# Psychological characteristics in cognitive presence of communities of inquiry: A linguistic analysis of online discussions

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**Abstract**

Benefits of social interaction for learning have widely been recognized in educational research and practice. The existing body of research knowledge in computer supported collaborative learning (CSCL) offers numerous practical approaches that can enhance educational experience in online group activities. The Community of Inquiry (CoI) model is one of the best-researched frameworks that comprehensively explains different dimensions of online learning in communities of inquiry. However, individual differences, well-established in educational psychology to affect learning (e.g., emotions, motivation and working memory capacity), have received much less attention in the CSCL and CoI research published to date. This paper reports on the findings of a study that investigated linguistic features of online discussion transcripts coded by the four levels of cognitive presence – a CoI dimension that explains the extent to which a community can construct meaning from the initial practical inquiry to the eventual problem resolution. The automated linguistic analysis, conducted by using the Linguistic Inquiry and Word Count (LIWC) framework, revealed that certain word categories – reported previously in the literature as accurate indicators of specific psychological characteristics – had distinct distributions for each level of cognitive presence of the CoI framework. The most significant finding of the study is that linguistic proxies of increased cognitive load have unique representation patterns across the four levels of cognitive presence. Consequently, this study legitimizes more research on individual differences in general and on cognitive load theory in particular in communities of inquiry. The paper also discusses implications for educational research, practice, and technology.

*Keywords:* Community of inquiry, Linguistic inquiry and word count (LIWC), Cognitive load, Computer supported collaborative learning

## 1. Introduction

Recent progress in computer-supported collaborative learning (CSCL) research and tool development (Clark et al., 2007) offered a number of important opportunities for learning and education such as development of argumentation and critical thinking skills (Weinberger & Fischer, 2006; Garrison et al., 2001), creating and enhancing the sense of community (Dawson, 2008), and fostering and measuring creative potential (Dawson et al., 2011). This progress enabled a critical shift from knowledge transmission pedagogies with instructors playing the central role in the process, to learner-centered approaches offering rich social learning experiences (Garrison & Anderson, 2000).

In parallel with and guiding the technological progress, comprehensive frameworks have emerged in order to assist i) instructors in designing courses that promote a deep and meaningful learning experience in communities of inquiry; and ii) researchers in understanding individual and group facets of learning in social interactions. The Community of Inquiry (CoI) model is one of the best-researched frameworks that comprehensively explains different dimensions of online learning in communities of inquiry[1] (Garrison & Anderson, 2000). The framework consists of three interdependent dimensions (Garrison, 2007; Garrison et al., 2010b; Kanuka, 2011) – social, cognitive and teaching presence. Social presence describes relationships and social climate in a learning community (Rourke et al., 1999). Cognitive presence covers the learning phases from the initial practical inquiry to the eventual problem resolution (Garrison et al., 2001). Teaching presence explains the instructional role during social learning (Anderson et al., 2001).

Research centered around the CoI model has been based on both: i) *qualitative methods* – by using quantitative content analysis (Krippendorff, 2013; Rourke & Anderson, 2004) of transcripts of online discussions based on the coding schemes specifically tailored for each of its three dimensions; and ii) *quantitative methods* – by developing a survey instrument for measuring perceived value of each of its three dimensions (Garrison et al., 2010a). Validity of both the survey instrument (i.e., consistency and factor loadings) and the coding schemes (i.e., high inter-rater reliability) have been confirmed in numerous empirical studies (Arbaugh et al., 2008; Gorsky et al., 2012; Rourke & Anderson, 2004). Probably, the most important finding is the central role of teaching presence in *"establishing and maintaining social and cognitive presence"* (Garrison et al., 2010a). This perspective holds that just establishing interaction between students is not enough, but interaction should be guided through a careful instructional design (i.e., teaching presence). Therefore, several pedagogical approaches and feedback loops have been proposed to inform instructional design and enhance educational experience through advanced cognitive and social presence (Kanuka, 2011; Swan et al., 2012).

[1] According to (Garrison & Anderson, 2003) (p. 2), a community of inquiry is *"a group of individuals who collaboratively engage in purposeful critical discourse and reflection to construct personal meaning and confirm mutual understanding."*

Educational psychology offers numerous accounts about importance of individual differences (e.g., prior knowledge (Kalyuga, 2007), working memory capacity (Paas et al., 2004), motivation (Pintrich, 2004), and metacognitive awareness (McCabe, 2011)) for learning success. However, individual differences in CSCL research have received much less research attention. Existing CSCL research with respect to individual differences can be characterized by two important foci. First, the studies focusing on individual differences related to social interaction such as classroom community facets (e.g., spirit, trust, and interaction) (Dawson, 2008) and communication styles (Cho et al., 2007). Second, the use of social network analysis to investigate relationship between individual network positions with the above-mentioned individual differences. Probably, the reason for the extensive use of social network analysis lies in the public availability of the tools for extraction and analysis of social networks that are easily pluggable in to the commonly-used learning environments (e.g., SNAPP (Dawson et al., 2010)).

Individual differences of learners in communities of inquiry have received much less attention in the research literature published to date. Only recently, initial research attempts have been made by Akyol and Garrison (Akyol & Garrison, 2011a). They defined metacognition in CoI as *"complementary self- and co-regulation that integrates individual and shared regulation"* (Garrison & Akyol, 2013) that can be measured through self-reports and analysis of online discussion transcripts (Akyol & Garrison, 2011a; Garrison & Akyol, 2013). While very valuable, these are only preliminary steps toward bridging the gap in understanding effects of a broad range of factors, well-established in educational psychology (e.g., cognitive load and affects (Janssen et al., 2010; Baker et al., 2013)), on learning in communities of inquiry.

In this paper, we propose that analysis of automatically-extracted linguistic features of online discussion transcripts can be beneficial in identification of psychological factors of learning in communities of inquiry. This is justified by the fact that a major method for research of communities of inquiry is based on content analysis and coding of online discussion transcripts based on the three dimensions of the CoI model (Rourke & Anderson, 2004). Therefore, it seems promising to study the connection between the three dimensions of the CoI model and psychological meaning of words (Tausczik & Pennebaker, 2010). Moreover, trace data recorded by online learning software are shown to be reliable indicators of psychological constructs important for learning (Winne & Jamieson-Noel, 2002; Zhou & Winne, 2012).

In particular, the study presented in this paper centers around the analysis of linguistic features of cognitive presence in online discussions. The study is conducted by analyzing transcripts of online discussion collected through multi-year offerings of a master's course. The linguistic features of online discussion transcripts are extracted by using the well-known Linguistic Inquiry and Word Count (LIWC) framework (Tausczik & Pennebaker, 2010). Consequently, the contributions of the study are

- identification of linguistic features – reported in the literature to be accu-

rate indicators of specific psychological characteristics (e.g., emotions and cognitive load) – and their distinct distribution patterns for each level of cognitive presence of the CoI model

- implications of the identified linguistic features of cognitive presence in relation to educational research, technology, and practice.

## 2. Theoretical Background and Research Questions

### *2.1. Community of inquiry: Cognitive Presence*

Garrison et al. (2001) presented a practical approach to evaluating the nature and quality of reflective (critical) discourse in a online discussions. Cognitive presence is recognized as a core concept in the CoI definition, and is focused on the processes of higher-order thinking. Cognitive presence is operationalized through practical inquiry (i.e. critical thinking) in order to support the development of the model for critical discourse assessment in continuous communication within educational environments. The model has been defined through four phases of comprehensive process of critical thinking, which include the problem definition (i.e., triggering phase), exploration of different ideas (i.e., exploration phase), construction of the meaning of the proposed solutions (i.e., integration phase), and specification of possibilities to apply developed knowledge (i.e., resolution phase).

Each phase in the process of a practical inquiry is characterized by different set of socio-cognitive processes. Manifestation of these processes, within asynchronous text-based collaboration, is described by using a comprehensive set of descriptors and indicators. Thus, the triggering phase was defined as "evocative" and "inductive", the exploration phase as "inquisitive" and "divergent", the integration phase as "tentative", while the resolution phase was described as "committed" (Garrison et al., 2001). By combining descriptors, indicators and socio-cognitive processes, coders of online discussions should be able to provide reliable categorization of the messages under study. Characteristics of each phase are presented in following paragraphs and more details are provided by Garrison et al. (2001) and Park (2009), as well as within the concept map developed by van Schie (2008).

The triggering phase is related to discussions of general concepts of an area of interest, but not strictly directed to defined learning topics (Garrison et al., 2001). Messages belonging to this phase assume posting a new question, thus focusing the discussion on a new topic. Another manifestation of this phase reflects in presenting background information about a certain issue that culminates in posting a question (Garrison et al., 2001).

The exploration phase is based on personal reflection and social exploration processes (Garrison et al., 2001). Among other characteristics, divergence within an online community and within a single message are important indicators of this phase. Divergence within the online community means posting messages that contradict the general opinion of the community, introduce new ideas and view points, or make distinction among different ideas. Divergence within a

single message assumes presenting several different ideas in one post (Garrison et al., 2001; Park, 2009). Other important properties are information exchange, making suggestions, brainstorming and posting unsupported conclusions. Information exchange is qualified by personal narratives, description of certain topic(s), and stating the facts that do not support a general conclusion. Messages where the author makes suggestions are often concluded with a question whether other community members agree with the stated opinion or not (Garrison et al., 2001). Brainstorming messages are based on the previously stated facts, but do not contribute to a conclusion. The exploration phase is considered critical for the advancement of the cognitive inquiry towards the integration and resolution phases (Garrison & Arbaugh, 2007).

The integration phase presents a constructed meaning from the developed ideas, and assumes a continuous process of integration and reflection (Garrison et al., 2001). In contrast to the exploration phase, the convergence among group members and within a single message along with connecting ideas and creating solutions are the main factors (Garrison et al., 2001; Park, 2009). Referencing previous messages, while creating an agreement based on the stated facts, and building further knowledge on the previously constructed ideas, are properties of the convergence between group members. On the other hand, the convergence within a single message anticipates presentation of a justified and constructed, but still tentative hypothesis (Garrison et al., 2001).

The resolution phase could be viewed in different ways, depending on whether the cognitive inquiry is assessed within educational or non-educational settings (Garrison et al., 2001). While in non-educational settings, this phase could be characterized with a practical application of the proposed solution, in educational settings this phase could lead to another problem. But, by all means, this phase anticipates clear strategies for applying newly created knowledge.

Further, Garrison et al. (2001) recognized another important step in message categorization process. Since the content analysis method has been used for assessing the level of cognitive presence, defining the unit of analysis plays a significant role. There are different perspectives what should be considered an optimal unit of analysis, and various approaches were used in previous studies (Gunawardena et al., 1997; Arora et al., 2009; Mu et al., 2012). In the present study, a message was adopted as a unit of analysis, as an objectively identifiable unit, which produces a manageable set of cases, and its parameters are defined by the author of the message. Thus, coders could reliably identify the point where the coding decision is to be made. However, a message as a unit of analysis has certain disadvantages. One of the downsides of this approach is the possibility that several socio-cognitive processes could be presented in one message. This further means that one message can implicate more than one (or even all) phase(s) of practical inquiry process. Therefore, to overcome this problem, the following two heuristics have been established in the CoI literature: *"code down"* and *"code up"* (Garrison et al., 2001). The first rule means that if a message does not reveal indicators of any phase of cognitive presence, the code should be at the same level as its author's previous message. The second rule applies when a message clearly shows indicators of several phases; in that

case, the message should be coded to the highest level.

Many authors used the theoretical framework developed by Garrison, Anderson and Archer (Garrison et al., 2001) to assess students' epistemological engagement operationalized using cognitive presence indicators and descriptors, both in online and blended education (e.g. (Akyol & Garrison, 2011b; Kanuka & Garrison, 2004; Schrire, 2006; Stein et al., 2007), and (Vaughan & Garrison, 2005)). In those studies, researchers usually applied techniques of quantitative content analysis on online discussion transcripts, which are useful for isolated research studies.

To our knowledge, there have not been any previous studies that used automated analysis of linguistic features of different levels of cognitive presence that can be indicative of constructs established in educational psychology[2].

### *2.2. Psychological foundation: Psychological meaning of words*

Much research in psychology has focused on words and language use as a significant indicator of social integration, personality and cognitive processes (Tausczik & Pennebaker, 2010). Various authors studied language as a predictor of psychological, emotional and health change (e.g. (Pennebaker & Graybeal, 2001; Creswell et al., 2007; Kahn et al., 2007; Darabi et al., 2011; Ullrich & Lutgendorf, 2002)), reflection of situational and social processes (e.g. (Kahn et al., 2007; Arguello et al., 2006)), and individual differences (e.g. (Tetlock, 1981; Oberlander & Gill, 2006)). Moreover, exploration of linguistic style, rather than linguistic content, attracts even more attention with the advancement of artificial intelligence and text analysis software (Pennebaker et al., 2003).

Pennebaker et al. (2003) explored the methods of language use, and presented psychological word count approaches. According to their study, there have always been two alternative perspectives in methods of studying language and word use. While the first approach assumes that analyzed content must be observed within a specific context, the other perspective suggests statistical (quantitative) analysis of word use. The former approach can be classified into three methodologies: i) thematic content analysis, which usually involves judges who are trying to reveal specified thematic references, by their own experience, or by a pre-established coding scheme; ii) word pattern analysis, a method that uses artificial intelligence techniques to mathematically detect word patterns (e.g., latent semantic analysis – LSA), and iii) psychological word count strategies, which could be applied for both content and style analysis (Pennebaker et al., 2003).

The method we use in this study is based on the word count strategies, which is geared toward revealing psychological meaning of words, independently from their literal and semantic context. Furthermore, amongst approaches, such

[2]It is important to note that the goal of this study is not automation of the quantitative content analysis technique, which is an important research challenge (McKlin et al., 2002; McKlin, 2004). The goal is to deepen understanding of emerging psychological processes in cognitive presence that can be identified through the automatic linguistic analysis of discussion transcripts.

as the General Inquirer or analyzing emotion-abstraction patterns, presented in Pennebaker et al. (2003), we decided to use Linguistic Inquiry and Word Count (LIWC), as the most suitable tool for analysis of online discussion messages, and assessment of various psychological constructs (e.g., cognitive, social, and emotional processes) (Mehl, 2006).

Numerous researchers demonstrated that LIWC can be used in a wide variety of experiments for detecting meaning of words. Tausczik & Pennebaker (2010) described the process of development and validation of LIWC, and showed its potential in experiments which included discovering of attentional focus, revealing emotional status and social relationships, assessing thinking styles, and individual differences (e.g., age, sex, mental health and personality). For our study, the most significant findings were those related to thinking styles, and word categories that could indicate the complexity and depth of thinking. As Tausczik and Pennebaker noticed, the level of cognitive complexity could be observed through the level to which someone differentiate among competing solutions, or its possibility to integrate among those options. Both processes are integrated by LIWC categories: the prior process is depicted with *exclusive* words (e.g., but, without, exclude), while the subsequent one is captured within the *conjunctions* word category (e.g., and, also, although). Thus, it is possible to conclude that exclusive words are common when someone is trying to make distinctions, while conjunction words are more often used in connecting ideas, and developing coherent narrative.

Tausczik & Pennebaker (2010) showed that *prepositions*, *cognitive mechanisms*, and *words longer than six letters* are indicators of more compound language structures. They argued that a significantly larger number of prepositions is often used when someone is trying to provide more concrete details on a discussion topic. Further, they also identified cognitive mechanisms, more precisely *causal* (e.g., because, hence) and *insights* (e.g., consider, think, know) words, as indicators of an intensive reappraisal process. Causal words are also more often used when a person tries to integrate ideas and thoughts and to provide more concise explanations. On the other hand, *tentative* (e.g., perhaps, maybe, guess) and *filler* (e.g., blah, you know, I mean) words are associated with an insufficient level of knowledge and/or certainty to discuss on a specific topic.

Several studies showed that certain word categories are related to an increased level of cognition. Although those studies were not in the areas of education, the underlaying cognitive processes are of direct relevance for our study of the relationships between cognitive presence and lingustic features. Pennebaker & Graybeal (2001) showed the relation between word choices and psychological changes and health improvement, i.e. how writing can be used as a therapeutic process. In contrast to their initial assumptions, they revealed that *affective* words (e.g., love, nice, sweet) were weakly related to health improvement, while *cognitive (causal and insight)* words showed a significant association with a health outcome. More precisely, individuals who showed an increased level of cognitive words in their narratives demonstrated a significantly larger health improvement. This observation was also presented in Pennebaker's previous work (Pennebaker, 1997), where he noticed that over the time, individuals were

able to provide more precise and concise descriptions of their current situation, and thus, showing improvement in the level of cognition and understanding of their problem. Ullrich and Lutgendorf had similar findings in their study (Ullrich & Lutgendorf, 2002) on journaling about stressful events. They found that participants who involved in higher cognition and deeper emotions while journaling, showed better understanding of a stressful event, and a stronger health improvement. An increased level of cognition was followed by the increased usage of *cognitive* and *positive emotion* words. Following Pennebaker's work, Jones & Wirtz (2006) defined similar LIWC categories in order to examine participants' turns in an appraisal-based model of confronting. More precisely, they used *positive*, *negative* and *cognitive* process word categories. Although emotional changes are followed by a certain form of cognition, their study showed that only positive words in conjunction with the reappraisals process showed the effect on emotional improvement.

Creswell et al. (2007) attempted to reveal which of the underlying psychological processes of expressive writing has the most positive effect on health. Defining three mediator variables, self-affirmation, cognitive processing, and discovery of meaning, they also assessed the association among their coding scheme and LIWC categories. They measured association between defined mediators and LIWC categories for *positive and negative emotions*, as well as *insight* related word categories. They discovered that only positive emotion words are associated to all three mediators, while other categories did not reveal significant association.

Linguistic features extraction and content analysis using LIWC was also applied in the human-computer interaction field. Khawaja et al. (2009) analyzed which linguistic features of speech are the most relevant indicators of the current cognitive load. Those features should enable response and patterns adjustment within adaptive interaction systems that are aware of a user's cognitive load in order to assist the user to solve their problems more effectively. Findings presented in their study, indicate that the following categories showed a statistical significance with the level of cognitive load: count of *words per sentence*, *affective* words, *negative emotions*, *perception* and *cognitive* words, as well as words that denote feelings. On the other hand, total *word count* spoken by a user, count of long words (*longer than six letters*), and *inclusive* words are not significant, but could be used to support previously stated features. Further, Hancock et al. (2007) tried to assess emotional states in computer-mediated communication, while Joyce & Kraut (2006) assessed emotional tone using LIWC categories as a one of the potential predictors of continued participation in a newsgroup. Kramer et al. (2004) and Kramer et al. (2006) also used linguistic feature, generated by LIWC, with the aim to describe the nature and reveal the level of presence in computer-mediated communication. It is interesting to note that one of the findings, in the former study by Kramer et al., revealed that a higher level of presence in online communities was related to the lower usage of words that characterize *cognitive* processes. However, in contrast to our approach, the operational definition of presence in studies by Kramer et al. is analogous to the construct of social presence within the CoI framework.

Recent studies reported the use of LIWC in educational reseach/learning sciences. Robinson et al. (2013) assessed lexical diversity in students' self-introductions at the beginning of the semester to predict the final course performance based on those differences. Their study showed promising results and revealed that the use of *punctuation*, *first-person singular pronouns*, *present* tense, and words characterizing *biological* processes along with personal concerns were significant indicators of academic performance. Further, (Carroll, 2007) analyzed critical thinking essays and showed that students less commonly used *insight*, *discrepancy* and *tentative* words while the number of *inhibition* and *causal* words increased towards the end of the semester. On the other hand, the study of Lengelle et al. (2013) on career-related narratives revealed that more creative, expressive, and reflective writing was characterized by more frequent use of *insight* and *positive emotion* words. Those results were in line with the study of Peden & Carroll (2008) on analyzing differences between self-assessment and traditional academic assignment comparing students' lexical styles. Their study revealed that more reflective writing, supported through self-assessment assignments, differ in a more intensive use of *insight* and *positive emotion* words, while traditional assignments were more linguistically complex (i.e. more words larger than six letters, more words per sentence and less dictionary words).

### *2.3. Research questions*

The aim of this study is to identify features that could more precisely describe each phase of cognitive inquiry. Indicators presented in Section 2.1 allow human coders to code messages according to the phases of cognitive presence. Our study aims to reveal features that would characterize psychological processes indicative of different phases of the cognitive presence construct of the CoI framework.

Analysis of LIWC categories, presented in Pennebaker et al. (2007), is fairly complex regarding the number of psychologically meaningful categories and their application in relatively different environment. Tausczik & Pennebaker (2010) assumed that a frequent use of *tentative* and *filler* words means that a person presents a concept which is not completely developed. Although Garrison et al. (2001) identified **integration** phase as *"tentative"*, we expect that this category could be related to the **triggering** phase as well. This stems from the difference in the semantics of the word "tentative" used in the two different frameworks – CoI and LIWC. In the integration phase, tentativeness refers to hypothesized or tentative solutions built upon the evidence from the studied information or practical experience. For a hypothesized/tentative solution to become committed, the students need to reach to the resolution phase. Hypothesizing solutions usually require a more complex language and formulations. In contrast, as indicated in Section 2.2 the LIWC tentative words are associated with uncertainty. Uncertainty is more related to the "sense of puzzlement" defined as an indicator of the triggering phase (Garrison et al., 2001). Therefore, we defined our first research question:

**RQ 1** *Are linguistic features of online messages, categorized as tentative and filler words, viable indicators of initial socio-cognitive processes of cognitive inquiry (i.e. triggering phase)?*

Further, more frequent use of *exclusive* words indicates that a person is trying to make a distinction among several, probably equally significant, solutions (Tausczik & Pennebaker, 2010). *Causal* words are used in an active process of reappraisal and creating causal explanations (Pennebaker & Graybeal, 2001). Therefore, we assume that these two categories of words could also be used to identify the **exploration** phase of cognitive inquiry. We also wanted to extend these assumptions by including the category of *discrepancy* words too, since one of the characteristics of the exploration phase is the evaluation of different (often opposite and conflicting) solutions (Carroll, 2007). Thus, we define our second research question:

**RQ 2** *Is the higher ratio of causal, exclusive, and discrepancy words indicative of messages belonging to the exploration phase of cognitive presence?*

Several studies (e.g. (Pennebaker & Graybeal, 2001; Creswell et al., 2007; Lengelle et al., 2013; Peden & Carroll, 2008)) found that *causal* and *insight* words are related to the level of cognition. Thus, it seems reasonable to expect a more frequent use of these two subcategories of *cognitive* words with the advance of cognitive inquiry. Summarizing their findings, as well as observations from related studies Tausczik & Pennebaker (2010) and Pennebaker et al. (2003), as well as the studies by Robinson et al. (2013) and Carroll (2007), stated several potentially significant conclusions. Those studies identified *pronouns* and *verb tense* linguistic elements as good indicators of focus, which can further help identify a person's intentions and priorities. Further, those studies found an increased use of *assents* as factors of higher group agreement, while *conjunctions* are used to create consistent narrative, and logical grouping of multiple thoughts. *Prepositions*, *cognitive mechanisms*, and *words greater than six letters* are also indicators of more complex linguistic constructions. All these categories were also identifies in Khawaja's study (Khawaja et al., 2009) as indicators of increased cognitive load. According to the previously stated, it seems reasonable to anticipate a more frequent use of all these categories within the **integration** and the **resolution** phases. Thus, we define our third research question:

**RQ 3** *Do complex linguistic constructions, indicated by a more frequent use of words belonging to psychological categories of linguistic, affective, and cognitive processes, suggest advance in cognitive inquiry? More precisely, in what ways these categories can identify the integration and resolution phases of cognitive presence.*

Although there are 82 psychological meaningful categories of words defined in the LIWC dictionary (LIWC Inc., 2013a), we assume that the most significant categories for defining features of cognitive phases are the categories of cognitive processes and function words.

## 3. Methodology

In this section, we describe the data collection process and measures used in the study, the procedure we followed to conduct the study, and the analysis we performed on collected data.

### *3.1. Data collection*

For the purpose of our research, we used the dataset obtained from a research intensive software engineering course of a master's in information systems program in an online Canadian university. The discussions were part of a course assignment, which was scheduled in weeks 3–5 of the 13 weeks long course. In the assignment students were asked to i) select a peer-reviewed paper, ii) prepare and record a presentation of the paper, iii) upload the presentation to a university hosted video streaming website, and iv) share the information about the presentation with the rest of the class by initiating a new discussion thread in the forum module of learning management system Moodle. The other students of the class were then requested to take part in the discussion about the presented paper, direct their questions about the presentation to the presenter, and brainstorm ideas (e.g., topic, research questions, and methods) about the research project they would need to work on in the following assignments in relation to the presented paper. The presenter played the moderator and expert roles in the discussions. Participation in the discussions was graded and valued 5% of the overall course grade. Although planned for weeks 3–5 for grading purposes, the discussions would typically continue into weeks 6 and 7 (total of five week for discussions), before a midterm (literature review) paper is scheduled for submission.

The dataset contained 1747 messages of students' online discussions within an asynchronous forum with 84 different topics (i.e. peer-reviewed papers that students presented) from the course offerings in Winter 2008(N=15), Fall 2008 (N=23), Summer 2009 (N=10), Fall 2009 (N=7), Winter 2010 (N=14) and Winter 2011 (N=13). Two human coders independently coded the messages, and achieved disagreement in less than 2% cases (i.e., 32 messages), with high inter-rater reliability (Cohen's kappa of .97). Those disagreements were further discussed to reach the agreement of the final code assigned to each message. Among the coded messages, there were 308 messages in the triggering phase, 684 in the exploration phase, 508 in the integration phase, and 107 in the resolution phase, while 140 messages were coded as "other"[3]. All the students (N = 82) actively participated in discussions with the descriptive statistics of their cognitive presence reported in Table 1.

[3]In this study, consistent with the common practice in the CoI research, category "other" is introduced in order to label messages that did not contain indicators of any phase of cognitive presence.

Table 1: Descriptive statistics (median, 25th and 75th percentile) posted messages, for each phase of cognitive presence, by the students involved in the study

| Cognitive presence | Median (25%, 75%) |
|---|---|
| Other | 2 (1, 3) |
| Triggering | 2 (1, 5) |
| Exploration | 7 (4.25, 11) |
| Integration | 5 (3, 8) |
| Resolution | 2 (1, 3) |

Table 2: LIWC variables used to address the first research question (LIWC Inc., 2013b)

| Category | Abbreviation | Example | Measure |
|---|---|---|---|
| Tentative | tentat | maybe, perhaps, guess | Count of tentative words in a message |
| Fillers | filler | Blah, I mean, you know | Count of filler words in a message |

### *3.2. Measurements*

LIWC defines four general descriptor categories of output variables, namely: linguistic processes, psychological processes, personal concerns, and spoken categories (LIWC Inc., 2013b). However, to assess assumptions presented in the RQs, based on the reviewed literature, we identified several subcategories that include general categories of linguistic processes, functional words, cognitive processes, and spoken categories, as a relevant for our study. For the first RQ we used the measures presented in Table 2, while the second RQ is related to the subcategories of the cognitive processes, and includes the measures described in Table 3. For the third RQ, we performed an analysis on a larger number of psychologically meaningful categories. The measurements used to address this research question are presented in Table 4 and are extracted from the linguistic, affective and cognitive categories.

Table 3: LIWC variables used to address the second research question (LIWC Inc., 2013b)

| Category | Abbreviation | Example | Measure |
|---|---|---|---|
| Causation | cause | because, effect, hence | Count of causal words in a message |
| Discrepancy | discrep | should, would, could | Count of exclusive words in a message |
| Exclusive | excl | But, without, exclude | Count of discrepancy words in a message |

Table 4: LIWC variables used to address the third research question (LIWC Inc., 2013b)

| Category | Abbreviation | Example | Measure |
|---|---|---|---|
| Word count | wc | | Count of words in a message |
| words/sentence | wps | | Average count of words per sentence in a message |
| Words>6 letters | sixltr | | Total count of words with length larger than 6 letters in a message |
| Total function words | funct | | Total count of function words in a message |
| Total pronouns | pronoun | I, them, itself | Count of pronouns in a message |
| Articles | article | A, an, the | Count of articles in a message |
| Common verbs | verb | Walk, went, see | Count of common verbs in a message |
| Auxiliary verbs | auxverb | Am, will, have | Count of auxiliary verbs in a message |
| Prepositions | prep | To, with, above | Count of prepositions in a message |
| Conjunctions | conj | And, but, whereas | Count of conjunctions in a message |
| Cognitive processes | cogmech | cause, know, ought | Count of words that presents all cognitive processes in a message |
| Insight | insight | think, know, consider | Count of insight words in a message |
| Certainty | certain | always, never | Count of certainty words in a message |
| Inhibition | inhib | block, constrain, stop | Count of inhibition words in a message |
| Inclusive | incl | And, with, include | Count of inclusive words in a message |

### *3.3. Study procedure*

For the purpose of the study, we setup a MongoDB database instance, and stored all the collected messages into the database. Each message record contained general information (i.e. post ID, title, body, forum information, and course related information) along with the assigned codes according to the four phases of cognitive presence. Since LIWC2007 did not provide an API, each message was stored in a separate file for further processing using this software. Results obtained after LIWC analysis are stored in a CSV file which is convenient for further processing using different data analysis softwares such as R or SPSS.

### *3.4. Analysis*

The distribution of variables was tested for normality using the Shapiro-Wilk test, which revealed non-normal distribution. This was further confirmed using P-P plots. Moreover, we tried to repeat test on log-transformed data, and confirmed previous findings. Given the non-normal distribution, we decided to perform non-parametric tests with all dependent variables.

To test RQ1, we used the Kruskal-Wallis test to determine if there are significant differences between the phases of cognitive presence with respect to the count of tentative and filler words. In order to reveal which groups were significantly different, we conducted a post hoc paired comparison – after the Kruskal-Wallis – by using the Mann-Whitney test with the Bonferroni correction. The same tests were performed for variables defined in RQs 2 and 3. Results were considered significant if p was less than .05. When the Bonferroni correction was applied, given the 5 categories in our study that required 10 pairwise comparisons, p was less than .005. All statistical tests were performed using the R software, version 3.0.1.

## 4. Results

### *4.1. Research question 1*

The descriptive statistics for variables used in analysis of the RQs 1 and 2, are presented in Table 5. Due to the non-normal distribution of the data, median, $25^{th}$ and $75^{th}$ percentile values are reported.

A Kruskal-Wallis test was conducted to evaluate differences among the phases of cognitive presence on median change in the count of tentative and filler words. The test was significant for both categories: *tentative* – $\chi^2$ (4, N=1747) = 54.24, p <.001 as well as *filler* words – $\chi^2$ (4, N=1747) = 50.16, p <.001. A follow-up analysis using the post-hoc Mann-Whitney test with the Bonferroni correction produced results presented in Table 6. These results revealed significant differences between the triggering and exploration phases and between the triggering and integration phases, w.r.t. the use of tentative words. On the other hand, significant difference regarding filler words was present only between the triggering and resolution phases.

Table 5: Descriptive statistics for tentative, filler, causal and exclusive words categories

| **Category** | **Mean (25%, 75%)** |
|---|---|
| *Research question 1* | |
| tentat | 3.29 (1.77, 4.49) |
| filler | 0.12 (.00, .00) |
| *Research question 2* | |
| cause | 2.65 (1.21, 3.80) |
| excl | 2.29 (.90, 3.37) |
| discrep | 1.64 (.00, 2.44) |

Table 6: Median ($25^{th}$ and $75^{th}$ percentile) of counts of Tentative, Filler, Causal, Exclusive and Discrepancy words, defined in Research Question 3, across the four phases of cognitive presence, with the results of the Kruskal-Wallis test and the post-hoc Mann-Whitney test with the Bonferroni correction

| **Category** | **Triggering** | **Exploration** | **Integration** | **Resolution** | **Sig.** |
|---|---|---|---|---|---|
| *Research question 1* | | | | | |
| tentat | 2.87 (.96, 4.10) | 3.55 (2.06, 4.77) | 3.36 (2.10, 4.48) | 3.27 (2.05, 4.20) | p <.001 $^{a,b}$ |
| filler | 0.07 (.00, .00) | 0.12 (.00, .00) | 0.14 (.00, .00) | 0.15 (.00, .29) | p <.001 $^{b,c}$ |
| *Research question 2* | | | | | |
| cause | 2.03 (.00, 3.29) | 2.85 (1.31, 4.09) | 3.08 (1.84, 4.20) | 2.85 (1.83, 3.66) | p <.001 $^{a,b,c,d}$ |
| excl | 1.66 (.00, 2.79) | 2.49 (1.10, 3.52) | 2.46 (1.33, 3.36) | 2.60 (1.55, 3.58) | p <.001 $^{a,b,c}$ |
| discrep | 0.96 (.00, 1.60) | 1.72 (.54, 2.51) | 1.88 (0.92, 2.59) | 2.50 (1.51, 3.39) | p <.001 $^{a,b,c,e}$ |

a. p <.001 Triggering vs. Exploration; b. p <.001 Triggering vs. Integration; c. p <.001 Triggering vs. Resolution; d. p <.001 Exploration vs. Integration; e. p <.001 Exploration vs. Resolution; f. p <.001 Integration vs. Resolution

### *4.2. Research question 2*

In order to evaluate differences among different phases of cognitive presence w.r.t. causal and exclusive words, we also performed the Kruskal-Wallis test. The test was significant for both word categories: *causal* – $\chi^2$ (4, N=1747) = 157.17, p <.001, as well as *exclusive* words – $\chi^2$ (4, N=1747) = 93.75, p <.001. In order to examine differences among different phases, we also conducted the post-hoc Mann-Whitney test with the Bonferroni correction (Table 6). In case of causal words, results indicated significant differences among almost all the comparisons, except for the resolution phase compared to either the exploration or integration phase. On the other hand, for exclusive words, tests revealed statistical significance only between the triggering and the three other phases.

### *4.3. Research question 3*

To test assumptions presented within the third research question, we also performed the Kruskal-Wallis test. As illustrated in Table 7, only in case of the

verb category, the results were not statistically significant, while the test was significant in case of *all other word categories*.

Further, we conducted the post-hoc Mann Whitney test with the Bonferroni correction in order to evaluate differences between various phases of cognitive presence (Table 7). Although the test was statistically significant for all the categories tested, it did not reveal differences in distribution of Sixltr, pronoun nor inisght categories over the phases of cognitive presence. However, it is interesting to note that only *WC* showed differences between all phases. On the other hand, in case of *WPS* results did not indicate significant differences in case of the triggering phase compared to the exploration phase, as well as the integration phase compared to the resolution phase. Similar results were obtained for the *auxiliary* verbs category. This category also revealed significant differences among most of the comparisons, except for the exploration phase compared to the integration phase, as well as the integration phase compared to the resolution phase.

The test also revealed that the use of several categories of words is statistically different between the triggering phase of cognitive presence and all the other phases. These categories are *dictionary* and *functional* words, as well as *articles*, *prepositions*, *conjunctions* and words that belong to the *cognitive processes* category, *further inhibition* and *inclusive words* categories. On the other hand, pronouns and insight words were not significantly different across the levels of cognitive presence. However, the distribution of discrepancy words was different for all the comparisons made, except between the exploration and integration phases.

## 5. Discussion

### *5.1. Interpretation of the results with respect to the research questions*

Various studies have demonstrated interdependence between the level of cognition and words used in writing and/or computer-supported communication (e.g. (Creswell et al., 2007; Khawaja et al., 2009; Pennebaker et al., 2003; Tausczik & Pennebaker, 2010)). However, the results of our study show that different phases of cognitive presence have distinct levels of word use. In order to highlight how various psychological properties of messages are related to description of different phases of cognitive presence, we organize our discussion around the measures studied within the proposed research questions.

It is interesting to note that messages in different phases of cognitive presence did not reveal a difference in the use of insight words and pronouns (RQ3). Although these categories were identified as valid indicators of higher levels of cognition (e.g., (Pennebaker & Graybeal, 2001; Creswell et al., 2007), as well as indicators of focus, intentions and a person's priorities (Khawaja et al., 2009), our analyses did not reveal differences in the usage of these categories over various processes of cognitive presence. This might be due to the context of our study in which data were collected (i.e. the course design and characteristics

Table 7: Descriptive statistics (median, $25^{th}$ and $75^{th}$ percentile values) of the variables, defined in RQ3, across the phases of cognitive presence, with the results of the Kruskal-Wallis test and the post-hoc Mann-Whitney test with the Bonferroni correction

| Cat. | Triggering | Exploration | Integration | Resolution | Sig. |
|---|---|---|---|---|---|
| WC | 82.03 (55.00, 99.50) | 122.71 (73.25, 149.50) | 185.53 (115.00, 221.00) | 291.24 (168.00, 338.00) | $p<.001^{a-f}$ |
| WPS | 24.29 (13.25, 28.85) | 24.74 (16.00, 27.18) | 27.83 (17.75, 29.16) | 32.18 (18.29, 34.73) | $p<.001^{b,c,d,e}$ |
| Sixltr | 26.86 (21.82, 31.06) | 26.18 (21.96, 29.54) | 26.19 (22.94, 29.25) | 25.89 (22.84, 28.70) | ns* |
| Dic | 71.18 (62.50, 83.28) | 78.62 (74.31, 84.20) | 79.29 (75.19, 84.27) | 79.56 (76.02, 83.73) | $p<.001^{a,b,c}$ |
| funct | 43.06 (33.37, 54.31) | 50.73 (46.91, 55.99) | 51.66 (48.26, 55.98) | 51.88 (48.93, 55.88) | $p<.001^{a,b,c}$ |
| pronoun | 9.71 (5.33, 13.78) | 10.60 (7.92, 13.23) | 10.24 (8.11, 12.48) | 9.84 (8.11, 11.62) | ns* |
| article | 6.66 (4.00, 8.82) | 8.09 (6.10, 10.19) | 8.25 (6.67, 9.72) | 8.48 (6.76, 10.16) | $p<.001^{a,b,c}$ |
| verb | 14.33 (11.55, 16.67) | 13.83 (11.52, 16.18) | 13.78 (11.80, 15.83) | 14.21 (12.27, 16.54) | ns |
| auxverb | 7.28 (4.57, 10.00) | 8.48 (6.41, 10.70) | 8.75 (7.25, 10.31) | 9.37 (7.59, 11.03) | $p<.001^{a,b,c,e}$ |
| preps | 10.31 (7.41, 13.06) | 12.47 (10.78, 14.29) | 12.88 (11.25, 14.45) | 12.84 (11.22, 14.29) | $p<.001^{a,b,c}$ |
| conj | 4.19 (2.18, 5.71) | 5.43 (3.96, 6.90) | 5.54 (4.39, 6.59) | 5.72 (4.31, 6.89) | $p<.001^{a,b,c}$ |
| cogmech | 14.49 (10.34, 18.69) | 18.09 (15.18, 20.85) | 1.88 (15.91, 20.82) | 2.50 (16.14, 21.24) | $p<.001^{a,b,c}$ |
| insight | 4.05 (2.25, 5.51) | 4.01 (2.50, 5.31) | 3.75 (2.42, 4.82) | 3.40 (2.44, 4.14) | ns* |
| certain | 0.90 (0.00, 1.64) | 1.14 (0.00, 1.70) | 1.26 (0.53, 1.81) | 1.45 (0.71, 2.11) | $p<.001^{a,b,c,e}$ |
| inhib | 0.58 (0.00, 0.70) | 0.79 (0.00, 1.27) | 0.82 (0.00, 1.21) | 0.70 (0.00, 1.09) | $p<.001^{a,b,c}$ |
| incl | 2.88 (1.52, 4.13) | 3.54 (2.16, 4.76) | 3.75 (2.63, 4.89) | 3.69 (2.65, 4.57) | $p<.001^{a,b,c}$ |

a. $p<.001$ Triggering vs. Exploration; b. $p<.001$ Triggering vs. Integration; c. $p<.001$ Triggering vs. Resolution; d. $p<.001$ Exploration vs. Integration; e. $p<.001$ Exploration vs. Resolution; f. $p<.001$ Integration vs. Resolution; ns. $p>.05$ for all comparisons

* although the results of the Kruskal-Wallis test were statistically significant, the post-hoc Mann Whitney test with the Bonferroni correction did not reveal differences between phases of cognitive presence.

of communication which was more formal, and strictly focused on a specific task defined in the course work). A similar conclusion could be drawn for filler words (RQ1); since we analyzed online communication between students enrolled in a graduate course, it is unlikely to expect an intensive use of fillers throughout the learning process. This is also confirmed with the descriptive statistics presented in Table 5. Moreover, the results of comparisons made on the usage of words, whose length was more than 6 letters (RQ3), indicate that once students are involved in the cognitive inquiry, this linguistic category is highly represented through all the four phases of cognitive presence: from the problem description (i.e., the triggering phase) to the resolution phase. However, it would be important to validate these results on another dataset collected in a different context.

The count of words is the only linguistic category that showed differences among all the comparisons made. Further, the count of words per sentence, as well as the count of causal and discrepancy words (RQs 2 and 3) also differed among most of the pair-wise comparisons between the cognitive presence phases, but with slightly different implications. The results indicated that the count of words per sentence was not significantly different between the triggering and exploration phases and between the integration and resolution phases. This might suggest similarities between two different groups of processes. On the one hand, the triggering and exploration phases are characterized by intensive search for a solution, issuing queries and generating often shallow ideas and/ or leaping into conclusions. On the other hand, the integration and resolution phases tend to introduce more details on a certain topic and offer an answer, possibly by using more complex linguistic categories including more words per sentence (Park, 2009; Akyol & Garrison, 2011b).

We expected that the usage of discrepancy and causal words (RQ2) would significantly differ between the exploration and other phases of cognitive presence; however, the results were not quite in line with our expectations. In case of discrepancy words, the results were not significantly different between the exploration and integration phases. This might be due to the fact that both categories introduce new ideas (divergent or convergent) (Park, 2009), and thus, words such as "should", "would", and "could" are likely to be equally represented. Moreover, differences of counts of causal words were not significant between the resolution phase and either the exploration or integration phase. These results indicate that a linguistic count of words can be used to identify these language categories, however, for further differentiation and more precise categorization of each process, we need to assess the meaning of relations among concepts introduced in different levels of cognitive presence.

All other measures, namely articles, prepositions, conjunctions, auxiliary verbs, certainty, exclusive, tentative, functional, inhibition, inclusive and cognitive processes words (RQs 1 and 3), share a common pattern: all these categories reveal significant differences only between triggering and other phases of cognitive inquiry. Thus, we are able to conclude that these results are in line with previous findings (Khawaja et al., 2009, 2012), since all these categories are recognized as indicators of an increased cognitive load.

### *5.2. Limitations*

The nature of this study introduces possible limitations. We analyzed messages of students' online collaboration within an asynchronous forum from one course in different offerings. However, for external validity of our study, it is important to analyze datasets from several courses with different subject domains (such as social and educational sciences, or literature), as well as various pedagogical approaches and different levels of education (i.e. undergraduate and graduate). Moreover, we did not analyze the individual contribution of each student to the messages that were coded in particular phases. More precisely, if a particular student contributed the majority of messages belonging to a specific phase of cognitive presence, the characteristics of their individual language use could introduce a certain level of skewness into the linguistic analysis. Thus, language use profiling should be considered in the future research to study differences in LIWC patterns across the levels of cognitive presence. Another limitation is that we decided to use LIWC as we find it the most suitable for analysis of psychological traces in online discussion transcripts. However, different tools such as Coh-Metrix that implements well-established measures for coherence of text (Graesser et al., 2004) or tools evaluated by Pennebaker et al. and Mehl (Pennebaker et al., 2003; Mehl, 2006) (e.g., General Inquirer, DICTION, or TAS\C), as well as different semantic text analysis strategies (e.g., LSA (Landauer et al., 1998; Foltz et al., 1998)) should also be assessed. Another concern could be an influence of individual students on the creation of the data set used in this study – i.e. the transcripts of online discussions. That is, in the case when a minority of students are involved in a discussion, a resulting data set might depict individual characteristics of few discutants, instead of the whole group. However, our data set was obtained from an active participation of all the students in the discussion (see Table 1); thus, representing a balance of individual characteristics.

### *5.3. Implications for educational research, technology, and practice*

The results of the LIWC-based linguistic analysis offer distinct proxies of cognitive presence with a high practical potential for educational technology. Currently, quantitative content analysis according to different categories of cognitive presence is the primary method that CoI research uses and this method is highly laborious (Mu et al., 2012). The identified linguistic proxies of cognitive presence can be used as a foundation for learning analytics tools (Ferguson, 2012) for instructors offering (i) insights in the quality of their instructional designs guiding the educational experience of communities of inquiry. Such insights can enable the instructors to intervene timely and thus, enhance teaching presence as the critical factor for high levels of cognitive and social presence (Garrison et al., 2010a; Arbaugh et al., 2008; Swan & Ice, 2010); and (ii) real-time monitoring of the effectiveness of instructional designs on the level of individual learners, not on the group level only (this factor is further discussed below). Such analytics about social learning activities are shown, in a recent study (Ali et al., 2013), to have a high probability for acceptance by instructors.

As our results indicate, linguistic proxies of increased cognitive load have unique representation patterns across the four levels of cognitive presence (i.e., higher levels of cognitive presence have increased use of linguistic proxies of cognitive load). Therefore, our results warrant future research of the relation between cognitive presence and cognitive load theory (Paas et al., 2004). Namely, an effective text comprehension (in this case online discussions and other course readings) happens when information read from a text previously is kept accessible in working memory (Ericsson & Kintsch, 1995). However, working memory is a limited resource by the amount of information that can be kept and cognitive operations that can be applied to that information (Sweller & Chandler, 1994). Working memory capacity is significantly explained by the schema-level prior knowledge of an individual (Kalyuga, 2007). The cognitive load theory posits that instructional design can have a negative effect on learning, if information being studied is not aligned well with the the schema-level knowledge of learners (Kirschner et al., 2011; Merrienboer & Sweller, 2005; Paas et al., 2003, 2004; Sweller et al., 1998). While information being studied possesses the so-called intrinsic load (instructional designers have no control over), instructional design should be respectful of a single most significant predictor of learning – prior knowledge – by offering individualized instruction to learners to promote effective learning. Unfortunately, most of instructional designs, including those for CSCL and communities of inquiry, assume that the level of students' knowledge is on the same level (i.e., novice). Thus, while those designs might be effective for novice, they are shown to have often no or even a negative effect on learning of advanced students – i.e., produce the so-called expertise reversal effect (Kalyuga, 2007).

Research and practice of instructional design for CSCL (Wise et al., 2012; Weinberger et al., 2005) in general and the CoI model (Kanuka, 2011) in particular published to date has not paid sufficient attention to individual differences. Although it has been shown that in some situations group work can help distribute the individual cognitive load and improve learning (Kirschner et al., 2009), future research should investigate i) what effect "one size fits all" instructional strategies to promote cognitive presence have on learners with different levels of schema-level knowledge of the studied information; and ii) whether increasing the overall level of cognitive presence of a group of students has a negative effect on learners with low-levels of prior knowledge; i.e., high cognitive presence in online discourse of some group members can introduce an additional level of (extraneous) cognitive load for others. Through addressing these questions, we might also be able to extend current understanding of some of the commonly reported concerns of learners when participating in CSCL tasks such as *"the imbalance in the level of ... quality of the individual contributions and the excess time spent on the online CSCL tasks"* (Capdeferro & Romero, 2012).

Our findings additionally reinforce a need for practice and research of adaptive instructional designs (Fischer et al., 2013; Kalyuga, 2007) in order to cater to the needs of different learners participating in a community of inquiry. First, course design should offer different instructions for students expectations for learners in different stages of courses. For example, for students with high-level

prior knowledge, there is probably no need to offer detailed guidance how to seek relevant information that needs to be integrated and discussed online. On the other hand, it is likely that learners with low-level prior knowledge may require more detailed instructions, not only related how to structure their messages, but even where and how to find relevant information and how to integrated that information into discussions with high cognitive presence. Second, roles for group activities should be assigned to learners in accordance to their level of prior knowledge. For example, it is probably not reasonable to expect learners with low-level prior knowledge to be able to play effectively some roles in group discussions (e.g., moderator and summarizer) (De Wever et al., 2008; Wise et al., 2012) that require higher levels of cognitive presence and before schemas are developed, and thus, inherently may impose a higher level of cognitive load for some students.

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