Trust and Cognitive Load in the Text-Chat Environment: The Role of Mouse Movement

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ABSTRACT
This paper examines how different levels of cognitive load can affect trust in the text-chat environment. It also examines how the mouse movements of participants can indicate the level of cognitive load when they chat with each other. We designed two chat systems: one in which subjects chat under low mental load and the other in which subjects chat under high mental load. Twenty subjects participated in the study and the results showed significant differences in the level of trust between subjects under different cognitive loads; that is, subjects who chatted under low mental load showed more trust in their partners. Moreover, the mouse data obtained proved to be effective in indicating the level of cognitive load existing between the subjects. However, this work suggests that to establish trust in the chat environment, it is better to communicate under a low cognitive load. Our findings also show the ability of designed systems to measure cognitive load via tracking mouse events for the purpose of providing assistance to communicators.

Author Keywords
Trust, Cognitive Load, Text-Chat Environment, Mouse Movement, Social Dilemma

ACM Classification Keywords
H5.3. Information interfaces and presentation: Group and Organization Interfaces - collaborative computing, computer-supported cooperative work

INTRODUCTION
Trust refers to a situation when someone can predict how others will behave and what will occur from their behaviors (Starker, 2008). It is also defined as "*a willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party*" (Mayer et al., 1995). However, researchers have found that a lack of trust exists between interlocutors in the text-chat environment (Bos et al., 2002), but despite a lack of trust, this chat medium is commonly used. For instance, it has been found that within an organization, the chat medium is used between workers significantly more than telephone calls and face-to-face communication (Quan-Haase et al., 2005).

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Cognitive load refers to the amount of mental load imposed on a human's working memory when a person attempts to accomplish a task (Chandler and Sweller, 1991). People's working memories have limitations in terms of holding and processing new information (Gerven et al., 2003). An increased amount of new information has a significant impact on the way people behave, for example, people engaged in a low cognitive load task use a greater variety of words when speaking compared with people engaged in a high cognitive load task (Khawaja et al., 2010). The language they use changes as cognitive load increases, with people using more negative words and longer sentences (Khawaja et al., 2014). However, previous research showed that if people were given extra time (15 minutes) to chat in the text chat environment, it built a higher level of trust between them when they chatted again later via the same medium compared with people who didn't chat for additional time (Zheng et al., 2002). This finding raises a question about what happens to the trust between people in this medium when their attention is distracted from the communication. To explore this question, we examine the effects of cognitive load on trust under two different conditions: low load and high load tasks, to find out if the building of interpersonal trust can be affected. We also examine a novel approach, namely mouse movement measures, which are a set of indicators to track the mouse cursor, to measure the cognitive load level in this chat medium.

The findings of this study could have implications for improving communication in the text-chat environment. We are interested in whether a high cognitive load can have a negative effect on building trust, and whether mouse data can be used to monitor cognitive load levels between team members.

BACKGROUND LITERATURE
In a less rich medium, the text-chat environment, where significant communication cues such as facial expressions are lost, there is a clear lack of trust between people compared with those who engage in face-to-face communication, as well as those who use other computer-mediated forms of communication, such as audio and video (Bos et al., 2002). Previous research has demonstrated that the trust between people in the text-chat medium can be affected by giving them additional time to communicate (Zheng et al., 2002). To the best of our knowledge, there are no existing studies which investigate the effects of cognitive load on trust in computer-mediated communication. However, previous research on trust and automated systems showed that people are too dependent on the system when they experience a high cognitive load (Biros et al., 2004).

The behaviours of people vary significantly under different levels of cognitive load. For example, it was found that the length of pauses in the speech of people who were under a high cognitive load was longer (Khawaja et al., 2008), and people speak more, use more disagreements terminology and more plural pronouns under high load (Khawaja et al., 2012). In relation to using mouse movements as indicators to measure cognitive load, an existing study has investigated the relationship between a user's cognitive load and their mouse activities and proposes one indicator for measuring cognitive load (pauses) as there was a strong correlation between an increased numbers of pauses in mouse activity and a high cognitive load (Arshad et al., 2013). However, in this study, we expect to find that distracting the attention of people who are communicating will hinder the building of trust between them in the text-chat medium. In addition, we expect to find that requiring people to undertake complex tasks makes them concentrate more on solving the task, resulting in less mouse movements. In order to determine whether there are significant differences in the mouse movements used by people who are communicating under high and low cognitive loads, novel measures which we have developed, such as distance travelled, will be used. If these measures show significant differences, they can be used to distinguish the level of cognitive load. The hypotheses of this study are:

(H1) The establishment of trust will increase with a lower level of mental load.
(H2) An increase in mouse movements is associated with a lower level of mental load.

METHOD

Participants

Twenty participants were recruited for this study (13 males and 7 females, aged between 22 and 40). All the participants were university students and none of them had met each other prior to the task. The participants were randomly assigned to chat with their partner.

Procedure

We collected the data using the DayTrader task (Bos et al., 2002; Scissors et al., 2009) which requires players to communicate with each other to play an investment game. This investment game follows the rules of the Prisoner's Dilemma game. To obtain high and satisfying rewards, players must trust each other. The data collected from this game can be used to measure the extent of interpersonal trust between people, therefore, for this reason, it was chosen.

Each participant chatted and played with one other participant only. Therefore, there were ten pairs of partners in the study. The total chat time was thirty minutes in duration, divided into six sessions. The participants played the investment game and in each session, the participant and their partner chatted for five minutes about how much they would invest. At the end of each session, the participants commenced investing in the market and they were not able to chat again until they had finished making their investment. The participants had to invest five times with their partners in each of the six sessions, so the total number of rounds for investment was thirty. In each round, the participants were given $60 to invest and they could invest an amount between $0 and $60. After each round, the participants received a payoff as follows: the money invested in the market was multiplied by three and was split equally between both participants, while the money which was not invested by each participant was only multiplied by two and was calculated separately for each participant. However, after each investment round, a random amount of money of between −$3 and +$3 was given to participants for their payoff to increase the defections and cheating between participants (Scissors et al., 2009; Zheng et al., 2002). Also, after each investment round, the participants were not able to see their partner's payoff until the end of the game (Scissors et al., 2009).

Each participant was exposed to two cognitive load conditions, low load and high load, but only during their chats with each other. We asked the participants to sum random numbers in their heads, without using pen and paper or a calculator, and enter the total of the numbers at the end of each session. In the low cognitive load condition, the participant summed small random numbers, either 1 or 2, but in the high cognitive load condition, the participants summed large random numbers between 100 and 300. During each five-minute chat session, different numbers were shown eight times in pop-up boxes in the chat window. Each pop-up box was displayed for 15 seconds and then closed automatically, unless the participant closed it. As the participants chatted for six sessions, five pairs of partners were firstly given a low cognitive load for three chat sessions followed by a high cognitive load for three chat sessions; while the other five pairs of partners were firstly given a high cognitive load for three sessions followed by a low cognitive load.

However, the participants were told before the game that they would earn between $10 and $22 based on their performance to motivate them to take the investment game more seriously and sum the numbers correctly.

Mouse Motion

In this study, the movements of the mouse cursor in the graphical user interface were recorded only when the participants were chatting (that is, the mouse movements were not recorded when they invested). During chatting, the participants move the mouse and perform the following tasks: 1) read all messages exchanged using the horizontal scrollbar; 2) check all investment payoffs from the sessions which have been completed using the horizontal scrollbar; 3) put the mouse cursor in the text field to write a new message; and 4) close the pop-up boxes which display the random numbers to be summed.

Cognitive Load and Trust Measures

We used a post-questionnaire to check our approach in relation to cognitive load to make sure there is a clear difference in the level of mental load imposed on the participants. Another post-questionnaire was also used in conjunction with the investment game to measure the participant's level of trust in their partners. Each

Measure	High Load *Mean(SD)*	Low Load *Mean(SD)*	*t*	*p*-value
Distance (pixels)	16954(6549)	25026(10055)	3.93	0.004
Positive Slope (+)	478(299)	861(497)	3.74	0.005
Negative Slope (-)	1058(440)	1490(450)	4.32	0.003
Movement Count (movements)	556(236)	809(378)	2.89	0.015
Duration (seconds)	655(231)	710(172)	0.90	0.401

Table 1. Summary of mouse movement measures when cognitive load is low and high.

questionnaire, either the cognitive load questionnaire or the trust questionnaire, was given to each participant twice, once after the low cognitive load sessions and the other after the high cognitive load sessions. The cognitive load questionnaire comprised one question adapted from (Nasa, 1986): "Please rank the mental effort you had to expend while summing these numbers". The trust questionnaire comprised several questions: e.g., "I feel my partner didn't do anything to cause me to have less money than them." These questions were adapted from Butler (1991), which provides a long list of questions to measure trust.

Mouse Movement Measures

During the chat sessions, when the mouse cursor moved, the time stamps and coordinates (*X*, *Y*) of the mouse cursor were recorded. For each two sequential pairs of coordinates (*X*, *Y*) and (*X*, *Y*) which constitute a line (in other words, a movement), we called these two *A* (*AX*, *AY*) and *B* (*BX*, *BY*) to carry out the calculation. We calculated a set of measures for the mouse movements. These measures are:

• Distance: The total distance travelled which are between each two sequential pairs of coordinates.

• Slope (both positive and negative): The total steepness of the straight lines which are between each two sequential pairs of coordinates.

• Movement Count: The total number of lines which are between each two sequential pairs of coordinates.

• Duration: The total length of time when the mouse cursor isn't moving.

RESULTS AND DISCUSSION

We analyzed and compared the data for each participant independently from their partner in the low load condition and the high load condition, using a dependent-sample two-tailed t-test with $\alpha=0.05$.

Cognitive Load Results

The participants showed differences in the evaluation of the summing numbers task. The results revealed that mental load increased significantly ($t(19)=9.99$, $p<0.000$) from a mean value of 2.5 ($SD=1.64$) under a low cognitive load condition to a mean value of 7.25 ($SD=1.41$) under a high cognitive load condition.

Trust Results

The questionnaire results showed that the level of trust increased significantly ($t(19)=2.18$, $p=0.039$) from a mean value of 19.9 ($SD=6.42$) under a high cognitive load condition to a mean value of 25.1 ($SD=8$) under a low cognitive load condition. However, in some cases the payoff from the investment game didn't illustrate the trust between participants as shown in previous studies (e.g., Scissors et al., 2008; Scissors et al., 2009) where they didn't use payoff to measure trust in their analysis. We found this to be the case in our study as the results were not significant. The reason for this is because the rules of the game rely on high payoff and whenever the payoff is high, the trust will be high, but in fact, even those who have high trust may reap a low payoff. For example, if two participants agree to invest $40 each but one invests $40 and other invests $38, and another two participants agree to invest $20 each and they both invest $20, the first group which invested $40 and $38 will receive a higher payoff than the second group despite the existence of cheating, unlike the second group which kept their promises because of the existence of trust.

Mouse Movement Results

The distance travelled by the participants' mouse was significantly higher ($p=0.004$) when the participants' mental load was low ($M=25026$ pixels) compared with when the participants' mental load was high ($M=16954$ pixels). Similarly, the total steepness of lines for positive and negative slopes increased significantly ($p=0.005$, $p=0.003$), from when the participants' mental load was high ($M=+478$, $M=-1058$) to when the participants' mental load was low ($M=+861$, $M=-1490$), respectively. In addition, the total number of movements significantly increased ($p=0.015$), from when the participants' mental load was high ($M=556$ movements) to when the participants' mental load was low ($M=809$ movements). Finally, the total length of time that the mouse cursor stopped failed to show significant results ($p=0.401$). All of these results with standard deviation values (*SD*) and statistical values (*t*) are summarized in Table 1.

Discussion

It was noted that when the participants summed large random numbers, they faced an extreme load on their working memories which was reflected directly in their attitudes and feelings toward their partners and their way of moving the mouse. The trust results revealed support for hypothesis H1 that the level of cognitive load affects the building of trust when people communicate in the chat medium. These results are consistent with another study which demonstrated that extra time spent in communication builds trust between people (Zheng et al., 2002), which is similar to what happened indirectly in the low cognitive load sessions, where the participants were in more communication with each other which led to building higher trust.

In relation to mouse movements, the results also provided support to hypothesis H2. The relationship between mouse movements and cognitive load was observed as there was less mouse movement under the high mental load condition compared with the low mental load condition, indicating the versatility of hand movements at the low level of mental load. The reason for this was because the participants were preoccupied by summing large numbers which required more thinking and focus, thus hindering their mouse movements. The findings in relation to mouse movements are also compatible with other studies on the effects of cognitive load on people's movements, for example, the mean stride length and velocity of people while walking were less with a high cognitive load task compared to a low cognitive load task (Martin & Bajcsy, 2011). They are also closely related to Van Gog et al.'s (2009) ideas where they show that human movement can be used to reduce cognitive load, while here we show that the amount of human movement can also be an expression of level of cognitive load.

The measures of distance, slope and movement count varied substantially between high and low cognitive load sessions and indicate the mouse role in distinguishing the mental load level. In the case of duration, this was not a significant factor by which to measure cognitive load, as the results showed that in both high and low cognitive load sessions, the participants moved the mouse cursor an equal amount of time, however, there was a significant difference in the speed of this movement, where the mouse cursor was moved more quickly in the low cognitive load sessions, resulting in a greater distance and a higher slope and movement count than in the high cognitive load sessions.

The results of this study have implications which indicate the possibility of improving communication in the text-chat environment. This work demonstrates an optimal way to build trust between individuals in the chat medium by avoiding high cognitive load which has a negative effect on the process of building trust. In addition, the mouse data can be used to develop interfaces and applications to monitor the different levels of cognitive load between team members and to support them.

CONCLUSIONS AND FUTURE WORK

This study showed encouraging evidence for how to establish interpersonal trust between people in the chat medium. As trust has already been found to be weak in this medium (Bos et al., 2002), it is possible that this study will show that a higher cognitive load will worsen the situation in relation to trust building. Moreover, based on the present findings, mouse movements were proven to be a reliable indicator for the level of cognitive load. For future work, we will attempt to build a predictive model with high accuracy for cognitive load classification during mouse movement. In addition, it may also be valuable to manipulate trust in the chat medium to answer the following question: if a high level of trust has been built between individuals, is it possible that a high cognitive load still has a negative effect on trust.

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