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# ReCALL



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## **Eyetracking methodology in SCMC: a tool for empowering learning and teaching**

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## Eyetracking methodology in SMC: a tool for empowering learning and teaching

### Abstract

Computer-assisted language learning, or CALL, is an interdisciplinary area of research, positioned in tension between science and social science, computing and education, linguistics and applied linguistics. This paper argues that by appropriating methods originating in some areas of CALL-related research, for example, HCI or psycho-linguistics, the agenda of 'attention-focus' research can be shifted from a cognitive perspective to a learner-centred approach, understanding online language learning and teaching spaces as mediated by technology, second/foreign language, and online teaching culture.

Taking a method that has traditionally been used within a positivist paradigm, the authors exemplify the potential of eyetracking to progress online language learning research - extending it in ways compatible with a sociocultural paradigm. This is evidenced by two pioneering studies in which an innovative combination of methods allows participants, whose gaze focus during synchronous computer-mediated communication (SMC) has been recorded, to reflect back on their involvement. Eyetracking is combined with stimulated recall interviews that trigger deep reflection on learner and teacher strategies by directing participants' recollections on their attention focus.

The rich, multifaceted results shown by this original and innovative use of eyetracking methods in a sociocultural framework direct a way forward in researching online learning by integrating insider and outside views coherently and systematically.

### Key words

eyetracking, SMC, sociocultural, methodology, online language learning

## 1 Introduction

Eyetracking is a relatively new approach in the research area of second language learning and teaching and is just making its way into the study of computer-assisted language learning (CALL) and synchronous computer-mediated communication (SCMC). In two pioneering studies we demonstrate how the combination of eyetracking with other, more qualitative methods, can be used within a sociocultural paradigm (Authors, in preparation; Author, 2015; Authors, 2014, 2015b). This paper will set the context of qualitative and mixed-method studies in CALL, evaluate eyetracking as a method for Second Language Acquisition (SLA) research in a psycholinguistic context, and describe an expanded method adding a usability perspective taken from Human-Computer Interaction (HCI) research, before moving the method on towards its potential use in SCMC research within a sociocultural paradigm.

### 1.1 Innovative approaches in CALL research

In their CALL journal Editorial, Mike Levy, Philip Hubbard, Glenn Stockwell and Jozef Colpaert (2014) identify questions of pedagogy, design and research as the most pressing in our field. They position CALL in a space between different disciplines, which makes CALL research fundamentally interdisciplinary (see also Author & colleague, 2015) and embraces a wide variety of research methods. As Author & colleague (2015a) have shown, occupying this space between different disciplines and their fundamental, but often unspoken, tenets is at the same time promising and challenging - not least because selecting methods that originate in qualitative or quantitative paradigms and combining them to form new and innovative methodological approaches necessitates an understanding of the underlying ontologies and epistemologies (Riazi & Candlin, 2014).

This paper adopts a sociocultural paradigm (Block, 2003; Lantolf & Thorne, 2007; Vygotsky, 1978) emphasising that all our actions are influenced by the social and cultural contexts in which they take place, and these in turn are based on historical developments. For Vygotsky mediation through language is one of the fundamental ways of mediation allowing humans to achieve “higher mental functions” (Vygotsky, 1978). Taking a sociocultural perspective is thus relevant in language learning situations (Block, 2003), and even more so in language learning online (Bee Bee & Gardner, 2012), as the communication is mediated in two ways: through the use of a second language (Lantolf, 2000), and through the technology employed with its affordances (Dougiamas, 1998; Lamy & Hampel, 2007; Wertsch, 2007). Mediation through technology is another of Vygotsky’s basic examples of mediation, also already well researched (Hampel, 2009) in online language learning.

As a research paradigm, sociocultural theory (SCT) places the CALL researcher at the crossing point of theory (or ‘research’) and practice (or ‘pedagogy’): the knowledge that all action is mediated (Wertsch, 1994) makes the context of a study part of its field and encourages a) naturalistic or ecological studies, b) the collection of rich data, and c) methods of analysis that involve participant checks and reflection. The conviction that every action is meaningful (Schwandt, 2000) makes the researcher responsible for the outcomes, in terms of research findings or knowledge generation

1  
2  
3 and also in a wider sense for the change engendered by the research, the influence on  
4 practice, and – in our field – the improvement of pedagogy or learning opportunities,  
5 as Lantolf & Thorne (2007) state:  
6

7       Because of its emphasis on praxis, SCT does not rigidly separate  
8 understanding (research) from transformation (concrete action). While SCT is  
9 used descriptively and analytically as a research framework, it is also an  
10 applied methodology that can be used to improve educational processes and  
11 environments. (Lantolf & Thorne, 2007, p. 216)  
12

13 CALL research over the past decade has shifted from predominately quantitative  
14 studies to a more conscious employment of qualitative methods in mixed approaches  
15 or ecological studies (see Benson, Chik, Gao, Huang, & Wang, 2009). As Levy and  
16 colleagues point out, this has also led to a selection of methods from a range of  
17 different disciplines.  
18

19       Frequently, those working in CALL do not simply transfer research methods  
20 or designs from cognate disciplines, or if they do, important adjustments are  
21 made while in transit. Sometimes the method or design in CALL is quite  
22 unique or distinctive. (Levy et al., 2014, p. 4)  
23

24 These innovative approaches have resulted in a richness of data and insights (see for  
25 example, the studies assembled in the Special Issue of the CALICO journal devoted to  
26 qualitative methods in CALL (CALICO 32, 3, 2015)). What is sometimes still  
27 missing is a clear description of the theoretical foundations and the sources of  
28 methodological inspiration (see also Riazi & Candlin, 2014).  
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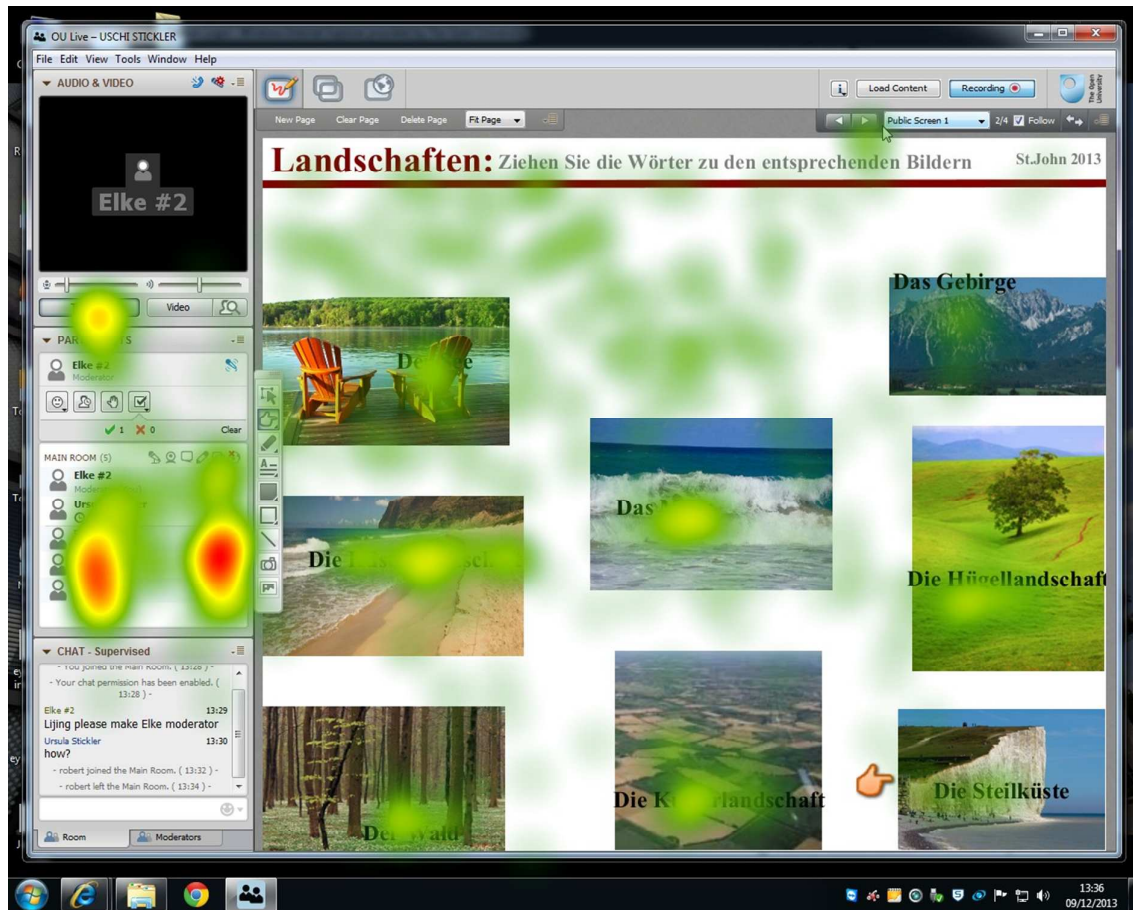
### 31 **1.2 Eyetracking research in CALL**

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34 Eyetracking can show where a person's gaze is focused at a particular time  
35 (“fixation”). From this information it is possible to draw certain conclusions about the  
36 attention focus of the user (Just & Carpenter, 1976). Eyetracking as a research method  
37 has been used for over 100 years in the field of linguistics (Jacob & Karn, 2003), first  
38 and foremost as a method in reading research: by recording the gaze fixations of  
39 readers, i.e. where a person's gaze is focused at a particular time, linguists  
40 investigated the process of reading (Rayner, 1978, 1998).  
41  
42

43 Nowadays, in addition to the computer generated statistical information eyetracking  
44 data can be represented visually in videos and images. Like other video recordings,  
45 the visual information is available for scrutiny immediately after the collection of data  
46 but eyetracking has specific advantages over other visual data: a) it adds a layer of  
47 information to a simple recording of screen interactions, and b) it can cluster this  
48 information (see Illustration 1 for an example of a heatmap and Illustration 3 for an  
49 example of a gazeplot image) showing cumulative attention focus points<sup>1</sup>.  
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53 *Illustration 1: Heatmap of German teacher*  
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As visual data representation becomes increasingly important amongst the communicative formats we use in the 21st century, eyetracking can be confirmed as a current and relevant method to present research data<sup>11</sup>.

Leow, Grey, Marijuan and Moorman (2014), in their article comparing different research methods, point towards an increased interest in SLA to investigate internal processes of learners during language learning. The three methods they investigate in detail are Think-Aloud-Protocols, eyetracking, and measuring the response time, for the investigation of cognitive processes, elaborating on shortfalls of all. In their judgement, "... ET [eyetracking] is arguably the most robust measure of learner attention given the rich data it gathers in relation to participants' eye movements." (p.117). The "recent prominence" of eyetracking for investigating cognitive processes in SLA was confirmed in the introduction to the Special Issue of the journal *Studies in Second Language Acquisition* (Winke, Godfroid, & Gass, 2013, p. 205).

This special issue is devoted to eye movements by L2 learners in the belief that, through these data, researchers will gain a better and more complete understanding of the processes of L2 development. (Winke et al., 2013, p. 207)

Most of the articles in the special issue compiled by Winke, Godfroid and Gass, as indeed most SLA eyetracking studies in the past, are interested in a cognitive perspective and deal mainly with experimental studies. Even those concerned with 'ecological validity' (Spinner, Gass, & Behney, 2013) conclude that a more

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2  
3 naturalistic setting might have to be sacrificed in favour of unrealistic tasks to gather  
4 more reliable and comparable data: they obtained more accurate data by enlarging the  
5 font of the text example and changing the layout, resulting in a format that does not  
6 compare to students' normal reading material.  
7

8 Eyetracking studies investigating communication in online shared spaces, i.e.  
9 synchronous computer-mediated communication (SCMC), are rare. Bryan Smith  
10 (Smith, 2010, 2012), Breffni O'Rourke (2012), Marije Michel (Smith & Michel,  
11 2014), and Therese Örnberg Berglund (Berglund, 2012) are amongst the few to have  
12 tackled this challenging task. Based on a Symposium at the 2013 WorldCALL  
13 conference, O'Rourke and other members of the panel (Authors & colleagues, in  
14 press) point out reasons why this might be the case: although eyetrackers are  
15 becoming more widespread and easily available, the research design of eyetracking  
16 when users are engaged in real communication and work with a screen that changes  
17 often and in unpredictable ways, is still challenging. And in this developing field,  
18 research methodologies are not yet firmly established; as Spinner, Gass and Behney  
19 note:  
20

21  
22 As SLA researchers become more sophisticated in their use of eye-trackers,  
23 they will need to move away from reliance on methodologies established by  
24 researchers in other fields, given the different foci of the research questions.  
25 (2013; p. 390)  
26

27 In a contribution to Caws' & Hamel's (in press) collection of new methodological  
28 approaches in CALL research, Authors & colleagues (in press) attempt to show the  
29 additional benefits of applying eyetracking to SCMC research. The uniqueness of the  
30 direction taken in our research can best be appreciated from a more traditional  
31 understanding of eyetracking: following the eye movements on already moving  
32 screens poses an additional technical challenge; analysing the data gathered from the  
33 eyetracker itself and combining this with additional layers of information makes our  
34 method complex but also relevant for answering future questions of language learning  
35 online. For example, future questions could include: "What do learners and teachers  
36 pay attention to during synchronous online interaction?", "What areas of the screen  
37 attract attention and why?", "What is the influence of formal or informal settings on  
38 attention patterns and awareness?", "What happens during phases of silence and  
39 apparent inactivity during online language learning sessions?" Our own experience in  
40 SCMC research (Authors, 2015b) is grounded in a sociocultural perspective and we  
41 are aware that the 'unexpectedness' and the resulting 'messiness' of data are a natural  
42 part of communication. It is therefore necessary to find a way of integrating  
43 eyetracking into a methodology that can cope well with more naturally occurring  
44 language learning and teaching.  
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## 49 **2 Combining methods systematically**

50  
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52 The research presented in this paper – while rooted in sociocultural theory – draws on  
53 methods from a variety of fields. From psychology and psycholinguistics we take the  
54 inspiration of looking at learners' eye movements to draw conclusions about the focus  
55 of their attention at any given moment (Just & Carpenter, 1976; Rayner, 2009). In this  
56 perspective, fundamentally a positivist stance, data gains in validity by being  
57 objective, i.e. a look from the outside onto learners' experience of language learning.  
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3 The richness of detail and the accuracy of measurements and recordings are  
4 appreciated by researchers in this field whereas questions of subjective interpretation  
5 and context are largely left aside.  
6

7 HCI research makes more practical and pragmatic use of eyetracking for the  
8 examination of online spaces (Poole & Ball, 2006), for example websites. The users'  
9 experience here is of more importance and therefore some HCI eyetracking experts  
10 (e.g. Nielsen & Pernice, 2010) and SLA researchers (Godfroid, Housen, & Boers,  
11 2010) recommend combining eyetracking with other methods, e.g. stimulated recall,  
12 to achieve more clarity on the meaning of their findings. However, our distinctive mix  
13 of methods develops eyetracking substantially beyond its forms of use by HCI  
14 researchers or psycholinguists, i.e. beyond a purely pragmatic or objectifying stance,  
15 mainly interested in exploring the internal psychological processes of research  
16 participants and proving their relevance for, and fit with, language learning tenets. We  
17 also eschew the danger of limiting ourselves to a positivist paradigm as, in our  
18 studies, participants play a central role in contributing their reflections, thoughts and  
19 insights. Furthermore, the participants' reflections support their own awareness  
20 raising and help them to develop as learners and teachers.  
21  
22

23 Educational research provides us with the methods for investigating learners' or  
24 teachers' thought processes and reflective practice (Hammersley, 2005). Finding out  
25 what learners think has taken two different approaches traditionally: on the one hand  
26 observations from the outside are used to establish more or less tentative connections  
27 between observable behaviour and thought. Examples for methods in this perspective  
28 are keystroke and screen recordings, reaction time studies and classical eyetracking  
29 studies. On the other hand, introspective data are generated by asking learners to  
30 verbalise their own thinking processes and use recollection or reflection to share these  
31 processes with the researcher. Examples from this strand include think-aloud  
32 protocols and stimulated recall interviews.  
33

34 Gass & Mackey (2000) show how Stimulated Recall (SR) can be used in applied  
35 linguistics research in general. Introspective methods are often hampered by a lack of  
36 memory. Presenting a stimulus can aid this memory and make recollections more  
37 accurate. The emphasis of Gass & Mackey's approach to SR is still on veracity of  
38 recollections, their potential to capture "true" representations of learners' thought  
39 processes, although they are aware of the subjectivity of recall and descriptions from  
40 the learners' perspective.  
41  
42

43 More recently, SR has also been employed to explicitly aid reflection: the stimulus is  
44 used to access a deeper level of the participants' thoughts on their past actions. These  
45 would include memories of reasons for action and descriptions or speculations on  
46 processes. Messmer (2015), for example, employs SR to fuel deeper reflection as well  
47 as making thought processes of teachers visible. He uses SR for the investigation of  
48 how teachers make decisions about their teaching. His study is based on video  
49 recordings of face-to-face classroom interactions, and he shows that teachers use four  
50 types of reasoning to describe their actions retrospectively: explanation (*Erklärung*),  
51 justification (*Begründung*), vindication (*Rechtfertigung*), and conclusion (*Folgerung*).  
52 In addition to the knowledge generated by this qualitative analysis, he also claims that  
53 SR acts as an encouragement for deep reflection in teachers.  
54

55 Der Zusammenhang von Methode und Fragestellung scheint insbesondere in  
56 Bezug auf die Untersuchung von Denkprozessen nicht unbedeutend. Inwiefern  
57 LehrerInnen sich in einem Reflexionsprozess an ihre ursprünglichen  
58  
59  
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Gedanken "erinnern", hängt explizit auch vom methodischen Vorgehen ab (Messmer, 2015, n.p. §4)

(The relation between method and research question seems to be particularly relevant in connection with the investigation of thinking processes. How far teachers 'remember' their original thoughts during the reflective process will also depend explicitly on the methodological procedures. – our translation)

From the field of CALL, we take the general direction for future research as outlined by Levy and colleagues (2014) and also specific ideas on involving research participants as co-investigators, as for example, proposed by Cutrim Schmid (2011). In her longitudinal study on the use of whiteboards in face-to-face classrooms, Cutrim Schmid engages teachers to reflect on their own teaching using video recordings of classroom interaction that involve the use of digital whiteboards for language teaching.

Our methodological approach with its specific combination of methods allows us to look at mediated action (Wertsch, 1994) as a basis for learning in online spaces; the reflections of our participants can offer valuable insights into this. In our approach, combining eyetracking data with participant's stimulated recall data, we aim at generating insights into observable learner and teacher behaviours ("true recollections" of thought processes), and reflections on these processes. We even go beyond that by taking our participants' reflections as an integral part of the research process. Together with them we speculate on reasons for their actions in context, we can judge them as typical or atypical, we evaluate them – in a dialogue – as helpful or hindering their learning and teaching processes. Our claim is that our methodological approach is unique in generating these insights; however, we want to establish that this is the case.

In brief, our research questions are:

- Does our specific combination of methods help us – as researchers and as participants – to understand the process of online language learning and language teaching better?
- Does this specific combination of methods benefit the participants in developing their online language learning and language teaching skills and strategies?
- Does this specific combination of methods fit within a socio-cultural framework and add to its explanatory / hermeneutic power?

In the subsequent sections we will show how eyetracking, as a method originating in psychology and adopted by HCI for usability studies, has the potential to enrich the socioculturally-based research on online language learning. We will first describe a unique mix of methods deploying eyetracking and how this was used in two studies. Following the project description and findings we will discuss the methodology used, in its epistemological context and compared to other options. We will show the benefits of starting with an explicitly sociocultural paradigm. Finally, we will suggest some options for future studies.

### 3 A mixed-method eyetracking model for SCMC: description

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2  
3 Eyetracking is an excellent method to record the gaze focus of users engaged in  
4 working on a screen. Our studies employ the principles of eyetracking during  
5 synchronous computer-mediated-communication (SCMC) tasks combined with a  
6 stimulated recall interview immediately following the online task.  
7

8 In a laboratory setting, an online language learning task, mirroring as closely as  
9 possible a naturalistic task, is set up. Participants are introduced to the task and the  
10 laboratory, explaining in detail what our research questions and our methods are, how  
11 eyetracking works, and what specific contributions are expected of them. The  
12 laboratories have integrated ceiling video cameras to record participants during their  
13 interaction with the computer or with other people in the room.  
14

15 Before the actual online eyetracking task, we collect some baseline data from  
16 participants; either in the form of a short biographical questionnaire (students) or  
17 during a short pre-study interview asking for previous teaching experience (teachers).  
18 Then the eyetracker needs to be calibrated for every individual user to achieve close  
19 approximation of the actual gaze focus. When these preliminary steps are concluded,  
20 we start the actual eyetracking.  
21

22 As the tasks are carried out in a synchronous CMC environment, the set-up needs to  
23 be carefully planned, so that all participants are ready at the same time. During the  
24 task, the eyetracker records the gaze focus, and this data can be immediately  
25 converted into gazeplot videos, a standard representational format for eyetracking  
26 data showing how participants' eye focus moves on the screen (see Illustration 3 for a  
27 still image of a gazeplot). These video-clips are played back to the participants after  
28 the completion of the online task, forming the basis of the stimulated recall interview.  
29 The gazeplot video is repeatedly stopped to allow participants to describe in detail  
30 what they noticed about their behaviours.  
31

32 Core data for our project comprises: 1) ceiling camera recordings of participants'  
33 interaction with the computer, 2) eyetracking data including gazeplot videos,  
34 heatmaps, fixation count and duration, and other statistical measures recorded by the  
35 eyetracker, plus 3) screen recordings of the online tutorial interactions, and 4)  
36 recordings of stimulated recall interviews. Together with baseline questionnaires and  
37 follow-up questionnaires, field notes taken by the researcher present either in the lab  
38 or in the observation room, and follow-up notes and comments from the participants,  
39 these data form a rich and complex source of information about online learning and  
40 teaching.  
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### 45 **3.1 Two mixed-method eyetracking studies: participants and procedures**

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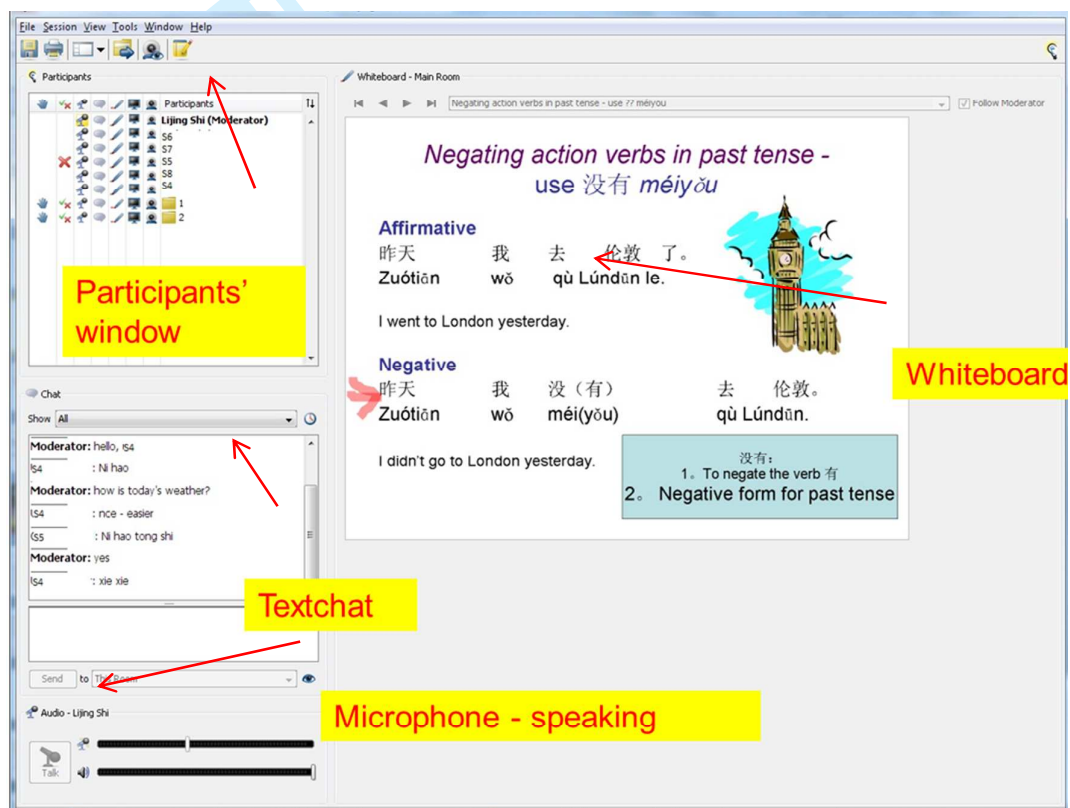
48 Following the methodology described above, we have carried out two studies to  
49 investigate language learners' and teachers' attention during synchronous online  
50 tutorials, using a Tobii eyetracker. The first study was conducted in 2012 with ten  
51 adult learners whose Chinese linguistic skills ranged from A1 to B1 on the Common  
52 European Frame of Reference (CEFR). This is the level that attracts most students and  
53 hence has the highest number of learners and teachers.  
54

55 Before the eyetracking started, participants filled in a background questionnaire about  
56 their language and ICT skills. In the first eyetracking activity, each of them was asked  
57 to fill in the answer to reading comprehension questions based on a short Chinese text  
58  
59  
60

with Pinyin transcription below. Characters, Pinyin and English questions were all presented in the same whiteboard area of an online video-conferencing interface, *Elluminate* (see Illustration 2, below).

In *Elluminate*, learning materials (text, pictures, movable objects) are made visible to everyone on the whiteboard. To speak and be heard by all other participants, users need to click a microphone button. They can also use a textchat function to communicate. The participant window on the left shows users' names with a list of icons which either indicate the activities they are doing (e.g. typing in the textchat) or their emotional responses (e.g. smiling or sad). They can use a 'Yes/No' button to cast votes, and activate a 'Raised-hand' icon if they wish to speak or ask a question.

Illustration 2: *Elluminate* interface with main areas labelled



In the second eyetracking activity, each of the learners participated in a short online tutorial with a teacher and three or four other learners via *Elluminate*. Based on our findings from a pilot study, we were aware that eyetracking generates a large amount of complex data and therefore decided to keep the interactions short to allow us to investigate more different learners. The interactive activity emulated a typical online tutorial requiring learners to read, listen, speak or move objects on the screen in real time. Four weeks after the eyetracking experiments, each participant received an email asking them whether the eyetracking experience had had any impact on their Chinese learning. For more details on this study, please refer to Authors (2015).

1  
2  
3 In 2013-14, applying the same methodology, three teachers took part in our second  
4 study focusing on teachers' attention during online language tutorials. All of them  
5 were experienced language teachers teaching Chinese, French or German as a foreign  
6 language in a distance context at a British university. The German teacher had taught  
7 online for more than 10 years and was very familiar with the new online teaching  
8 platform that had replaced *Elluminate*. The Chinese teacher had started teaching  
9 Chinese online via *Elluminate* in 2008, but she had not used the current software. The  
10 French teacher had never taught online before this study but was familiar with both,  
11 *Elluminate* (see Illustration 2) and *Blackboard Collaborate*, the current software (see  
12 Illustration 1).  
13

14  
15 These three teachers were interviewed on their teaching beliefs and experiences,  
16 offline and online, before eyetracking. Then, they delivered a 20-minute online  
17 tutorial with four learners in a lab where their eye movements were tracked by Tobii.  
18 Subsequently, the teachers watched the gazeplot video with a researcher, recalling  
19 what had happened, explaining, commenting and reflecting on their teaching. Four  
20 weeks after the eyetracking experience, they received an email asking them to provide  
21 further thoughts on the effect of eyetracking on their thinking and teaching practice.  
22 In addition, the researchers also asked those learners who had participated in the three  
23 online tutorials to report any technical or linguistic problems to provide extra  
24 contextual information for the study.  
25  
26

## 27 28 **3.2 Findings**

### 29 30 31 3.2.1 The learner study:

32  
33 Our investigation of students learning Chinese in online settings showed that all  
34 beginners or lower intermediate learners (A1 to A2 CEFR) used the Pinyin  
35 transcription to some extent if it is offered on screen. Only advanced learners relied  
36 solely on character recognition for comprehension checks. This can be evidenced  
37 through analysis and interpretation of the numerical information collected during the  
38 eyetracking. For the interpretation of learners' strategies and reasons for the use of  
39 Pinyin, however, we needed the additional information from the SR interviews. We  
40 garnered three different reasons for focussing on the Pinyin: some learners used it for  
41 comprehension if their recognition of Chinese characters was not well-developed,  
42 some checked Pinyin for confirmation although they generally had a good idea of the  
43 meaning of the characters; and finally, some learners used Pinyin simply for  
44 convenience or "because they were there", rather than employing a particular strategy.  
45

46  
47 In the analysis of the second part of our learner study, concerned with interactive  
48 online speaking, we found the areas of interest (AoIs) learners focused their gaze on  
49 of particular relevance. We divided the screen into three types of areas: content,  
50 technical and social. These labels are used as shortcuts, where "content" refers to  
51 language teaching content, "technical" describes areas where active use of a  
52 communication feature is possible, and "social" are those areas of the screen where  
53 information on other participants is displayed but which cannot be used actively. The  
54 content area, the main part of the whiteboard where the information, language help  
55 and language tasks are displayed (see Illustration 2), attracted the majority of fixations  
56 (70%); the technical area, e.g. the microphone button and textchat, features that  
57 participants had to use to communicate with others, attracted less than 10% of  
58  
59  
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attention. Our major finding, confirming the inherently social nature of online language tutorials, is the 20% of fixation directed to the social areas, features of the screen that provide information about other participants, e.g. their status of presence or absence, their names, emoticons they chose to display.

Again, confirmation of the importance of social presence indicators came from the SR interviews where learners mentioned the need to “see” who’s there, find out who is speaking to them, etc. Mediation through technology that is capable of displaying this information in a timely and comprehensible manner proved an important factor in the understanding of online language learning our participants explained (see Authors, 2015).

### 3.2.2 The teacher study:

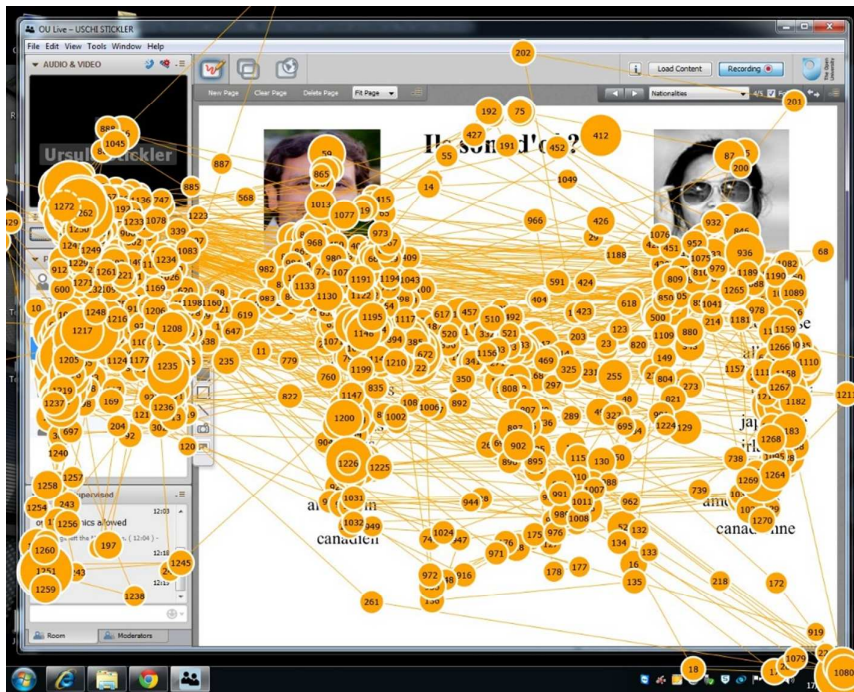
A fuller picture of online language teaching was revealed by the combination of quantitative and qualitative data produced in a teacher eyetracking study. Regarding teacher’s attention during synchronous language teaching (SCMC), we discovered that teachers paid considerable attention to the social and technical areas of the screen in addition to their focus on teaching content.

*Table 1: Three teachers’ fixation ratio on different AoIs during online teaching*

Areas of Interest (Aoi)	Chinese Teacher <i>experienced online language teacher, unfamiliar with current software</i>	French Teacher <i>No online language teaching experience, familiar with current software</i>	German Teacher <i>experienced online language teacher, highly familiar with current software</i>
Content	54.58%	33%	63.45%
Social	25.86%	28%	24.68%
Technical	19.57%	39%	11.87%

Though this level of information can be derived at from simple numerical eyetracking data, employing a stimulated recall interview in the second step of the study moved teacher participants into the role of quasi co-researchers who gained an understanding of the information eyetracking representations such as gazeplot videos can provide and how to interpret them. The gazeplot video shows teachers their eye movements in detail and makes them aware of the complex multitasking they undertake while teaching online, thereby deepening their understanding, supporting their reflections, and guiding the questions and comments during the reflective interviews. As an illustration of the complexity of a teacher’s tasks during online language teaching see illustration 3, a gazeplot image taken of a teacher’s shift of attention focus during a short sequence in her tutorial.

*Illustration 3: Gazeplot image of French teacher*



SR data confirmed that unfamiliarity with the online teaching tool was the main reason for increased attention to technical areas (e.g. the microphone). The relative lack of visual clues pushed teachers to rely on the social areas of the screen to gather feedback from learners. As teachers need to pay attention to different areas of the screen, they felt that online teaching was more cognitively demanding ('intensive'). SR also reveals that teachers made conscious decision as to what content they paid closer attention to. For example, the French teacher speculated on her attention focus: "...you need to focus on the talk button and the, obviously, the participants window as you are interacting with them orally, you know the board there –", recognizing the different needs of online vs. face-to-face teaching. The Chinese teacher's gaze focused on the Pinyin tone markers when she listened to learners repeating sentences shown on the screen; in the SR interview she reported that this attention focus was based on her belief that tones rather than pronunciation were the main speaking challenge for learners at this level.

In the SR sessions, all three teachers agreed that watching their own eye movements recorded during online tutorials was interesting and inspiring. The German teacher commented: "that's why it is so good to watch your own tutorial, the recordings we make often for the students,... but I find it is important that you as a teacher should watch it, so you reflect on it."

Watching their eye movements provided each teacher with solid ground to reflect on their teaching techniques. The German teacher identified her monitoring of the online classroom as a controlling function and felt that contrary to her conscious teaching style, her tutorial slipped into a teacher-centred fashion. Critically evaluating her own cognitive stress caused by the multitasking of online teaching, she also became aware of a possible 'cognitive overload' for students when considering how many tasks needed to be completed in a short timeframe. As a 'novice' online teacher, the French teacher frequently compared her online teaching experience with her classroom

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3 practice. She first felt that the online tutorial was ‘restricted’, ‘less dynamic’, ‘slower’  
4 compared to her usual teaching, but near the end of the session, she came to realise  
5 that the design of the online tasks should be adjusted (“I would need more props, I  
6 would have needed more screens”), and acknowledged that online teaching also  
7 offered a different way of teaching which could be more effective compared to  
8 classroom teaching.  
9

10 The reflections of our teacher participants show their distinct approaches to teaching  
11 and learning; these are partly based on their understanding of how language is learned  
12 influenced by their pedagogies; partly on the affordances of the online environment  
13 that mediates communication; and partly on their institution’s preferred teaching  
14 approach and the training they have received in their place(s) of employment.  
15

16 This study is only described here to a limited extent, presenting highlights relevant  
17 for the methodological argument. A fuller account will be published in due course  
18 (Authors, in preparation).  
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#### 20 21 **4 Methodology Discussion** 22 23

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25 With eyetracking generated information it is possible to draw certain conclusions  
26 about the attention focus of the user (Just & Carpenter, 1976). This step already  
27 implies interpretation based on certain hypotheses (“eye-mind-hypothesis”). In a  
28 psycholinguistic framework/study, data collected with the help of eyetracking can be  
29 used to form tentative explanations of users’ behaviour, it is one type of information  
30 that allows a researcher to look at what is going on “inside a learner’s head”. Within a  
31 paradigm that emphasises explanation over understanding and allows proof to be  
32 based on generalised statistical likelihood, the numerical data from eyetracking  
33 studies is sufficient to support the benefits of this method for advancing SLA. In his  
34 keynote speech at the BAAL-CUP symposium on eyetracking in online language  
35 learning (Authors, 2015a), Bryan Smith pointed out that eyetracking can be used to  
36 conduct exploratory research, to confirm other measures, to test assumptions of CMC,  
37 and to test SLA notions in CALL (Smith, 2015).  
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40 As mentioned above, we base our studies on sociocultural principles, and so our data  
41 collection does not end with the glimpse “inside the user’s head” interpreting what the  
42 eyetracking data offers us. We add retrospective and introspective methods into the  
43 mix to further our understanding of what is happening during an online learning  
44 episode. A qualitative research paradigm, emphasising understanding over explaining,  
45 does not rely solely on generalisability based on sufficient statistical data. Instead, it  
46 requires proof of a different kind to generate a convincing depth of description, proof  
47 that genuine empathy has been sought and the participant’s voice is respected  
48 alongside the researcher’s. In our unique mix of methods, SR interviews based on a  
49 replay of eyetracking data have been used to generate this depth.  
50

51 SR is a method used to collect reliable self-reported data on participants’ thoughts  
52 during a recorded task or episode of language learning or teaching; it also is a useful  
53 tool to aid reflection and lead to deeper thinking (see e.g. Messmer, 2015). It offers  
54 participants a chance to present any strategies they are conscious of, confirm that their  
55 behaviour matches their own expectations or express their surprise about unexpected  
56 fixations. This allows for deeper thinking processes and a critical distance from the  
57 actual behaviours. As opposed to Think-Aloud-Protocols, SR is non-intrusive, the  
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3 interviews do not distract from the actual task (Gass & Mackey, 2000). For reading or  
4 writing tasks Think-Aloud-Protocols interfere less with the actual language learning,  
5 however, in our case (SCMC) where interactive speaking and listening play an  
6 important role, SR is more suitable for reflecting, as well as commenting on the tasks  
7 retrospectively.  
8

9 As we have shown, eyetracking is an up-to-date method for displaying visual data,  
10 furthermore, it can also be a valuable tool to engage participants in an interpretation  
11 of the findings. In addition to aiding memory by replaying events, eyetracking  
12 visualisation can add detail to our understanding of online behaviour, thereby making  
13 reflections potentially more powerful and more meaningful. In contrast to a simple  
14 audio or video replay, it can also accumulate the information, thus presenting a final  
15 record of major focal points or “heat areas” on a screen. (“I think I probably focus  
16 quite a lot on the technical part because this thing is pretty new ...” Chinese teacher,  
17 reflection interview) This building up of a memory trace culminating in an  
18 interpretative image is not possible with the fleeting traces provided by other replay  
19 methods.  
20

21 Within a sociocultural context our two exemplary studies show how appropriating  
22 eyetracking, which is often used for HCI or psycholinguistic studies, and combining it  
23 with other, qualitative methods can potentially shift attention-focus research from a  
24 cognitive perspective to a learner-centred, hermeneutic approach. The examples from  
25 our learner study show how online language learning and teaching spaces are  
26 mediated by technology as well as by the second or foreign language. The reflections  
27 generated by the stimulated recall interviews in our teacher study add the dimension  
28 of an online teaching culture as mediating factor.  
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31 Research, in our context, is not just a means to generate knowledge but also a  
32 responsibility. In addition to its qualitative stance, our project is also pedagogical: we  
33 want to improve online language learning and teaching and make it more beneficial  
34 for learners and more satisfying for teachers. This can be seen in parallel to a user-  
35 centred approach in HCI research. For this purpose the potentially reflective aspect of  
36 stimulated recall has been used in our mix of methods. As Levy and Kennedy claim,  
37 we “...have reached a point where we recognize that learners need reflective activities  
38 to develop language awareness, as well as productive activities, in order to become  
39 effective and autonomous learners.” (Levy & Kennedy, 2004, p. 53) For the adult  
40 learners in our study, seeing where their attention is focused has provided additional  
41 insights and has led to deep speculation and reflection on learning strategies and the  
42 reasons for using input. (“I do remember being panicked because there are some clues  
43 and if I don’t pick up on the clues, I might pick up afterwards but I didn’t recognize  
44 the Chinese characters.” Jie Ni SR interview). Thus, stimulated recall based on  
45 gazeplot videos has proven effective in raising learners’ awareness of the strategies  
46 they employ in online learning and has led them to reconsider their approaches.  
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49 For eyetracking studies in a socio-cultural framework this additional perspective is  
50 indispensable, and a combination of introspective and external methods will be  
51 requisite for any future study claiming ecological validity. The user’s own  
52 understanding of their attention and conscious or pre-conscious actions is necessary to  
53 support any claims of interpreting the meaning of online interaction. Lacking this  
54 perspective, the study remains on a surface level of linking gaze focus tentatively to  
55 attention without viewing the wider context of learning and teaching and without the  
56 prospect of contributing to a deeper understanding of the field.  
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3 For teachers, the experience of reflecting back on their teaching is not unique; the  
4 “reflective practitioner” (Schön, 1987) uses the cycle of action and reflection  
5 continually for professional growth and continuing professional development.  
6 Messmer (2015) uses stimulated recall to access the deeper thinking of teachers  
7 during their face-to-face classroom practice. In the area of CALL teaching, Cutrim  
8 Schmid (2011) promulgates the idea of using video stimulated reflection on the use of  
9 interactive whiteboards in face-to-face classrooms. However, none of these studies are  
10 transferable to online language teaching. Eyetracking data in the way we propose to  
11 use it, is a novel form of information supporting deep reflection in teachers by  
12 offering enhanced information (gaze focus), by concentrating recall and reflection on  
13 certain areas of attention focus, and by adding a cumulative perspective on sequences  
14 of online interactions (heat maps).  
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16  
17 Even the most experienced online teacher we interviewed was impressed by the  
18 richness of information provided through this method. And all teachers used the study  
19 as a chance for reflection. As Messmer found out, SR can lead to teachers becoming  
20 aware of the basis for decisions that influenced their behaviour (Messmer, 2015, n.p.  
21 para 16).  
22

23 To answer our research questions, we can confirm that, firstly, by investigating tasks  
24 and interactions in online tutorials with eyetracking we can find out how these tasks  
25 are actually used and speculate about cognitive processes (see Leow et al., 2013), e.g.  
26 in reading comprehension (Authors, 2015b). With the stimulated recall interpretations  
27 we can also confirm the conscious strategies and intentions in play. They bring to the  
28 fore reflections based on an awareness participants gain from viewing a gazeplot  
29 video that shows in detail where their (attention) focus was at any particular time in  
30 the online interaction. Their reflections are by no means a direct confirmation of what  
31 an external viewer would see, they allow the additional perspective of the “insider”,  
32 the actual user and agent, to be considered as part of the rich picture of an online  
33 learning or teaching event.  
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36 Secondly, through our mix of methods participants can benefit directly by becoming  
37 more informed and more reflective learners and teachers. We use the eyetracking  
38 videos to support reflectivity, a focus on one’s own learning and teaching that could  
39 not be stimulated to such a depth with less detailed materials. By bringing in the  
40 voices of our participants to confirm our findings and to enhance their own  
41 reflectivity as learners and teachers in online environments, we aim to make research,  
42 as Onwuegbuzie and Frels (2013) suggest, a more democratic and equal process.  
43

44 And thirdly, our unique combination of methods, making use of technology-supported  
45 investigation methods and reflectivity-enhancing interviewing formats, is suitable for  
46 a framework that sees learning as an inherently social process and can significantly  
47 enhance our understanding of the different forms of mediation underpinning online  
48 language learning and teaching from a socio-cultural perspective. We can see the  
49 insider and the outsider view of online language learning and teaching, and we  
50 understand our own “learning” or knowledge generation as intertwined with our  
51 participants’ contributions and reflections; furthering our own search for a suitable  
52 mix of methods to investigate online language learning.  
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## 55 56 **5 Conclusion and further studies** 57 58 59 60

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3 This paper is framed in sociocultural theory, an approach that posits that learning  
4 takes place in the interaction of the individual with its environment, supported by  
5 factors that support or “scaffold” steps of learning. Within this framework human  
6 agency is neither determined by our sociocultural environment and history nor  
7 entirely controlled by individual “will” or deliberation; instead actions are “mediated”  
8 (Wertsch 1994).  
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10 This theoretical position precludes a simplistic epistemology of cause and effect and  
11 makes it desirable to approach learning from different perspectives, as a) an  
12 observable behaviour, b) a deliberate action on the part of the learner, and c) as a  
13 socioculturally determined interaction between learners and teachers in designated  
14 spaces for learning. Based on this, we chose a mix of methods to investigate language  
15 learning and teaching in online synchronous multimodal environments.  
16

17 Apart from the pilot studies necessary to refine our methods, two studies were  
18 carefully designed and conducted to exemplify the power of this new methodological  
19 approach and prove that our innovative combination of methods can produce relevant  
20 results. We have shown how technology mediates the online learning and how  
21 learners make use of the affordances of the online environment. We have brought to  
22 light strategies employed by language learners. Giving a voice to our participants  
23 through stimulated recall, and ensuring that they benefit from an enhanced reflectivity  
24 on their learning through on-going discussions and a follow-up questionnaire as part  
25 of our research project has changed the research perspective from an outsider view on  
26 cognitive processes to an insider-outsider perspective on sociocultural learning events  
27 online.  
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30 Although these initial studies are sufficient proof that combining methods taken from  
31 different areas of the interdisciplinary field that comprises CALL research is fruitful  
32 and worthwhile, further studies would be of interest. For example, the specific  
33 teaching skills employed by the online language teachers necessitate investigation;  
34 “cultures of teaching” related to cultures of origin, training, and residence of different  
35 language teachers are another field that could lead to theoretical insights and valuable  
36 pedagogic conclusions. A comparison of teachers’ and learners’ ideas about pedagogy  
37 and online learning can be stimulated by applying our combined methodology in  
38 situations where the educational background and training of participants is different.  
39 Another avenue of research could be the delayed reflection of teachers and the  
40 influence their eyetracking experience had on their online presence and behaviour in  
41 future tutorial. Currently, this longitudinal aspect is still missing in our own research.  
42 An area that has shown to be of particular importance in online teaching events is the  
43 use and interpretation of silences in online language classrooms; this also merits  
44 further investigation. In a more practical vein, more work is needed to establish how  
45 eyetracking can be used in teacher training and self-reflective practice.  
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48 Some limitations of our methodology are of a very practical nature: it is still a  
49 technology with limited availability. For our studies we could only track one person at  
50 a time, and due to the fixed nature of our eyetracker we had to collect data in a  
51 laboratory setting. These issues might have influenced the behaviours of participants  
52 (Authors & colleagues 2015). For qualitative studies a small sample size should not  
53 be detrimental, however, some larger scale studies are needed to create a baseline of,  
54 for example, linguistic skills, reading levels, etc. These eyetracking studies could  
55 become a valuable frame of reference or backdrop for studies following a mixed or  
56 qualitative methodology.  
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3 In this methodologically focused paper we have shown how a particular combination  
4 of methods used in a particular theoretical framework can move our understanding of  
5 online language learning and teaching forward, potentially challenging more  
6 traditional approaches that would not have been able to uncover the same rich,  
7 multifaceted findings. We have also implicitly shown how important it is for the  
8 researcher to keep in mind at all times the underlying epistemology and ontological  
9 stance to do justice to the research process and help to progress pedagogy and  
10 learning.  
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54 <sup>i</sup> When investigating screens that remain static during the entire eyetracking process,  
55 creating heatmaps is relatively simple. In cases of dynamic screens, where the  
56 properties change and attention focus needs to be matched to the different visual  
57 properties of the screen, cumulative measures are more complex as the video needs  
58 to be cut into scenes and a series of heatmaps or gazeplot images need to be created.  
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ii Another valid method currently used is video screen capture, sometimes combined with keystroke capture (see e.g. Smith 2009).

For Peer Review

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## Reviewer(s)' Comments to Author:

Reviewer: 1	Authors' responses
<p>This is a well-written methodological article, grounded in theory and previous research, adding a novel perspective on eyetracking methodology in a CALL context. The article has a clear structure, and the methodological discussion presented is framed as a separate study.</p> <p>My main concern with the article is that a discussion <b>concerning potential limitations/drawbacks with the suggested methodology is lacking</b>. Other than that, I only have minor comments:</p>	<p>Thank you for your valuable comments.</p> <p>A section on limitations and drawbacks has been added on Page 16:  <b>“Some limitations of our methodology are of a very practical nature: it is still a technology with limited availability. For our studies we could only track one person at a time, and due to the fixed nature of our eyetracker we had to collect data in a laboratory setting. These issues might have influenced the behaviours of participants (Authors &amp; colleagues 2015). For qualitative studies a small sample size should not be detrimental, however, some larger scale studies are needed to create a baseline of, for example, linguistic skills, reading levels, etc. These eyetracking studies could become a valuable frame of reference or backdrop for studies following a mixed or qualitative methodology.”</b></p> <p>A section on future development has also been added on Page 16.</p>
<p>The authors talk about "re-claiming" eyetracking on a few instances in the text, and this terminology seems a bit problematic. Can something be re-claimed if it has never been used within the suggested paradigm to begin with? Is it not rather a question of appropriating the methodology to fit the socio-cultural paradigm?</p>	<p>We have changed "re-claiming" to 'appropriating'.</p>
<p>On p. 3 some advantages of eyetracking are listed, and the first one could benefit from further explanation:          “a) it is available immediately after the collection of data,”          -- How is this different from other types of video recordings, for instance?</p>	<p>This has been changed to the following:  <b>“Like other video recordings, the visual information is available for scrutiny immediately after the collection of data but eyetracking has specific advantages over other visual data.”</b></p>
<p>The third one is also problematic in the</p>	<p>It is possible to crate a series of</p>

<p>SCMC context:  “c) it can cluster this information (see Illustration 1 for an example of a heatmap and Illustration 3 for an example of a gazeplot image) showing cumulative attention focus points.”  -- This is only relevant when investigating static properties of the screen. The authors later turn to the complexity of SCMC data, with shifting backgrounds etc., and might want to comment on the problems with cumulative attention focus in this context.</p>	<p>cumulative attention visuals, by splitting the video recording into individual scenes and collecting focal points as long as the screen remain unchanged. Admittedly, this is a complex procedure but well worth the effort for the impressive results. Therefore, endnote 1 has been added to explain further.</p> <p>“<sup>1</sup> When investigating screens that remain static during the entire eyetracking process, creating heatmaps is relatively simple. In cases of dynamic screens, where the properties change and attention focus needs to be matched to the different visual properties of the screen, cumulative measures are more complex as the video needs to be cut into scenes and a series of heatmaps or gazeplot images need to be created.”</p>
<p>On pages 5, 6 and 7, the authors refer to eyetracking as providing an outsider perspective, which appears to be different from a claim made in the methodological discussion (p. 13), where it is argued that eyetracking provides a glimpse inside the user's head. Perhaps it is rather a distinction between objective and subjective than between outside and inside perspectives?</p>	<p>On Page 5 and 6, we explained other people's research and described eyetracking in a positivist paradigm which is different from our research methodology described on Page 13.</p> <p>Revisions have been made on Page 7 and 13.</p> <p>“ In our approach, combining eyetracking data with participant's stimulated recall data, we aim at generating insights into observable learner and teacher behaviours (“true recollections” of thought processes)”</p> <p>look at what is going on “inside a learner's head”.</p>
<p>The authors claim to borrow stimulated recall from HCI research. However, also in other, more traditional fields of eyetracking research, triangulation, for instance through stimulated recall (or retrospective think-aloud) is argued to be of importance. This could be made clearer, together with a</p>	<p>A new reference from SLA has been added on Page 6:  “and SLA researchers (Godfroid, Housen, &amp; Boers, 2010) recommend combining eyetracking with other methods, e.g. stimulated recall”</p> <p>An explanation and emphasis on our</p>



<p>comment on the uniqueness of the suggested approach in also raising awareness among participants.</p>	<p>unique approach has also been added:          “Furthermore, the participants’ reflections support their own awareness raising and help them to develop as learners and teachers.”</p>
<p>Reviewer: 2</p> <p>Section 4. Comments to the author(s)          This article is interesting, well-written and contributes to the field. I particularly enjoyed reading the discussion about sociocultural theory in the first section which grounds well the empirical study. The research questions are very relevant. The 'teachers' study is particularly insightful.</p>	<p>Thank you very much for your positive comments.</p>
<p>Some remarks:          Perhaps mentions could have been made with regard to video screen capture technology which also consists of a valid method for the investigation of learners' internal/external processes during language learning. (Cf. p. 4).</p>	<p>A new reference has been added in Endnote 2 to clarify:          “Furthermore, the participants’ reflections support their own awareness raising and help them to develop as learners and teachers.”</p>
<p>p. 5 'but also relevant for answering future questions of language learning online.'          - could you name a few possible questions?</p>	<p>A few questions have been added on Page 5:          For example, future questions could include: “What do learners and teachers pay attention to during synchronous online interaction?”, “What areas of the screen attract attention and why?”, “What is the influence of formal or informal settings on attention patterns and awareness?”, “What happens during phases of silence and apparent inactivity during online language learning sessions?”</p> <p>See also Page 16 for suggestions for future studies.</p>
<p>p. 14 'Within a sociocultural context our two exemplary studies show how re-claiming eyetracking, which is often used for HCI or psycholinguistic studies, can shift attention-focus research from a cognitive perspective to a learner-centred, hermeneutic</p>	<p>Revision made on Page 14:          “Within a sociocultural context our two exemplary studies show how appropriating eyetracking, which is often used for HCI or psycholinguistic</p>

<p>approach.'</p> <p>- this is somehow a big claim which your study because of its limits/size does not entirely support. (I find it positivist...). In my opinion, SR is core and in fact the powerful method when combined with any other methods that capture online behaviours.</p>	<p>studies, and combining it with other, qualitative methods can <b>potentially</b> shift attention-focus research from a cognitive perspective to a learner-centred, hermeneutic approach.”</p> <p>Also see limitations of our study on Page 16.</p>
<p>p. 15 'Eyetracking data in the way we propose to use it, is a novel form of information supporting deep reflection in teachers by offering enhanced information (gaze focus), by concentrating recall and reflection on certain areas of attention focus, and by adding a cumulative perspective on sequences of online interactions (heat maps)'</p> <p>- yes, this shows the added-value specific to eyetracking.</p>	<p>Thank you!</p>
<p>p. 15 typo : eytracking</p>	<p>Corrected</p>
<p>p. 15 bringing in the voice of participants is really what 'user-centered' i.e. "ergonomic" studies are about. Perhaps you could refer to this important HCI concept in your paper...</p>	<p>A new sentence has been added on Page 14:</p> <p>“This can be seen in parallel to a user-centred approach in HCI research.”</p>
<p>p. 16 Would eyetracking be used to investigate 'cultures of teaching', how? Perhaps suggest further investigations that eyetracking could undertake.</p> <p>Apart from helping teachers noticing aspects of their behaviour and having them think about their teaching style/approach, what did the use of eyetracking brought, any changes in behaviours? Did they need eyetracking for that, would a video screen capture have provided similar results (captured in a more naturalistic/practical/less intrusive manner)? I wonder... It would certainly be nice to compare.</p> <p>What could 'trained' teachers with eyetracking technology do with it. Perhaps you could make a few suggestions.</p>	<p>The paper on the teacher study is working in progress, which should give a fuller explanation.</p> <p>Here, a short explanation has been given on Page 16:</p> <p>“A comparison of teachers’ and learners’ ideas about pedagogy and online learning can be stimulated by applying our combined methodology in situations where the educational background and training of participants is different. Another avenue of research could be the delayed reflection of teachers and the influence their eyetracking experience had on their online presence and behaviour in future tutorial. Currently, this longitudinal aspect is still missing in our own research.”</p>