Global Text Processing in CSCL with Learning Protocols: A Coding Scheme for Eye Movement Analyses

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Abstract: Although eye movements have proved to be a valuable source of information for the study of cognitive processes, they are hardly regarded within CSCL. A crucial reason for this is the lack of suitable observational schemes. To bridge this gap, a coding scheme for global text processing in CSCL on the base of established well-defined eye movement measures is proposed. The scheme was evaluated in a study on explicit references in CSCL with learning protocols.

Introduction

Computer-supported collaborative learning (*CSCL*) is based upon successful communication, i.e., the collaborators should understand each other's contributions to the learning discourse and build a shared understanding of the content. 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 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 was suggested. Similar approaches have been developed (Kollar, Fischer, & Hesse, 2006). The learning protocol approach can be viewed as a special variant of CSCL (Kollar, Fischer, & Hesse, 2006; Pfister & Mühlpfordt, 2002). 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. These sets of rules, which we call 'learning protocols', can be regarded as a kind of collaboration script controlled and moderated automatically by the learning system itself. 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. 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. We suppose that explicit references enhance the coherence of the learning discourse and therefore simplify the learners' global text processing. This question is addressed in the current experimental study by means of eye movement analyses to gain indications of learners' use of explicit references. Scince a behavioural coding scheme for eye movement analyses of global text processing is lacking in the field of CSCL research, at first a suitable one had to be developed for this purpose. In this paper the defined categorial coding scheme for eye movement analyses will be introduced as well as preliminary results on learners' use of explicit references will be reported.

Methods

Students ($N = 24$; 18 female and 6 male) from different faculties and of different age ($M = 23.17$; $SD = 4.17$) volunteered as participants in this experimental study. Participants were randomly assigned to two experimental treatments, following an about 20 minutes long standardised learning discourse about the topic

'earthquakes' within a learning protocol environment, based on the Concert Suite® software. In the *two different treatments* participants were either provided with a learning discourse including explicit references or not. Within the treatment without explicit references, these were substituted by equal textual hints. 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. 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 significant and well-defined eye movement measures in terms of fixations and saccades (e.g. Radach and Kennedy, 2004). The second category *ii) point of interest* indicated the point within the learning protocol environment, the i) behavioural category was related to (e.g. 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 (κ_M = 0.86) and point of interest (κ_M = 0.91). With regard to the guidelines for the collection and standardised analysis of eye movements proposed by Scott and Findlay (1993), the developed coding scheme in the current study meets the required quality standards of objectivity and reliability.

Results

Results showed different text processing between the two experimental treatments. If explicit references were provided, learners read current contributions 25% more frequently $t_{(46)} = 5.339$, $p < .001$. Furthermore they spent on average 0.10 seconds per word more on reading the current contribution $t_{(46)} = 2.978$, $p = .005$. 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), $t_{(46)} = 4.009$, $p < .001$.

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. The empirical evaluation showed its high objectivity and reliability. So it could serve as an additional approach to lighten CSCL processes. Besides, the experimental results of eye movements showed that explicit references caused a more intensified text processing among learners. Conclusions for the design of (chat-based) CSCL environments will be derived.

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