actors' appropriation of the environments.

The study we present in this article takes a clinical approach (Brassac 2003) to collective cognitive activity and constitutes a fundamental contribution of the Silex group in that it grounds the team's scientific orientation. The study was aimed at examining the roles and functions of interaction traces in a computer-mediated, joint human activity taking place at a distance. More specifically, we wanted to find out (i) whether actors use the computer traces of interaction displayed on the interface to carry out the writing activity and if so (ii) how and to what extent the use of

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these traces contributes to the appropriation of the digital environment by the actors.

On the methodological level, we took a singularist approach here insofar as we conducted a case study (Leplat 2002, Yin 2003, Passeron and Revel 2005). To study the interactions taking place between actors and between the actors and the digital equipment, we took an ethnographic approach, in view of shedding light on the roles and functions of activity traces in the interactive phenomena observed. On the theoretical level, the entire study adopts a non-mentalistic stance on cognition and therefore grants a substantial role to the mobilisation of artefacts in cognitive processes. Our approach to cognition is an interactionist one, wherein meanings arise from interactions between users *and* between users and the environment (Brassac 2004) and as such, our perspective is 'situated' and 'distributed'. It interlinks Suchman's (1987) and Hutchins's (1995) proposals, and more generally, research into the praxeology of human behaviour (Brassac *et al.* 2008).

We begin by stating the objectives of the study and the type of activity observed, i.e. joint mediated writing. Then, we describe our procedure by justifying our methodological choices, detailing the setup of the study and describing the modes used to present the observables. Next, we present our analysis of a session, while revealing some intermediate results related to the properties of computer traces of interaction and their use in the course of the session. We end with a discussion of the results and limitations of the study followed by the conclusion, which opens up some pathways for designing 'tracing systems' capable of supporting joint mediated activities.

3. Study goals and activity observed

3.1. Computer traces of interaction

We have shown elsewhere that digital environments offer trace information at different levels of abstraction (Ollagnier-Beldame and Mille 2008). The tracing may or may not be accessible to the user. When the user has access to the traces, they are displayed on her screen. Certain groupware interfaces that support joint activities and certain communication interfaces leave traces on the screen of what the users produce throughout the interaction. It is precisely the case in text writing applications and in instant messaging systems. These 'fingerprints' of the group's activity, which are inscribed in and by the work environment can be called 'computer traces of interaction'. It is precisely these traces and these system 'side effects' that appear *de facto* at the interface of certain joint-activity applications, which are the focus of the study presented here.

As mentioned earlier, we suggest that the presentation of interaction traces to the concerned actors can promote their appropriation of the digital environments being used. According to Millerand *et al.* (2001), this kind of appropriation can only be grasped if framed as a process involving transformations of the situation by its users. From this angle, when users select and adapt a given functionality of the computer to make it meaningful for their own use, they in effect 'redefine' the tool. Such observed 'deviations' from standard ways of using the tool can thus be seen as 'revealers of the diverse dynamics of appropriation at work in forming [new] practices' (Millerand *et al.* 2001, p. 403). According to these authors, it is 'in' the experience that a user has with a device that its appropriation takes place, and more broadly, in the 'object-generating process' that makes the technique into an object. For Rabardel (1995), appropriation results from a process in which instrumental genesis and actor development become intertwined in a nonlinear and difficult way that creates tensions between the object of appropriation and how it is used by the actor in a particular context. We retain Rabardel's definition, adding that, for us, the appropriation is an iterative process wherein the meaning negotiation at play during object use by a given individual authorises both its adoption and its adaptation to the current situation. We contend that the appropriation process takes place between two meaning-stabilisation moments, during 'intermediate' periods and ends up transforming both the individual and the situation.

3.2. Study goals

It will have become clear that our objective is twofold: analyse the link between tracing and appropriation, and relate the analysis to the situated and distributed nature of cognitive processes. To this end, we placed two people in a situation where they had to collaborate at a distance via digital machinery, in such a way that we could reach two goals. First, we need to document the use of computer traces of interaction, taking place during the appropriation of the digital artefact. Indeed, we observed operations such as backing up via the scroll bar, cut-and-paste operations and, perhaps, the timing of these operations to specify the roles and functions of these traces. Secondly, we aimed at bringing to light the collaborators' co-responsibility for the joint production of the object, while attempting to account for its situated, distributed and opportunistic nature.

3.3. Activity observed: joint mediated writing

The object to be co-produced was a set of instructions. The interacting participants were asked to jointly produce discursive forms in written format. The activity we observed, then, was the joint mediated writing of a procedural text, which is a particular case of 'conversational writing' (Krafft and Dausendschön-Gay 1999, de Gaulmyn *et al.* 2001), with the specificity that the 'conversation' is not really a conversation, in the strict sense, because the actors are not speaking but interacting via the net. Procedural texts and technical writings, as 'language, action and cognition' (Pascual *et al.* 1997), have been studied by psychologists and linguists (Heurley 1997, 2001, Ganier 2004) who highlighted definitions and dimensions of them.

Most studies on collaborative writing agree that it involves a series of writing phases and communication phases, i.e. periods of synchronous activity where the members of the group work at the same time and periods of asynchronous work where they write alone. To compose the joint text, each co-writer progresses in accordance with her perceptions of the actions of the others. In this type of activity, it is sometimes difficult to determine the exact output of the co-writing process, i.e. it is hard to distinguish the co-written productions from productions aimed at communication. The task we proposed here is similar to the one studied by Krafft and Dausendschön-Gay and (1999), where two or more persons who form a 'writing system' sit down around a table to compose a text together. These authors demonstrated the existence of an interaction-space construction stage in this type of activity, that is, a stage in which the actors identify and delineate the space and time where the collective work will take place. Social rapports, interaction roles and task execution are given in place at the same time, by way of this goal-oriented activity and the actors' interactions. In our own research on the joint design of forms (Grosjean *et al.* 2000, Brassac and Arend 2007), we have found that conversation-based writing is one of the activities in which the negotiation of meaning is at its peak. The collective design of a manufactured object (Brassac and Grégori 2003) or a graphic representation (Brassac and Le Ber 2005) is based on discursive productions that are necessarily subject to substantial debate. In joint text writing, unlike such objects or graphics, the product itself is a set of discursive forms, so the negotiation of meaning about the terms that will be settled upon for the final text is indeed crucial. In the case of interest to us here, the meaning-negotiation process has a large artefactual component in addition to its collective and individual dimensions. To carry out the activity, the writers interacted by and with the digital devices they had at their disposal.

In our experimental situation, the actors had to write origami (paper folding) instructions for making a paper box. The instructions were to be directed at an adult, hereafter called the 'third-party addressee'. We chose this type of text because it does not have a single 'translation' into words. Writing such a text involves more than just solving a one-solution problem. On the contrary, it is a creative design task, but one that can be performed by adults without any special skills. Two actors who did not know each other communicated at a distance. They were given various resources to carry out the task, including a video of hands doing the folding operations they had to describe, a chat panel for communicating with each other and a textboard where they were to write the folding instructions. The chat panel and textboard were taken from a software package called *Drew* (Corbel *et al.* 2003) developed at the Ecole des Mines of Saint-Étienne, France. *Drew* has several modules that support argumentation, including the chat panel and the textboard. We chose this software because it has an interaction 'playback' feature that produces post-activity traces without interpretation, and then exports them to a spread sheet for subsequent analysis.

4. Joint writing at a distance

4.1. Methodological principles

The activity under study here was mediated by language, and by a digital machine made available to the actors. The actors communicated and accomplished the task by the way of the keyboard, screen and mouse of the computer they were using, which was connected to the internet. They also relied on written task instructions provided on paper at the beginning of the experiment. We analysed their joint activity by the way of a set of 'observables' capable of accounting for several aspects of the activity. The observables included the final folding instructions turned in by the co-writers, the activity traces written in the digital device and video recordings of the interactions (films of the actors and their screens). These observables were not 'givens' but were 'constructed' in the sense proposed by Latour (2001) in his statement, 'Decidedly, one should never speak of "givens" but always of "obtaineds"' (p. 49). Accordingly, our observables did not become observables until the situation was set up and the activity of the actors had begun. They were not pre-existing givens that one could simply 'collect' for the purpose of analysis.

In this situation, the so-called 'collection' procedure was based on an ethnographic approach to the interactions, recorded in the form of videos and traces. The digital machine set up for the actors was equipped with a 'tracing' system (*Drew*) explicitly designed to record the events and operations they performed. Our rationale for choosing this method was the fact that only a qualitative method capable of revealing the fine-grained processes underlying interactions between humans, and between humans and digital artefacts, is well suited to observing, describing and analysing processes as poorly understood as the mechanisms of trace-based appropriation of a work environment. Indeed, we think that the 'temporal succession of actions' is important. That is why our analysis deals with the micro-temporality of the succession of linguistic, bodily and artefactual actions. In the situation staged here, all aspects of the writers' activity were recorded. Their actions on the screen (viewing and manipulation of the origami video, flow of (written) utterances in the *Drew* chat panel and textboard) were recorded by screen-capture software, and their discursive productions were traced by *Drew* itself. Actors were also filmed close up so that their faces and hands moving on the peripherals could be seen.

4.2. Setting up the experimental situation

Below, we present the key elements of the experimental setup: the actors and what they did, the digital machine and its interface, and the observables. The entire setup is described in detail in Ollagnier-Beldame (2006).

4.2.1. Actors

Given the methodological choices stated above for this case study, we considered the activity of one pair of actors. The two actors who carried out the activity were undergraduate students majoring in information and communication science at the University of Lyon. They were 23- and 25-year-old women, whom we nicknamed Rastaban and Yildun. They were French native speakers; they both knew how to use a computer online and were familiar with chatting in particular. They worked in pair without knowing who their partner was. On the computers, we had installed software that generated screen videos of the session. This gave us a continuous record of all interactions with the interface. The participants were filmed close up. After a demonstration of the tools with other students, the two actors were led into separate rooms. First, they carried out a simple, 5-minute co-writing task using the same resources as they would for the main activity. Then, for the next 55 minutes, they performed the writing activity aimed at producing the folding instructions for the box (with a different partner than in the first simple task).

4.2.2. Digital environment

The digital environment used by each pair of actors consisted of two computers connected via the internet. As the activity progressed, i.e. as each actor made keystrokes, the discursive segments produced were displayed in three, clearly delineated zones of the screen. A fourth zone showed the folding video, which the actors could manipulate themselves by backtracking, freezing on an image, etc. The actors had no other material resources at their disposal. Thus, to accomplish the task they were assigned (write instructions for folding a paper box), each actor had a screen divided into four zones, which looked as follows:

- The video of the folding procedure, which could be played, paused, forwarded, reversed, slowed down or stopped as the actor desired. The video lasted about 2 minutes.
- The chat panel of the *Drew* software developed to trace interactions, which was composed of (see Figure 1):
  (1) A private zone (input zone) called the 'private chat area', seen only by the writer. Each actor wrote in this zone and then made their utterance public by pressing the enter key.
  (2) A shared zone (where the utterances were sent) called the 'public chat area', which was visible to both actors.
- The textboard, a shared zone of the *Drew* software adapted to our experiment by Dyke (2006) to include two cursors instead of one. Each actor had their own cursor, which means that both could write at the same time.

Let us add the following remarks about the private chat area. When the actors wrote in this zone, they could go back and forth in the sentence, either to erase parts and make changes, or to leave it as is. Once the sentence was in its final state, a send operation had to be performed to make the utterance public. In this manner, the actors could each verify what their partner was going to read to make sure it said what they intended. Our screen-capture system thus allowed us to view the micro-history of the production of each utterance (in the private chat area) at a very fine-grained level (every character written).

4.2.3. Observables

To study the actors' activity, we chose observables capable of capturing the mediated co-writing process, i.e. ones that could account for the dynamics of the activity, not just the final product. The main observables for our analyses were the interaction traces from *Drew*. Figure 2 shows an example of the traces generated by *Drew* (Dyke 2006).

From left to right, the four columns contain the time, the actor's name, the utterance and the name of the tool used to carry out the action. In this example, '**begins writing**' in the utterance column indicates that an actor has put her cursor on the textboard; the '1' in '1>' indicates that writing is occurring on line 1 and the '>' indicates that the actor is starting to write at this location on the line. The 1 in '1<' indicates that writing is occurring on line 1 and the '<' indicates that there was already some text on that

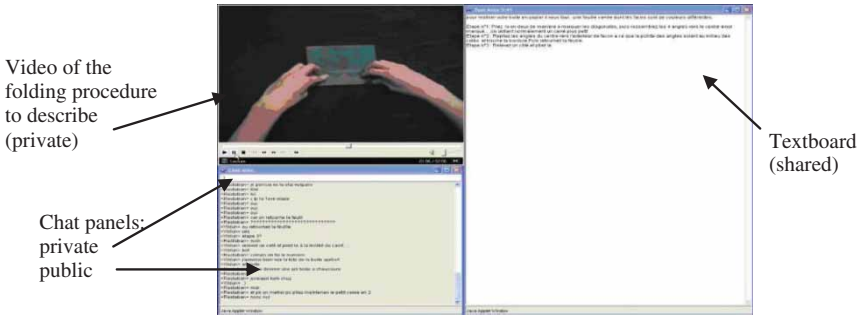

Figure 1. Four-zone interface used for the main task.

Time	*Speaker*	*Utterance*	*Tool*
0:07:00	Yildun	I'm trying on the textboard, something like: you have a square sheet of paper to work with	*Chat*
0:07:16	Rastaban	yes that's perfect	*Chat*
0:07:49	Rastaban	**begins writi ng**	*Textboard*
0:07:49	Yildun	with different colored sides?	*Chat*
0:07:50	Rastaban	1> you *** production: speaker was interrupted	*Textboard*
0:07:54	Yildun	**begins writing**	*Textboard*
0:08:07	Rastaban	yes it's better	*Chat*
0:08:07	Yildun	1< you 1> you have a square sheet of paper to work with *** production: timeout	*Textboard*

Figure 2. Computer trace generated by *Drew*. (Note. Our translations of the actual text written in French do not replicate any incorrect grammar, slang, misspelled words or instant-messaging shortcuts found in the French.)

line. After the '1>', we find the production the actor adds to what was already there on the textboard. For example, '***production: speaker was interrupted' means that the actor who was entering text was interrupted by the other actor. Similarly, '*** production: timeout' means that the actor interrupted her own input (she left her cursor in the same position for more than five seconds, or she positioned it elsewhere on the textboard). In the example in Figure 3, the line produced by *Drew* should be read as follows: at eight minutes and seven seconds, Yildun acts upon the textboard; to the 'you' already written on textboard line 1, she adds 'you have a square sheet of paper to work with' and then moves to another area of the screen or pauses for more than five seconds.

0:08:07	Yildun	1< you 1> you have a square sheet of paper to work with *** production: timeout	*Textboard*

Figure 3. Excerpt from Figure 2.

4.3. *Presenting the observables*

Below, we describe our presentation of the observables, based on a number of methodological choices regarding the readability and granularity of the interactions to be analysed.

4.3.1. *Synchronised 'multiscope'[1] layout of the discursive spaces*

It was necessary to compile a corpus that contained a record of the labile events occurring during the experiment. Insofar as the actors did not express themselves orally, and their gestures and facial expressions in front of the screen were minimal, we did not include the close-up films in our analysis. To present the observables, we chose a synchronised 'multiscope' layout of the four discursive spaces used by each actor: the chat panels (private and public), the textboard and the origami video. This gave us a synchronised presentation of the actors' written productions and their manipulations of the video. The multiscope layout was done using video montage software (see Figure 4).

4.3.2. *Written productions*

We had to think carefully about how to present the corpus because of the fact that each actor had three writing areas

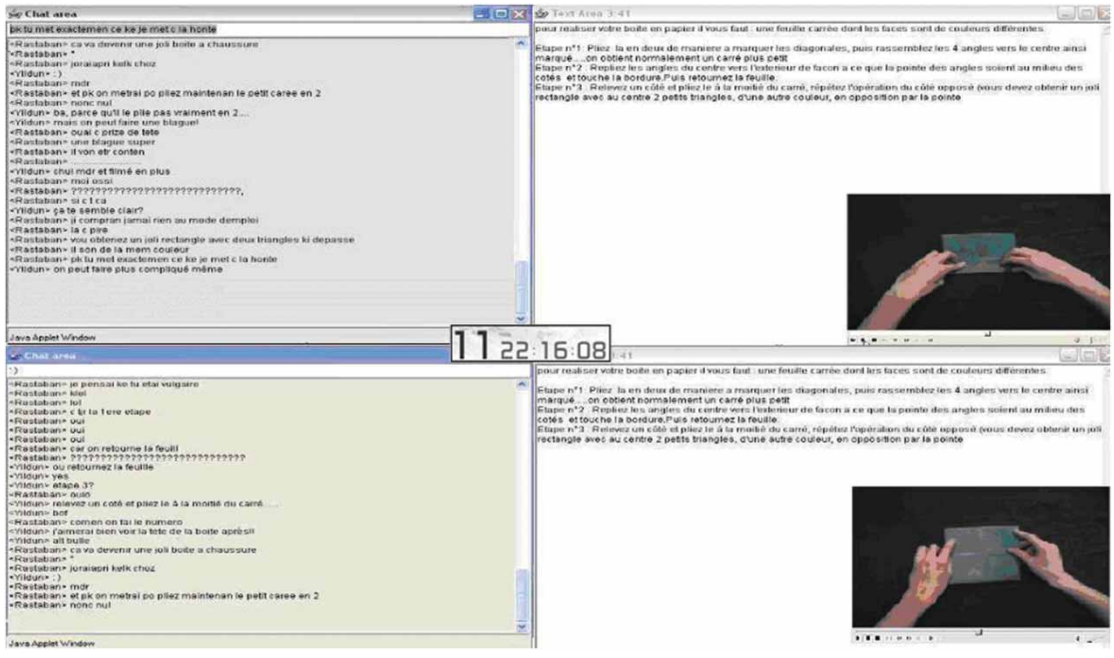

Figure 4. Synchronised 'multiscope' layout of the discursive spaces and the origami video used for the analysis.

Time	Rastaban's Private Chat Area		Public Chat Area		Yildun's Private Chat Area		Textboard	
	R81a	*still have to fold the two [angles that weren't folded]*			*Y80a*	*[normally what one gets is a smaller square]*		
0:24:08			*Y80*	*normally what one gets is a smaller square*	Y80b	Send		
0:24:09	R81b	Send	*R81*	*still have to fold the two angles that weren't folded*				
							E2-Y77d	Correction (the angles > the 4 angles)
					Y82a	*is it clearer if we say 4?*		
0:25:24			*Y82*	*is it clearer if we say 4?*	Y82b	Send		
	R83a	*Yes*						
0:25:38	R83b	Send	*R83*	*Yes*				
			Y84a	Copy *(normally what one gets is a smaller square)*				
0:25:50	*R85a*	*[but your center] isn't defined very well*					E3-Y84b	[Paste *(normally what one gets is a smaller square)*]

Figure 5. Portion of the excerpt analysed.

on the screen. Our final solution for showing both actors' written productions was a five-column table (see Figure 5). From left to right, the columns contain the time, Rastaban's private chat area, the public chat area, Yildun's private chat area and the textboard. Only column 3 (displaying the written conversation) and column 5 (the final instructions gradually taking shape) contain utterances that could be seen by both actors. Each of the last four columns has a subcolumn for labelling the occurrence and a subcolumn containing the content of the occurrence. The term 'occurrence' is used here to refer to an 'accomplished thing', so the activity consisted of a continuous stream of 'accomplished things'. It was also a succession of entities. The term 'entity' refers to one or more productions that were potential bearers of meaning from the standpoint of our *a posteriori* analysis. Entities were made up of occurrences, which could be of different types. In our presentation, we have reported all of the actors' exchanges that were in discursive form, according to the conventions detailed in Ollagnier-Beldame (2006).

5. Analysis

Before going on to our analysis of a conversational co-writing episode, we will consider the different types of traces at play and how they were actually used.

5.1. Multiple characterisations of traces

As stated above, the design of the digital environment used by the actors was such that it automatically provided them with traces of their activity. Basing our description on the multiscope layout of the discursive spaces and the five-column table of the actors' utterances, we will show below that these traces and their use have a number of specific properties. A careful look at the activity allowed us to discern these properties, not in an absolute sense, but relative to the actors who were 'putting them to work'. Two ways of categorising a trace became clear: as an inscription and as a medium.

5.1.1. Properties of traces as inscriptions

First, we sorted the traces into two broad categories: '**own**' and '**other**'. From the standpoint of a given actor, traces written by oneself were called 'own'; they were the tangible result visible on the screen of one's own interaction with the environment or with the partner via that environment. When it was her interlocutor who was acting, the trace was labelled 'other'.

The second sorting was strictly linked to the device used. It divided up the traces according to where on the screen the actor put or saw them (private chat area, public chat area or textboard). The private chat area and the textboard were considered as 'work areas', since utterances written in these areas, which appeared as soon as they were entered on the keyboard, could be modified or even erased. This was always the case for private-chat traces and could be the case for textboard traces. The public chat area was considered to be strictly a 'writing area', since traces in this area, which did not appear immediately after they were written, were prepared first in the private zone. For this reason, they were seen as events resulting from expression operations rather than as operations themselves. The written traces in these three zones were qualified, respectively, as '**short-lived**', '**long-lasting**' and '**labile**'. Traces of the first kind were called short-lived because they lasted only for the time the utterance was being entered, before it was made public or erased; they appeared in the private chat area where the

writer could work on how to express her idea before letting the partner see it. Traces of the second kind, located in the public chat area, were long-lasting because they remained in this area and could not be modified. Traces of the third type were called labile because they could be modified; they appeared on the textboard, they could be written directly in this zone or be the result of copy-and-paste operations coming from the public chat area and they could undergo transformations up until the time when the dyad decided that the text was finished. Their lability placed them somewhere between the rough draft of one of the interacting partners and the more finalised quality of the co-written text.

A third criterion for categorising the traces was the addressee, which was also linked to trace visibility. The addressee in question was the addressee of the traces themselves, not of the utterances produced. That is to say, we were not interested in the addressee of the actor's intended content, but in the addressees of the places where the traces were visible to one or the other actor. We identified two types of trace addressees. The first was the addressee of traces in the private chat area, which were directed at the actor who was writing. She was the only one who could see what she was in the process of producing. These traces were called '**self-directed**'. Secondly, there were '**other-directed**' traces, which were located in the public chat area or on the textboard. Even though the author of a 'writing turn' (comparable to a speaking turn in oral conversation) produced in the public chat area could read its content, these traces were mainly directed at the partner. Traces on the textboard were of course seen by their producers in real time, but they were mainly directed at the third-party addressee, as described above: the instructions were being drawn up to be read and interpreted by a person trying to make an origami box.

5.1.2. Use of traces as mediums

Whether short-lived, long-lasting or labile, self- or other-directed, all traces could be utilised by the interactants. Here again, a look at how they were actually used immediately brought out a distinction that was invaluable in our analysis. First, one or both actors could simply view the traces during the activity. For example, the fact that the conversation history was being read could be detected by looking at moves of the scroll bar in the public chat area. The movement of the cursor on the textboard was indicative that one of the actors was scanning the text during writing. We called this use of traces 'consultatory'. Secondly, one or both actors could perform operations on the traces. We have already noted this type of operation when we mentioned using the copy–paste function to move something from the public chat area to the textboard. Via this operation, a given sentence produced during the conversation could be imported verbatim into the instructions. This use of traces was called 'operatory'.

These different properties of the interaction traces and their use served as indicators and resources for obtaining our results, which pertain to the role and status of computer traces in the progression of the activity observed here.

5.2. A joint writing episode

Even though it has become very common to communicate remotely via the exchange of language segments, and even though analyses of the construction of meaning that takes place therein are just as common, the situation we are studying here has a particularity of its own: there was an imposed goal, namely, write something with another person (still a rare activity in the communication arenas just mentioned) using a textboard displayed on the screen next to a chat window. The merits of our analysis lie precisely in this point. The modes of meaning generation underlying such computer-mediated conversations are well-known today: the actors must do without the nonverbal and paraverbal modalities; the other person is not watching the 'speaker', so he/she has no way of taking the other's approval or disapproval into account; laughing is not visible so it must be stated explicitly if it is to be conveyed; requests for an opinion or explanation, questions and surprise must be made manifest or even explicitly brought to the fore if they are to be perceived by the other person; and the hesitations inherent in all verbal productions are eliminated by the filtering process that takes place between the private chat area and the public chat area. In short, a large number of core phenomena that occur in face-to-face conversation are absent. In contrast to these well-known phenomena, our task in the present study was to examine a relatively unexplored facet of this kind of activity: how and to what extent the joint meaning-construction process is affected by the presence of different types of interaction traces and their interplay.

The analysis we propose below is part of a broader research project (Ollagnier-Beldame 2006) in which three excerpts were selected on the basis of the following observations. As the activity progressed, we noticed that the writing of the instructions took place in stages. First, we noted several stabilisation stages during the meaning-negotiation process that supported the discursive production activity. In particular, the end of each excerpt was marked by such a stabilisation stage. To locate the beginning of an excerpt, we moved back up through the interaction until we found the utterance where the negotiation seemed to begin moving in the direction of that particular end-of-excerpt stabilisation point. The first excerpt concerns the preparatory phrase of the co-writing process, the second pertains to the joint writing of the introductory sentence of the folding instructions and the third corresponds to the joint writing of the first step of the instructions. Unlike the first two excerpts, where the person's own traces in the public and private chat areas were used for consultatory purposes, the third excerpt included an operatory use of the actor's own traces in the public chat area.

5.2.1. The analysis proper

We are going to analyse the third excerpt here (writing of the first step of the folding instructions). At the end of the co-writing activity, the instructions read as follows.

Co-written Instructions

To make your paper box you have to use a square sheet of paper with different coloured sides:

> *Step* 1: Fold it in half to mark the diagonals.
> **Then bring together the four angles into the centre just marked …**
> **Normally what one gets is a smaller square.**
>
> *Step* 2: Refold the angles from the centre outward so that the point of the angles is in the middle of the sides and touches the edge.
> Then turn the sheet over.
>
> *Step* 3: And fold it at the midpoint of the square.
> Repeat the operation on the opposite side.
> You should obtain a nice rectangle with two little different-coloured triangles in the centre.
>
> *Step* 4: Take one of the sides you just folded and put it on top of the other and then refold the angles on the lower part.
> Repeat the operation on the other side.
> Open, you get the box!

We are mainly interested in the production of the two sentences shown in boldface: 'Then bring together the four angles into the centre just marked' (hereafter called S1) and 'Normally what one gets is a smaller square' (hereafter called S2). This portion of the interaction is presented in Figure 6.

Briefly, we can see that it is mainly Yildun who is 'leading the dance' in this excerpt. At the time when the last sentence written on the textboard was 'Fold it in half to mark the diagonals', she states that she's 'attempting to go on' (Y74). Her partner agrees, seems to be wondering about something, prompts her again and writes something in her private chat area. During this time, Yildun produces two utterances, in two different areas: first, she writes directly on the textboard, 'Then bring together the angles into the centre just marked …' and then she writes in the public chat area, 'Normally what one gets is a smaller square'. It is a mere second after this second sentence was made public that Rastaban sends 'still have to fold the two angles that weren't folded' (R81). The excerpt ends with (i) a correction of the first of these two sentences, which, by the addition of the number 4, becomes S1, and (ii) the pasting of the second sentence (S2) without modification. The move onto the second step follows without questioning of the wording used in the first step, or about how they came about it. Therefore, curiously, it is the content of a discursive segment put onto the textboard on the sole accord of one of the partners that will be subject to negotiation and will become S1, whereas the content of the other sentence (S2), even though it was initially produced in the conversation area, will not be discussed. Let us take a closer look at this.

'I'm attempting to go on' (Y74) echoes an earlier utterance, 'I'm trying on the textboard, something like: you have a square sheet of paper to work with', produced by Yildun a few minutes before that when they were just starting to write the instructions. The two utterances are in the first person singular of the present tense and contain two synonymous verbs 'to try' and 'to attempt'. This reformulation at a distance seems to gain strength, since 'the attempt' involves more risk than 'the try'. Whatever the case may be, Yildun expresses this intention by putting it into the conversation area; it is immediately validated by Rastaban in two of her replies (the second of which changed her strange 'esysy' (R75) into 'yes' (R76)). At this point (0:22:19), the two protagonists agree that one of them will be in charge of proposing a portion of text. In other words, Yildun's proposal to act is validated … but it is nonetheless questioned about half a minute after that. Right after making Y74 public, Yildun places the cursor on the textboard, where several tens of seconds later, she writes 'then' (Y77a). This element stays by itself long enough for Rastaban to produce the string of question marks in the public chat area (R78). Note in passing that R78, addressed to Yildun, could convey several types of questions. Does her question pertain to the meaning of 'then' (Why did you write 'then'?)? Is it about why Yildun pauses in writing the sentence that begins with then (Why are you waiting?)? Does it conceal a proposal by Rastaban to help her confederate (Do you want me to help you?)? The communicational significance of these question marks will appear less ambiguous to Yildun when, a few seconds later, she is able to read 'how's it coming along' (R79). In saying this, Rastaban is signalling her support of Yildun's attempt to compose, whose relevance had already been validated. Y77b and c are produced with great hesitation (Yildun is writing one letter at a time and takes six seconds to add 'bring together'), and very slowly (she takes 23 seconds to type 'the angles into the centre just marked …', which will end up being S1). The function of the suspension points is hard to ascertain. Are they indicative of Yildun's difficulty writing the end of this sentence? Are they a mark of dissatisfaction? Do they announce a change of writing area? We have no information that allows us to draw a conclusion on this point, but it is clear that in what follows, Yildun will make a decision that seems quite unusual: she will switch writing areas by putting an utterance in the public chat area, and she will use 'one' in the conversation area. Let us look at the conditions under which this switching of writing areas takes place.

The micro-temporality of the keystrokes is particularly important here. The two utterances made public at virtually the same instant, Y80 and R81, were the result of writing phases that were only slightly shifted in time. If we look specifically at the private chat areas, we can see that S2 was

Time	Rastaban's Private Chat Area		Public Chat Area		Yildun's Private Chat Area		Textboard	
					Y74a	*I'm attempting to go on*		
0:22:11			*Y74*	*I'm attempting to go on*	Y74b	Send		
	R75a	*Esysy*						
0:22:16	R75b	Send	*R75*	*Esysy*				
	R76a	*Yes*						
0:22:19	R76b	Send	*R76*	*Yes*				
							E2-Y77a	*then*
	R78a	*??????????????????????*						
0:22:42	R78b	Send	*R78*	*??????????????????????*				
	R79a	*[how's it coming along*					*E2-Y77b*	*[bring together]*
0:22:47	R79b	Send]	*R79*	*how's it coming along*				
							E3-Y77c	*the angles into the center just marked....*
	R81a	*still have to fold the two [angles that weren't folded]*			*Y80a*	*[normally what one gets is a smaller square]*		
0:24:08			*Y80*	*normally what one gets is a smaller square*	Y80b	Send		
0:24:09	R81b	Send	*R81*	*still have to fold the two angles that weren't folded*				
							E2-Y77d	Correction (the angles > the 4 angles)
					Y82a	*is it clearer if we say 4?*		
0:25:24			*Y82*	*is it clearer if we say 4?*	Y82b	Send		
	R83a	*Yes*						
0:25:38	R83b	Send	*R83*	*Yes*				
			Y84a	Copy *(normally what one gets is a smaller square)*				
0:25:50	*R85a*	*[but your center] isn't defined very well*					E3-Y84b	[Paste *(normally what one gets is a smaller square)*]

Figure 6. Observables of Excerpt 3.

written faster than ‘still have to fold the two angles that weren’t folded’. We attempt to illustrate this in Figure 7.

Note several things at this location. Yildun is writing much faster than when she produced the words ‘bring together’ a little earlier, and much faster than when she wrote the sentence starting with ‘the angles’; she is writing twice as fast as Rastaban (24 s vs. 11 s). And for the first time in the session, she uses the personal pronoun ‘one’ in the conversation area. In fact, this double entry in the public chat area (R81 and Y80) points both backward and forward: backward to the instructions already written (at Y77a-b-c) and forward to the instructions that will follow (Y80, to be copied–pasted).

(1) For the backward reference, it is important to note that Rastaban begins to write in her private chat area when she can see and therefore read Y77a-b-c, which is already on the screen. This stretch of text is part of her partner’s attempt to propose something for the next instruction. In thinking about this and suggesting an improvement, Rastaban is playing her role of co-writer. By writing ‘still have to’, she points out that Y77c is incomplete (note, however, that from the geometric standpoint, the centre is clearly marked when only two opposing angles have been folded). Yildun seems to validate this incompleteness by making a simple proposal, to add the number 4, which she does in two stages: she begins by correcting the textboard to add this number to Y77c (Y77d is produced at 0:24:34) and then 40 seconds later, she follows the correction by a request for the partner’s point of

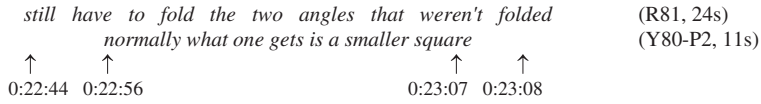

Figure 7. Concomitance of two productions, Y80 and R81.

0:24:34	Y77d	Yildun	Correction on textboard
0:24:42 ---- 0:25:05		Rastaban	Viewing of video (folding the four angles)
0:25:15 ---- 0:25:21	Y82	Yildun	Suggestion: "is it clearer if we say 4?"
0:25:38	R83	Rastaban	Validation: "yes"

Figure 8. Joint production of 'adding a 4'.

view (Y82). Between these two moments, Rastaban views the folding video again at the point where one can clearly see all four angles being folded (between 0:24:42 and 0:25:05). Ten seconds later, she responds positively to Yildun's suggestion in a clear and unambiguous way (R83). The process of 'adding a 4' achieved in response to Rastaban's dissatisfaction thus unfolds as follows (Figure 8): As we can see, Yildun is the one who assumes the role of writer and is therefore in a better position to 'lead the dance' as we said earlier. However, she does not act on her own accord without consulting her partner. Her lengthy hesitation about the 'bring together', and the time taken to compose Y77c, nicely illustrate the difficulty she has with this attempt. Moreover, the text she proposes becomes the subject of negotiation. Temporarily setting aside her Y80, she takes her partner's remark about the inadequacy of her wording into account, and her response to it is revealing in this respect. Even though she first corrects the sentence on the textboard (by 'adding a 4'), she then explicitly asks for an opinion from Rastaban, who reacts positively right away. At this point (0:25:38), the second sentence of Step 1 has been stabilised. Note that it will become fixed a minute later when the discussion that began in R85 ends with a mutual agreement that ratifies the final wording (not included in the excerpt).

(2) Now let us look at what happens in the forward direction. Remember that at the time when 'still have to fold the two angles that weren't folded' is made public (R81), the conversation area is occupied by the utterance 'Normally what one gets is a smaller square', which quickly becomes S2. Let us look at how this transition occurs. This latter utterance is fundamentally ambiguous, due to the use of the personal pronoun 'one'.[2] More exactly, the 'one' used in the public chat area seems to refer to the two protagonists who are working on writing the instructions, and who, as we have just seen, are striving to *jointly* compose them. As such, this use of 'one' (see footnote 2) seems to refer to the two actors as a single 'writing unit'. If Yildun had put it on the textboard, this personal pronoun would have had a different anaphoric function. In that case, it would have referred to all potential readers of the instructions and would, therefore, have been a truly indefinite pronoun, whereas being placed in the conversation area, it referred solely to Rastaban and Yildun, the two co-writers. This difference is critical from the interactional standpoint: placed by Yildun in this screen location (the public chat area), it could either have an *explicative* function, or it could serve as a *proposal of how to pursue* with the instructions.

- It could be *explicative*, to the extent that during the painstaking writing process, Yildun may have wanted to support (i.e. justify) the content of Y77a-b-c in Rastaban's eyes, or she may even have been justifying her decision to herself.
- It could be a *proposal of how to pursue*, to the extent that if it was aimed at completing Step 1, it could serve to reassure the potential reader of the instructions about the progression of the folding.

Remember that Yildun wrote this utterance (Y80) very quickly and made it public immediately after she had hesitatingly written Y77a-b-c; it was clearly directed at Rastaban. What becomes of this utterance is very different from that of S1. What happened was that as soon as Rastaban validated the 'adding of 4', Yildun went into the public chat area to get this utterance and then re-mobilised this trace of her own activity by copying and pasting it directly onto the textboard. In other words, Yildun did not confer with Rastaban about the copy-paste operation, as if she somehow 'sensed' that 'Normally what one gets...' belonged on the textboard. In doing so, she 'inscribed' this part of the instructions totally on her own accord and this changed the referential significance of the word 'one'. In short, the shifting of 'one' from the conversation area to the

"Normally what **one** gets is a smaller square" S2	Writing Area
we could put that the result is normally a smaller square	Public chat panel
↓	↓
you get a smaller square	Textboard

Figure 9. S2's move from the public chat area to the textboard.

textboard triggered a shift in referent: [Yildun and Rastaban] became [Reader of the Instructions]. In the area it came from, the 'one' was a 'we'; in the area it ended up in, it was a 'you'! With this status change from a long-lasting trace to a labile trace, the 'one-we' became a 'one-you'. Obviously, we are not saying that Yildun was consciously aware of the relationship between these semantic and micro-geographic changes! We are simply pointing out that the writing area, the inscription medium, configured the interactional significance of an utterance generated in it. Yildun's mobilisation of one of her own long-lasting traces demonstrates what we call an 'augmented' use of a trace. Indeed, the first production (in Y80) was a proposal for a possible way of continuing the instructions that was directed at Rastaban during the conversation and was designed to stay in the chat panel. When Yildun pasted it onto the textboard, it became labile and took on a new, more finalised status since it was now located in a work area where its addressee became the future paper folder. The trace had the same textual content in both cases, but its move from a location in one medium to a location in the other changed its semantic significance in the activity. Figure 9 attempts to illustrate the 'sleight of hand' taking place here.

Here we can see that when trace Y80 moved from the public chat area to the textboard, it kept the same textual content but changed statuses via a modification of its lability property. According to the categorisation proposed above, its status went from being a long-lasting trace to being a labile trace. Indeed, the trace was first intended to stay the same until the end of the activity and it became a long-lasting one but modifiable at any time by either co-writer. This does not mean, however, that we are attributing to Yildun any kind of intention to 'manipulate' this lability property in her production, contrary to what happened in the preceding excerpt (*Excerpt 2*: see Ollagnier-Beldame 2006), where the partners alternated between producing labile traces and other-directed traces, and where Rastaban put something directly into the instruction-writing area in an apparent attempt to use the textboard to leave a more long-lasting trace of her production than in the public chat area.

Let us go back to the use of the pronoun 'one' by the co-writers, as a typical example of meaning-construction supported by traces of activity and linked to their properties. It is quite interesting to note that this personal pronoun appears only once in the instructions. Referring back to the co-written instructions (see above), we can see that this 'one-that-means-you' is the sole place in the final text where the future paper folder is addressed in the third person singular. This peculiarity of the written instructions reveals the micro-history behind the production of S2. The copy-paste operation that produced this sentence was a direct consequence of an atypical use of the various screen writing areas and their relationships to each other.

Another example of this meaning-construction process is that of the presence of the adverb 'normally'. Needless to say, this adverbial modal is out of place in a set of instructions, which should be a sort of algorithm or procedure, and by that token, should not be approximate (or at least as little as possible!). Here again, the meaning of the word 'normally' is directly dependent upon where it was written. Its use is appropriate in a discussion between two persons about the wording of a text they are in the process of writing, namely, in the public chat area. Its abrupt transfer to the textboard made it inappropriate, since it would be both confusing and counterproductive for a potential paper folder to read that he/she 'should' (rather than 'must'!) obtain a smaller square. This second element adds to the strangeness of this third sentence of Step 1, caused by the peculiar way Yildun used the writing areas.

The presentation of this excerpt (Figure 6) analysis highlights dynamic processes of meaning co-construction based on interaction traces and their status in activity.

5.3. Discussion

This study of a computer-mediated interaction provides some food for thought about the general issue of collective cognitive processing. Far from being a case of two subjects equipped with brains alone, we see this joint cognitive activity as resulting from a complex interdependence between what it requires (embodied actors and a digital machine) and that which shapes it. We see in addition that the tracing process plays a key role therein, not only because it is a resource for communication but also because it is its source. The fact that the communicational significance of the traces, which we categorised on the basis of three criteria, were closely tied to their location on the screen suggests that the content of the writing was much more than a mere projection, into the material world of the interaction, of verbal proposals generated by two subjects' brains. As an example and a common finding of studies on meaning generation in conversations, the meaning of the words 'one' and

'normally' evolved radically as the writing task progressed but also *as a function of their place of inscription*. In the transfer from one writing area to another, they acquired very different meanings. Indeed, the word 'one' changed from meaning a 'we' that referred to the co-writers, to a 'you' that referred to the reader of the final text; the word 'normally' changed from an appropriate adverb for a creative discourse-construction dynamic, to an incongruity in a text whose tone was prescriptive. These transformations were the outcome of an ongoing and ever-changing relationship between the actors and the technical device. The process was distributed across the two interactants and situated in artefactuality (Brassac 2004). This modest example provides grist to the mill for the idea that the study of cognitive processing requires *Putting Brain, Body, and World Together Again*, as proposed by Clark (1997). Conducted within the framework of a praxeology of human behaviour (Brassac *et al.* 2008), our proposed analysis aligns with the theses defended by Kaptelinin and Nardi (2006) in terms of the design of digital devices for cooperating at a distance.

Regarding computer traces of interaction, we think that this type of analysis can uncover useful results. In this study, we examined actors using a digital environment to carry out a task they had been assigned. As the actors wrote, traces of their activity appeared on the screen, acting as 'fingerprints' of the activity inscribed in and by the work environment. The way the actors used this computer-based symbolic kind of mediation led us to differentiate the traces by the actor's relationship to them, and by the micro-geographic location where they were mobilised by the actors (private chat area, public chat area, textboard). The traces examined here turned out to be objects that continuously evolved as the activity progressed and that acted as a support for activity-related negotiation.

From a fundamental standpoint, this study provides insight into the relationship between computer traces of interaction and knowledge in the process of co-construction: both served not only as a medium of communication between the actors but also as a means of interaction with the other person and with oneself, via a reflexive type of process. Indeed, they were both resources for the exchange and sources for the co-creation of the text. From a methodological standpoint, this study shows that a qualitative, ethnographic type of investigation can bring to light micro-processes occurring between individuals involved in a situation, processes that are so difficult to access via data of a quantitative nature. In sum, the present case study approach offers material for research into the collective utilisation of digital environments by humans and can serve as a starting point for analogous analyses of situations like the one set up here. In this respect, we fall in line with the inquiry type of approach advocated by Smith *et al.* (1995), who developed a method called analytic induction aimed at 'deriving theoretical explanations from a set of cases' (1995, p. 67).

6. Conclusion

The prospective nature of our study does not prevent us from sketching out some avenues for designing and developing 'tracing systems'.[3] Systems of this type are purposely designed to trace interactions between actors, and between actors and their environment, and to display the traces on the interface. Research and experiments have shown that such systems have a great deal of potential. But they also appear to run up against some major obstacles that must be overcome before 'suitable' systems can be developed for tapping into the wealth of real-time experiences yet to be discovered, reused, shared and put to profitable use. In particular, we are contemplating the design of systems that refer users back to their immediate interaction history, to help them 'stand back' and look at their own activity and the underlying processes of human development. In our minds, the very fact of showing users the history of their interactions with the system, and of enabling them to act upon that history, is likely to be a highly relevant and effective principle for designing digital environments that are anthropocentred, especially ones geared to learning. We think that the overall approach and the results presented in this paper may help the design of new tracing systems for joint activities, allowing researchers and designers to:

(1) Understand and formalise the use of digital traces in co-design activities. Indeed, our study helps to build a solid foundation of knowledge on 'traces practices' occurring in collaborative sense-making processes, since these practices are still largely unknown: formalisation of observed uses, identification of new traces properties and search for invariants in traces uses.
(2) Specify new ways of acting and interacting with digital traces as temporalised data: representation of their lifecycle, temporal metaphors (timeline, spiral, wheel, star, table, etc.). We believe it is necessary to propose a trace providing different 'points of view' on activity: by user, by type of action, etc. (Ollagnier-Beldame 2009, Pfaender 2009).
(3) Specify tools to act on traces: editing, rewriting transformations, filtering, searching, sharing, exporting or printing traces (now, some blogs are printed to be retained), etc. Possible actions on traces are innumerable but their ergonomics is still to invent and to test.
(4) Propose 'standard' ways to interact with temporalised data (e.g. to 'navigate in time') from models and conduct experiments to evaluate these proposals.

Finally, our results may contribute to the development of new tracing systems more usable, i.e. better adapted to observed practices and allowing situating user's activities regarding other users and regarding time. According to us, this design should be done based on several principles:

(1) considering the activity rather than functionnalities to perform, (2) considering the observation of reality rather than an abstraction, (3) rejecting the primacy of representation. Thus, following the work of Winograd (1989), we defend the idea of a designing practice, which does not seek to create intelligent systems but seeks to develop usable systems as extensions of human cognitive abilities. Participatory design methods have been developed based on these principles. These methods are particularly relevant in the era of Web because they mobilise users not only at a preliminary design, but throughout the digital environment mediated activity.

From this angle, in the Silex research team, we are looking into having digital 'tracing' environments that offer tools for working with interaction traces, i.e. objects made available to users for carrying out their activities. Rabardel's (1995) principle of 'operational transparency', which stipulates that 'the properties characteristic of the instrument and suited to the actions of the user, as well as the way the instrument makes them accessible, understandable and even perceivable to the user' (p. 150) should dictate the modelling and formatting of these new trace-related objects and their features. In particular, concerning the implementation of mediated learning situations, we suggest that using digital devices featuring interaction-trace viewing can help learners step back from their activity to gain greater control over their learning, seen as a process situated in time and in the digital spaces made available. We believe that joint activities carried out in learning contexts have much to gain by having digital environments in which computer traces of interaction can be put to use. In such situations, the construction of meaning is clearly a necessity, and argumentative negotiations are likely to draw considerable benefit from support in the form of visible traces of actor–actor and actor–computer interactions (Dillenbourg 1999).

In conclusion, future research articulating the analysis, utilisation and appropriation of computer traces of interaction by actors, along with studies on trace formatting and viewing, should promote a better characterisation of the modes in which situations of joint-mediated activity are managed.

Notes

1. We also could have called this type of layout 'quadravision'.
2. The French pronoun used here was 'on', the third person singular indefinite personal pronoun. 'On' is widely employed in informal French to mean 'we'.
3. What we have in mind here are computer systems capable of recording information about system utilization by users, putting that information in a form that is 'intelligible' for humans (other than log files), and then displaying it to the person, whether it be the user him/herself or an analyst of the situation. The reader will find a four-family classification of such 'tracing systems' in Ollagnier-Beldame (2006).

References

Brassac, C., 2003. Éléments pour une psychologie clinique de l'activité cognitive. *In*: M.-C. Mietkiewicz and S. Bouyer, éds. *Où en est la psychologie clinique?* Paris: L'Harmattan, 111–118.

Brassac, C., 2004. Action située et distribuée et analyse du discours: quelques interrogations. *Cahiers de Linguistique Française*, 26, 251–268.

Brassac, Ch. and Arend, B., 2007. Production située et distribuée d'une forme discursive à visée pédagogique: le cas d'une rédaction conjointe. *Rencontres du réseau International de Recherches en Éducation et Formation*, Sherbrooke, Canada, 9–10 October.

Brassac, C. and Grégori, N. 2003. Une étude clinique de la conception collaborative: la conception d'un artefact. *Le Travail Humain*, 66 (2), 101–127.

Brassac, C. and Le Ber, F., 2005. Inscription spatiale d'une activité cognitive collective de représentation de l'espace. *Intellectica*, 41–42, 181–200.

Brassac, Ch., Fixmer, P., Mondada, L., and Vinck, D., 2008. Interweaving objects, gestures, and talk in context. *Mind, Culture and Activity: An International Journal*, 15 (3), 208–233.

Clark, A. 1997. *Being there: putting brain, body, and world together again*. Cambridge: Massachusetts Institute of Technology Press.

Corbel, A., Jaillon, P., Serpaggi, X., Baker, M., Quignard, M., Lund, K., and Séjourné, A., 2003. DREW: Un outil Internet pour créer des situations d'apprentissage coopérant. *Actes de la conférence EIAH 2003*, Strasbourg, 109–113.

Dillenbourg, P., 1999. What do you mean by collaborative learning?, *In*: P. Dillenbourg, ed. *Collaborative Learning: Cognitive and Computational Approaches*. Oxford: Elsevier, 1–19.

Dyke, G., 2006. Extension of the Musette framework for synchronous collective activities. Master's Thesis. EPFL, Lausanne, Switzerland.

Ganier, F., 2004. Factors affecting the processing of procedural instructions: implications for document design. *IEEE Transactions on Professional Communication*, 47 (1), 15–26.

de Gaulmyn, M.-M., Bouchard, R., and Rabatel, A. 2001. *Le processus rédactionnel. Écrire à plusieurs voix*. Paris: l'Harmattan.

Grosjean, S., Fixmer, P., and Brassac, Ch. 2000. Those psychological tools inside the design process. *Knowledge-Based Systems*, 13 (7–8), 3–9.

Heurley, L., 1997. Vers une définition du concept de texte procédural: le point de vue de la psycholinguistique. *Les Cahiers du Français Contemporain*, 4, 109–133.

Heurley, L., 2001. Du langage à l'action: le fonctionnement des textes procéduraux. *Langages*, 141, 64–79.

Hutchins, E. 1995. *Cognition in the wild*. Cambridge: Massachusetts Institute of Technology Press.

Kaptelinin, V. and Nardi, B.A., 2006. *Acting with technology. Activity theory and interaction design*. Cambridge: Massachusetts Institute of Technology Press.

Krafft, U. and Dausendschön-Gay, U., 1999. Système écrivant et processus de mise en mots dans les rédactions conversationnelles. *Langages*, 134, 51–67.

Latour, B. 2001. *L'espoir de Pandore. Pour une version réaliste de l'activité scientifique*. Paris: Éditions de la Découverte.

Leplat, J., 2002. De l'étude de cas à l'analyse de l'activité. *Pistes*, 4 (2), 1–31.

Millerand, F., Giroux, L., and Proulx, S., 2001. La 'culture technique' dans l'appropriation cognitive des TIC. Une étude des usages du courrier électronique, Dans Actes du colloque international ICUST 2001, Paris, France, 400–410.

Ollagnier-Beldame, M., 2006. Traces d'interactions et processus cognitifs en activité conjointe: Le cas d'une co-rédaction

médiée par un artefact numérique. Thèse de Doctorat. Université Lumière Lyon 2, France.

Ollagnier-Beldame, M., 2009. Spécifications fonctionnelles d'un outil de visualisation interactive de traces. Activity report for the PROCOGEC Consortium.

Ollagnier-Beldame, M. and Mille, A., 2008. E-learning: Tracer l'activité des apprenants pour favoriser leur appropriation des systèmes? Forthcoming in *La Revue du Management Technologique*, 15–3, 2008.

Pascual, E., Nespoulous, J.-L., and Virbel. J., 1997. Le texte procédural: langage, action et cognition. Pôle Universitaire Européen de Toulouse & Prescot.

Passeron, J.-C. and Revel, J., 2005. *Penser par cas*. Paris: Éditions de l'École des Hautes Études en Sciences Sociales.

Pfaender, F., 2009. *Spatialisation de l'information*. PhD Dissertation. Compiègne University of Technology.

Rabardel, P., 1995. Les hommes et les technologies: approche cognitive des instruments contemporains. Paris: Armand Colin.

Smith, J.A., Harré, R., and Van Langenhove, L., 1995. Idiography and the case-study. *In:* J.A. Smith, R. Harré, and L. Van Langenhove, eds. *Rethinking psychology*. London: Sage Publications, 59–69.

Suchman, L., 1987. *Plans and situated actions. The problem of human/machine communication*. Cambridge: Cambridge University Press.

Winograd, T., 1989. Heidegger and the design of computer systems. Conference on Applied Heidegger, Berkeley, September. Text traducted by Jean Lassègue in "Winograd, T. and Lassègue, J., 1993. Heidegger et la conception des systèmes informatiques. *Intellectica*, 51–78".

Yin, R.K., 2003. *Case study research. Design and methods*. 3rd ed. London: Sage.