Explicit References in Chat-Based CSCL: Do They Facilitate Global Text Processing? Evidence from Eye Movement Analyses

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Abstract: Chat-based Computer Supported Collaborative Learning (CSCL) often suffers from limitations due to the communication medium. A frequently reported consequence is the lack of discourse coherence and by this a lack of cognitive coherence in the learning process. To overcome these deficiencies, the implementation of explicit references with chat messages caused higher learning results. We analysed eye movements during a chat-based CSCL scenario to gain indications of learners' use of explicit references for text processing.

Introduction

Probably the most important prerequisite for successful computer-supported collaborative learning (CSCL) is a successful communication process. Due to the medial properties of synchronous chat communication, a, frequently reported negative phenomenon is the somewhat 'chaotic' discourse structure, i.e., often the group discusses several topics in parallel, so apparently related turns are, in contrast to spoken conversations, sometimes not adjacent. Hence, chat-based communication usually suffers from communication deficits due to incoherence of contributions and related problems (e.g., Herring, 1999). Participants are frequently not able to identify the relationships among individual contributions – a phenomenon called co-text loss by Pimentel, Fuks, and de Lucena (2003).

To improve matters, the learning protocol approach (Pfister & Mühlpfordt, 2002) as a special variant of scripted collaboration in CSCL was suggested. Similar approaches have been developed (Kollar, Fischer, & Hesse, 2006). It proposes that synchronous chat-based discourses can be improved by controlling learners' discourse interactions by implementing a set of discourse rules in the virtual learning environment. Among other features, learning protocols define the sequence of participants' contributions, they require to assign a contribution type (such as 'question', 'explanation', etc.) to each contribution, and, most importantly, they require participants to explicitly indicate the reference of their contribution. Learners indicate what the referred to element of the current contribution is. This might be a previous contribution from the chat-history, or a fragment of some additional learning material, such as a common text, images, or diagrams provided by the learning environment accessible for all participants. The system automatically visualizes the referential relation with an arrow. As a result, the relationship of a contribution to previous contributions can be directly perceived on the screen, by simply following the connecting arrows. Theoretically, these explicit references should increase the coherence of the discourse and, as a consequence, improve global text processing, understanding and learning performance. In previous studies the potential benefits of learning with this kind of learning protocols in contrast to an unstructured chat discussion could be demonstrated for specific knowledge domains (Pfister & Oehl, in press). Especially, it was found that it is the referencing function, i.e., visualizing relationships among contributions or between a contribution and additional fragments, which is of major importance with respect to learning outcomes (Mühlpfordt & Wessner, 2005; Stahl, Zemel, Sarmiento, Cakir, Weimar, Wessner, et al., 2006). However, so far it is still unclear in which way these explicit references influence the cognitive processing of learners within a CSCL setting in order to provoke higher learning results, as reported.

Studies in research on CSCL usually gain their scientific findings from pre-/post-tests, video or logfile analyses. Although eye movements have proved to be a valuable source of information for the study of cognitive processes, they are hardly regarded in the field of CSCL. There are only very few eye tracking studies in research on learning. A crucial reason for this is the lack of suitable observational schemes. To bridge this gap, we proposed a categorial coding scheme for global text processing in CSCL on the base of established well-defined eye movement measures (Oehl, Pfister, & Gilge, 2008). In the current experimental study, we analysed eye movements during a chat-based CSCL scenario with learning protocols to gain indications of learners' use of explicit references. We suppose that explicit references enhance the coherence of the learning discourse and therefore simplify the learners' global text processing. As we know from previous studies, the explicit references chosen by learners are not automatically right, i.e., the referred to element of any current contribution of a learner could be false. Because of this, we addressed a second research question to our current study: How text processing is affected by true or false explicit references and which gaze patterns could be observed?

Methods

In this experimental study students (N = 24; 18 female and 6 male) from different faculties and of different age

(M = 23.17; SD = 4.17) volunteered as participants. To observe the gaze patterns of text processing within a usually rather complex chat-based CSCL scenario (e.g., different synchronous contributions, many gazes back and forth within the chat history and the whole interface, etc.), we simulated an about 20 minutes long standardised learning discourse with confederates about the topic 'earthquakes' within a learning protocol environment, based on the ConcertSuite® or ConcertChat® software, a platform for collaborative learning developed by the Fraunhofer Institute IPSI, Germany. All participants were randomly assigned to the experimental treatments, following an experimental design with two factors and two levels each (2x2-factorial-design). The first factor (between subjects design) was the type of learning protocol used for the learning sessions, i.e. participants either learned with a learning protocol with or without explicit references. Within the treatment without explicit references (simple chat), these were substituted by equal textual hints. The second factor (within subjects design) was the type of explicit referencing balanced over all participants, i.e. all participants had to cope with a defined number of chat contributions by the confederates within the standardized learning discourse whose explicit references could be either true or false. Eye movements, as dependent variable, were recorded by the head-mounted eye-tracking device iView X™ HED® and encoded with the software Interact® (version 6.10.4). For the eye movement analysis a categorial coding scheme had to be defined (Oehl, Pfister, & Gilge, 2008). Participants' eye movements were finally encoded according to two information categories: (i) behaviour and (ii) point of interest. The first category (i) behaviour comprised all possible behavioural actions of learners within the learning protocol scenario (reading, searching, browsing and writing). The definitions of the variables were based on gaze patterns, i.e., significant and well-defined eye movement measures in terms of fixations and saccades (e.g., Hyönä, Lorch, & Rinck, 2003). The second category (ii) point of interest indicated the point within the learning protocol environment, the (i) behavioural category was related to (common learning material, discourse contributions within the chat-history, etc.). The variables within each category were mutually exclusive and the combination of two variables out of the two categories resulted in one definite eye movement code for global text processing. Three trained raters encoded the recorded eye movements according to the developed categorial coding scheme. On average each participant's experimental session resulted in about 400 definite eye movement codes. For each category of the coding scheme high inter-rater reliabilities could be obtained: (i) behaviour ($\kappa_M = 0.86$) and (ii) point of interest ($\kappa_M = 0.91$). With regard to the guidelines for the collection and standardised analysis of eye movements proposed by Scott and Findlay (1993), this coding scheme meets the required quality standards of objectivity and reliability.

Three research questions were addressed to this experimental study: 1) Text processing between the two learning protocol treatments, i.e., with or without explicit referencing, is different. It is supposed that text processing of contributions with explicit references is intensified because of a higher coherence. 2) Text processing of contributions with true and false references is different. It is supposed that false references especially in the treatment with explicit references are confusing for text processing. 3) Less text processing is necessary to make a chat contribution without explicit referencing than with explicit referencing.

Results

Results showed different text processing between the two experimental treatments of the first factor (type of learning protocol, i.e., with or without explicit referencing). If explicit references were provided, learners read current contributions 25% more frequently (M = 2.21 times, SD = 2.21 times) $t_{(46)} = 5.339$, $p < .001$. Furthermore they spent on average 0.10 seconds per word more on reading the current contribution (M = 0.73s, SD = 0.14s) $t_{(46)} = 2.978$, $p = .005$. Additionally explicit references caused learners to search the reference scope about 2.7 times more frequently $t_{(46)} = 9.67$, $p < .001$ and to read it twice as long (M = 3.48s, SD = 1.82s) than without explicit references (M = 1.70s, SD = 1.20s), $t_{(46)} = 4.009$, $p < .001$. With respect to the second factor (type of explicit referencing, i.e., true or false), the following gaze patterns for text processing could be observed. Within the experimental group with explicit references, participants read current contributions with true references 20% longer (M = 17.02s, SD = 2.76s) than current contributions with false references (M = 14.20s, SD = 2.94s), $t_{(22)} = 2.415$, $p = .013$. Moreover, they read false reference scopes (M = 4.46s, SD = 1.69s) approximately 70% longer $t_{(22)} = -3.089$, $p = .003$ and about 25% more frequently $t_{(22)} = -2.282$, $p = .016$ than true reference scopes (M = 2.51s, SD = 1.39s). Within the experimental condition without explicit referencing, participants' text processing in terms of reading duration of current contribution or reference scopes was not affected by true or false hints serving as substitutions for explicit references. However, participants within the learning protocol treatment with explicit references needed nearly 28% more time to find the true reference scope than subjects within the learning protocol condition without explicit referencing, $t_{(22)} = 7.506$, $p < .001$. Nevertheless, no difference could be observed with regard to reading true reference scopes. On average learners within the experimental group with explicit references read the true reference scope M = 0.297 times (SD = 0.14) and about M = 1.18 s (SD = 0.84) per false referencing. The experimental group without explicit referencing read true reference scopes on average M = 0.32 times (SD = 0.26) and about M = 1.15 seconds (SD = 1.28). Instead the experimental group without explicit referencing read other previous contributions to the chat history absolutely about 3.3 times longer, $t_{(22)} = -3.053$. $p = .005$, and per word about 2.5 times longer, $t_{(22)} = -3.055$, $p = .004$, as well as about 2 times more frequently, $t_{(22)} = -1.827$, $p = .044$ if false references were presented. With regard to participants' own contributions to the chat discourse, different text processing in preparation of a contribution could be observed. If participants had to define an explicit reference accompanying their contribution, they needed on average approximately twice more searching time and browsing time in the chat history and the text material until they made their contribution (M = 48.30s, SD = 22.36s) compared to participants in the experimental treatment without explicit referencing (M = 25.14s, SD = 12.90s), $t_{(22)} = 3.108$, $p = .005$.

Conclusion

Studies in research on CSCL usually gain their scientific findings from pre-/post-tests, video or logfile analyses. Although eye movements have proved to be a valuable source of information for the study of cognitive processes, they are hardly regarded in the field of CSCL. A crucial reason for this is the lack of suitable observational schemes. To bridge this gap, we proposed a categorial coding scheme for global text processing in CSCL on the base of established well-defined eye movement measures. Experimental results of eye movements showed that explicit references caused a more intensified text processing among learners. They read current contributions more often and longer compared to learners without explicit references and especially they were caused by the explicit references to relate the current contribution better to the referred to element of the learning material or of a previous contribution. However, if the explicit reference was false, learners had bigger problems to disintegrate the false reference in order to find the true reference scope. In this case, learners in the condition without explicit referencing needed less time to find the true reference scope. Moreover, they used their time to read previous contributions, if they were provided with false references. With regard to participants own contributions learners without explicit references made faster contributions to the chat discourse compared to learners with explicit referencing. But the need to identify a true element to refer to, caused an intensified text processing in terms of searching and browsing the learning material as well as the chat history.

Taken together, explicit references provoke an intensified text processing regarding the receiver of a chat message – no matter if the referencing is true or false, and they demand an intensified text processing regarding the producer of a chat contribution. However, the current experimental study addressed only text processing in terms of eye movement analyses in a first preliminary step. Of course further questions have to be addressed and discussed especially how eye measurements predict dependent variables such as learning performance or grounding in communication? These questions are focussed on in further research to give advanced guidelines for (chat-based) CSCL.

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