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AUTOMATIC CODING OF COMMUNICATION IN COLLABORATION PROTOCOLS

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Abstract

An automatic coding procedure is described to determine the communicative functions of messages in chat discussions. Five main communicative functions are distinguished: *argumentative* (indicating a line of argumentation or reasoning), *responsive* (e.g., confirmations, denials, and answers), *informative* (transfer of information), *elicitative* (questions or proposals requiring a response), and *imperative* (commands). A total of 29 different dialogue acts are specified and recognized automatically in the chats of students during collaboration.

The validity of the automatic coding procedure was examined using three different types of analyses. First, an examination of group differences was used to provide evidence about the validity of the automatic coding procedure. Ideally, the coding procedure should be able to distinguish between groups who are likely to communicate differently. For example, it has been shown extensively, that women communicate differently than men do: women use more affiliative language, whereas men use more assertive language. The coding procedure was able to mostly replicate these findings. For example, women were found to use more responsive dialogue acts, whereas men used more informative and imperative dialogue acts.

Second, to examine the validity of the automatic coding procedure through examination of experimental intervention, the results of the automatic coding procedure of students with access to a tool that visualizes the degree of participation of each student were compared to students that did not have that sort of visualization. It was expected that students with access to the tool would engage in more argumentative interactions. This expectation was partly confirmed as it was found that students with access used more conditional arguments. However, they did not use more reasons, contra arguments, etc.

Finally, the validity of the automatic coding procedure was examined using correlation analyses. Results of the automatic coding procedure were correlated with results of a manual coding procedure. This manual coding was aimed at identifying the task-related and social aspects of online collaboration. Because some aspects of the manual coding procedure focused on similar aspects of online collaboration as the automatic coding procedure, moderate to strong correlations were expected. Indeed, several significant correlations were found In conclusion, the results presented in this paper indicate favorable results concerning the validity of the automatic coding procedure for dialogue acts.

AUTOMATIC CODING OF COMMUNICATION IN COLLABORATION PROTOCOLS

Introduction

Over the last decades, numerous advances have been made in information and communication technology. Nowadays, e-mail, real-time chat, file sharing, and instant messaging are being used by more and more people. These developments in ICT have also reached teacher’s classrooms. In schools, teachers and students are increasingly using ICT to facilitate learning in various subjects (O’Donnell, 2006). ICT applications, such as tutorials, simulations, and computer-mediated communication (CMC) are regarded as promising tools for education. *Computer-supported collaborative learning* (CSCL) is one educational application of ICT which has received considerable attention by educational researchers (e.g., Dillenbourg, Baker, Blaye & O'Malley, 1995; Van der Meijden, 2005; Van Drie, 2005). CSCL aims to provide students with an environment that supports and enhances collaboration, in order to facilitate their learning processes (Kreijns, Kirschner, & Jochems, 2003). When using CSCL environments, students usually communicate with group members using discussion forums or chat rooms. A CSCL environment tries to offer tools that facilitate sharing of information and ideas, and the distribution of expertise among group members (Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003).

CSCL has been regarded as a potential tool for education for several reasons. First of all, research has demonstrated positive effects of using *ICT in education* (e.g., Fletcher-Flinn & Gravatt, 1995). Second, research has also demonstrated positive effects of using *collaborative learning*. When students work together in small groups, they perform better and learn more, compared to students working individually (Johnson & Johnson, 1999; Slavin, 1996). Third, CSCL is seen as a promising combination of ICT *and* collaborative learning.

Indeed, a meta-analysis by Lou, Abrami, and d'Apollonia (2001) demonstrated that combining small group learning with ICT was more effective than combining individual learning with ICT. Additionally, Cavanaugh (2001) demonstrated the effectiveness of interactive distance education technologies. Thus, the perceived potential of CSCL seems to be, at least partially, supported by research outcomes.

Studying interactions during computer-supported collaborative learning

Researchers seem to agree that the interaction between group members, is the mechanism which fosters students' learning during collaborative learning whether online or face-to-face (De Wever, Schellens, Valcke, & Van Keer, 2006; Van Meter & Stevens, 2000). During CSCL, the interaction between group members is recorded in protocols of the online collaboration process. The study of collaboration protocols has been the focus of much research in the CSCL community. This research on the *process* of collaboration seeks to determine which types of interactions contribute to students' learning during collaboration (Van der Linden, Erkens, Schmidt, & Renshaw, 2000).

Initially, analyses of computer-supported collaboration focused on surface level characteristics of the communication, such as the number of messages sent (Strijbos, 2004). However, over the last 15 years the analysis of communication protocols is being used more and more to study collaboration processes (Rourke & Anderson, 2004). The development of a systematic and valid method that can be used to analyze communication protocols can be difficult. Furthermore, the process of analyzing a great number of protocols can be time consuming. Therefore, in order to speed up the process of coding communication protocols, an automatic coding procedure was developed. This procedure has been used in several research projects at Utrecht University (Erkens, 1997; Erkens, Jaspers, Prangsma, &

Kanselaar, 2005; Janssen, Erkens, & Kanselaar, submitted; Janssen, Erkens, & Schep, submitted).

The coding system developed identifies 'dialogue acts,' that is, the communicative function of each utterance typed by students during online collaboration and communication. Five main communicative functions are distinguished: *argumentative* (indicating a line of argumentation or reasoning), *responsive* (e.g., confirmations, denials, and answers), *informative* (transfer of information), *elicitative* (questions or proposals requiring a response), and *imperative* (commands). A total of 29 different dialogue acts are specified. For instance, an *imperative action* (*ImpAct*) indicates a commanding utterance with regard to a specific action to be taken. For an overview of the dialogue acts, the coding categories and examples of discourse markers see Table 1.

--- INSERT TABLE 1 ABOUT HERE ---

To automatically code a protocol and identify which dialogue acts are used during collaboration, the *Multiple Episode Protocol Analysis* (MEPA) computer program is used (Erkens, 2005). This program can be used for the analysis and coding of collaborative discussions. Additionally, the program offers facilities for automatic coding. A production rule system was created that automatically categorizes utterances into dialogue acts. A set of *if-then* rules uses pattern matching to look for typical words or phrases, in this case for discourse markers. Discourse markers are characteristic words signaling the communicative function of a phrase in conversation in natural language (Schiffrin, 1987). For example, *why* at the beginning of an utterance usually indicates an *open question (EliQstOpn)*. Discourse markers are used to obtain coherence in spoken text by signaling the function of the next utterance by an idiomatic phrase or word. (Byron, & Heeman, 1997). The underlying assumption is that in a language a limited set of discourse markers exist, that, although dynamically changing over time and (sub)culture, are being used by speakers to establish coherence in their talk. If it is a limited set they can be recognized also by an computer system.

The developed production rule system consists of a rule system for automatic segmentation of utterances in single messages (300 rules) and a rule system for dialogue act coding (1250 rules). In this way, MEPA is able to code a protocol consisting of 1,000 utterances in less than a second .

The rule system for segmentation of utterances (*Segmentation Filter, SEG filter*) scans strings for punctuation characters (i.e. '?','!', '.'), connectives ('however,', 'so,', 'but') and starting discourse markers ('well', 'on the other hand'). The utterance is being split before or after the marker. Exception rules prevent segmentation when the same markers are used in situations that do not signal new messages. For example, the use of full stops in abbreviations, or the non- connective use of 'but' in utterances like "we proceed slowly <u>but</u> surely". The *Dialogue Act Coding filter (DAC filter)* is used after segmentation of the utterances and labels messages with dialogue act codes based on recognition of discourse marking words, phrase, idiom or partial phrases. In the DAC filter discourse markers are used that signify the communicative function of the message. Similar exception rules are used to prevent triggering of same markers that signify another functions. If the system does not find a discourse marker in a message, the message is coded by the label '*InfStm?*'. Information statements are statements that in most cases are not signaled by discourse markers like "I tell you that…". The '*InfStm?*' coded message are checked and coded manually. Sometimes (in fact quite seldom), a "new" discourse marker is found signaling another dialogue act and added to the *DAC* filter rule system.

Although automatic coding can dramatically speed up the coding process, several methodological issues need to be addressed. The first issue is the reliability of the system. Of course, stability in coding is not at stake. The *DAC* filter will apply the same rules in the same way every time over and will result in the same coding for the same messages (except for a few new rules that are added in the meantime. Another reliability check that has been done (and is repeated from time to time), is coding error analysis. The error analysis is an interrater reliability analysis comparing hand coding and automatic coding on dialogue acts of the same protocol. Over 500 messages a interrater agreement percentage (human–computer) is obtained of 96 % with a Cohen's kappa of .78, which is rather good regarding the large number of dialogue act coding categories that are being used. Another issue is the validity of the coding procedure (De Wever et al., 2006; Rourke & Anderson, 2004). Rourke and Anderson (2004) have outlined three types of analyses which can provide information about the validity of the automatic coding procedure: examination of group differences, examination of experimental intervention and correlational analyses. The aim of this paper is to examine the validity of the automatic coding procedure by performing these three types of analyses. Furthermore, this paper aims to the strengths and weaknesses of the automatic coding procedure.

Research Questions

1. Can the automatic coding procedure be validated through examination of group differences?
2. Can the automatic coding procedure be validated through examination of experimental intervention?
3. Can the automatic coding procedure be validated through correlation analyses?

Method and Instrumentation

Participants

Participants were 69 eleventh-grade students from a secondary school in The Netherlands. Students came from three different classes and were enrolled in the second stage of the pre-university track. Mean age of the students was 16 years. During the experiment, the participating students collaborated in groups of three or four; students were randomly assigned to a group by the researchers.

Tasks and materials

CSCL-environment: VCRI

Students collaborated in a CSCL environment named *Virtual Collaborative Research Institute* (VCRI, Jaspers, Broeken, & Erkens, 2004). The VCRI program is a groupware program designed to facilitate collaborative learning. The program offers students several tools that they can use while they are collaborating on research projects or inquiry group tasks. For example, students can read the description of the group task and search for relevant historical information using the *Sources* tool. This information can be communicated and shared with group members, using the synchronous *Chat* tool. To write research reports and argumentative texts or essays, students can use the *Cowriter*. The *Cowriter* is a shared text-processor, which can be used by students to work simultaneously on the same text. Figure 1 shows a screenshot of the VCRI program. Other tools, not shown in Figure 1, include for example the *Logbook*, which students can use to record which activities they have carried out, and the *Diagrammer*, which can be used to construct argumentative diagrams.

--- INSERT FIGURE 1 ABOUT HERE ---

Group task

The participating students collaborated on a historical inquiry group task. Inquiry tasks are an important part of the curriculum in the Dutch upper secondary levels. Subject of the task was witchcraft and the persecution of witches. The groups had to use different historical and (more) contemporary sources to answer questions and co-author argumentative texts. Approximately 40 sources from textbooks and the Internet were available to the students through the *Sources* tool. Students were instructed to use the VCRI program to communicate with group members. Students were told they had eight lessons to complete the inquiry task.

The introduction of the task stressed the importance of working together as a group on the subtasks, and pointed out that group members were themselves responsible for the successful completion of the task. To successfully complete the inquiry group task, all group members had to participate during the group process. Positive interdependence and individual accountability were incorporated in the group task, thus making high levels of collaboration necessary in order to successfully complete the group task (Johnson & Johnson, 1999).

Examining validity through examination of group differences

Rourke and Anderson (2004) describe how examination of group differences can contribute to the validation of the automatic coding procedure. Ideally, the coding procedure should be able to distinguish between groups who are likely to communicate differently. For example, it has been shown extensively in face-to-face collaboration, that women communicate differently than men do (Leaper & Smith, 2004; Ridgeway, 2001). Women are more likely to use affiliative language (e.g., indicating agreement, giving praise), while men are more likely to use assertive language (e.g., instructing others, giving arguments, indicating disagreement). These differences between men and women have also been found during CMC (e.g., Herring, 1993; Wolfe, 1999). Thus, the automatic coding procedure should be able to demonstrate that women use different dialogue acts than men do.

In order to demonstrate whether the automatic coding procedure was able to demonstrate the expected gender differences during online communication, the communication of the female students in the sample described above was compared to the communication of the male students. It was expected that male students would use more assertive language during online collaboration, while female students were expected to use more affiliative language. Dialogue acts that signal affiliative language are confirmations (ResCfm and ResRplfCfm), acceptations (ResAcc and ResRplAcc), and positive evaluations (InfEvlPos). Dialogue acts that signal assertive language are argumentatives (ArgRsn, ArgCnt, ArgCon, ArgThn, ArgDis, ArgCcl, and ArgEla), denials (ResDen and ResRplDen), negative evaluations (InfEvlNeg), informative statements (InfStm), and imperatives (ImpAct and ImpFoc).

Examining validity through examination of experimental intervention

According to Rourke and Anderson (2004), experimental intervention may also be used to examine the validity of the automatic coding procedure. Using this strategy, an attempt is made to modify students' behavior. It is then examined whether these changes in behavior can be detected using instrument to be validated.

In the sample of students described above, some students had access to the *Participation tool* (PT), whereas others did not (see Figure 2). The PT visualizes how much each group member contributes to his or her group's *online communication*, through for example the Chat tool shown in Figure 1. In the PT, a sphere represents each student; group member's spheres are grouped together. While students are communicating with each other in the online environment, the PT is continually updated, allowing students to compare their participation rates to those of their group members. It was assumed that the PT would influence group members' participation, and their online collaboration and communication (Janssen, Erkens, Kanselaar, & Jaspers, in press). For example, because group members become more aware of who is contributing sufficiently and insufficiently to online communication. This raised awareness may help students to engage in group processing, that is discussions about the manner in which they are collaborating (Yager, Johnson, Johnson, & Snider, 1986).

--- INSERT FIGURE 2 ABOUT HERE ---

In order to demonstrate the validity of the automatic coding procedure, the procedure should be able to demonstrate differences between students with access to the PT and students without access to the PT.

Examining validity through correlational analyses

Finally, correlational analyses can be used to establish the validity of the automatic coding procedure. During such an analysis, it is attempted to demonstrate that the results of the automatic coding procedure are consistent with measurements of the same construct through other methods. In order to so, the results of the automatic coding procedure were correlated with the results of a manual coding procedure.

In contrast to the automatic coding procedure, the manual coding focused not on dialogue acts, but on collaborative activities. The aim of this manual coding was to provide insight into the task- and group-related processes taking place between students while working together. The coding scheme used during manual coding consists of four different dimensions. Each dimension contains two or more coding categories. In total, the scheme consists of 19 categories. The first dimension referred to performance of task-related activities. These activities are aimed at solving the problem (Jehn & Shah, 1997). This dimension contained two categories pertaining to the discussion of relevant task-related information: exchanging and sharing task-related information (*TaskExch)* and asking task-related questions (*TaskQues*). In brackets, the abbreviations of the codes are given.

The second dimension referred to *regulation and coordination of task-related activities*, encompassing four categories. Metacognitive activities that regulate task performance (e.g., making plans, monitoring task progress), are considered important to successful group performance (Van der Meijden & Veenman, 2005). First, planning (*MTaskPlan*) involved discussion of strategies necessary to complete the task, and delegation of task responsibilities. Second, monitoring (*MTaskMoni*) involved exchange of information that could be used to monitor task performance and progress, and assessing the amount of time available. Finally, evaluation involved appraisal and discussion of task performance and progress, which could be either positive (*MTaskEvl+*) or negative (*MTaskEvl-*).

Performance of social activities was the third dimension of the coding scheme. Group members also have to attend to the social and emotional element of collaboration to successfully complete a group task (Rourke, Anderson, Garrison, & Archer, 1999).This dimension contained five categories. First, greetings (*SociGree*) contribute positively to group atmosphere and a feeling of social presence (Rourke et al., 1999). Second, social support remarks (*SociSupp*) referred to comments that contributed positively to group atmosphere, such as exchanging positive comments, and disclosure of personal information. Third, social resistance remarks (*SociResi*) referred to behaviors that contributed negatively to group atmosphere, such as insults and displaying negative emotions. Fourth, shared understanding (*SociUnd+*) referred to confirmations and indications of agreement, which serve to reach and maintain joint understanding. Similarly, loss of shared understanding (*SociUnd-*) referred to denials, and expressions of incomprehension.

The fourth dimension referred to *regulation and coordination of social activities*. Group members need to discuss collaboration strategies, monitor their collaboration process, and evaluate and reflect on the manner in which they collaborated. This dimension contained four categories. First, planning (*MSociPlan*) involved discussion of collaboration strategies, such as helping each other, or proposals to work together on certain tasks. Second, monitoring (*MSociMoni*) referred to the exchange of information that could be used to monitor group processes. Finally, evaluation involved appraisal and discussion of group processes and collaboration, which could be positive (*MSociEvl+*) or negative (*MSociEvl-*).

Statements that addressed neutral, negative, or positive technical aspects of the CSCL-environment were also included in the coding scheme (codes *TechNeut*, *TechNega*, and *TechPosi*). Finally, statements that did not fit into any of the previously mentioned categories were coded as *Other*, referring mostly to nonsense and off-task remarks.

For the current analysis the results of the automatic coding procedure were correlated with the results of the manual coding procedure. Several positive correlations were expected between dialogue acts and collaborative activities. In Table X these are indicated by cells with a grey background.

Results

Examining validity through examination of group differences

In order to determine whether male and female students used different types of dialogue acts during online collaboration, multilevel analysis was used. First, a model was constructed which included the number of dialogue acts typed by a student. This was done because female students typed significantly more dialogue acts than female students. By including dialogue acts, the effects of gender could be investigated independent of the total number of dialogue acts sent (M_{male} = 241.92, SD_{male} = 106.52; M_{female} = 322.40, SD_{female} = 162.37). During the second step, gender was added to the model. For the effect of gender to be significant, its coefficient had to be significant. Furthermore, the model including gender also had to be a better model, indicated by a significant χ^2 value.

--- INSERT TABLE 2 ABOUT HERE ---

Table 2 shows the results of the examination of differences between male and female students. As can be seen, male and female students differed considerably. Consequently, several effects of gender were found. Firstly, female students used more argumentatives overall than male students did, $t(62) = 2.58$, $p = .01$. More specifically, female students gave more reasons (ArgRsn), $t(62) = 2.50$, $p = .01$. Furthermore, female students formulated more conclusions (ArgCcl), although the associated χ^2 only approached significance, $t(62) = 1.98$, $p = .03$; $\chi^2 = 3.77$, $p = .05$. Secondly, Table 2 shows female students to overall use more responsive dialogue acts, $t(62) = 2.19$, $p = .02$. As can be seen in Table 2 this is due to female students typing more confirmations during online conversation, $t(62) = 2.41$, $p = .01$. Thirdly, male students were found to use more informative dialogue acts, $t(62) = -2.15$, $p = .02$. More specifically, male students use more informative statements (InfStm), $t(62) = -2.36$, $p = .01$, and more nonsense informative statements (InfStmNon), $t(62) = -3.18$, $p = .00$. Additionally, the coefficient for gender for negative evaluations (InfEvlNeg) was significantly negative, although the associated χ^2 value was not, $t(62) = -2.01$, $p = .02$, $\chi^2 = 3.79$, $p = .05$. Finally, male students were found to use more imperative dialogue acts than female students, $t(62) = -2.45$, $p = .01$. This difference is mainly due to male students using more imperative statements which focus group members' attention, $t(62) = -2.00$, $p = .02$.

In sum, most of the differences between male and female students were mostly in line with our expectations. Female students used more affiliative language by typing more confirmations. Male students used more assertive language by typing more negative evaluations, informative statements, and imperatives. The finding that female students used more argumentative dialogue acts was contrary to our expectation, however.

Examining validity through examination of experimental intervention

To examine the validity of the automatic coding procedure through examination of experimental intervention, the results of the automatic coding procedure of 52 students with access to the PT were compared to those of 17 students without access. It was expected that students with access to the PT would participate more actively during online discussions. It was expected that this increased participation would result in more argumentative interactions. Thus, an effect of the PT was mostly expected on students' use of argumentative dialogue acts.

--- INSERT TABLE 3 ABOUT HERE ---

As can be seen from Table 3, this expectation is only slightly confirmed. This Table does indeed show some differences between students use of dialogue acts during online collaboration. The effect of the PT was examined using multilevel analysis. Again the number of dialogue acts typed was also included as a predictor in the multilevel model, since in a previous study an effect of the PT on participation was found (Janssen et al., in press). This way, the effect of the PT on dialogue acts used could be investigated independent of students' participation levels. Concerning argumentative dialogue acts, an effect of the PT was found on conditional arguments (ArgCon): students with access to the PT used more contra arguments, *t(65)* = 1.92, *p* = .03. This result should be interpreted cautiously however, since the associated χ^2 was only marginally significant, $\chi^2 = 3.58$, *p* = .06. Other differences between students with and without access to the PT were found as well. First, students with access to the PT used more confirmations in reply to elicitatives typed by group members (ResRplCfm), *t(65)* = 2.10, *p* = .02, $\chi^2 = 4.14$, *p* = .04. Second, students with access to the PT replied less with statements to elicitatives (ResRplStm) typed by group members, *t(65)* = -2.35, *p* = .01, $\chi^2 = 5.31$, *p* = .02. Third, students with access to the PT used less informatives, *t(65)* = -1.94, *p* = .03. The associated χ^2 was only marginally significant however, $\chi^2 = 3.54$, *p* = .06. Fourth, students with access to the PT used more performatives (InfPer), *t(65)* = 1.96, *p* = .03. Again, the associated χ^2 was only marginally significant, $\chi^2 = 3.51$, *p* = .06. Fifth, students with access to the PT used less informative statements (InfStm), *t(65)* = -2.08, *p* = .02, $\chi^2 = 4.08$, *p* = .04. Sixth, students with access to the PT used less social informative statements (InfStmSoc), *t(65)* = -2.25, *p* = .01, $\chi^2 = 4.54$, *p* = .03. Seventh, students with access to the used more elicitative proposals for action (EliPrpAct), *t(65)* = 1.68, *p*= .05. The associated χ^2 was not significant however, $\chi^2 = 2.67$, *p* = .10. Finally, students with access to the PT typed more imperatives, *t(65)* = 2.09, *p* = .02, $\chi^2 = 5.92$, *p* = .01.

Examining validity through correlational analyses

Table 4 presents the correlations between dialogue acts and collaborative activities. Several positive correlations were found, although most of them were weak to moderate (*r* = .30 - .60). As expected, several significant correlations between exchange of task-related information (*TaskExch*) and argumentative dialogue acts were found. Furthermore, a significant correlation was found between exchange of task-related information (*TaskExch*) and information statements (*InfStm*). Task-related questions (*TaskQues*) were positively correlated with open questions (*EliQstOpn*) but not with the other types of questions determined by the automatic coding procedure (*EliQstVer* and *EliQstSet*). In addition, positive correlations were found between making task-related and social plans (*MTaskPlan* and *MSociPlan*) and proposals for action (*EliPrpAct*). Most likely, because all three codes involve formulating proposals during the online collaboration.

--- INSERT TABLE 4 ABOUT HERE ---

Positive correlations were also expected between positive task-related and social evaluations (*MTaskEvl+* and *MSociEvl+*) and positive evaluative dialogue acts (*InfEvlPos*) as well as between negative task-related and social evaluations (*MTaskEvl-* and *MSociEvl-*) and negative evaluative dialogue acts (InfEvlNeg). Only a weak correlation between *MTask Evl+* and *InfEvlPos* was found.

As expected, a strong correlation between greetings (*SociGree*) and performatives (*InfPer*) was found. Furthermore, social supportive remarks (*SociSupp*) correlated moderately with social information statements (*InfStmSoc*). Additionally, because social resistance remarks (*SociResi*) often involve negative emotions, a positive correlation was expected with negative evaluations *(InfEvlNeg*). Indeed, a weak correlation was found.

Shared understanding (*SociUnd+*) was expected to correlate positively with confirmations and acceptations (*ResCfm*, *ResRplCfm*, *ResAcc*, and *ResRplAcc*). A strong correlation between *SociUnd+* and *ResCfm*, as well as a moderate correlation between *SociUnd+* and *ResRplCfm* was found. Similarly, loss of shared understanding (*SociUnd-*) was expected to correlate with denials (*ResDen* and *ResRplDen*). Indeed, weak to moderate correlations were found.

Conclusions and Discussion

This paper described an automatic coding procedure, which can be used to code collaboration protocols automatically in a few seconds. The automatic coding procedure determines the communicative functions of messages. Five main communicative functions are distinguished: *argumentative* (indicating a line of argumentation or reasoning), *responsive* (e.g., confirmations, denials, and answers), *informative* (transfer of information), *elicitative* (questions or proposals requiring a response), and *imperative* (commands). A total of 29 different dialogue acts are specified.

Additionally, this paper examined the validity of the automatic coding procedure using three different types of analyses. First, an examination of group differences was used to provide evidence about the validity of the automatic coding procedure. Ideally, the coding procedure should be able to distinguish between groups who are likely to communicate differently. For example, it has been shown extensively, that women communicate differently than men do: women use more affiliative language, whereas men use more assertive language. The coding procedure was able to mostly replicate these findings. For example, women were found to use more responsive dialogue acts, whereas men used more informative and imperative dialogue acts.

Second, to examine the validity of the automatic coding procedure through examination of experimental intervention, the results of the automatic coding procedure of 52 students with access to the Participation Tool (PT) were compared to those of 17 students without access. It was expected that students with access to the PT would participate more actively during online discussions. More specifically, it was expected that they would engage in more argumentative interactions. This expectation was partly confirmed as it was found that students with access to the PT used more conditional arguments. However, students with access to the PT did not use more reasons, contra arguments, etc.

Finally, the validity of the automatic coding procedure was examined using correlational analyses. Results of the automatic coding procedure were correlated with results of a manual coding procedure. This manual coding was aimed at identifying the task-related and social aspects of online collaboration. Because some aspects of the manual coding procedure focused on similar aspects of online collaboration as the automatic coding procedure, moderate to strong correlations were expected. Indeed, several significant correlations were found. For example, informative statements (*InfStm*) correlated significantly with exchanges of task-related information (*TaskExch*). Furthermore, proposals for action (*EliPrpAct*) were positively correlated with making task-related and social plans (*MTaskPlan* and *MSociPlan*). However, not all expected correlations were found. For instance, it was expected that argumentative dialogue acts would correlate with exchange of task-related information. Only reasons (*ArgRsn*), conditional arguments (*ArgCon*), and concluding arguments (*ArgCcl*) correlated significantly with exchange of task-related information, however. The other argumentative dialogue acts did not.

In conclusion, the results presented in this paper indicate favorable results concerning the validity of the automatic coding procedure for dialogue acts. Of course, automatic coding can only be used for content and observational variables that can be indicated or signaled by specific marker words, phrases or actions. For more interpretative variables automatic coding is not suited. Thus, in future research we will continue to use automatic coding alongside manual coding and further analysis of online collaboration. For example, although the automatic coding procedure does not provide insight into the structure of online discussions (see also Chinn, this symposium), the procedure can be a starting point for more complex analyses of sequential interaction patterns. These sequential analyses can subsequently be used to capture the structure and quality of online discussion.

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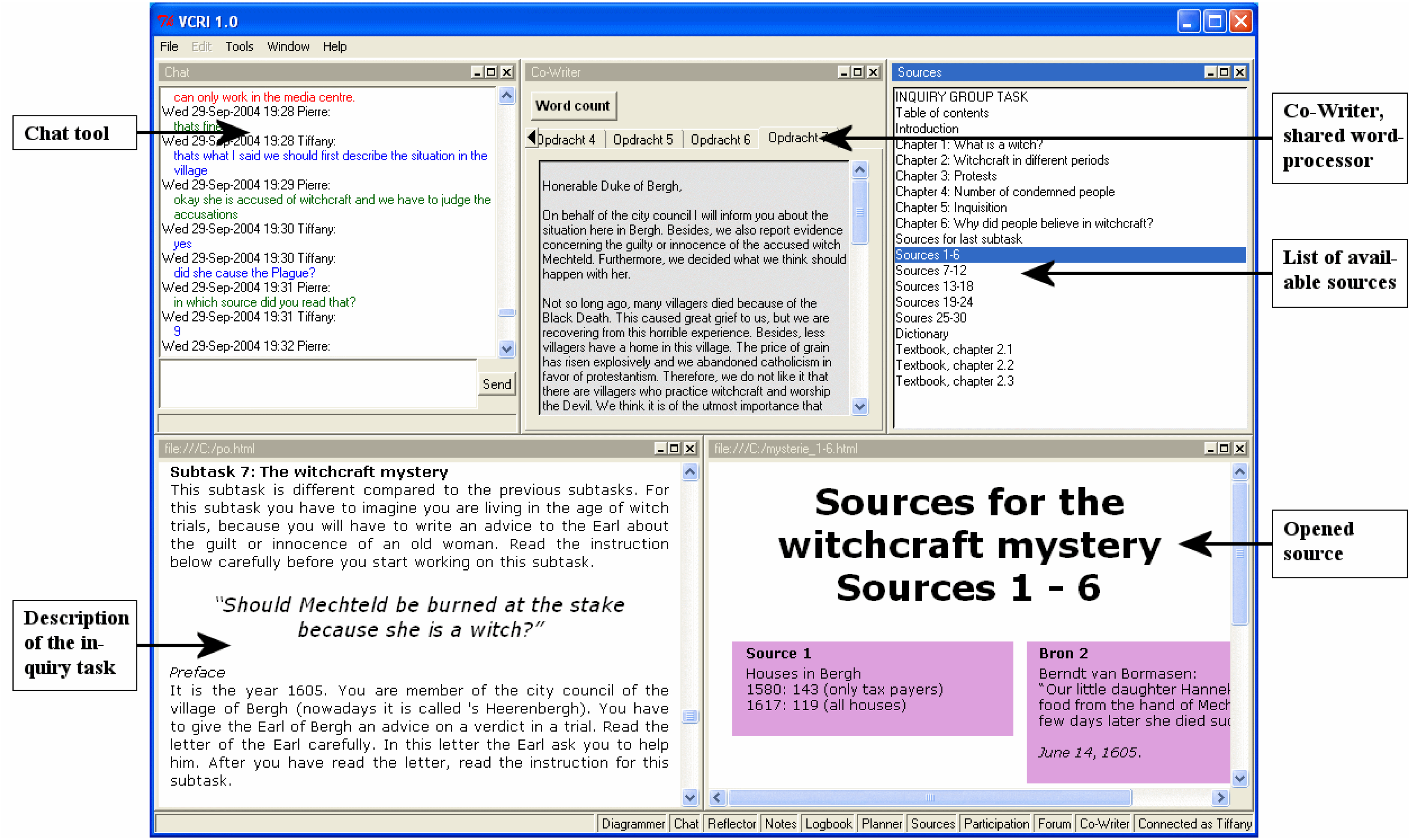

Figure 1

Screenshot of the VCRI program, detailing some of its tools (translated from Dutch).

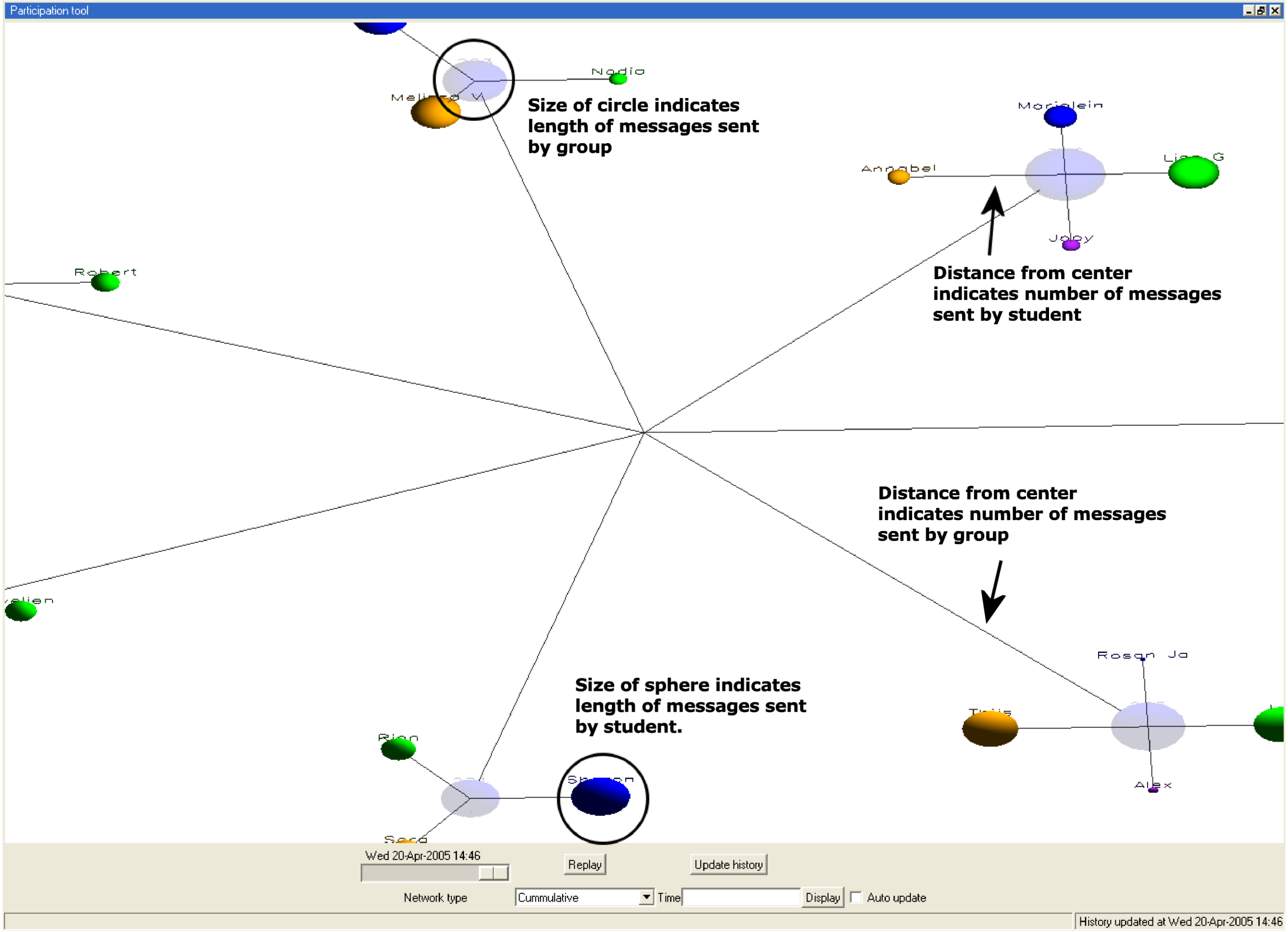

Figure 2

Screenshot of the Participation Tool (PT).

Table 1

Overview of dialogue acts, coding categories and examples of discourse markers

Communicative function	**Dialogue act**	**Specification**	**Code**	**Description**	**Discourse marker, i.e.**
Argumentatives	Reason		ArgRsn	Reason, ground	"Because …"
	Contra		ArgCnt	Counterargument	"However, …"
Reasoning	Conditional		ArgCon	Condition	"If …"
	Then		ArgThn	Consequence	"Then …"
	Disjunctive		ArgDis	Disjunctive	"Or …"
	Conclusion		ArgCcl	Conclusion	"So, …"
	Elaboration		ArgEla	Continuation	"Furthermore, …"
Responsives	Confirmation		ResCfm	Confirmation of info	"Right"
	Deny		ResDen	Refutation of info	"No"
Reaction, or	Acceptation		ResAcc	Acceptance of info	"Oh"
response to an utterance	Reply	Confirm	ResRplCfm	Affirmative reply	"Sure"
		Deny	ResRplDen	Negative reply	"No way"
	to an	Accept	ResRplAcc	Accepting reply	"Okay"
	elicitative	Statement	ResRplStm	Statement reply	" …"
		Performative	ResRplPer	Performative reply	"Thanks"
Informatives	Performative		InfPer	Action performed by saying it	"Hello"
Transfer of information	Evaluation	Neutral	InfEvlNeu	Neutral evaluation	"…easy …"
		Positive	InfEvlPos	Positive evaluation	"Nice!"
		Negative	InfEvlNeg	Negative evaluation	"Awful …"
	Statement		InfStm	Task information	" …"
		Action	InfStmAct	Announcement of actions	"I'll do …"
		Social	InfStmSoc	Social statement	"Love you …"
		Nonsense	InfStmNon	Nonsense statement	"grrumppphh"
Elicitatives	Question	Verify	EliQstVer	Yes/no question	"Agree?"
Utterances		Set	EliQstSet	Set question/ multiple choice	"…. or….?"
requiring a		Open	EliQstOpn	Open question	"Why?"
response	Proposal	Action	EliPrpAct	Proposal for action	"Let's change …"
Imperatives		Action	ImpAct	Order for action	"W8!"
Commanding utterances		Focus	ImpFoc	Order for attention	"Watch!"

Table 2

Differences in dialogue acts between male and female students.

	Male students ($N = 25$)		Female students ($N = 40$)				
Dialogue acts	M	SD	M	SD	Coeff.	SE	χ^2
Argumentatives	*28.96*	*15.48*	*55.25*	*38.98*	*5.09***	*1.98*	*6.29**
ArgRsn	4.00	2.80	8.50	6.41	1.20**	.48	5.85*
ArgCnt	7.92	4.42	14.65	11.20	1.25	.78	2.44
ArgCon	2.40	2.33	4.95	4.32	.57	.35	2.57
ArgThn	4.36	3.32	6.15	4.59	.20	.41	.23
ArgDis	.88	1.17	1.38	1.96	-.03	.18	.02
ArgCcl	3.68	3.13	8.93	8.10	1.09*	.55	3.77
ArgEla	5.72	4.49	10.70	9.63	.67	.62	1.15
Responsives	*52.12*	*26.96*	*79.53*	*38.99*	*5.91**	*2.70*	*4.60**
ResCfm	30.48	20.58	52.77	31.33	5.67**	2.36	5.37*
ResDen	3.32	2.30	4.35	3.17	-.09	.29	.09
ResAcc	1.92	1.87	3.15	3.23	.26	.32	.62
ResRplCfm	5.84	3.77	7.98	4.58	.61	.51	1.41
ResRplDen	1.32	1.60	1.33	1.40	-.08	.19	.20
ResRplAcc	.36	.70	.35	1.08	.02	.12	.03
ResRplStm	8.52	3.73	9.10	5.17	-.41	.51	.65
ResRplPer	.36	.57	.50	.78	.06	.09	.36
Informatives	*110.24*	*52.13*	*133.35*	*79.39*	*-6.83**	*3.17*	*4.45**
InfPer	7.88	8.99	8.70	4.68	-.51	.75	.45
InfEvlNeu	.08	.28	.35	.62	.09	.06	2.08
InfEvlPos	2.92	2.45	4.82	4.35	.47	.42	1.20
InfEvlNeg	2.52	2.18	2.28	2.52	-.51*	.26	3.79
InfStm	87.60	46.18	103.75	66.98	-7.16*	3.04	5.27*
InfStmAct	6.48	5.23	8.63	5.13	-.22	.44	.24
InfStmSoc	2.40	3.55	4.75	5.46	.55	.53	1.08
InfStmNon	.36	.64	.08	.27	-.17**	.05	9.05**
Elicitatives	*34.88*	*15.47*	*46.33*	*22.36*	*1.25*	*1.57*	*.63*
EliQstVer	16.72	9.15	24.10	12.94	1.48	1.11	1.74
EliQstSet	.92	.86	1.55	1.72	.12	.15	.55
EliQstOpn	11.80	6.27	12.95	6.85	-.64	.65	.96
EliPrpAct	5.44	3.55	7.73	5.35	.37	.46	.65
Imperatives	*9.08*	*8.39*	*46.33*	*22.36*	*-1.72***	*.70*	*5.50**
ImpAct	4.52	4.46	4.50	3.11	-.43	.44	.95
ImpFoc	4.56	7.17	3.30	3.19	-1.21*	.60	3.89*

$^{*}p < .05.$ $^{**}p < .01.$

Table 3

Differences in dialogue acts between students with and without access to the Participation Tool.

	Access to the PT (N = 52)		No access to the PT (N = 17)				
	M	SD	M	SD	Coeff.	SE	χ^2
Argumentatives	48.13	36.93	29.47	17.12	2.48	2.70	.82
ArgRsn	7.10	6.00	4.76	4.12	.12	.60	.04
ArgCnt	12.85	10.57	7.71	4.58	.77	1.16	.43
ArgCon	4.46	4.11	1.94	1.48	.79*	.41	3.58
ArgThn	5.69	4.19	3.94	3.91	.09	.53	.03
ArgDis	1.37	1.84	.47	.62	-.03	.09	1.89
ArgCcl	7.38	7.56	4.59	4.27	.26	.89	.09
ArgEla	9.29	9.13	6.06	3.60	.13	.74	.03
Responsives	71.19	39.69	56.76	21.43	1.21	3.42	.03
ResCfm	46.27	31.76	32.71	16.34	1.67	3.21	.27
ResDen	4.02	2.99	3.53	2.72	-.10	.43	.05
ResAcc	2.62	2.87	2.76	2.49	-.39	.38	1.04
ResRplCfm	7.77	4.59	4.76	1.99	1.25*	.59	4.14*
ResRplDen	.29	.78	.53	1.28	-.19	.22	.70
ResRplAcc	1.27	1.51	1.41	1.28	-.15	.14	.30
ResRplStm	8.50	4.88	10.76	3.95	-1.38*	.59	5.31*
ResRplPer	.46	.73	.29	.59	.03	.11	.06
Informatives	125.62	76.92	108.94	39.59	-8.52*	4.40	3.54
InfPer	9.40	6.95	3.76	2.31	2.24*	1.14	3.51
InfEvlNeu	.25	.56	.24	.44	-.02	.08	.07
InfEvlPos	4.06	3.15	3.71	5.29	-.45	.56	.63
InfEvlNeg	2.35	2.46	2.35	1.93	-.27	.38	.50
InfStm	98.10	65.59	86.71	31.54	-7.91*	3.79	4.08*
InfStmAct	8.00	5.55	6.29	3.72	-.11	.69	.03
InfStmSoc	3.23	4.26	5.82	5.97	-1.89*	.84	4.54*
InfStmNon	.23	.51	.06	.24	.11	.08	2.10
Elicitatives	43.63	21.56	34.65	15.49	1.54	1.86	.68
EliQstVer	21.98	12.72	18.06	9.88	.40	1.33	.09
EliQstSet	1.42	1.55	.71	.99	.15	.21	.53
EliQstOpn	12.77	6.64	11.82	6.14	-.06	.78	.01
EliPrpAct	7.46	5.11	4.06	2.36	1.10*	.66	2.67
Imperatives	9.33	6.82	5.41	4.36	1.72*	.70	5.92*
ImpAct	4.94	3.87	3.35	2.80	.87*	.51	2.80
ImpFoc	4.38	5.47	2.06	2.22	1.22*	.72	2.81

$^{*}p < .05$. $^{**}p < .01$.

Table 4

Correlations between results of automatic coding and manual coding.

	TaskExch	TaskQues	MTaskPlan	MTaskMoni	MTaskEvl+	MTaskEvl-	SociGree	SociSupp	SociResi	SociUnd+	SociUnd-	MSociPlan	MSociMoni	MsociEvl+	MSociEvl-	TechNeut	TechNega	TechPosi	Other
Argumentatives																			
ArgRsn	.37**			.39**						-.36**								-.27*	
ArgCnt								-.30*	-.35**								-.41**		
ArgCon	.26*		.29*					-.27*		.25*		.26*		.44**					-.27*
ArgThn		-.26*	.44**									.29*		.30*					
ArgDis		.26*																.32**	
ArgCcl	.35**			.33**						-.24*						-.25*	-.29*		-.28*
ArgEla			.53**	.35**		-.29*											-.30*		
Responsives																			
ResCfm	-.44**				.24*				-.28*	.92**									
ResDen											.44**				-.27*				
ResAcc																.25*			
ResRplCfm										.41**									
ResRplDen		.24*									.41**					.27*	.25*		
ResRplAcc																			
ResRplStm																			
ResRplPer										.34**									
Informatives																			
InfPer				-.31*			.86**												
InfEvlNeu										.36**								.33**	
InfEvlPos					.30*			.53**											
InfEvlNeg		.27*						.39**	.40**	-.26						.34**	.34**		
InfStm	.56**							.32**	.24*	-.51**									.33**
InfStmAct																			
InfStmSoc	-.26*							.62**	.29**		.30*						.42**		
InfStmNon		.26*																	

Note Cells with a grey background indicate expected correlations between dialogue acts and collaborative activities. $^{*}p < .05$. $^{**}p < .01$.

Table 5

Correlations between results of automatic coding and manual coding - continued.

	TaskExch	TaskQues	MTaskPlan	MTaskMoni	MTaskEvl+	MTaskEvl-	SociGree	SociSupp	SociResi	SociUnd+	SociUnd-	MSociPlan	MSociMoni	MsociEvl+	MSociEvl-	TechNeut	TechNega	TechPosi	Other
Elicitatives																			
EliQstVer				$.27^{*}$															
EliQstSet																			
EliQstOpn		$.36^{**}$									$.44^{**}$					$.28^{*}$			
EliPrpAct			$.37^{**}$					$-.24^{*}$	$-.26^{*}$	$.30^{*}$		$.57^{*}$					$-.30^{*}$		
Imperatives																			
ImpAct									$.25^{*}$			$.35^{**}$				$.35^{**}$			
ImpFoc						$.42^{**}$													

Note Cells with a grey background indicate expected correlations between dialogue acts and collaborative activities. $^{*}p < .05$. $^{**}p < .01$.