



HAL
open science

Assessing the use of a Trace-Based Synchronous Tool for distant language tutoring

Mireille Betrancourt, Nicolas Guichon, Yannick Prié

► **To cite this version:**

Mireille Betrancourt, Nicolas Guichon, Yannick Prié. Assessing the use of a Trace-Based Synchronous Tool for distant language tutoring. *Computer-Supported Collaborative Learning*, Jul 2011, Hong Kong, China. pp.478-485. hal-00806428

HAL Id: hal-00806428

<https://hal.science/hal-00806428>

Submitted on 31 Mar 2013

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Assessing the use of a Trace-Based Synchronous Tool for distant language tutoring

Mireille Bétrancourt, FPSE, University of Geneva,
CH-1211 Geneva 4, Mireille.Betrancourt@unige.ch

Nicolas Guichon, Université de Lyon 2, Laboratoire ICAR, Université Lyon 2,
5, Parvis Descartes, 69342 Lyon cedex 07 FRANCE, Nicolas.guichon@univ-lyon2.fr

Yannick Prié, Université de Lyon, CNRS Université Lyon 1,
LIRIS, UMR5205, F-69622, France, yannick.prie@liris.cnrs.fr

Abstract: This article presents a pilot study carried out to investigate the potential of a functionality marker setting, included in a synchronous collaborative videoconferencing platform (VISU). Markers, supported by a trace-based system, are designed to facilitate tutors' activity. They provide tutors with (1) the possibility of annotating their distant learners' learning activity, and (2) information pertaining to their own behavior during pedagogical interaction, which can potentially enhance their professional performance as online language tutors. This study concentrates on the marker-based traces of eight language tutors collected in the course of pedagogical interactions with their distant learners during a seven-week transnational collaborative project. It presents both quantitative and qualitative analyses of the use of markers during synchronous language teaching sessions and assesses the utility and usability of such a functionality for language tutoring in order to inform future design and training.

Introduction

While asynchronous collaborative distant learning is now relatively well researched, synchronous distant learning is less well documented although it is gaining more and more attention thanks to the availability of efficient technologies for synchronous communication (videoconferencing, chat, whiteboards, screen sharing, etc.). This research was conducted in the context of the ITHACA¹ project, an interdisciplinary (language education, computer science, cognitive science) project whose aim is to study how traces can be used for providing such synchronous collaborative systems with reflective features so as to enhance their functionalities in the context of activities involving tutoring at a distance. We define traces as features of the system that offer the means to provide instant or delayed feedback regarding the unfolding of the pedagogical interaction, and thus allow both learners and tutors to reflect on the experience.

This paper is organized in two parts. First, we will present the rationale and the design of a synchronous trace-based prototype tool called VISU2 featuring means to share and interact with three types of traces: automatically recorded interaction traces; marker-based traces composed of *ad hoc* annotations added by the user in the course of the activity; comment-based traces composed of *post hoc* annotations added by the user in order to comment upon his/her past activity. In the second section of the paper, we will focus on the use of one type of trace - marker-based traces – as used during a real 7-week long real distant pedagogical interaction between language tutors in France and distant learners from a North-American university. Our results, which are mostly qualitative, tend to support the potential of such traces for online language teaching as well as language teachers' professional development. The article is organized as follows: We begin with a brief overview of distant tutoring and trace-based reflexivity, before examining the VISU tool in section 3, the experiment in section 4 and the results in section 5.

Theoretical rationale

Tutoring in synchronous distant learning

Synchronous collaborative learning systems support more or less predefined collaborative activities (Lonchamp, 2006), with various roles for the users and various tasks to be carried out. When synchronous online tutoring is involved, teachers are often faced with an ill-defined pedagogical situation and have to develop new competencies and attitudes that are necessary for effective interactions with distant learners in addition to more traditional pedagogical skills (see Guichon, 2009). Besides, conducting a synchronous online interaction induces a high cognitive cost because it involves carrying out several tasks at the same time as well as managing interrupted connections and various distractions (Oviatt et al., 2004). Social and Cognitive Awareness and Navigation (SCAN) tools (Buder et al., 2009) can provide feedback and a sense of group awareness to participants of the interaction. The rationale that underpins this research is that teaching (and teacher training)

can be facilitated with trace-based SCAN systems that foster teachers' reflexivity. Such systems help augment their awareness by providing them with traces that are pertinent for their activity, all the more so when these traces are generated by the users themselves.

Systems which foster reflexivity

Reflexivity, defined as the capacity to reflect upon one's activity, is deemed crucial in learning processes, be it for simple adjustments of one's actions or attitude in the course of one's activity (self-awareness) or for meta-cognitive regulation tasks that involve assessment or extension of one's knowledge, individually and collectively (Yukawa, 2006). Reflexivity can be fostered by systems that provide users with two kinds of elements upon which to build a reflective activity. The first level is related to *instantaneous reflection*: it provides *feedback on the activity* such as clues about the effectiveness of one's actions such as mirroring of the activity (Jermann et al., 2005), real time collaboration indicators (Nova et al., 2006), temporal/social representations of current group activity (Farooq et al., 2007) or peer feedback (Phielix et al., 2009). The second level of reflexivity involves *delayed reflection*: it provides *representations of the interaction beyond its scope* such as histories or Edit or Read ware (Hill et al., 1992), "reflective follow-up" representing one's way of solving a problem (Katz et al., 1992), indicators summarizing the interaction within a group (Bratitsis et al., 2006), or activity summaries (Laffey et al., 2009).

Trace-based Systems

The present research project focuses on *traces of interactions* between users and systems. Those that should not be confused with traces generally defined as what remains of an activity, including documents produced by participants. Logs are obviously traces for engineers who need to understand the functioning of the systems they build. While some approaches have tried to design log-mining techniques in order to obtain higher-level user activity-related traces (see Romero & Ventura, 2007 for a survey of the educational use of traces), our own approach pertains to research dealing with explicitly designed rich histories of interaction. Such traces can be used either by professional analysts to understand the activity that has taken place (Avouris et al., 2007) or by users willing to make sense of their own activity by consulting Web navigation histories (Weinreich et al., 2006) or even by replaying online interactions in which they took part (Plaisant et al., 1999).

Because most such tracing systems are designed in an *ad hoc* way to test particular research ideas related to dedicated activities, it is rarely possible to reuse these tools in subsequent projects. To go beyond such punctual approaches, we have proposed a model-based approach to traces, formally defining Trace-Based Systems (Settoui et al., 2009a) as systems built upon "modeled traces" organized in trace bases. A trace model is an ontology of the *obsels* (observed elements) that can be collected in one trace. Trace transformations in trace bases allow simplifying, merging or rewriting traces so as to obtain higher-level traces that present users with adequate representations of their activity. A formalization of our proposal can be found in (Settoui et al., 2009b).

The VISU Tool

VISU is a trace-based tool that features a number of different modeled traces for instantaneous and delayed reflection in the context of synchronous tutoring interaction.

Three levels of traces in VISU

Our videoconference tool provides three types of trace. Each corresponds to a distinct obsel type:

- *Interaction traces* are histories of users' actions automatically collected in real time from their interactions with the software. Events such as "launch video", "open image" or "begin a new activity" are considered. In Figure 1, the raw interaction trace of user1 has been filtered (transformation τ_1), and the resulting trace is shared. In Figure 2, the vertical timeline features (a) and (b) that correspond to representations of obsels that have been shared by learners with their tutor while (c) is a representation of the "beginning of a new activity".
- *Marker-based traces* refer to text annotations that are written during the activity describing events such as "vocabulary" or "problem with microphone". Such annotations are similar to notes that are usually jotted down by a teacher during a learner's oral presentation so as to provide her with feedback. These traces can refer to the tutor's activity, the learner's or their joint activity. In figure 1, the marker-based trace has been built (transformation τ_2) from the marking trace (which describes the activity of creating, deleting, modifying markers). On the vertical timeline shown in Figure 2, (d) and (e) are markers that have been set by the tutor.
- *Comment-based traces* correspond to text annotations that are added after the activity with obsels such as "effective dialogue between learners" or "nice piece of dialogue". A comment-based trace can be considered as a *post-hoc* manual transformation / rewriting (τ_3) of traces that have been collected during the activity. On the vertical timeline shown in Figure 2, (g) is a comment-based trace.

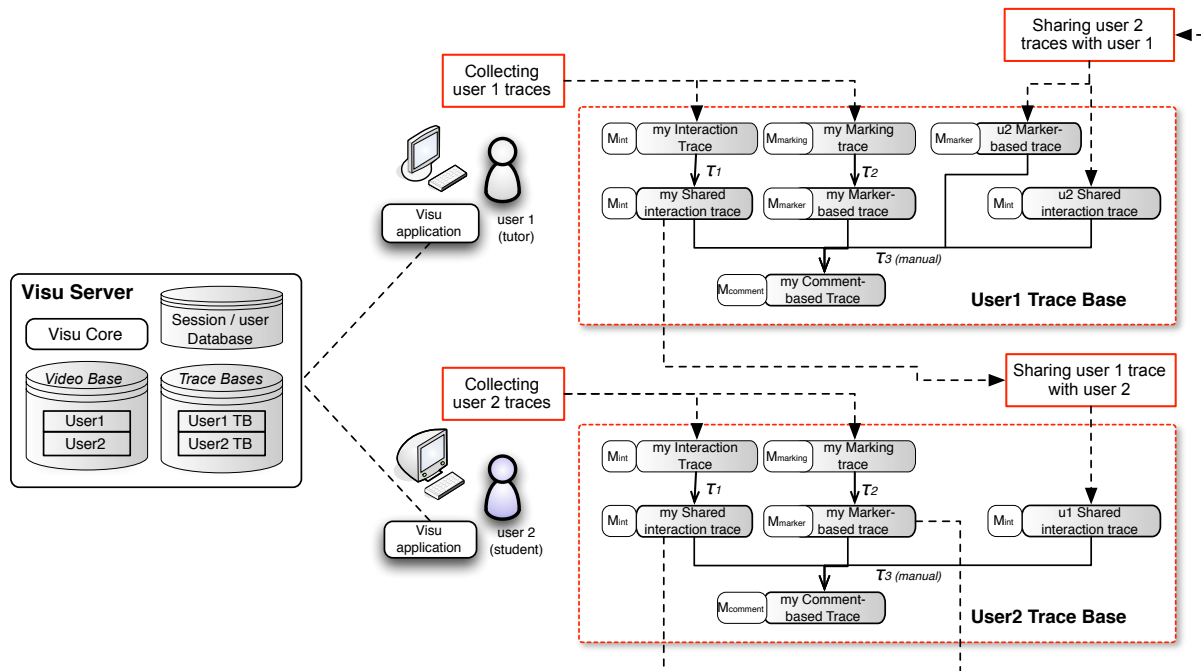


Figure 1. A tutor (*user1*) is interacting with a learner (*user2*). A video base stores the video streams that have been recorded during the interaction. Each user has her own trace base. *User1*'s trace base contains 7 traces, 5 of which have been collected from her activity, while 2 have been shared by *user2* from her trace base. *User2*'s Trace Base contains 6 traces, 5 of which have been collected from her activity, and 1 has been shared by *user1* from her Trace Base. As a tutor, *user1* does not share her marker-based trace while, as a learner, *user2* does.

Instant reflection in the interaction room: a synchronous timeline for activity awareness and activity annotation

The interaction room (Figure 2 - left) is a classical videoconference room with a text chat. Tutors have access (on the left of the screen) to their “session manager”, which gathers planned session activities, instructions and keywords. The main feature which distinguishes VISU from other videoconference tools is the vertical “synchronous timeline”. This timeline presents users with selected elements from interaction traces (here “Image received” obsels represented as thumbnails) as well as marker-based traces.

VISU's synchronous timeline is designed to foster instant reflection by augmenting synchronous interaction with elements of other participants' activity (e.g. indicating when a document is accessed) and it allows participants to take notes on the activity with markers. Instant sharing of interaction traces is a means of extending collective awareness amongst participants. Using markers allows tutors to select critical events in the course of the activity in order to come back to them in order (1) to provide learners with feedback at the end of the session and (2) to reflect on one's own activity in the retrospection room.

Delayed reflection in the retrospection room: obsels and comments for experience reconstitution

The retrospection room (Figure 2 - right) basically functions as a video player allowing users to review previously recorded sessions (video and audio). The playback feature is supplemented by a horizontal timeline displaying the collected obsels (interaction + marker-based traces) organized either by obsel types or by users. The annotating tool (“*Mes commentaires*” [my comments]) allows the user to annotate events that occurred during the session. Such comment-based traces will serve as a basis for teacher development and be used for example in weekly trainee teacher debriefing sessions in which pedagogical interactions are analyzed.

The retrospection room in VISU is designed to foster delayed reflection. The delayed retrospection made possible in the retrospection room allows for teacher development in the following way. To learn professional competencies such as monitoring distant learner interactions effectively, providing clear and concise instructions, giving useful and timely feedback, trainees are confronted with traces of their own situated activity of a past online teaching session and are asked to select samples of this activity, analyze them and comment upon them during a collective debriefing session (Guichon, 2009). Several operations are required: noticing critical events that are worth commenting upon, categorizing them (what is the purpose of a specific

sequence of actions?) and assessing their efficiency or lack thereof (was it adequate, timely, etc.?) against a professional repertoire (see for instance Hampel & Stickler, 2005). The aim is thus to help trainees to explore and reflect on a still ill-defined professional situation and retrospectively make sense of problematic events that occurred in the course of the activity. We contend that getting apprentices to analyze their own context-embedded practice is a necessary condition to make them aware of their behavior in context and a way to provide them with some kind of "annotated template[s] for future praxis in similar situations" (Olson, 1995: 121).

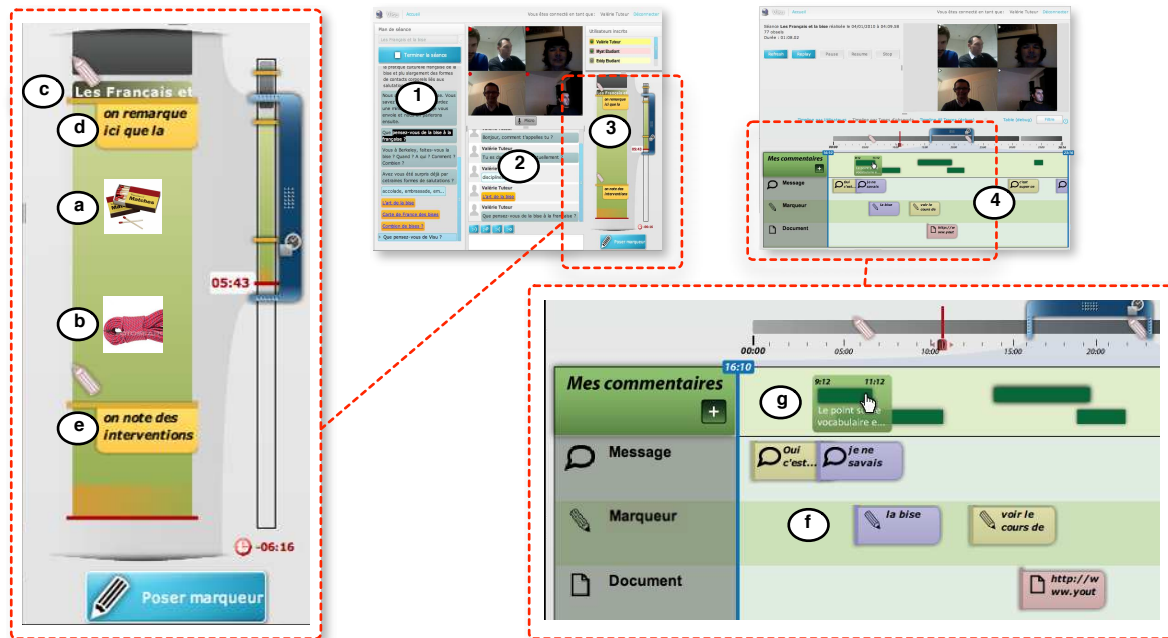


Figure 2. Interaction room (left) and retrospection room (right) in VISU1. The interaction room is used during the synchronous interaction: it provides (1) a session manager, (2) a chat window and (3) a vertical timeline, which features several presentations of obsels from both the interaction trace (a, b, c) and the marker trace (d, e). The retrospection room is used asynchronously after the interaction. It has a horizontal timeline (4) that presents markers and interaction obsels (f). It also allows the user to add comment obsels. (g) Unlike interaction trace and marker-based trace obsels, comment-based trace obsels can have a duration.

A pilot study of marker-based traces

An exploratory study was conducted in real teaching context in order to (1) investigate the quantitative and qualitative use of markers during synchronous language teaching sessions and (2) assess the utility and usability of such a functionality for language tutoring. The ultimate aim was to further investigate design and training issues. Although the markers were also used in the delayed retrospective phase, only what happened in the interaction room was analysed. We focus here on the interaction trace, which appears on the timeline in real time and is also recorded in the chat history that remains available throughout the session.

Method – Experimental Data

The study was part of a telecollaborative project between the university of Berkeley and the University of Lyon 2. The VISU tool was used to support distant synchronous French lessons given by trainee French teachers in Lyon to language learners in Berkeley. Each session was organized in three phases:

- Each week, teacher trainees in Lyon (now referred to as tutors) had to prepare a lesson that aimed at fostering oral communication and to conduct it with one or two learners in VISU's interaction room. At the end of the session, tutors were instructed to conduct a rapid debriefing with the learners on linguistic issues with the help of the markers they had set during the interaction.
- After the interaction, the tutors had to analyze the learning session on the basis of the traces recorded in VISU's retrospection room.
- The following week, teaching interactions were then displayed and discussed in a plenary session with all the tutors and trainers in order to raise language teaching and tutoring issues (see Guichon, 2009 for the detail of the training program).

Tutors were given an introductory training session on the VISU platform, but the use of markers was not a focus. Thus we have the opportunity to study the tutors' intuitive use of these markers as they learned to use the technology to teach their distance language sessions.

Data collection and analysis

The data regarding marker setting and chat messaging were collected from 8 tutors over 7 tutoring sessions. At the end of the third session, each tutor was interviewed in order to comment on the markers he/she created during the session. They were also asked about their global perception of VISU. A quantitative analysis was conducted on the number of markers and text chat messages over time and across the sample of the 8 tutors. In addition, qualitative analyses were conducted on the type of markers produced by 2 specific tutors, selected before the first session on the basis of their prior experience: These two tutors had similar one-year experience in face-to-face language teaching but none in online tutoring. Interviews data were used to complement the quantitative analysis of markers.

Results

Given that the tutors were not familiar with the tool and rather new to online tutoring, it was expected that they would find the early sessions cognitively challenging. We predicted that markers set by the tutors would improve over time, both qualitatively and quantitatively, for two non exclusive reasons: first, the tutors gradually develop competence with the tool and the task so that cognitive resources would be sufficient for carrying out this dual task; second, their perception of the utility of setting markers to prepare for the debriefing and the next tutoring session would rapidly increase once the markers had been used for language teaching and reflexive analysis.

We present quantitative analyses of the number of markers and chat edited by all tutors (Figure 3), followed by a qualitative analysis of the type of markers set by two tutors.

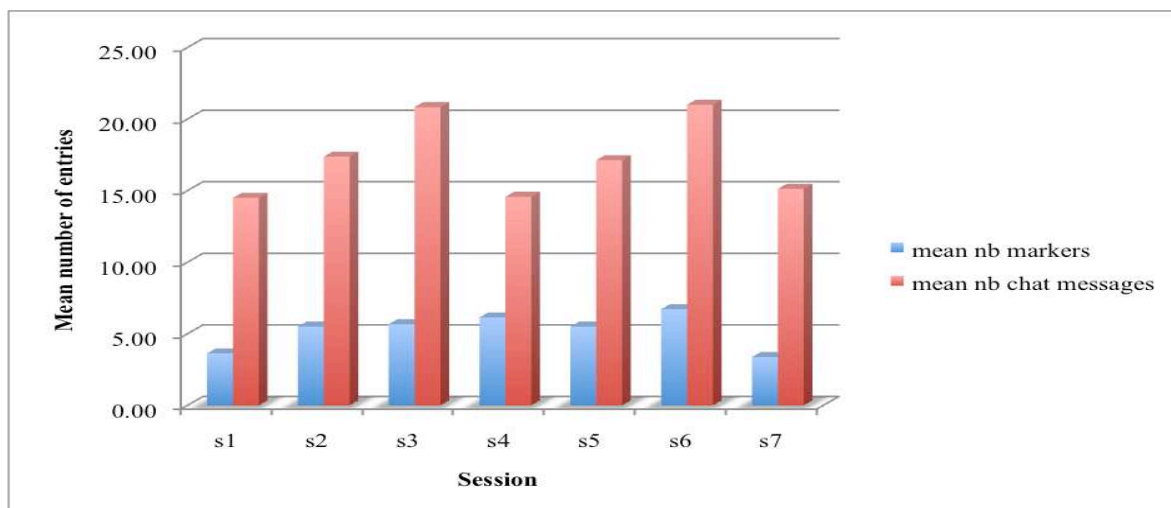


Figure 3. Mean number of markers and chat messages averaged across tutors over the 7 sessions

Number of markers edited over the 7 sessions

As shown in Figure 3, the number of markers increased from the first to the second session and remained stable across the next sessions, except for a drop in the last session. Overall, the mean number of markers did not differ significantly across sessions ($F(6,42) = 1.624$, NS). However, a large variation across tutors was observed (min = 0.29 and max = 12.7 mean number of markers per session) and the difference was statistically significant ($F(1,7) = 10.47$, $p < .05$). Moreover, there were significant correlations between the number of markers set by each tutor for session 2 to 6 (all $r > .80$, $p < .01$), but not between session 1 nor 7 and the others, meaning that in sessions 1 and 7 the tutors behaved differently than in other sessions. These results suggest that participants quickly became acquainted with the system and the task since they were able to set markers in a stable way as early as the second session. The drop in the number of markers set in the 7th session is probably related to the fact that it was the last session. If the markers were used not only to keep track of linguistic issues during the session but also to prepare for the next session, there would be less need to set markers in the last session.

Number of chat messages over time

The tutors wrote a large number of messages in the chat ($M = 15.94$, $SD = 12.56$, see Figure 3). The mean number of messages seemed to vary over time but the difference did not reach statistical significance ($F(6,24) = .343$, NS). As for markers, the variation across tutors was large (min = 8 and max = 34.28 mean number of chat messages per session) and was statistically significant ($F(1,7) = 28.73$, $p < .001$). There was no correlation between the number of markers and the number of chat messages ($r = .63$, NS), suggesting that the variability across tutors was not linked to a general writing behavior but rather to a differentiated use of the marker and chat functionalities.

Qualitative analysis of markers

As mentioned in the methodology, the markers set by two tutors during their interaction with the distant learners across the 7 sessions were further analyzed in order to better evaluate the type and function of markers in this situation. We used Daele & Docq's (2002) typology, based on previous work on face-to-face and distant tutoring, which classifies tutor's interventions according to different purposes. It has to be noted that Daele & Docq's classification was elaborated to analyze tutor interactions with the learners while here the markers were also intended to regulate the tutors' own activity and were not displayed to learners. The four categories proposed by Daele & Docq (2002) were thus adapted as followed:

- *Social function*: pertaining to the quality of the communication and its social quality (e.g. "learner 1 is pleased")
- *Organizational function*: dealing with the organization of the session (e.g. "learner 3 arrives", "use of keywords")
- *Pedagogical function*: providing indications on learners' linguistic skills and their recurrent mistakes (e.g. "pronunciation of *fromage*")
- *Technical function*: corresponding to comments on the system (e.g. "learner 3 does not see the image")
- A fifth category (*other*) was created for markers that did not fit any of the above categories.

The classification (displayed in Table 1) was made thanks to the analysis of the content of the markers and the context in which they occur. In addition, the interviews with these two particular tutors were taken into account so as to better comprehend how they used the markers.

Table 1 - Number of markers in each category for the two tutors (names have been changed)

Category	Cindy	Nelly
Social	13	0
Organizational	22	0
Pedagogical	37	48
Technical	8	0
Other	5	3
Total	85	51

As shown in Table 1, though pedagogical markers were the most frequent for both tutors, other specific uses of the markers can be observed. Nelly used them exclusively to take notes about pedagogical events that she could use for the wrap-up at the end of the session, or to prepare the next session. Cindy used the whole range of categories. Further examination showed that many of the markers created by Cindy were used to keep track of her evaluation of learner's behaviors, personality and skills ("S is not talkative" "they use the vocabulary from last session, good") and reflections on her own tutor practice ("+ good idea for the dialogue", "- I interrupted her").

An interesting phenomenon is the emergence of operative language over time. For example, "pronunciation" is shortened into "pron" by Nelly from session 3 on. Personal cues were sometimes used by Cindy, like + or -, to indicate when she evaluated the event as positive or negative, or capitals for emphasis ("SHE TALKS A LOT"). Interviews with the two tutors indicated the development of instrumentation over time. For example, Nelly first noted only "pronunciation" or the correct sentence without indicating where the mistake was. Then she found ways to keep track of what was said by the learner, for example by using capitals to indicate the place where the mistake was (e.g. "tellemenT"), or by noting a phonetic approximation of the learner's contribution rather than the correct sentence.

Usability and subjective utility

All the tutors were interviewed after session 3 about their perception of the tool and particularly their use of the markers. As expected, tutors appreciated the fact that they could set markers about learner's mistakes without interrupting the oral interaction. Moreover, they kept track of events they could use during the debriefing sessions with the other tutors and the teacher trainers. However, they found that the interaction was disturbed when they were in the process of setting markers because, thanks to the webcam, learners could see that the tutor was typing something that they could not see and was thus not looking at them at that precise moment. For these reasons, they reported using the markers for important events only and tried to find suitable moments (e.g., when the learner was looking at a video) to set markers. Regarding usability, they reported that setting a marker required more effort than writing in the text chat, particularly because the marker zone was very small. Finally they underscored that writing on the vertical timeline was not natural at all.

Discussion and future work

This study aimed at evaluating how novice language tutors used the functionality of setting markers during the synchronous session. Regarding marker setting, although markers were used overall as early as the second session, considerable differences in behaviour were observed across tutors, both qualitatively and quantitatively. Some tutors appreciated to keep track of learners' mistakes without interrupting the oral interaction. But some considered that the time taken and the attention required to set the marker caused a major disturbance in the flow of the activity and therefore they seldom used this functionality. Moreover, the qualitative in-depth analysis of two tutors' behaviors and perceptions revealed that the use of markers is not self-evident, one of the tutors exploiting all the possible functions of the marker while the other concentrated only on its corrective function. In addition, the tutors complained that the marker functionality was not easy to use. Therefore, design issues had to be examined since they dramatically affected the actual utility of the marker functionality, both as an external memory of the activity and support for practice. In this exploratory study, tutors have been explained how the marker functionality worked, but not how they could use it to improve the tutoring situation since no similar situation has been studied before. The present results suggest that tutors have also to be trained to make an optimal pedagogical use of markers, prompting tutors to use markers not only for keeping track of learners' mistakes, but also for fueling their reflection on their own practice and on the learning situation.

A second version of the application, VISU2, has been designed on the basis of the results obtained through this study. In order to avoid the split-attention effect and lessen the disruptive effect of setting markers, the marker text field has been enlarged and now appears next to the chat window and just below the webcam images. After being edited, markers are automatically moved to the right of the timeline. In addition, the timeline has been set horizontally to align it with the regular representation of time and ensure consistency with time representation in the retrospection room. Preliminary observations with the new version of VISU suggest that different tutors now set more markers than with the previous version of the tool. If confirmed, this result will reinforce the hypothesis that metacognitive or awareness tools need to be integrated into the workspace in order to be attended to without too much extraneous cognitive load (Buder, in press).

Future studies will focus on (1) evaluating how tutors make use of the markers in the retrospection room to analyze their tutoring activity retrospectively and (2) whether markers modify distant learners' behaviors and contribute to enhance their language competence.

Endnotes

- (1) ITHACA (Interactive Traces for Human Awareness and Collaborative Annotation) is a project funded by the French Research Agency (ANR), see <http://liris.cnrs.fr/ithaca>
- (2) VISU V1 adopts the architecture for trace-based synchronous collaborative systems defined in Clauzel et. al (2010). It is open source software (LGPL) based on Adobe® Flash/Flex and Red5 server. Olivier Aubert, Lionel Breduillieard and Serguei Sayfulin are the main developers.

References

- Avouris, N. Fiotakis, G. Kahrmanis, G. Margaritis, M., & Komis, V. (2007). Beyond logging of fingertip actions: analysis of collaborative learning using multiple sources of data. *Journal of Interactive Learning Research*, 18(2), pp. 231-250.
- Bratitsis, T., & Dimitracopoulou, A. (2006). Monitoring and analyzing group interactions in asynchronous discussions with the DIAS system. In *CRIWG 2006, Lecture Notes in Computer Science 4154*. 54-61.
- Buder, J., Bodemer, D., Dehler, J., & Engelmann, T. (2009). SCAN tools for collaborative learning. In *International Conference of Computer Supported Collaborative Learning* (pp. 606–615), Rhodes, Greece.
- Buder, J. (in press). Group awareness tools for learning : Current and future directions. *Computers in Human Behavior*, 10-13.

- Clauzel, D., Sehaba, K., & Prié, Y. (2010). Enhancing synchronous collaboration by using interactive visualisation of modelled traces. *Simulation Modelling Practice and Theory*, In Press, Corrected Proof.
- Daele, A., & Docq, F. (2002). Le tuteur en ligne, quelles conditions d'efficacité dans un dispositif d'apprentissage collaboratif à distance ? in *Proceedings of the AIPU Conference*, Louvain-la-Neuve.
- Farooq, U., Carroll J.-M., & Ganoë, C.-H. (2007). Supporting creativity with awareness in distributed collaboration, in *International Conference on Supporting Group Work* (pp 31-40).
- Guichon, N. (2009). Training future language teachers to develop online tutors' competence through reflective analysis. *ReCALL*, 21(2), 166-185.
- Hampel, R., & Stickler, U. (2005). New skills for new classrooms: training tutors to teach languages online. *Computer Assisted Language Learning*, 18(4), 311-326.
- Hill, W. Hollan, J. Wroblewski, D., & McCandless, T. (1992). Edit wear and read. In *Conference on Human Factors in Computing Systems (CHI'92)* (pp 3-9).
- Jermann, P., Soller, A., & Muehlenbrock, M. (2005). From mirroring to guiding: a review of the state of the art technology for supporting collaborative learning. *International Journal of Artificial Intelligence in Education*, 15, 261-290.
- Laffey, J., Amelung, C., & Goggins, S. (2009). A Context Awareness System for Online Learning: Design Based Research. *International Journal on E-Learning*, 8(3), 313-330.
- Lonchamp, J. (2006). Supporting synchronous collaborative learning: a generic, multi-dimensional model, *International Journal of Computer Supported Collaborative Learning*, 1, 247-276.
- Nova, N. Wehrle, T. ,Goslin, J., Bourquin, Y., & Dillenbourg, P. (2006). Collaboration in a multi-usergame: impacts of an awareness tool on mutual modeling. *Multimedia Tools and Applications*, 32(2),161-183, 2006.
- Oviatt, S., Coulston, R., & Lunsford, R. (2004). When do we interact multimodally? Cognitive load and multimodal communication patterns. In *Proceedings of the 6th Int. Conference on Multimodal interfaces* (pp 129-136), Penn. State College.
- Olson, M. R. (1995). Conceptualizing narrative authority: Implications for teacher education. *Teaching and Teacher Education*, 11, 119-135.
- Phielix C., Prins F.-J., & Kirschner P.-A. (2009). The design of peer feedback and reflection tools in a {CSCL} environment, in *International Conference CSCL* (pp.626-635).
- Plaisant, C., Rose, A., Rubloff, G., Salter, R. & Shneiderman, B. (1999). The design of history mechanisms and their use in collaborative educational simulations, in *Proceedings of the International Conference on Computer Supported Collaborative Learning* (pp. 348-359).
- Romero, C. & Ventura, S. (2007). Educational data mining: A survey from 1995 to 2005. *Expert Systems with Applications*, 33(1), 135-146.
- Settouti, L.-S., Prié, Y., Marty, J.-C., & Mille, A. (2009a). Trace-based system for technology-enhanced learning systems personalization, In *9th IEEE International Conference on Advanced Learning Technologies*, Riga, Latvia.
- Settouti, L.-S., Prié, Y., Champin, P.-A. Marty, J.-C., & Mille, A. (2009b). *A Trace-Based Systems Framework: Models, Languages and Semantics*, LIRIS Research Report, inria-00363260, 40 pp.
- Weinreich, H., Obendorf, H., Herder, E. & Mayer, M., (2006). Off the beaten tracks: Exploring three aspects of web navigation. In: *World Wide Web Conference* (pp. 133-142).
- Yukawa, J. (2006). Co-reflection in online learning: Collaborative critical thinking as narrative. *International Journal of Computer-Supported Collaborative Learning*, 1(2), 203-228.

Acknowledgments

We are grateful to J. Lüthi who carried out the data collection for this study and D. Pries, R. Kern and D. Malinowski from UC Berkeley who made this experiment possible in Berkeley and N. Guichon and C. Develotte at the University of Lyon 2. We also wish to acknowledge Shona Whyte's insightful remarks on a previous version of this paper.