Eye Gazing Behaviors in Online Deception

Jinie Pak
Department of Information Systems
University of Maryland Baltimore County
jpak3@umbc.edu

Lina Zhou
Department of Information Systems
University of Maryland Baltimore County
zhoul@umbc.edu

ABSTRACT

Psychophysiological behaviors of deceivers have been used as an effective leakage channel of face-to-face deception. Among various psychophysiological behaviors, eye movement has been identified as one of the most reliable sources of deception behavior in face-to-face communication. However, empirical studies of eye movement behavior in online deception remain scarce. In this research, we investigated eye gazing behaviors of deceivers in online video chatting. Based on the findings of previous deception studies and the unique characteristics of online video chatting, we hypothesized that online deception has an impact on eye gazing behaviors. In addition, we innovatively operationalized eye gazing behaviors in terms of areas of interest. We conducted a lab-based experiment to test the hypotheses. The results supported the effect of deception on eye gazing behaviors. The findings of this study provide insights on how to improve the performance of online deception detection and how to apply eye tracking technologies to understand emerging human behaviors in online communication.

Keywords

Online deception, eye movement, psychophysiological behavior, gaze behavior

INTRODUCTION

Online deception poses a threat to the effectiveness of pervasive online communication. Psychophysiological technologies such as thermal (Pavlidis, Eberhardt, and Levine, 2002), cardio-respiratory metrics (Kurohara, Terai, Takeuchi, and Umezawa,. 2001; S. Mann, A. Vrij 2002), and functional magnetic resonance imaging (fMRI) (Mohamed, Faro, Gordon, Platek, Ahmad, and Williams, 2006) have been applied in deception detection and credibility assessment to identify potential indicators of deception in the past decades. Given the emergence of neural IS and the easy access to modern psychophysiological technologies, there is a resurgent of interest in leveraging such technologies in addressing deception detection in a new environment.

Among the various psychophysiological technologies, eye movement tracking technology is one of the most reliable and widely used. Deception research has constantly investigated the link between eye and deception as one of non-verbal cues although there were the studies that found about no significant correlation between them(Sporer and Schwandt, 2007; Zuckerman and Driver, 1985). Such efforts are grounded on the supposition that deception can be revealed by psychological and physical arousals, emotions, cognitive processes, and attempted controls (Zuckerman, DePaulo and Rosenthal, 1981) and moreover, psychophysiological cues to deception cannot be easily controlled by a human, while some behaviors can be controlled strategically during deception (Burgoon and Buller 1994; Burgoon, Derrick, Elkins, Humphreys, Brooks, and Diller, 2008).

Most studies on eye and deception have been examined from the aspect of face to face (FtF) communication, but little from the aspect of computer mediated communication (CMC). Although non-verbal cues to deception have been studied in online deception, the empirical studies of eye movements have been largely ignored since the availability of eye movements in CMC is quite limited. Furthermore, these deception studies in FtF communication mostly investigated participants' eye movements from the direct observation in controlled experimental settings (e.g. a mock crime, an interview, object recognition) to extract a set of features (Derrick, Elkins, Burgoon, Nunamaker, and Zeng, 2010; Meservy, Jensen, Kruse, Burgoon, and Nunamaker, 2005; Miron Zuckerman, Koestner, and Colella, 1985). Thus, the results from the studies in FtF communication may not be directly applied to detecting deception in CMC.

Despite of the inconsistent findings about eye movements in deception, and the limited availability of non-verbal cues in CMC, still many studies have attempted to find evidence that eye movements are correlated to deception such as pupil size, blinking rate, and gaze pattern in CMC (Carlson, George, Burgoon, Adkins, and White, 2004.). However, their experiment settings were limited to avatar-based or conversational agent mediated communications. Our previous study on eye movements in deception detection attempted to explore pupil dilation and blinking rate as indicators of deception in online video chatting and confirmed that there was a significant deception effect on pupil dilation (Pak and Zhou, 2011). Motivated by the previous findings, we extend the study to investigate eye movements of deceivers in synchronous CMC, applying AOI (Area of Interest) analysis that is commonly used in human computer interaction research.

The rest of the paper is organized as follows. We first review previous studies particularly in eye movements and propose our hypotheses. Next, we present methodology design, data analysis, and results in sequence. Finally, we discuss implications of findings, limitations, and further research direction.

THEORETICAL BACKGROUND AND HYPOTHESES

Bridging Eye and Cognitive Process

Eye movement is an important resource that reveals underlying cognitive processes (Just and Carpenter, 1976) and is also significantly sensitive to the psychophysiological states of an individual (Raidt, Bailly, and Elisei, 2007)). For instances, eye behaviors such as pupil dilation, blinking rate, and fixation duration are reported as reliable indicators of cognitive workload, which can be applied to predict one's task performance in real-time (Tsai, Viirre, Strychacz, Chase, and Jung, 2007). It is also shown that visual scan paths are closely related to the focus of one's attention (Vertegaal, Slagter, Der Veer, and Nijholt, 2001). Thus, the correlation between eye movements and the mind has attracted research attention from a number of disciplines. In psychological and human behavioral research, eye movements have been studied from many functional aspects of cognition such as providing information, regulating interaction, exercising social control, facilitating service and task goals, problem solving, reasoning, mental mapping, and search behaviors (Kleinke, 1986). In human computer interaction, eye movements have been studied to understand cognitive processes and to engage human factors in interface usability and ergonomics. Moreover, the remarkable advance of eye tracking technology further motivates this trend by making it possible to collect and analyze a large amount of eye movement data accurately.

In view that deception reflects a type of complex cognitive and emotional arousal state, there has been a resurgence of research interest in using the eye movement analysis to identify deception indicators. Eye movements as psychophysiological responses to deception are grounded on the following three assumptions: 1) human perception, emotion, thought, and action are concerned with phenomena–human behavior and experience in the physical and social environment (Cacioppo, Tassinary, and Berntson, 2007); 2) the responses of the corporeal brain and body convey psychological information about human cognitive processes; and 3) the eye is an organ of information processing, firmly connected to a part of the brain (Pinker, 1999). Additionally, Baron-Cohen (1995) has claimed that eye-direction detector and intentionality detector are located in the brain lesions (the superior temporal sulcus, amygdala, and orbitofrontal cortex), as the mind-reading mechanisms, which are able to use gaze information to attribute mental state. Later studies have provided support for his proposition by showing that perception of gaze direction activates the same areas of the brain that are involved in making attributions of intention and beliefs (Emery, 2000). According to fMRI and polygraph investigation (Mohamed et al., 2006), fourteen areas of the brain would be active when participants are probably involved in suppressing or inhibiting truths, memory encoding and retrieval, and emotional arousal such as anxiety and nervousness.

Eye Tracking Technology

Eye tracking is a technique that measures an individual's dynamic eye movements, which allows researchers to obtain an objective source of both where a person is looking at any given time and the sequence in which their eye are shifting from one location to another (Poole and Ball, 2006). Area of interest (AOI) is an oculometric analysis method used in eye tracking technology. Researchers would define certain areas of a display or interface and analyze on the eye movements that fall within such areas. Accordingly, depending on which areas of interest are specified, AOIs hold significant meaning or indicate a specific source of information. AOI analysis is based on eye fixations (pauses over informative regions of interest) (Salvucci, Anderson, and Koedinger, 1999) as well as gaze metrics (the grouping of fixations within a single region of interest) (Hendrickson, 1989). One of benefits of using AOI analysis is that the size and complexity of eye movement protocols can be reduced significantly (Salvucci et al., 1999), including the potential for narrowing areas for further investigation. In addition, such fixation-derived metrics are used to interpret cognitive load, emotional arousal, or social interaction of an individual (Poole and Ball, 2006). For instance, higher fixation frequency or longer fixation duration on a particular area can be indicative of greater interest in the target and cognitive load (Poole and Ball 2006).

Deception in Online Video Chatting, Gaze Behaviors, and Areas of Interests

Online video chatting is emerging as one of the common forms of CMC. As technology continues to advance, video chatting and conferencing have increasingly been involved in business meetings, educational training, or instruction and collaboration with others. According to Skypejournal.com, Skype has about 560 million registered accounts and the number is expected to reach one billion by 2015. In terms of usage of calls, 34 % of Skype to Skype calls involve video calls. With the rapid growth in usage of online video chatting, the chances of facing deception have noticeably increased.

Deception is defined as a message knowingly transmitted by a sender to foster a false belief or conclusion by the receiver (Buller and Burgoon, 1996). Particularly, deception in CMC is referred to as an intentional act or message that occurs when individuals are communicating via one of forms of CMC such as email, instant messages, video conferencing, and so on. No matter where such deception occurs, it is a very complex task involving many factors such as psychological and physical arousal (e.g. pupil dilation, blink rate, speech error, etc.), attempted control (e.g. facial expression, posture, gesture, etc.), emotion (e.g. guilt, feat, anxiety) and thinking (e.g. cognitive overload)(M. Zuckerman et al., 1981). Accordingly, deception requires more cognitive processes than truth telling.

With regard to eye movements as deception indicators, most studies on deception in CMC have adopted findings from deception studies on FtF communication, and few has empirically evaluated gaze behaviors on specific areas in CMC displays or interfaces. Only several studies investigated eye movements and deception under avatar-based or conversational agent based communication (Kurohara et al., 2001). Proudfoot et al. (2012) has evaluated gaze behaviors on AOIs in face recognition to identify familiarity with an object as a Guilty Knowledge Test (GKT). Although online video chatting is similar to FtF communication, the former is different in a way that it appears to affect conversational interaction processes such as backchannels, interruption, overlaps, turn-taking, feedbacks, and handovers (Isaacs and Tang, 1993; O'Conaill, Whittaker, and Wilbur, 1993). As a result, the findings from online video chatting does not provide the same benefits as FtF communication in terms of interaction(Gwyenth Doherty-Sneddon, O'Malley, Garrod, and Anderson, 1997). Since several areas in a display are available for an individual to gaze on during online video chatting, defining AOIs of the display would provide high performance accuracy of eye gaze and details of gaze behaviors of an individual during either deception or truth-telling.

Recent research has shown that eye movements and gaze behaviors can serve as important sources of cues to deception. Gaze behaviors can manifest the cognitive process, emotional arousal and social interaction of an individual. With regard to the link between gaze aversion and cognitive difficulty, people tend to avert their gaze, when they try to deploy additional cognitive resources to the task in order to improve their performance (Doherty-Sneddon and Phelps 2005; Glenberg, Schroeder, and Robertson, 1998). Gaze aversion also can play a role in reducing anxiety and embarrassment, whereas eye contact is associated with an increase in such emotions (Burgoon, Manusov, and Mineo 1985). Accordingly, if an individual experiences cognitive difficulty, an increase in anxiety, and/or emotional arousal during deception, he or she is likely to avert his or her gaze from a communicating partner and fixate his or her gaze on other areas. Thus, we proposed the following two hypotheses:

H1: Gaze fixation is less during deception than during truth-telling.

H2: Gaze aversion is more during deception than during truth-telling.

METHOD

A laboratory experiment was conducted to test the hypotheses. The study adopted a within-subjects design, where each participant performed tasks under both deception and truth-telling conditions.

Participants

The participants were recruited from a university on the east coast of the U.S. through online advertisement and fliers. The participants could either earn extra course credits (upon the approval of the instructor), or receive $10 as compensation of their participation. There were 22 participants (7 females and 15 males) who completed the study. Among them, the eye movement behaviors of 17 participants were recorded successfully throughout the experiment. They ranged from 18 to 29 years of age with an average level of experience with CMC.

Procedure

The task scenario was set in a hypothetical online dating environment, where a pair of dating partners communicated using an online video chatting tool. The study was conducted in three rooms simultaneously, which were assigned and equipped for participants, confederates, and the moderator, respectively. None of them could see one another during the study. The participants performed their tasks in a usability lab where an eye tracking system, Tobii T120 was furnished for capturing and recording their eye movements. All conversations and participants' behaviors were recorded by Tobii Observer in real time in the observation room, where the moderator stayed to monitor the experiment process and participants' task performance. Confederates were placed in another usability lab where the online video chatting tool was set up for communication. The lab experimental setting is shown in Figure 1.

In the usability lab, the webcam was located above a computer monitor and it could be adjusted for displaying optimal eye contact and upper body and face of a participant. The audio signals were exchanged via microphones and headsets to prevent noise and echo from interrupting conversation. Video and audio signals as well as gaze behaviors were recorded by Tobii studio during the entire conversation.

Tobii studio was programmed to use a web page (www. tokbox.com) as stimuli type. The website offers users a browser-based video chat environment and the browser would be opened up in full screen size at the start of recording. Once a participant got connected to a confederate, two small display windows (165h X 220w) would be opened in the browser side by side, showing the upper body and face of each of the 'dating partners' separately, as shown in figure 2. Areas of interest (AOIs) were defined within the stimuli to collect the data associated with fixation and gaze per AOI. AOI is used for quantifying gaze data at a higher level and can be integrated with direct gaze coordinates of the participants, based on the frequency, time, etc.

Upon arrival, participants were first asked to complete a consent process and instructed about the overall procedure of the study. They were then given a list of topics and the sequence of discussing the topics. Before performing the tasks, participants were given time to prepare and practice what they would be discussing on each topic. When participants were ready for the study, first they were asked to fill out short questionnaires on basic demographic information and online communication experience. Then the browser based online video communication between the confederate and the participant would be initiated automatically. The confederate played the role of a dating partner, and there were four confederates (two males and two females) who assisted the study. The confederates were blind to the deception manipulation and were instructed that they were going to have a conversation with another person who would be their 'blind date', and that their roles were to keep the conversation going smoothly. The confederates received the same list and sequence of topics as the participants did. In addition, the confederates were asked to interact with the participants by initiating questions related to the list of topics or using dynamic and immediate feedback such as 'uh huh' expressions and head nods, since the greater interactivity induces the higher participation of the participants in deception (Burgoon et al., 2001) .

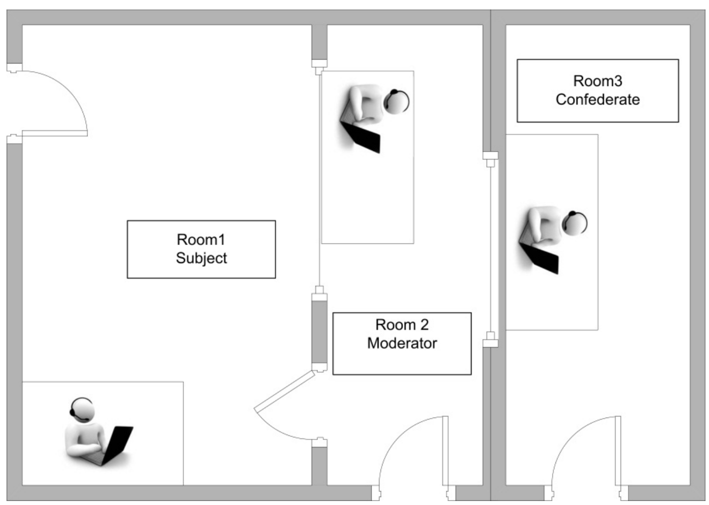

Figure1: Experimental Lab Setting

Participants engaged in discussion on four assigned topics one by one: personal attributes, family and friends, past experience, and life values. Among the four topics, participants were asked to deceive on two topics and to tell the truth on the remaining two. Both the sequence of topics and the condition for each topic were randomly assigned. Each topic has all truthful or all deceptive response. There was no time limit, and participants were asked to discuss each topic until they finished it and understood each other's responses. In terms of the forms of deception, the examples of common lies were provided and participants were told to use whatever forms of deception they wished to use, including outright lies, equivocations, exaggerations, evasion, omissions, and concealment. At the end, participants were asked to fill out a questionnaire about their task performance during the experiment.

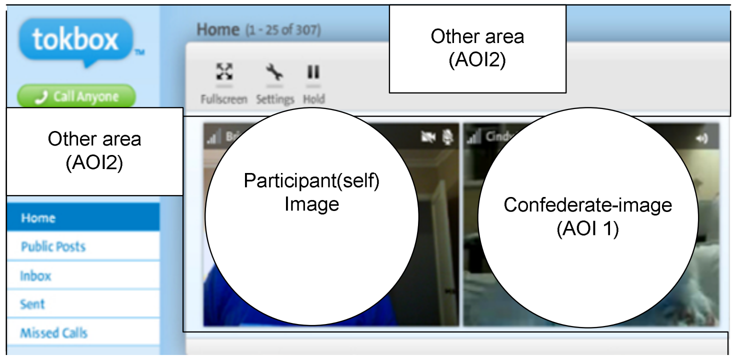

Figure 2: Video Chatting Window and Defined AOIs

In terms of manipulation check, a post-study questionnaire was employed to: 1) check whether the participants actually deceived or told truths on the assigned topics according to the experiment manipulation; 2) assess what forms of deception that the participants mostly used; and 3) allow the participants to rate their own behavior during the experiment. The first and the third questionnaires were asked on 5-point Likert scales, ranging from 1 (completely truthful) to 5 (completely deceptive), which was adopted from Vrij et al. (2001), and the second questionnaires was asked on multiple choices.

Operationalization of the Dependent Variables

The operationalization of the dependent variables is built on the notion of area of interest (AOI) in this study. It is common to include a video chat window with a communication partner (a confederate) on the screen in an online video chatting tool. In addition, previous studies of eye gazing behaviors in face-to-face deception assessed eye gazing behaviors from the communication partner's perspective. Thus, AOI1 was defined as a video chat window of a confederate in this study. Accordingly, gaze fixation is measured in terms of fixation duration on the above AOI 1, starting with fixation within the AOI1 and ending with fixation outside the AOI1. The fixation duration is measured in milliseconds for every time a participant looks within AOIs. The variable is measured for deception and true-telling conditions separately, and for each of the conditions, the average of the measurements was used.

In a similar vein, gaze aversion was defined as the fixation duration on AOI2 of screen areas other than the video chat window of the confederate (AOI1). For each of two conditions, gaze aversion was also measured as the average of the measurements for each condition (deception vs. truth-telling).

To measure two gaze behaviors more precisely, we further divided the timeframe of communication into three types: speaking, listening, and silent. Again, traditional studies of eye behavior in face-to-face deception communication only concern when an individual is talking, thus we filtered out those timeframes when participants were performing activities other than speaking in measuring the gaze behaviors. Further, to account for the variance in terms of the duration of communication in each condition, we normalized the raw gaze fixation values by the total duration of gaze fixation per a participant per a condition. Likewise, we normalized the raw gaze aversion values during speaking by the total duration of gaze aversion over all the three types of interactions.

ANALYSIS AND RESULTS

Repeated measures ANOVA (RMANOVA) was performed to test the effects of condition (deception vs. truth-telling) on gaze fixation and gaze aversion.

To collect and analyze the data accurately, we first defined segments for the timeframes that participants were speaking because eye behaviors displayed while a personal is speaking are expected to be different from those displayed while listening. In addition, previous deception studies of eye behaviors FtF communication were mostly conducted in monologue environment where the participant was talking. Thus, fixation duration and fixation count were collected for each AOI for the timeframe when the participants were speaking. The measure of fixation duration was normalized as a ratio for each participant since the raw values of such measures may vary greatly among participants. Thus, gaze fixation was divided by the total duration of fixation on each AOI and multiplied by 100. Descriptive statistics of dependent variables are reported in table 1.

Gaze Fixation	N	Mean	Std. Deviation
AOI 1[a]_D [b]	17	0.010	0.000
AOI 1_ T [b]	17	0.014	0.002
AOI 2[a]_D [b]	17	.0046	.0005
AOI 2_ T [b]	17	.0057	.0001

Table 1. Descriptive Statistics of Gaze Fixation

a: 1 (Confederate), 2(Other areas); b: D (Deception condition), T (Truth-telling condition)

To test the hypotheses, we first analyzed the effect of condition (deception vs. truth-telling) on gaze fixation and gaze aversion. The analysis yielded a significant effect of deception condition on gaze fixation and gaze aversion on AOI1 ($F(1, 16) = 105.6$, $p<.001$) and on AOI2 ($F(1, 16) = 59.86$, $p<.000$). Therefore, our hypotheses were supported. Table 2 displays the mean difference between deception and truth-telling conditions.

	Mean Difference	Std. Error	Sig.	95% Confidence Interval for Difference	
				Lower Bound	Upper Bound
AOI 1[a]_D [b] AOI 1_T [b]	-.005*	.000	.000	-.005	-.004
AOI 2[a]_D [b] AOI 2_T [b]	-.001*	.000	.000	-.001	-.001

Table 2. Pairwise Comparisons

a: 1 (Confederate), 2(Other areas); b: D (Deception condition), T (Truth-telling condition)

DISCUSSION

The objective of this study was to examine the effect of condition (deception vs. truth-telling) on gazing behaviors. The findings support both of our hypotheses. As we predicted, an individual fixes his or her gaze at a communication partner less during deception than during truth-telling. In addition, an individual averts his or her gaze more from a communication partner during deception than during truth-telling This results are consistent with the previous findings that an individual tends to avert her/his gaze while deceiving(G Doherty-Sneddon & Phelps, 2005; Vrij, 1996). Eye gaze behaviors hold many different aspects of information. According to the functional classification of nonverbal behavior proposed by Patterson(1982), gaze behaviors serve more than one function simultaneously. Thus, it could be necessarily subjective. However, deception is a complex cognitive activity as well as emotionally unstable state. In such an occasion, gaze aversion serves as a substantial cognitive load and the reduction in anxiety. The study has demonstrated that gaze fixation on certain AOI can serve as a reliable indicator of deception in online video chat.

The findings of this study have significant practical implications. Online video chat has been used to support personal communication as well as business communication (e.g., live meeting and online training). The effective cues discovered from this study can be applied to detecting deception in interpersonal chatting on social networking sites, in business communication (e.g. job interview and business collaboration), and in business-to-consumer communication. The study also can serve as an alternative method to polygraph test. Cyber security and credibility assessment have attracted a lot of attention from the government, research institutes, and industries in recent years. If deception studies offer measurable psychophysiological cues such as gaze behavior, pupil dilation, and blinking rate, they can be used to detect deception in real-time communication.

LIMITATION AND FUTURE RESEARCH

This study exposes some limitations in its experiment design, sampling, and factors control. First, this study carries some inherent limitation from a controlled lab setting and confirming levels of task completion. Although the experiment was designed to simulate a real-world scenario, participants may still perceive the task as a lab experiment and display some unnatural behavior. In addition, self-reported data was used to check whether the participants followed the sequence of conditions (deception and truth-telling) for the selected topics. Second, the deception scenario selected for this study did not require any serious risk that might lead to failure to produce a believable lie. This could affect participants' behaviors in deception condition. In high-stake deception contexts, deceivers tend to display more exaggerated behavioral changes due to a higher level of experienced anxiety and cognitive efforts. Third, the sample size was small. A larger sample would allow us to discover more effective cues. Fourth, there were some other factors that might influence participants' behaviors during experiments such as gender, multi-cultural issue, ethics, personality, social skills, and attitudes toward interaction (Riggio & Friedman, 1983). The study was designed to focus on two psychophysiological variables–gaze fixation and gaze aversion in real-time online video chat communication. For future research direction, it would be interesting to expand the scope of eye movement behavior to brain activities during deception. In addition, future study should increase the sample size. Further, to improve the accuracy of deception detection, the combination of visual with audio and text cues should be considered.

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