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Countermeasures and Eye Tracking Deception Detection

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Abstract

A new development in the field of deception detection is been the development of rapid, non-contact tools for automated detection. This research in progress paper describes a method for assessing the robustness of eye tracker-based deception detection to countermeasures employed by knowledgeable participants.

1. Introduction

Following the events of September 11, 2001, securing the US border has become a focal issue. As more people attempt to enter the country, manpower and current processes are proving insufficient to process the ever-increasing volume of travelers. In order to deal with these constraints, more efficient methods of processing potential entrants are being evaluated. One of the methods currently under development is an automated-screening kiosk. Users interact with the kiosk, and the kiosk integrates and analyzes data from various sensors to provide automated assistance in detecting deception [6]. An eye tracker is one of those sensors, and was recently shown to be effective in detecting deception using a Guilty Knowledge Test [7, 19].

One of the primary assumptions to this point in eye tracker-based deception detection research has been participants who are unaware of the nature of the eye tracking tests. In laboratory environments this assumption can be taken for granted. Unfortunately it will not always hold in a real-world environment. Participants' willingness to use the eye tracker could range from willing participation to belligerence. Additionally, participants may range from having no knowledge of the eye tracker to knowingly subverting the process. These differences could have a large impact on the ability to detect deception through eye behavior patterns. The same problems affect polygraph examinations [14]. While they may be able to reliably detect deception in willing participants, countermeasures can be employed to appear innocent [17].

Therefore, my research question for this study is the following:

- RQ1: How do individuals employing countermeasures differ from others in their eye movement patterns?

2. Eyes as Deception Cues

One of the most important issues in rapid credibility assessment is this: how can we reliably and unobtrusively detect deception? One of the tools currently under investigation for lie detection is the eye tracking camera [2]. Eye tracking cameras can be used for many different purposes in detecting deception because of the wealth of cues offered by the eye. The eye offers at least three different mechanisms that could potentially indicate deception: fixation points, blinks, and pupil dilation. These are important as they are likely related to the cognitive processes common to deception [22, 7, 8].

Eye gaze patterns are measured in various ways, one of which is fixation points. An analysis of these fixation points during a Guilty Knowledge Test was recently demonstrated to be an effective method of distinguishing deceptive participants from truthful ones [7]. The fixation patterns of deceptive participants were significantly different from those of innocent participants. Nonetheless, none of the participants were given information about what they eye tracker would be looking for. Knowledgeable participants may be able to modify their gaze patterns to appear innocent.

Two other eye-related cues of deception are blinks and pupil dilation. The blink rate was linked to cognitive effort, and blink latency (the time between the presentation of the stimulus and the first blink) was shown to be significantly different for the guilty knowledge than for other objects [15].

Pupil dilation has also been experimentally demonstrated to be effective at detecting deception [8, 5]. Similar to other psychophysiological cues of deception, pupil diameter is theorized to change based on the cognitive effort of the individual. Deceivers undergo additional cognitive processes compared to truth tellers because they must simultaneously think of the true and the false answer [16]. This additional cognitive load causes the pupil diameter of deceptive respondents to increase relative to truth tellers [8].

3. Deception Theory

All of these physiological cues of deception are based upon the underlying assumption that liars behave differently than truth-tellers. Deception theories have attributed the differing behavior to many potential causes. Zuckerman et al. [25] propose arousal and cognitive complexity as causal explanations for the increased pupil dilation and blinking associated with lying. Liars are in general more agitated and more cognitively taxed during the lying task. The different influences liars must confront while lying will lead to the leakage of cues while they attempt to deceive. Interpersonal deception theory [1] states that interpersonal communication is a complex task, and that the process of deception compounds the complexity.

For our purposes, deception can be defined as a message knowingly conveyed to lead the receiver to a false belief or conclusion [1, 9]. The complexity that comes with conveying the manipulated story causes an increased cognitive load on the deceiver [16]. Additionally, interpersonal deception creates the need for liars to monitor themselves to appear honest [4], and their targets to verify whether they are believed [1]. The emotional strain that occurs when liars experience *detection apprehension*, or the worry that they will be found out, contributes further to the effort differential between liars and truth-tellers [10]. This cognitive and emotional differential is the underlying principle behind the psychophysiological detection of deception [16, 24].

4. Countermeasures

The detection of deception relies on the assumption that not all behaviors can be controlled simultaneously [1]. The inadvertent behavior that allows deception detection, either computationally or manually, is called *leakage* [11].

The ability to reliably detect deception has been a problem significantly complicated by the use of countermeasures on the part of the deceivers [17, 18]. Countermeasures are purposeful techniques employed by guilty participants in order to appear innocent [14]. By simulating the effort necessary for deception during non-deceptive responses, participants were able to cloud the results of polygraph examinations. Two types of behavioral countermeasures are possible: physical and mental. Using physical processes such as biting the tongue or pressing one's toes against the floor, nearly 50% of guilty participants were able to successfully fool a polygraph examiner into believing they were

innocent [18]. Participants were also able to fool examiners by increasing their cognitive effort during irrelevant responses by counting backward by 7 from a number greater than 200 [17]. All of these countermeasures were employed by students with no more than 30 minutes of training. The ease with which the students were able to pass the polygraph examination draws attention to the need for validation of any psychophysiological measure of deception.

In order to understand the possibilities and limitations of deception detection technology, we must examine the possibility that knowledgeable, deceptive persons may attempt to exploit its weaknesses to appear truthful [14]. The polygraph, a very intrusive, time-consuming test for deception, has been subjected to numerous tests of its effectiveness in the face of participant countermeasures [12, 14, 13, 17, 18]. Understanding the effects of these countermeasures has assisted researchers in developing measures to mitigate their effectiveness [13]. If eye gaze behavior is to be used to detect deception, we must examine the possibility of countermeasures employed by subjects who do not wish to be detected.

- H1: Countermeasures reduce deception detection.
- H1a: Countermeasures will reduce the pupil dilation change on a relevant stimulus.
- H1b: Countermeasures will reduce the blink rate change on a relevant stimulus.
- H1c: Countermeasures will reduce time spent looking at the modified portion of a relevant stimulus.

5. Research Method

To study the proposed research model, two pilot studies and a laboratory experiment will be conducted. The guilty vs. not guilty condition will be manipulated via a simulated mock crime. Eye behavior will be measured via an eye tracker.

5.1. Experimental Design and Procedure

I propose to study the eye gaze patterns of naïve vs. deceptive participants using an experiment. The experiment will involve one control group and three treatment groups. The control group would pass through a screening-like kiosk interaction wherein their eye gaze patterns will be tracked as they view several images. The first experimental condition will be a treatment where participants complete a task similar to the bomb-making experiment conducted by Derrick, Moffit, and Nunamaker [7]. The participants

will then be shown the same images as the control group. One of the images will be related to the bomb they constructed before passing through the kiosk interaction. Their eye gaze behavior will be tracked using the eye tracker.

Two more treatment conditions will be composed of individuals who will be told about the eye tracker and given basic information about the Guilty Knowledge Test. They will also be trained in countermeasures proven to be successful in defeating a polygraph examination. These participants will then be instructed to subvert the eye tracking process and appear innocent. They will be divided into two sub-groups: guilty and innocent. Innocent participants will have nothing to conceal as they interact with the eye tracker. Guilty participants will participate in the bomb-making exercise. The innocent participants will provide a useful second control group to determine if knowledge of countermeasures and procedures can make even innocent participants appear guilty. A breakdown of the experimental conditions is shown in Table 1. All participants will be offered a \$10 reward for an innocent judgment. This should serve as a motivation, and raise the stakes for the deception [20].

Table 1 - Experimental conditions

	Bomb	No Bomb
No instructions to deceive	I	II
Instructed to deceive	III	IV

The calibration of the eye tracker will be conducted using an auto-calibration procedure to reduce the risk of hypothesis guessing among participants in conditions I and II. Hypothesis guessing occurs when participants in an experiment guess what experimenters are attempting to study [3]. Auto-calibration is the process of establishing reference points for participants' gaze without explicitly asking them to calibrate the machine.

Because countermeasures have never been studied in the context of an eye tracker, pilot testing will be conducted to provide preliminary results and provide a basis for prediction in the final experiment. Additionally, the countermeasures initially used will be the same as those employed in previous polygraph experiments. Pilot tests will allow an initial assessment of the countermeasures employed, and allow the development of new countermeasures if necessary. The specific patterns of behavior present in participants employing countermeasures will provide exploratory insight into the eye behavior and indicate theories which may be useful in predicting future results. In addition, the manipulation for

conditions III and IV will need to be tested to ensure that instructions are clear.

5.2. Countermeasures Training

The participants in the countermeasures treatment groups will receive training on the countermeasures reported to be successful by [17] and [18]. Specifically, they will be taught to bite their tongues (not enough to cause serious pain), press their toes against the floor, and count backward by seven. They will be instructed to employ the mental countermeasures throughout the interaction, as this has been demonstrated to be more effective than item-specific mental countermeasures [14]. In this way, they will be able to manipulate their physiological response to reduce the differences between relevant and irrelevant stimuli.

Participants will also be trained on the workings of the Guilty Knowledge Test [19]. They will be told that the GKT works by differentiating between irrelevant and relevant stimuli and that five irrelevant stimuli will be presented. Participants will also be told about the eye gaze portion, and that they should avoid looking at the relevant section for too long. They will also be instructed not to completely avoid looking at the relevant section, as this would still allow the differentiation of deceivers.

Finally, participants will be given motivational instructions to increase their confidence in successfully employing their countermeasures and deceiving the eye tracker. They will be told that, despite the accuracy of deception detection, intelligent people are able to defeat these machines with high levels of success [23].

6. Expected Results

Following the experiment, three different sets of data will first be analyzed individually, and then combined to determine the effectiveness of countermeasures against eye tracker-based deception detection.

6.1. Blinks

The first metric used to compare guilty vs. innocent participants in this experiment was the blink rate. After the visual stimulus is presented, the blink rate was expected to change for the relevant stimulus versus the irrelevant stimuli. The time following the display of visual stimulus will be divided into segments of 200 ms, and blink rate in each segment will be compared among groups. It is expected that early after the relevant stimulus is presented, the

blink rate will be lower for guilty groups, but guilty groups will have a higher peak blink rate after approximately 4 seconds. The comparison between groups will be done using ANOVA. It is anticipated that the guilty group employing countermeasures will appear more like the innocent control group than the guilty control group. The innocent countermeasures participants will likely appear guiltier than the innocent control group.

6.2. Pupil dilation

Pupil dilation and pupillary response will be compared among the groups using ANOVA. The primary measure will be the difference in pupil dilation immediately after the relevant stimulus is presented versus the average for the irrelevant stimuli. It is anticipated that guilty participants will have a larger change in pupil dilation than innocent participants. However, guilty participants who employ countermeasures should be able to influence their pupil dilation during irrelevant stimuli, thus reducing the change for the relevant stimulus. In this way, they will be able to appear innocent. The innocent participants employing countermeasures will probably experience no change, and thus appear innocent.

6.3. Gaze Behavior

Once again, the difference between guilty and innocent participants will be analyzed using ANOVA. The measurement in this segment will be done by identifying a target area of the relevant image. Here, the differentiation will have to be done between groups. Whereas blink rate and pupil dilation can be measured as a comparison of relevant versus irrelevant stimuli, the gaze behavior pattern is by nature a between-groups comparison. By displaying a modified image of the bomb participants built, the guilty participants' gaze will be drawn significantly more toward the modified region of the image. One-way ANOVA will be used to compare the time spent looking at the modified region for guilty and innocent participants. It is anticipated that subject with a knowledge of the eye tracker's workings will be able to appear innocent by reducing the amount of time looking at the modified region. Innocent participants employing countermeasures are not expected to be significantly different from those without countermeasures training.

7. Discussion

As the use of eye trackers for deception detection becomes more common, it is important that researchers and practitioners understand the limitations. These results should indicate that simple countermeasures such as pressing ones toes against the floor or counting backward by seven was sufficient to significantly reduce the deception differentiation capability of an eye tracker. One area for future research is the employment of counter-countermeasures similar to those used in polygraph examinations [18]. For example, a force plate placed underneath the participants during the eye tracker interaction may be sufficient to detect use employment of physical countermeasures such as pressing toes against the floor. Additionally, further analysis of reactions immediately after a relevant stimulus is displayed may prove to be effective regardless of countermeasures due to the orienting reflex [21]. The subconscious orientation toward a stimulus immediately after it is presented may allow researchers to detect deception before countermeasures can be consciously applied.

The addition of these simple techniques highlights the need for further research integrating more cues of deception into a rapid, non-contact screening device [6]. The integration of linguistic, vocalic, and rigidity analyses will increase the difficulty of overcoming deception detection by adding more facets of behavior that must be manipulated or controlled. This study is limited to the use of eye-based deception detection. Future research could examine the use of multiple sensors to increase the difficulty of successfully fooling the deception detection system.

8. Conclusion

The purpose of this research is to examine the limitations of eye tracker-based deception detection when faced with mental and physical countermeasures. The experiment to be conducted demonstrates that countermeasures allow people to effectively defeat the eye tracking deception detection process. Further research is necessary to integrate additional non-contact deception detection mechanisms in order to increase the robustness of these tests.

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