OCULAR-MOTOR METHODS FOR DETECTING DECEPTION: EFFECTS OF PRACTICE FEEDBACK AND BLOCKING

by

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ABSTRACT

The ocular-motor deception test (ODT) detects deception from patterns of reading behavior and pupil enlargement. This mock crime study manipulated guilt, blocking, practice with or without feedback, and interevent intervals to assess their effects on ocular-motor and behavioral measures of deception.

To test whether longer intervals disattenuate pupil responses, the present study also manipulated the time between the answer and the onset of the following statement.

Half of the participants were guilty of stealing $20 from a secretary's wallet, and the other 80 participants were innocent. Guilt was crossed with presentation format and feedback. Half of the participants received feedback in their ODT practice session and half did not. Half of the participants received statements of the same type presented in immediate succession (blocked), and half the participants received a distributed presentation. The interval between the participant's answer and the presentation of the next statement was manipulated within-subjects. There were two repetitions of the 48 True/False statements at each of three interevent intervals (500 ms, 1500 ms, and 3000 ms).

Guilty participants showed the largest pupil diameter while reading the cash statements. A discriminant functions of four ocular-motor measures correctly classified 86.3% of participants in the distributed condition, and another function of two measures correctly classified 83.3% of participants in the blocked condition.

All participants completed Behavioral Inhibition/Behavioral Activation Scales (BIS/BAS) and the Emotionality, Activity, Sociability and Impulsivity scale (EASI) prior to learning their group assignment, and all participants completed a working memory test and post-ODT questionnaire after the ODT. None of the individual difference measures moderated effects of guilt on ocular-motor measures. There were main effects of guilt on realism, concern about the cash items, and general worry about passing the ODT.

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INTRODUCTION

Various methods for detecting deception have been reported in the scientific literature. Prior research has demonstrated that there are several cues to deceptive behavior (Vrij, 2004). Indicators of deception for polygraph tests show increases in blood pressure and skin conductivity, and decrease in respiration while the participant answers a series of questions. Functional magnetic resonance imaging (fMRI) (Ganis, Kosslyn, Stose, Thompson, & Yurgelun-Todd, 2003) and event-related potentials (ERPs) (Rosenfeld & Greely, 2012) have also been used to measure changes in neural activity in the brain associated with deception. Other methods for deception detection include voice analyses (Patil, Nayak, & Saxena, 2013), nonverbal behavior (deTurck, 1991; Ekman, 1999; Vrij, 2004), thermal imaging of the face (Pavlidis & Levine, 2002), and momentary facial expressions (Ekman & Friesen, 1969). Although the polygraph is probably the best available technology for pre-employment screening, periodic testing of existing employees, and criminal investigation, it suffers from a number of serious problems (National Research Council, 2003). Among the concerns expressed in the NRC report were its inadequate construct validity, susceptibility to countermeasures, and its reliance on uncontrolled social interaction with a polygraph examiner.

Recently, Cook and colleagues (2012) introduced a computerized deception detection technique that uses reading and pupil measures called the ocular-motor deception test (ODT). Research has shown that changes in pupil diameter (PD) are

reliable and valid indicators of cognitive effort and emotional arousal (Loewenfeld, 1999), and most theories of deception detection posit that deception is cognitively more demanding than telling the truth (Johnson, Barnhardt, & Zhu, 2005; Kircher, 1981; Steller, 1989; Vrij, Fisher, Mann, & Leal, 2006). Lying can be more cognitively demanding for several reasons. First, creating a convincing lie itself may be cognitively demanding. Liars need to fabricate a story and keep track of it in order to maintain consistency. Second, deception is cognitively challenging because it requires two processes: (a) participants must inhibit the truthful response, and (b) they must formulate a deceptive response. Third, in the context of a polygraph examination, Kircher (1981) suggested that deceptive individuals attempt to monitor their internal physiological responses to test items. Monitoring internal states is a cognitive process that demands resources and produces autonomic and somatic changes that are characteristic of deceptive individuals.

Pupil Diameter

Consistent with the view that changes in pupil diameter (PD) are reliable and valid indicators of cognitive effort and emotional arousal (Loewenfeld, 1999), research on PD and lie detection has found that deception is associated with greater increases in pupil size than telling the truth (Cook et al., 2012; Webb, Honts, Kircher, Bernhardt, & Cook, 2009). Dionisio, Granholm, Hillix, and Perrine (2001) measured PD while participants made truthful and deceptive responses, and the largest increase in PD was found when participants were deceptive. Bradley and Janisse (1979) and Janisse and Bradley (1980) measured PD as participants answered truthfully or deceptively to questions regarding a numbered card they had chosen. PD discriminated between the

truthful and deceptive groups. Subsequent mock crime experiments revealed that PD discriminated between guilty and innocent participants who were given concealed information tests (Bradley & Janisse, 1981; Lubow & Fein, 1996) or probable-lie tests (Webb et al., 2009).

Although the changes in pupil size observed by Cook et al. (2012) were consistent with prior deception detection research, the reading behaviors observed by Cook et al. (2012) were not consistent with basic research on reading. In the psychology of reading literature, increases in PD, frequent fixations, and long reading times are viewed as indications that participants had difficulty processing those items (Rayner, 1998; Rayner, Chace, Slattery, & Ashby, 2006). If deception is more difficult than being truthful, then it should be associated with increased PD and longer reading times. However, in the Cook et al. experiments, within-subject contrasts revealed that deception was characterized by fewer fixations and shorter reading and rereading times than being truthful. The authors concluded that guilty participants, to avoid detection, made a concerted effort to spend as little time on incriminating items as possible. This finding is consistent with the view that participants can exert some conscious control over their reading behaviors to implement specific reading strategies (Hyona & Nurminen, 2006).

Blocking

The rapid presentation of test items that vary in content may interfere with the development of large diagnostic pupil responses when the person is deceptive. In a blocked design, all activity that takes place during a series of question of the same type could contribute to a single protracted physiological response, whereas the distributed condition may preclude the development of a sustained diagnostic response because each

item is followed by another item of a different type. Several fMRI studies have examined the differences between a blocked and what is called 'transient trial' related activity (e.g., Kato et al., 1998; Otten et al., 2002). Studies have found that the benefit of a blocked design is that activations could be used to study the questions separately as well as consider the sustained activity in the blocked set (Visscher et al., 2003).

Blocking might allow for the development of an emotional response. The three most common types of emotion associated with deception are fear, excitement ('duping delight'), and guilt (Ekman, 1989, 1992). Liars might be afraid of getting caught, they might become excited at having the opportunity of fooling someone, or they might feel guilty (Ekman, 1992). Blocking items might provide opportunities for deceptive participants to develop stronger emotions in response to incriminating statements that are interrupted with the presentation of nonincriminating statements in the distributed presentation format. The development of stronger emotional responses might lead to greater discrimination between guilty and innocent participants in pupil responses. Changes in item content every 3 or 4 seconds also may counteract attempts by deceptive people to implement reading strategies to defeat the test, and use of those strategies may be diagnostic (Hacker et al., 2014). On the other hand, since blocks rather than items would serve as the unit of analysis, the number of 'items' on the ODT would be reduced and that could adversely affect the reliability and validity of pupil measures. The present study tested if the benefits of blocking outweigh the cost of reducing the number of items.

Practice

Adams and Goetz (1973) showed that the accuracy of the participants' responses was positively related to the amount of feedback. Although their study had to do with

motor skills learning, according to Welford (1968), motor skills learning is not intrinsically different from cognitive skills.

Although feedback might encourage participants to minimize response errors on the ODT, the error rates in student samples already are less than 10%. Feedback might not reduce participants' response errors, but it could result in anchoring. Anchoring is the tendency to use initial information to establish a standard against which subsequent performance is evaluated. Response time and accuracy feedback during a practice session should serve to establish high expectations about subsequent performance on the ODT. If anchoring causes participants, especially innocent participants, to respond quickly and consistently, it should reduce variance between participants and maybe within item types. By reducing error variance, the signal to noise ratio should improve, and it might be possible to reduce test length and improve accuracy.

Interevent Intervals

In polygraph examinations, the examiner presents a question every 22-30 seconds. Webb et al. (2009) found that pupil responses during a polygraph examination can last 10 or 12 seconds. During the ODT, a computer presents the next test statement 500 ms following the participant's answer. In light of Webb et al. (2009), there is a possibility the rapid presentation of items interrupts a psychophysiological process that attenuates the participant's reactions to test statements. The current brief interevent interval may not allow sufficient time for the pupil response to reach its maximum and recover. The present study assessed the effects on physiological responses of longer interevent intervals.

A longer postanswer period, during which the participant recovers from the prior

event and prepares for the next, also might facilitate efforts to develop a diagnostic measure of eye blink rate. Prior research indicates that deception is associated with fewer eye blinks followed by increase in blink rate when the deception is complete (Leal & Vrij, 2008; Marchak, 2013). Cook et al. (2012) observed a similar pattern for the ODT, but the effect sizes were smaller than those reported by Leal and Vrij (2008). Lengthening the interevent interval could improve the reliability and usefulness of postanswer blink rates.

Self-Reports

Behavioral Inhibition/Behavioral Activation Scale (BIS/BAS)

To the extent that liars experience anxiety or fear of getting caught, behaviors indicative of guilt and fear may be shown more often by deceptive rather than truthful individuals. A secondary goal of the study was to explore the relationship between the behavioral inhibition systems (BIS) and behavior activation (BAS) and detectability on the ODT and to gain additional insight into Patnaik's (2013) results. The BAS is believed to mediate appetitive motives, where the goal is to move towards something that is desired. The BIS is said to mediate aversive motives, where the goal is to move away from something unpleasant (Carver & White, 1994). People with high BIS sensitivity should be especially responsive to punishment cues and should experience greater anxiety in situations with cues of impending punishment compared to people with lower BIS sensitivity.

Carver and White (1994) developed the BIS/BAS scale to measure individual differences in the sensitivity of the presumed underlying neurophysiological regulatory systems. The BIS/BAS questionnaire has one BIS scale and three BAS scales: BAS

Drive, BAS Fun Seeking, and BAS Reward Responsiveness. Typically, the BAS scales are not combined because they focus on different aspects of incentive sensitivity. The factor structure of the Carver and White's scale is a subject of debate. Pollina and Barretta (2014) modified the scale from a 4-point scale to a 5-point scale and collapsed the BAS results from the three individual BAS measures. Heubeck, Wilkinson, and Cologon (1998) found that BAS Reward Responsiveness correlates with both BIS and BAS. These findings suggest that the BIS/BAS subscales are not as orthogonal as the theory predicts.

Patnaik (2013) conducted a mock crime experiment and correlated scores on the BAS/BIS scales with discriminant scores based on ocular-motor measures. As predicted, there was a significant positive correlation between BIS scores and discriminant scores for guilty participants – more behaviorally inhibited participants were more easily identified as deceptive. Although Patnaik (2013) did not find the expected relationship between BAS and discriminant scores for innocent participants, the discriminant scores for guilty participants correlated positively and almost significantly with reward responsiveness, $r(46) = .318$, $p < .08$. To the extent that a strong BAS brings a person closer to punishment, the threat of punishment increases anxiety (Fowles, 1987). Since all the participants were motivated to pass the test with a monetary reward, guilty participants who were highly motivated to earn the reward may have been more anxious about failing the test and losing the bonus. If that were true, then the fear of failure could affect ocular-motor measures of deception.

The present experiment tested whether guilty participants with high BIS scores show greater diagnostic changes in PD and reading measures because they are more

concerned that their deception will be detected than guilty participants with low BIS scores. To clarify the relationships between BIS/BAS scales and ocular-motor measures, the present study re-examined the relationships between the BIS/BAS scales and discriminant scores with a larger and more diverse sample than in Patnaik (2013).

Emotionality, Activity, Sociability and Impulsivity (EASI) Scale

The Emotionality, Activity, Sociability and Impulsivity scale was developed by Buss and Plomin (1975) to measure inherited temperaments. Emotionality refers to the individual's intensity of reaction to a given set of circumstances. Activity is the total amount of energy expended by a person. Sociability is characterized by a desire to be with other people. Impulsivity is the inclination to respond to various impulses and urges quickly as opposed to constraining those responses.

The present study tested the hypothesis that PD responses to questions about the mock crime will be greater for more emotional than less emotional guilty participants. The present study also tested whether the effect of emotionality on PD responses is more apparent in the blocking than the distributed portion of the ODT. A quality of behavior that many theorists have related conceptually to BIS and BAS is impulsivity (Gray et al., 1983; Newman, 1987). However, they disagree as to what the relationship is. According to Fowles (1987), BIS/BAS theory predicts a strong positive affect with impulsivity, where those who are high in impulsivity are especially sensitive to rewards (Zuckerman, 1994). On the other hand, some authors say that impulsivity is a multidimensional construct and can correlate with either scale (Moeller, Barratt, Dougherty, Schmitz, & Swann, 2001). Since impulsivity is the tendency to respond quickly without considering the consequences, it will be interesting to test whether impulsivity correlates with

response time and errors as well.

Working Memory

If the ODT is emotion-based, it should correlate with emotionality. However, if the ODT primarily is cognition-based, then it should correlate with working memory (WM). The present study included the *n*-back test of WM. The *n*-back test is considered cognitively demanding because participants must continuously update an ever-changing rehearsal set while providing regular responses to displayed items (Kane, Conway, Miura, & Colflesh, 2007). In this test, participants are presented with a series of stimuli and required to decide whether the current stimulus is the same as the stimulus presented *n* trials back. In the present experiment, the stimuli were letters, and *n* was 2 and 3. Participants responded to each letter by pressing one key if the letter was the same letter *n* back and another key if the letter was different.

N-back tasks commonly are used to investigate WM processes. The amount of cognitive load is adjustable to meet the requirements of the experiment. Having a longer *n*-back interval (2 or 3) produces stronger cognitive load effects (Owen, McMillan, Laird, & Bullmore, 2005). If cognitive load is being manipulated with deception, then performance on the *n*-back task should correlate negatively with response time, errors, and pupil enlargement.

Post-ODT Questionnaire

A post-ODT self-report questionnaire was given to the participants to assess their subjective experiences during the ODT. The questions in this self-report pertained to the topics of how realistic the mock crime paradigm was, whether the participant was able to

concentrate while taking the ODT, how important they thought that speed and accuracy were, if they were motivated to pass the test, anxiety while answering questions about the cash items and card items, and how worried they were about failing the ODT.

Present Study

In all prior versions of the ODT, no two statements of the same type were presented in succession. The present study compared the standard, distributed presentation of item types with blocked presentations of items of the same statement type. As compared to the distributed presentation format, I expected the blocked presentation to produce greater differences in PD between statement types in deceptive individuals. Blocked presentations of test items of the same type also may encourage strategic processing of the text that result in diagnostic patterns of eye fixations on the text.

All participants were told that the ODT is based on the idea that deceptive individuals take longer to respond and make more mistakes on the test than truthful people, and it is, therefore, in their best interest to answer as quickly and accurately as possible. All participants also were given a set of practice items to become familiar with the manner in which items are presented and the procedures for responding with button presses. Participants in the practice-with-feedback condition were given intermittent feedback about the speed and accuracy of their answers during the practice session. In addition, if those participants exceeded a time limit, they were informed that they took too long, they were prevented from answering that item, and it was counted as an incorrect response. The practice with feedback condition was designed to stress the importance of responding quickly and accurately.

Prior ODTs presented the next test statement 500 ms after the participant answered

a statement. The present study assessed the effects of longer postanswer intervals on pupil and eye blink responses. I expected that longer intervals would produce more diagnostic measures of pupil and blink responses.

In contrast to prior mock crime studies of the ODT, the present study recruited participants from the general community rather than the university. A community sample should be more heterogeneous with respect to WM capacity than a sample of college students, and this may increase the chances of observing a relationship between WM and ODT outcomes. A community sample also may better represent a more general target population than a sample that consists of college students.

Research Questions and Aims

In summary, the present study attempted to answer the following questions:

1. Are ocular-motor measures more diagnostic of deception for blocked or distributed test statements?
2. Does performance feedback during the pretest practice session improve the accuracy of ODT outcomes?
3. Are changes in pupil size and eye blink rates more diagnostic of deception for longer postanswer periods?
4. Are BIS scores on the BIS/BAS scales more positively correlated with ocular-motor measures from guilty than from innocent participants (Group X BIS interaction), and are there main or interaction effects of BAS scales on ocular-motor measures for guilty and innocent participants?
5. Do ocular-motor measures of deception correlate positively with emotionality as measured by the EASI?

6. Do ocular-motor measures of deception correlate negatively with performance on a WM task?

7. Do ocular-motor measures of deception correlate positively with self-reported anxiety about the test outcome?

METHODS

Design and Analysis

The design was a 2 x 2 x 2 x (3 x 3 x 2) mixed design with three between-group factors and three within-subject factors. The between-group factors were guilt with two levels (guilty or innocent), feedback (practice with or without performance feedback), and presentation format (distributed or blocked). Twenty participants were randomly assigned to each treatment combination of guilt, feedback, and presentation format (N=160). A power analysis indicated that 160 participants was sufficient to detect large effects on outcome measures with a probability of at least .80. The three within-subject factors were statement type (neutral, cash, credit card), interevent interval (500 ms, 1500 ms, and 3000 ms), and repetition (2 repetitions of the items at each of the three interevent intervals). There were 16 neutral, 16 cash, and 16 credit card statements. The correct answer was True for 8 of the 16 statements of each type. Correct T/F answers were crossed with the presence/absence of negation ("not", "no", or "never").

In the blocked condition, four items of the same type (e.g., neutral) were presented in succession, followed by four items of a different type (e.g., cash). Before each blocked set of four items, a passage that informed the participants of the issue covered in the next set of items appeared on the computer screen for 3500 ms. For each participant, this process was repeated four times for each statement type in each of six sessions (two sessions at each of three interevent intervals). In the distributed condition, no two items of the same type appeared in succession. Participants were given a short,

30-60 second rest period between sets of test items. Time also was included as a within-subjects variable for the PD analyses. There were 40 levels for the time variable (10 Hz samples x 4 seconds).

Participants

Recruitment ads were posted on KSL, Craigslist, and City Weekly online and print that advertised an opportunity to earn $30 and a possible bonus of $30 (for a total of $60) for participation in a psychological experiment. Participants who spoke fluent English, were over the age of 18, with no eye (vision correction was okay), heart, or mental health issues, were scheduled for a session. Two hundred and eighty-five participants were recruited from the general community but only 178 arrived to participate in the study. Of these 178 participants, 5 chose not to participate after learning their experimental condition, 3 did not follow instructions, and 10 had poor or incomplete data. This resulted in a sample size of 160 participants. The average age of the participants was 33.6 years (*SD* = 12.99). The sample sizes for the groups into which participants were randomly assigned to are shown in Tables 1 and 2. Demographic information obtained from participants is presented in Table 3.

Apparatus

A SensoMotoric Instruments (SMI) RED-m remote eye tracker affixed to a 19-inch Dell flat screen monitor recorded eye movements and pupil diameter at 60 Hz. Viewing was binocular, and although the eye tracker allowed for free head movement, a chin rest was used to keep the participant's head still. Eyelab 3.48 (Kircher, Webb, & Cook, 2011) presented stimuli to the participant, and collected, edited, and analyzed the

ocular-motor data. Eyelab communicated with the SMI-RED-m eye tracker software via functions in SMI's software development kit (SDK). The 60 Hz PD data were imported into CPSLAB 11 (Scientific Assessment Technologies, Inc, Salt Lake City, UT), a general-purpose computer program for psychophysiological research. Stimuli were presented to the participant on the computer monitor positioned 65 centimeters from the participant's eyes. A floor lamp provided 5.57 lumens of light reflected off the ceiling measured at eye level facing the computer monitor.

The EASI scale assesses baseline temperament and included 20 items in four categories; Emotionality, Activity, Sociability, Impulsivity. The instrument is widely used and has good reliability and good validity (Buss & Plomin, 1975; Buss, Plomin, & Willerman, 1973).

The Post-ODT questionnaire was used to assess the participant's subjective experience during the ODT. Sixteen of the questions were presented on a Likert scale, two questions were multiple choice, and one question was open-ended.

Presentation Format

For the blocked presentation format, the computer presented four items of the same type. Additional analyses were conducted where the four statements in a block were treated as a single unit. As a result, for the area under the evoked pupil response waveform (PD Area), the standardized diameter of the pupil when the participant answered the item (PD Level), and blink rates, the first item of the block was coded. PD Area, PD Level, and Blink Rate were analyzed from 0 to 12,000 ms.

Practice and Feedback

Before the ODT, participants in the no-feedback condition answered 12 practice items twice in different orders. The participant was given a short break between repetitions of the practice items. Participants in the feedback condition answered 12 practice statements twice in different orders and were given feedback about their accuracy and response times after each repetition. If participants took too long to answer True/False, a "Time Out!" screen would appear, and the question was counted as an incorrect answer. The practice items included statements about crimes that were unrelated to the issues covered on the ODT.

Ocular-motor Deception Test (ODT)

The ODT consisted of 48 test statements, and these same 48 statements were presented six times using either the distributed or blocked presentation format. The computer presented statements one at a time in the center of the screen. A 'T/F' appeared to the right of the statement to remind participants of their answer choices. Participants answered by pressing green ('true') or red ('false') handheld push buttons. Instructions and test items appeared in black font on a gray background.

N-back

Trials were presented in blocks of 30 and consisted of one centered letter per screen, which appeared for 500 ms and then disappeared. Participants were instructed to respond to each trial by pressing a key marked 'yes' or a key marked 'no' depending on whether the current letter was identical to that seen *n* frames earlier. The next letter was presented 2000 ms after the disappearance of the previous letter regardless of whether the

participant responded or not.

The 2-back task occurred first for all participants and consisted of three blocks. Before beginning, the participant viewed a series of 12 instructional slides that were accompanied by an audio recording that explained the slides. After the three 2-back blocks, instructions for the 3-back slides were presented followed by three 3-back tasks. The entire *n* back task, including instructions and three blocks of the 2- and 3-back, lasted 14:40 min. Instructions and test items appeared in black font on a white background.

Procedures

Participants called in response to ads placed in the community. To see if they qualified for the study, a phone screen (Appendix A) gathered information on the participant. If the participant qualified for the study, they were scheduled for an appointment.

For their appointment, participants reported alone to a room in a building on campus. Instructions in an envelope addressed to the participant were taped to the door and instructed the participant to enter the room, read and sign the consent form, and complete the BIS/BAS scales (Appendix B), and EASI questionnaire (Appendix C). The participant then listened over headphones to a recording that gave the instructions for the study. A hard copy of the recorded instructions was included as well. A phone number was provided for participants to call if they did not wish to participate.

Half of the participants were in the guilty condition. Guilty participants were instructed to go to a secretary's office on another floor of the building and ask the secretary where Dr. Mitchell's office was located. The secretary informed the participant that there was no Dr. Mitchell in the building, and the participant left the office. The

participant waited inconspicuously for the secretary to leave her office unattended, entered her office, found her purse, removed $20 from a wallet in the purse, and concealed the money on their person. Participants were told to prepare an alibi in case they were caught and not to leave fingerprints. They were informed that they had no more than 20 min to commit the crime and report to the experimenter.

Half the participants were in the innocent condition. They were told that some participants had to steal money from a secretary or steal credit card information from a professor's office, but that they are innocent participants and should not steal anything. Innocent participants were instructed to wait approximately 20 min before reporting to the experimenter for the ODT.

All participants also were informed that there was another crime in which some participants had to download credit card information from a professor's computer onto a USB flash drive, but in actuality, no one committed that crime.

Participants reported to the experimenter after committing their crime or after an appropriate waiting period. The participants sat at a computer, calibrated to the SMI eye tracker, and were given the ODT (Appendix E).

The *n* back tests were given after the completion of the ODT test. After the *n* back tasks and before the participant was informed of the decision, the participants completed another questionnaire designed to assess their subjective experiences during the ODT (Appendix D). Participants were informed of the decision, paid, and debriefed.

Behavioral Outcome Measures

Response Time (RT)

RT was the within-subject standardized time from the appearance of the item on the screen to a button press response from the participant. For each participant, the 48 test items X 6 repetitions = 288 raw RT measurements were transformed to standard scores. The transformation removed the person mean from the RT and established a common, unit variance among participants.

Proportion Wrong

Proportion wrong for a particular item type (neutral, cash, card) was the number of incorrect responses divided by the number of items (16 X 6 = 96).

Ocular-motor Outcome Measures

An area of interest (AOI) was defined for each T/F test item. The AOI began with the first character of the item and ended at the period at the end of the statement. Vertically, the AOI occupied the middle third of the computer monitor. Horizontally, the AOI began five spaces to the right of the left edge of the screen, and the statement appeared in the middle of the AOI. Ocular-motor reading measures were computed for the fixations in each AOI. Fixations were determined from the data files produced by the SMI eye tracker by identifying a sequence of samples in which the eye showed little movement for at least 100 ms.

Number of Fixations

Number of fixations was the number of fixations detected in the AOI.

First Pass Duration

First pass duration was the sum of all fixation durations in the AOI before the eye fixated outside the AOI.

Reread Duration

Reread duration was the sum of all fixation durations that followed leftward eye movements in the AOI. This measure assessed rereading done by the participant whether or not the eye fixated outside the AOI.

PD Waveform

PD Waveform was the pupil response curve from response onset to the point at which the response returned to the initial level or to the end of the 4-second sampling interval, whichever occurred first in mm. PD Waveform was analyzed by a measure of deviations from the initial level, and as raw change.

Area Under the Pupil Response Curve

PD Area under the curve was the area under the response curve from response onset to the point at which the response returned to the initial level or to the end of the 4-second sampling interval, whichever occurred first in mm. Response onset was defined at the low point in the response curve from which peak amplitude was measured.

Level at Response Onset

The PD signal was standardized within repetitions of ODT test items. Typically, participants completed a set of 48 test items in about 4 minutes (240 seconds). With 4 minutes of PD data, standard scores would be computed using the mean and standard

deviation of the 240 X 60 Hz = 14,400 data samples. PD level was the mean of standard scores that began 1 second prior to the moment the participant pressed a key to respond to the statement and ended 1 second after the response. This interval was extended for longer interevent intervals.

Item Blink Rate and Next Item Blink Rate

Blink rate was the number of blinks per second. Blink rate was computed for each item (item blink rate) with an extraction interval 3000 ms before the response and for the item that followed (next item blink rate) with an extraction interval 3000 ms after the response. A decrease in item blink rate was considered an indicator of cognitive load, whereas an increase in next item blink rate was viewed as a measure of relief (Stern & Skelly, 1984).

Table 1
Sample sizes for cells of the distributed presentation

	No Feedback	Feedback
Innocent	20	20
Guilty	20	20

Table 2
Sample sizes for cells of the blocked presentation

	No Feedback	Feedback
Innocent	20	20
Guilty	20	20

Table 3
Frequencies and percentages for categorical demographic questions

Variable	Category	%
Gender	Male	52.5
	Female	47.5
Marital Status	Single	66.9
	Married	19.4
	Divorced	11.9
	Separated	1.3
	Widowed	0.6
Ethnicity	Caucasian	77.5
	Hispanic	9.4
	Asian	4.4
	African American	3.8
	Mixed	3.8
	South Pacific Islander	0.6
	Native American	0.6
Education	Some high school	0.6
	High school diploma	11.3
	Associates	10.6
	Some college	40
	Bachelors	23.1
	Some graduate school	3.8
	Graduate degree	1.3
Learned about the Study	Craigslist	48.1
	KSL	28.8
	City Weekly online	6.9
	City Weekly print	6.9
	Other	9.4
Handedness	Right	87.5
	Left	9.4
	Ambidextrous	3.1
Primary Language English	Yes	95.0
	No	5.0
Vision Correction	None	60
	Glasses/Contacts	40

RESULTS

Repeated measures analysis of variance (RMANOVA) was used to analyze each dependent variable. The between-subjects factors were guilt, presentation format, and feedback. The within-subjects factors were statement type, interevent interval, and repetition. For PD, time was an additional within-subjects factor. The RMANOVA contained many sources of variance. To simplify presentation of the results, only main effects of guilt and guilt interactions are presented and discussed in the text. Effect sizes for all statistically significant main effects and interactions for each dependent variable are presented in Appendix G. Significance for tests involving a repeating factor used Huynh-Feldt corrections for degrees of freedom. Effects were significant at $p < .05$ unless otherwise noted.

Means and standard deviations for the dependent variables are presented in Table 4. They are broken down by guilt, presentation format (distributed or blocked), and statement type (neutral, cash, and card).

The means, standard deviations, and ranges of participant's age and their answers on the additional measures are presented in Table 5.

Presentation Format

The first research question was whether ocular-motor measures were more diagnostic of deception for a distributed or blocked presentation format. The effects of

presentation format on outcome measures should be indicated by the Guilt X Presentation Format interaction and the Guilt X Statement type X Presentation format interaction. There were no interactions with Presentation format for RT, proportion wrong, number of fixations, first pass duration, or next item blink rate.

For reread duration, the Guilt X Statement type X Presentation format was significant, $F(2, 252) = 3.62$, partial $\eta^2 = .028$, and the group means are plotted in Figures 1a and 1b. Innocent participants spent more time rereading cash and card items than neutral items in the blocked condition as compared to the distributed condition. The Guilt X Presentation format interaction was not significant.

For PD waveform, the Guilt X Statement type X Presentation Format interaction was significant, $F(2, 256) = 4.06$, partial $\eta^2 = .031$ and is illustrated in Figures 2a, 2b, 2c, and 2d. Results indicate that the PD waveform was more diagnostic of guilt for distributed than for blocked participants. The Guilt x Presentation format interaction was not significant, $p = .99$.

For area under the pupil response curve, the Guilt X Statement type X Presentation format interaction was significant, $F(2, 288) = 5.64$, partial $\eta^2 = .038$. The means for distributed and blocked presentation formats are plotted in Figures 3a and 3b. The guilty distributed group showed stronger pupil responses to cash than credit card statements, whereas guilty blocked participants showed little difference in their pupil responses to cash and credit card statements. The Guilt X Presentation format interaction was not significant.

In contrast to the PD measures described above, PD level was extracted from a within-subject standardized pupil response waveform. The Guilt X Statement type X

Presentation format interaction was significant for PD level, $F(2, 256) = 5.15$, partial $\eta^2 = .039$ (Figures 4a and 4b). As compared to innocent participants in the distributed condition, innocent participants in the blocked condition reacted relatively less strongly to neutral statements. Guilty distributed and blocked participants responded similarly to neutral cash and credit card statements. The Guilt X Presentation format interaction was not significant.

The Guilt X Statement type X Presentation Format also was significant for item blink rate, $F(2, 254) = 3.42$, partial $\eta^2 = .026$. Figures 5a and 5b illustrate the interaction. As compared to guilty participants in the distributed condition, guilty participants in the blocked condition blinked less often while reading cash statements than neutral and card statements. The Guilt X Presentation format interaction was not significant, $p = .402$.

Block as the Unit of Analysis

In the blocked presentation format, the computer presented four statements of the same type consecutively as a block before it changed to a different statement type. The blocked format was designed to allow more time for an emotional response to develop. Alternatively, because the participant knew what type of statement was about to be presented, the blocking format allowed participants an opportunity to develop strategies to improve their chances of passing the test. For the blocked presentation format, additional analyses were conducted that treated the four statements in a block as a single unit.

Figures 6a and 6b show pupil size over a period of 12 seconds at 5 Hz beginning at the onset of a block of four items. The figures reveal that the pupil dilated in response to cash and card item over first 4 seconds by more than 0.10 mm and then slowly

recovered. The pupil was more dilated while guilty participants read and responded to cash items than to credit card or neutral items, whereas the opposite pattern was observed for innocent participants. The Guilt X Statement type X Time, $F(14.49, 1129.91) = 1.44$, partial $\eta^2 = .018$, and Guilt X Statement Type interactions were significant, $F(1.56, 121.80) = 6.35$, partial $\eta^2 = .075$. The simple main effect of Guilt for the block condition was not significant, $p = .45$.

Guilt X Statement type interaction was not significant for area under the pupil curve (PD area) $p = .463$, or blink rate, $p = .454$.

Figure 7 shows mean PD level over a period of 12 seconds that began at the onset of the first item in a block. The figure reveals that the pupil was more dilated when guilty participants responded to cash items than to credit card and neutral items. The Guilt X Statement type interaction was significant, $F(1.68, 130.94) = 9.341$, partial $\eta^2 = .107$. The simple main effect of Guilt for the blocked condition was significant, $F(1,78) = 7.800$, partial $\eta^2 = .091$.

Table 6 reports the reliability of ocular-motor measures (coefficient alpha) to determine if reducing the number of items on the ODT adversely affected the reliability of outcome measures. Reliability was measured across the six repetitions of the 48 ODT statements. As a result, the number of 'items' in the coefficient alpha was the number of repetitions. This approach was used for the distributed, blocked, and blocked unit formats. On average, there was little difference in reliability among distributed ($M = .61$), blocked ($M = .54$), and blocked unit ($M = .56$) formats.

Practice With or Without Feedback

The second research question in the present study was to test whether feedback during the practice session improved the accuracy of the ODT outcomes. Effects of practice feedback on outcome measures were indicated by the Guilt X Feedback interaction and the Guilt X Statement type X Feedback interaction. There were no interactions with Feedback for RT, proportion wrong, the reading measures, PD level, or blink measures.

Area under the pupil response curve in mm was significant for Guilt X Feedback, $F(1, 144) = 9.124$, partial $\eta^2 = .06$ as well as for Guilt X Statement type X Feedback interactions, $F(2, 288) = 3.151$, partial $\eta^2 = .021$, the latter of which is presented in Figures 8a and 8b. Guilty participants had greater increases in pupil size in the feedback condition than in the no feedback condition. Presentation format did not moderate these effects (Appendix G).

Interval

The present study also investigated whether changes in pupil size and eye blink rates were more diagnostic of deception for longer than for shorter postanswer periods. Effects of intervals on outcome measures were evaluated by tests of the Guilt X Interval interaction and the Guilt X Statement type X Interval interaction. The results were not significant for RT, reading measures, PD level, or for blinks.

The Guilt X Interval interaction was significant for PD area, $F(1, 144) = 5.145$, partial $\eta^2 = .021$. Condition means are presented in Figure 9. Although the absolute magnitude of the pupil response increased as the length of the postresponse interval increased, $F(1, 126)$ for linear effect = 281.0, $p < .01$, the difference between innocent

and guilty groups was greatest at the 500 ms interval. The Guilt X Interval X Presentation format interaction was not significant. These findings suggest that the 500 ms interevent interval interrupts the development of the evoked pupil response, but there was no evidence that the length of the interval affected the diagnostic usefulness of this or any other ocular-motor measure.

Measures Based on Longer Interevent Intervals

Additional analyses were conducted to determine if new PD level and blink rate measures that capitalized on longer interevent intervals are more diagnostic of deception than the traditional measures. A multivariate repeated measures ANOVA compared traditional measures for the two repetitions of test items presented with 500 ms interevent intervals to the alternative methods for repetitions presented with 1500 ms and 3000 ms interevent intervals.

PD level for 500 ms interevent interval was the mean standardized PD for an interval that began 1 second prior to the participant's response and ended 1 second after the response. PD level for 1500 ms interevent intervals was the mean standardized PD for interval that began at the participant's response and ended 1500 ms later (the onset of the next item). PD level for 3000 ms interevent intervals was the mean standardized PD that began at the participant's response and ended 3000 ms later. The Guilt X Statement type X Method interaction was not significant, $p = .733$.

Blink rate always was measured for the 3000 ms prior to the participant's response, and next item blink rate always was measured for the 3000 ms following the participant's response. Separate means were computed blink rate and next item blink rate for the two repetitions with 500 ms interevent intervals, the two 1500 ms interevent

intervals, and the 3000 ms interevent intervals.

The Guilt X Statement type X Interval interaction was not significant, $p = .595$ for item blink rate. The interaction was significant for next item blink rate, $F(3.43, 490.33) = 2.717$, partial $\eta^2 = .019$.

The difference between blink rate and next item blink rate was obtained of the above described intervals and analyzed as a multivariate measures ANOVA. The Guilt X Statement type X Interval interaction was not significant, $p = .387$.

Self-Report and Working Memory Scales

The present study included a number of self-report and working memory measures to test whether the differences between guilty and innocent participants depend on motivation, emotion, or working memory. The effect of each subscale on the BIS/BAS and EASI was analyzed in a separate multiple regression equation that included Guilt, Subscale, and the Guilt X Subscale cross-product as independent variables and an ocular-motor measure as the dependent (outcome) measure. The regression coefficients in those equations provided statistical tests for the main effect of Guilt, the main effect of self-report scale, and the Guilt X Scale interaction. To minimize multicollinearity among independent variables, Guilt and the self-report scale were centered about their respective grand means prior to calculating the cross-product term (Pedhazur, 1997). Because Guilt was a dichotomous variable coded 1 for guilty participants and -1 for innocent participants and the group sizes were balanced, Guilt already was centered. Working memory measures (2-back and 3-back *d*') were analyzed individually as independent variables in regression analyses of outcome measures in the same manner as were the self-report measures.

Each outcome measure was a person-mean for the entire ODT. Outcome measures included the following: (1) response time in seconds; (2) proportion wrong; (3) PD area under the pupil response curve in mm for a 4-second window that began at statement onset; (4) mean pupil size in mm for 1 second before and after the moment the participant responded (unstandardized PD level); and (5) difference between cash and card statements in pupil size following the response in standard score units (PDLevelCashCard).

Behavioral Inhibition and Activation Systems

The present study asked whether BIS scores on the BIS/BAS scales are more positively correlated with ocular-motor measures from guilty than from innocent participants and whether there are main or interaction effects of the Reward Responsiveness Scale on ocular-motor measures for guilty and innocent participants. Appendix B describes the scoring for the BIS/BAS scales. The results of the multiple regression analyses for the BIS and BAS Reward Responsiveness scales are presented in Tables 7 and 8, respectively. The BIS measure had seven items with a Coefficient Alpha of .749. There were main effects of Guilt on RT and PDLevelCashCard but there were no main or interaction effects of BIS.

The BAS Reward Responsiveness scale was composed of five items, and its Coefficient Alpha was .609. BAS Reward Responsiveness predicted pupil area under the curve, and Guilt predicted RT and PDLevelCashCard. On average, guilty participants had longer response times and larger differences in pupil responses between cash and card items than did innocent participants. The negative effect of BAS reward responsiveness on PD area indicated that participants with a higher reward

responsiveness had smaller pupil responses to test items.

Emotion Activity Sociability and Impulsivity Scales

Analyses were conducted to determine if ocular-motor measures of deception correlated positively with emotionality as measured by the EASI. The scoring for the EASI scale is included in Appendix C.

The results of multiple regression analyses of the EASI scales are presented in the next four tables. Emotionality had five items with a Coefficient Alpha of .660. The regression results are presented in Table 9. Results indicated that pupil dilation is correlated with self-reported emotionality as measured by the EASI. However, there was no Guilt X Emotionality interaction effect on the difference between pupil responses to cash and card items for PD level (PDLevelCashCard). That suggests that emotionality has no discernible effect on the diagnostic validity of this measure. There were main effects of Guilt on RT and PDLevelCashCard. BIS correlated with Emotion, $r(160) = .510$, $p < .01$, which indicated that more inhibited people were more emotional.

The Activity measure consisted of five items and had a Coefficient Alpha of .678. It measured the total amount of energy expended by a person that consists solely of movements of the head, arms, legs, and body (Buss & Plomin, 1975). The results of the multiple regression analysis are presented in Table 10.

The Sociability scale was composed of five items (Coefficient Alpha of .466), and the results are summarized in Table 11. The significant negative slope for Sociability indicated that less social participants exhibit stronger pupil responses during the test than do more social individuals.

The Impulsivity scale consisted of five items and had a Coefficient Alpha of .700.

The regression results are presented in Table 12. Aside from the main effects of Guilt described above, there were no main or interaction effects for Impulsivity.

Working Memory *n*-back

The present study also tested whether ocular-motor measures of deception correlate negatively with performance on a WM task. If guilty people with better cognitive ability show less effect of cognitive load during the ODT, they may be less distinguishable from innocent people. The sensitivity index *d*' was calculated from correct hits and false alarms. This measure provided an index of the participant's ability to discriminate targets from nontargets, with higher d' indicating better signal detection. D' was computed using the following formula: $Z_{Hit} - Z_{False\ Alarm}$ where the z scores were standardized hit and false alarm rates. The results of multiple regression analysis for the 2-back is presented in Table 13. There were three blocks of letters with a Coefficient Alpha of .740. Guilt predicted RT and PDLevelCashCard, otherwise there were no significant effects.

For the 3-back, there were 3 blocks of letters with a Coefficient Alpha of .737. The regression results for 3-back are presented in Table 14. The significant negative correlation between *d*' and RT indicated than when the participant was better able to identify the targets in the 3-back WM task, they responded more quickly to test items on the ODT.

The d' for the 2-back and 3-back tasks correlated .737, $p < .01$, which indicated that participants who were able to correctly identify the target in the 2-back also were able to do so in the 3-back. For both 2-back and 3-back, younger participants were better able to identify the targets than were older participants $r(158) = -.206$, $r(158) = -.207$,

$p<.01$, respectively.

Post-ODT Questionnaire

The post-ODT questionnaire asked about the participant's perceptions during the ODT. Two questions measured each of eight aspects of subjective experience (Appendix D). The mean of responses to the two items was computed for each participant and group means and standard deviations are reported in Table 15.

As compared to innocent participants, guilty participants thought the study was more realistic, were more concerned about the cash items, and were more worried about passing the ODT. Presentation format correlated with Concentration, $r(158) = .192$, $p < .05$; participants reported that they were better able to concentrate during the blocked than the distributed format. BIS correlated with Realism, $r(158) = .216$, $p < .01$, Accuracy, $r(158) = .231$, Motivation, $r(158) = .208$, $p < .01$, concern about the cash items, $r(158) = .210$, and General Worry, $r(158) = .240$, $p < .01$. Participants who were more inhibited found the study more realistic, were more concerned about answering questions accurately, were more motivated to pass the ODT, were more concerned about the cash items, and were more worried about passing the ODT. Emotion correlated negatively with Concentration, $r(158) = -.160$, $p < .05$. Sociability correlated negatively with concern about cash items, $r(158) = -.204$, $p < .01$, concern about the card items, $r(158) = -.160$, and General Worry, $r(158) = -.176$. The participants who were more social worried less about the cash items, were less concerned about the card items, and were less worried about passing the ODT.

Participants were asked to rate their anxiety levels while answering questions about the thefts. The results appear in Table 16. As compared to innocent participants,

guilty participants were more anxious when answering questions about the $20 than the credit card. However, almost half of both innocent and guilty participants reported being equally anxious when answering questions about the two thefts. The distribution of responses to this item differed for innocent and guilty participants, $\chi^2(3) = 23.02$.

The results in Table 17 indicate that more than half of the participants in the no feedback and feedback conditions thought that it was just as important to be fast as it was to be accurate. Further analysis revealed that whether or not a participant received feedback did not correlate with their concern about speed or accuracy. There was no relationship between answers to this question and feedback condition, $\chi^2(3) = 1.54$.

Discriminating Variables

To maximize the reliability of discriminating ocular-motor measures, repeated measurements were averaged across items of a given type (neutral, cash, or card) and across repetitions, yielding a mean for neutral items, a mean for cash items, and a mean for credit card items. In addition to the traditional method for extracting features from evoked pupil responses to individual items, in the case of blocked items, the change in pupil size across the entire block of four items was analyzed as a single evoked response. The person means for the three statement types were used to compute two discriminating variables. One variable was the difference between the means for cash and card items (CashCard). This difference provided a measure of deception that controlled for the perceived relevance of test items. Another variable was the difference between the mean for items answered deceptively by guilty participants (cash items) and mean for all other items, which were answered truthfully (LieTruth).

The point-biserial correlation between each derived variable and a dichotomous

variable that distinguished between guilty (coded 1) and innocent (coded -1) participants was an index of the measure's diagnostic validity. The point-biserial correlations are presented in Table 18 separately for groups that received the distributed and blocked format. Table 18 also reports the internal consistency reliability (Cronbach's alpha) for each measure. To calculate the reliability of a measure, a mean was computed for each repetition, and the number of 'items' was the number of repetitions.

PDAreaCashCard, PDAreaLieTruth, PDLevelCashCard, and PDLevelLieTruth contrasts for the distributed format had validity coefficients that exceeded .55 and were significantly greater than those obtained from the blocked condition. The pupil measures from the distributed format also tended to be more reliable (M = .61) than those from the blocked format (M = .54) (Table 18).

The negative point-biserial correlations for RT, number of fixations, first pass duration, reread duration, and item blink rate between cash and card items indicate that guilty participants were faster to respond, made fewer fixations, spent less time reading and rereading, and blinked fewer times on the cash items than card items. The negative correlations for RT, number of fixations, first pass, and reread durations between the cash and other items indicates that guilty participants took less time to respond, made fewer fixations, and spent less time reading and rereading cash items than credit card and neutral items. In addition, since blink rates were negatively correlated with Guilt, guilty participants blinked less on cash items than the other items. The correlations for the Cash versus Card and Lie versus Truth items were positive for PD area and PD level. As compared to innocent participants, guilty participants showed greater increases in pupil size in response to cash than other items.

A stepwise discriminant analysis indicated that PDAreaCashCard, PDLevelLieTruth, BlinkCashCard, and RTstandardizedCashCard best predicted guilt for the distributed format and NFixCashCard and PDLevelCashCard best predicted guilt for the blocked format. Coefficients for variables in each discriminant function were statistically significant, $p < .05$. The standardized canonical discriminant function coefficients are presented in Table 19. Classification results and jackknifed classification results are presented in Table 20.

Jackknifed classification results were obtained with the leave-one-out method; that is, each case was classified using discriminant coefficients for the predictor variables that were based on all cases except the one that was classified. As expected, accuracy was lower for jackknifed classifications than for the original discriminant function based on all 80 cases for distributed (86.3% versus 85.0%) and blocked conditions (83.3% versus 82.1%). Classification results for logistic regression using the same variables as were included in the discriminant functions were essentially the same as those obtained with discriminant analysis and are not reported.

Questionnaires

Each self-report and working memory measure was correlated with the discriminant scores to test whether they were related to a global ocular-motor index of deception. Correlations were obtained separately for distributed and blocked presentation conditions, converted to a z-score using Fisher's r to z transformation, averaged, and then converted back to correlations. The pooled correlations are presented in Table 21. None of the individual difference measures correlated with the ocular-motor index of

deception. Predictability, scales developed from the post-ODT questionnaire were based on only two items and were less reliable than scales composed of more items.

Table 4

Means and standard deviations for the dependent variables by distributed/blocked items, and statement type for innocent and guilty participants

Dependent Variable		Distributed						Blocked					
		Neutral		Cash		Card		Neutral		Cash		Card	
		Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Response Time	Innocent	-.183	.169	.099	.110	.086	.106	-.293	.128	.116	.088	.180	.081
	Guilty	-.156	.210	.015	.123	.145	.123	-.235	.200	.036	.151	.204	.114
Proportion Wrong	Innocent	.107	.077	.059	.054	.063	.039	.111	.118	.053	.060	.069	.068
	Guilty	.126	.103	.070	.076	.066	.087	.114	.087	.065	.065	.083	.071
Number of Fixations	Innocent	6.95	1.93	7.43	2.22	7.51	2.15	7.29	1.45	8.23	1.69	8.58	1.85
	Guilty	8.07	2.33	8.23	2.28	8.87	2.63	7.91	2.63	8.22	2.78	9.07	3.28
First Pass Duration	Innocent	1.89	.588	2.01	.627	2.09	.664	1.96	.478	2.21	.504	2.34	.534
	Guilty	2.08	.460	2.18	.466	2.34	.534	2.05	.633	2.20	.721	2.39	.801
Reread Duration	Innocent	.471	.237	.543	.292	.580	.298	.520	.226	.680	.246	.765	.278
	Guilty	.544	.239	.635	.267	.726	.293	.576	.311	.688	.358	.808	.420
PD	Innocent	-.034	.023	-.004	.006	.008	.009	-.012	.015	.000	.007	.004	.008
	Guilty	-.049	.030	.012	.010	-.003	.004	-.020	.016	.000	.003	.004	.004
PD Area	Innocent	.204	.076	.242	.759	.266	.097	.225	.084	.262	.100	.278	.097
	Guilty	.209	.104	.285	.126	.258	.117	.258	.110	.300	.117	.301	.121
PD Level	Innocent	-.105	.165	.072	.138	.182	.128	-.243	.245	.139	.169	.222	.181
	Guilty	-.225	.173	.237	.181	.158	.150	-.245	.213	.254	.290	.089	.214
Item Blink Rate	Innocent	.677	.452	.632	.429	.602	.449	.755	.560	.763	.568	.767	.569
	Guilty	.657	.461	.627	.482	.693	.516	.954	.630	.865	.637	.961	.688
Next Item Blink Rate	Innocent	.473	.180	.538	.191	.520	.182	.417	.229	.466	.235	.472	.213
	Guilty	.426	.240	.490	.233	.476	.243	.479	.191	.458	.176	.509	.164

Note. Response time is within-subject z-scores. Number of fixations is number of fixations in AOI. First pass duration and reread duration are in s. Pupil diameter is change from baseline in mm. Item blink rate is number of blinks per second on each item. Next item blink rate is number of blinks per second on the item following neutral, cash, and card items.

Table 5
Means, standard deviations, and ranges for age, BIS, BAS, EASI, n-back, post-ODT questionnaire

Variable	*M*	*SD*	Possible Range
Age	33.55	12.99	18 to 70
BIS	19.58	3.65	7 to 28
BAS Reward Responsiveness	17.31	2.18	5 to 20
EASI Emotion	12.98	3.65	5 to 25
EASI Activity	16.66	3.62	5 to 25
EASI Sociability	17.56	2.96	5 to 25
EASI Impulse	13.90	4.03	5 to 25
2-back *d*'	3.25	.07	-
3-back *d*'	3.05	.05	-
Was study realistic (high score = more realistic)[a]	6.95	1.84	2 to 10
Concentration (high score = more concentration)[a]	6.05	1.96	2 to 10
Worry about speed (high score = more worried)[a]	7.06	2.11	2 to 10
Worry about accuracy (high score = more worried)[a]	6.75	1.75	2 to 10
Motivation (high score = more motivated)[a]	8.07	1.68	2 to 10
Worry about cash items (high score = more worried)[a]	5.41	1.77	2 to 10
Worry about card items (high score = more worried)[a]	5.33	1.75	2 to 10
Worry about passing ODT (high score = more worried)[a]	5.51	1.91	2 to 10

[a] The score for each person was the mean response to two questions that addressed the same construct. If necessary, the item was reverse scored.

a)

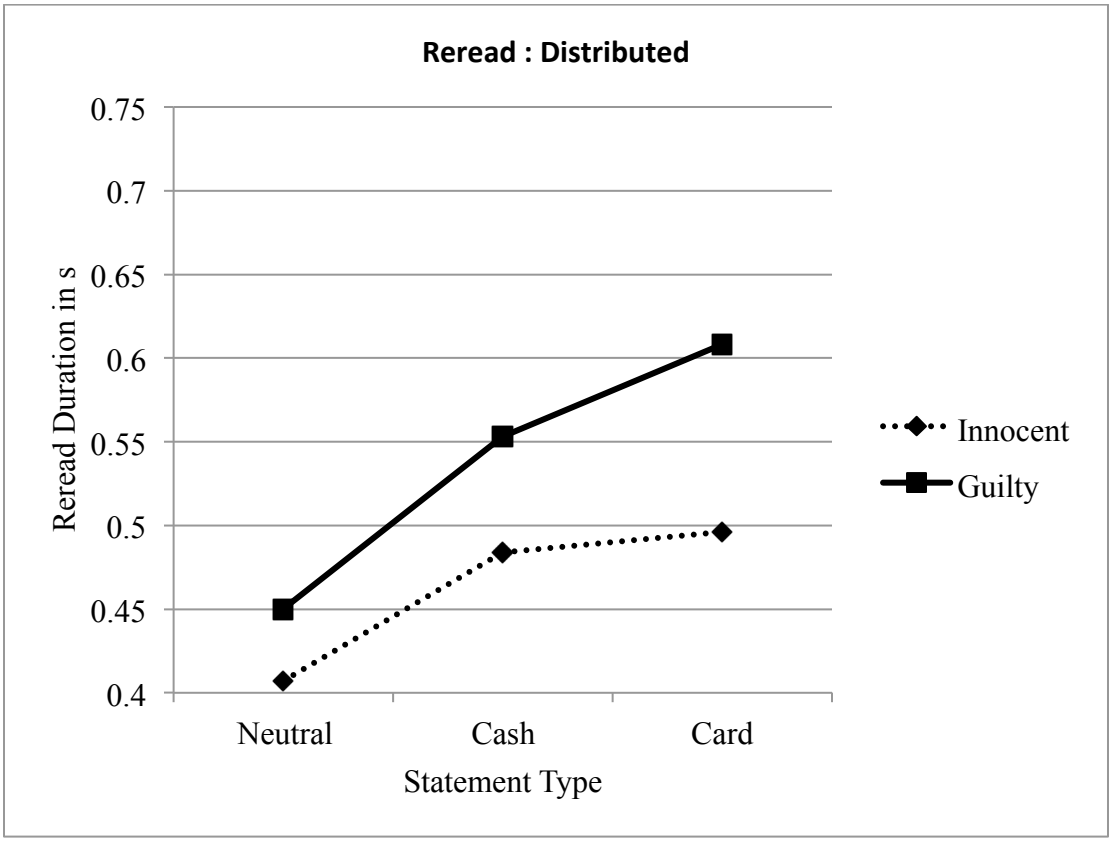

Figure 1. Reread duration to neutral, cash, and card items. a) Distributed format. b) Blocked format.

b)

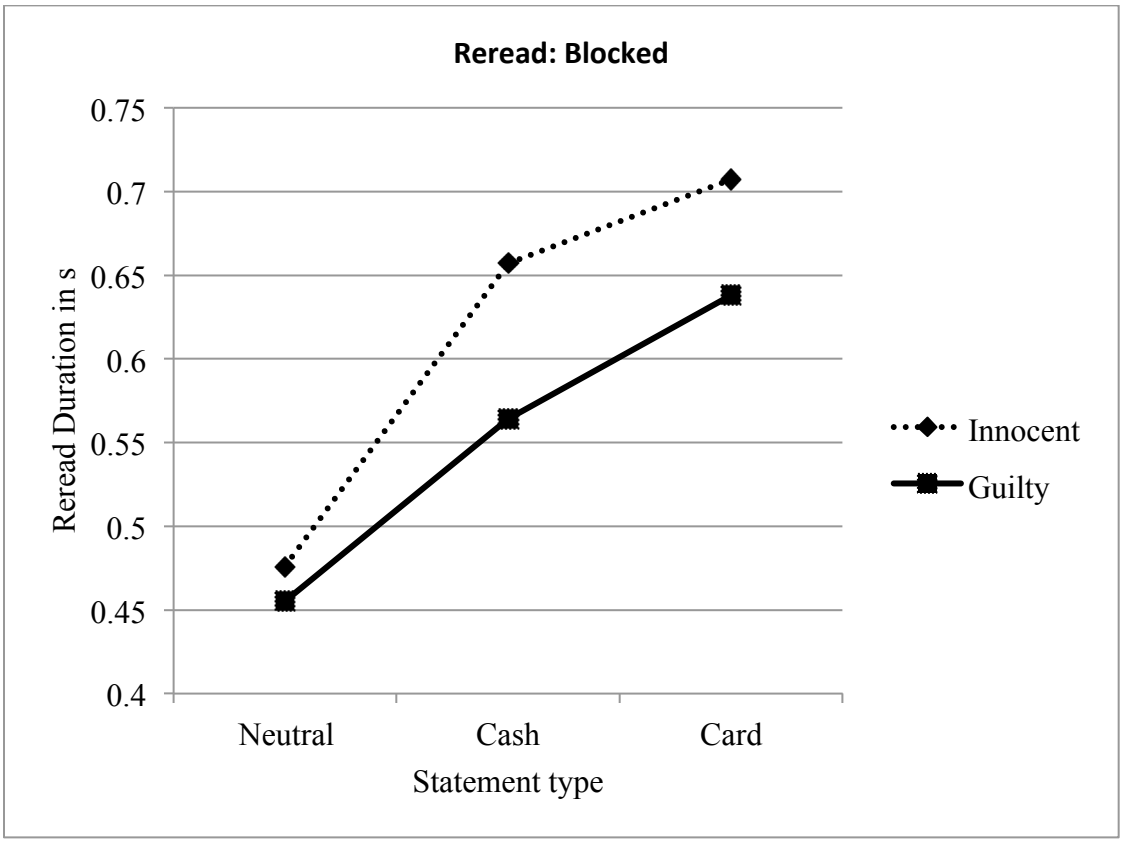

Figure 1. Continued

a)

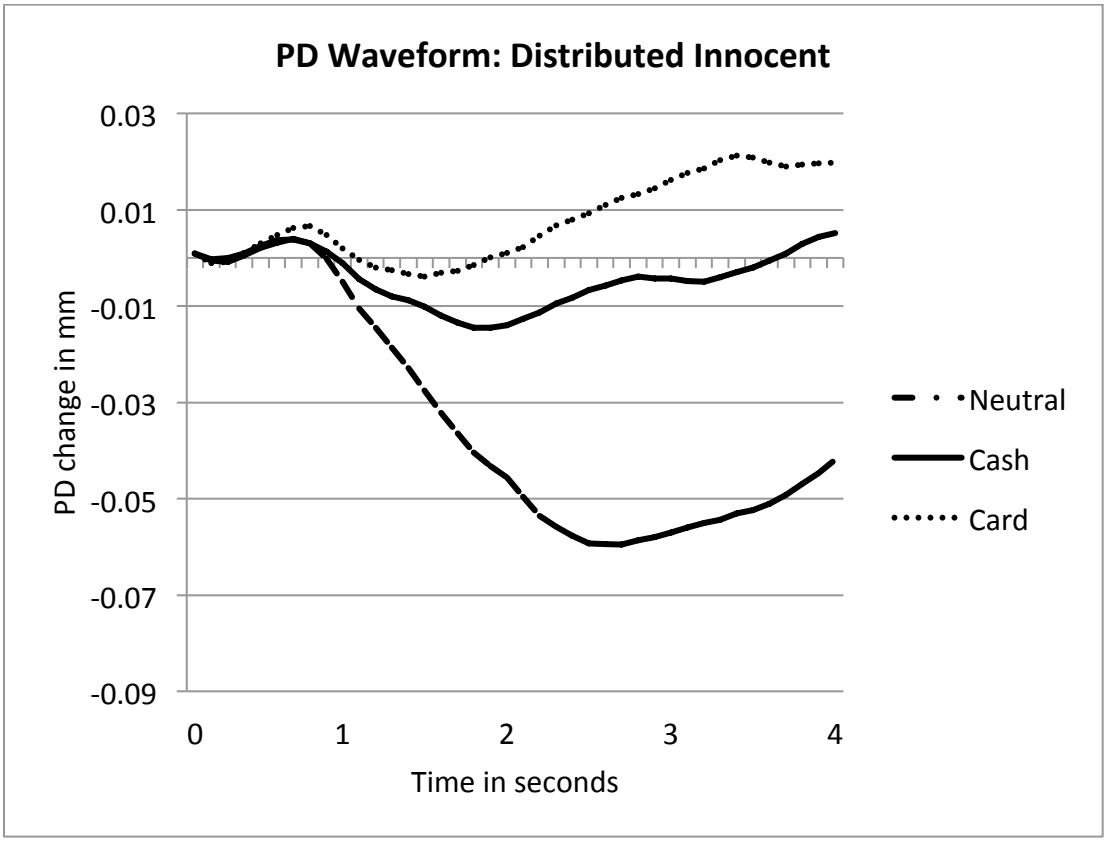

Figure 2. Pupil response to neutral, cash, and card items. a) Distributed format for innocent participants. b) Distributed format for guilty participants. c) Blocked format for innocent participants. d) Blocked format for guilty participants.

b)

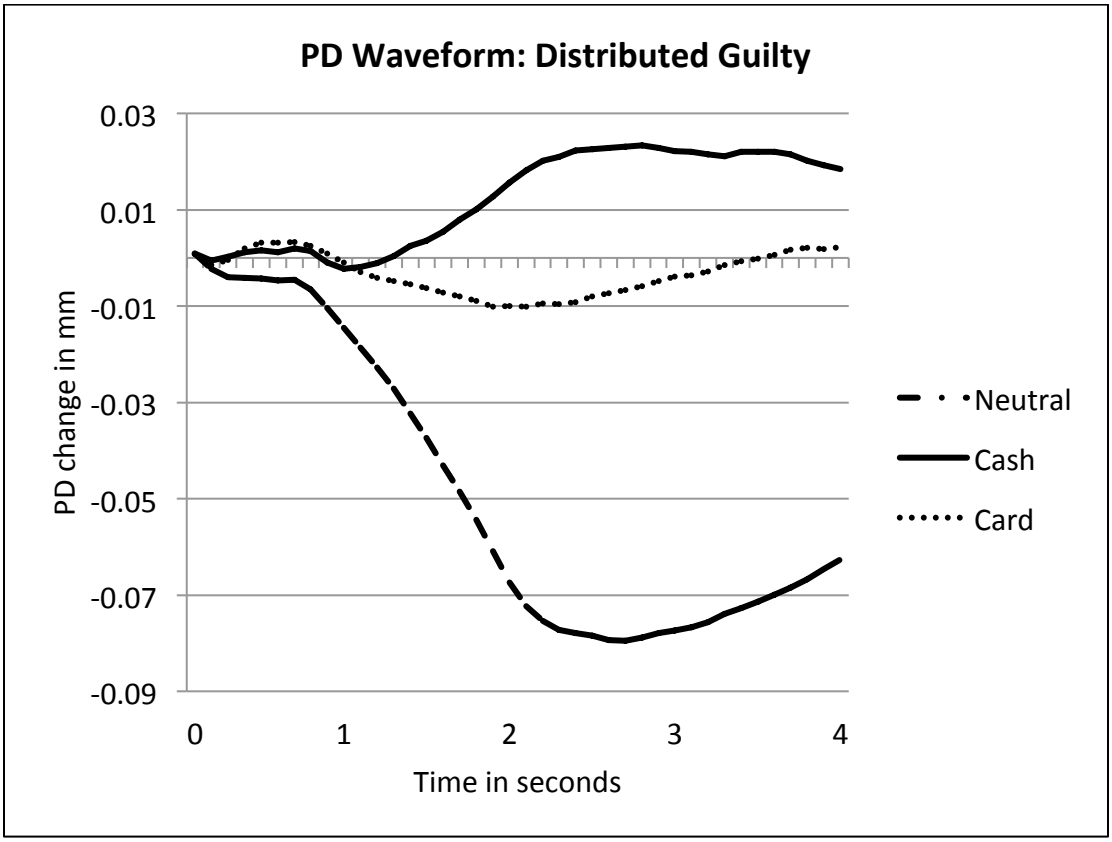

Figure 2. Continued

c)

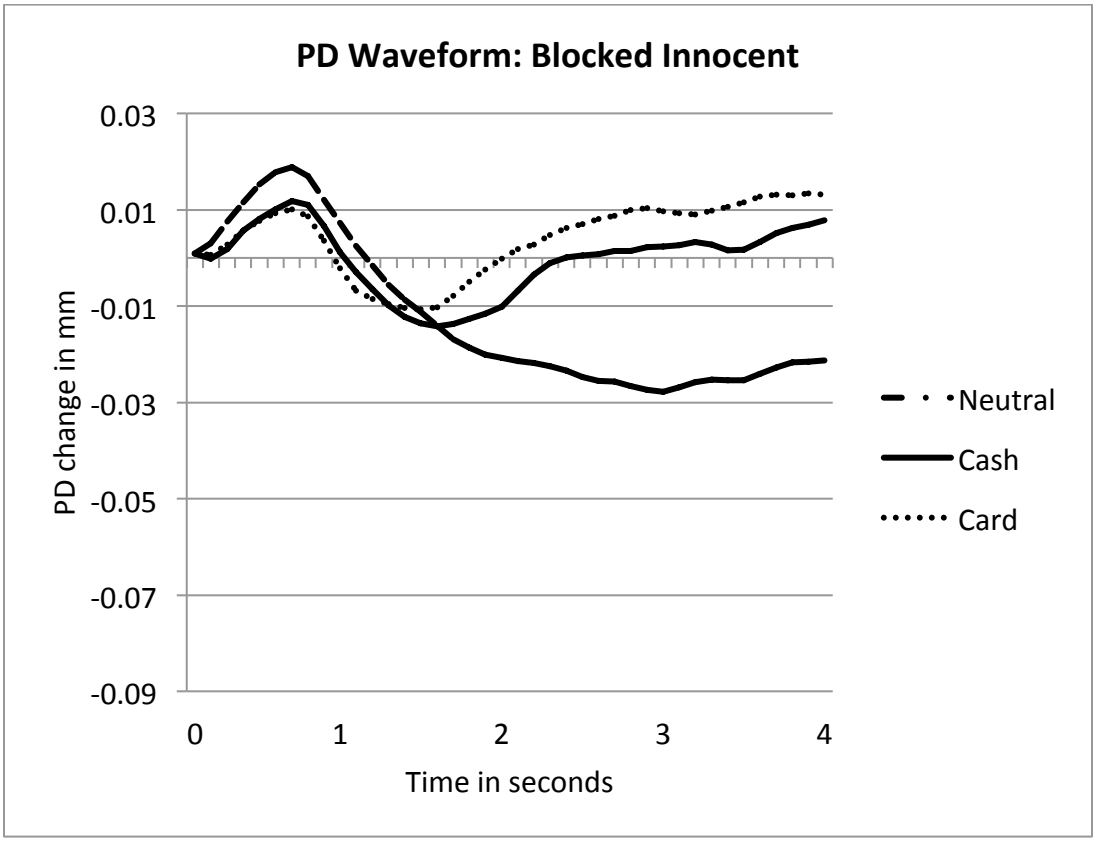

Figure 2. Continued

d)

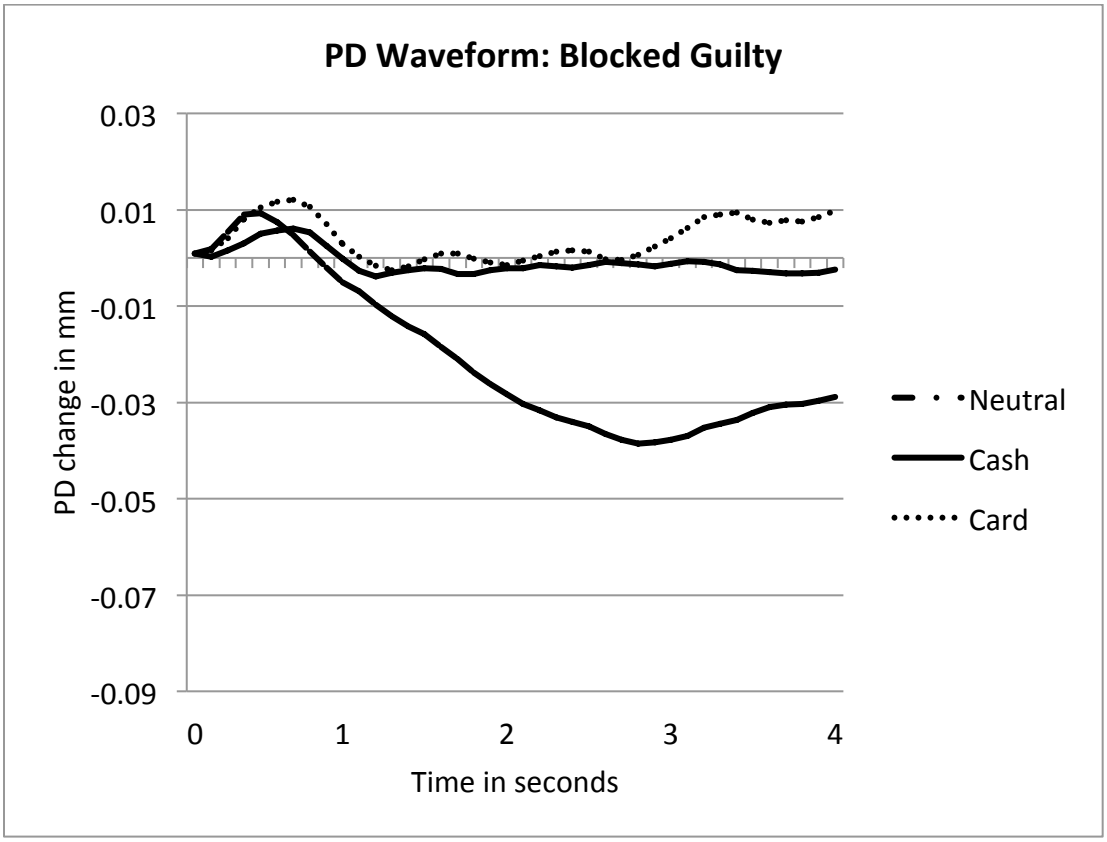

Figure 2. Continued

a)

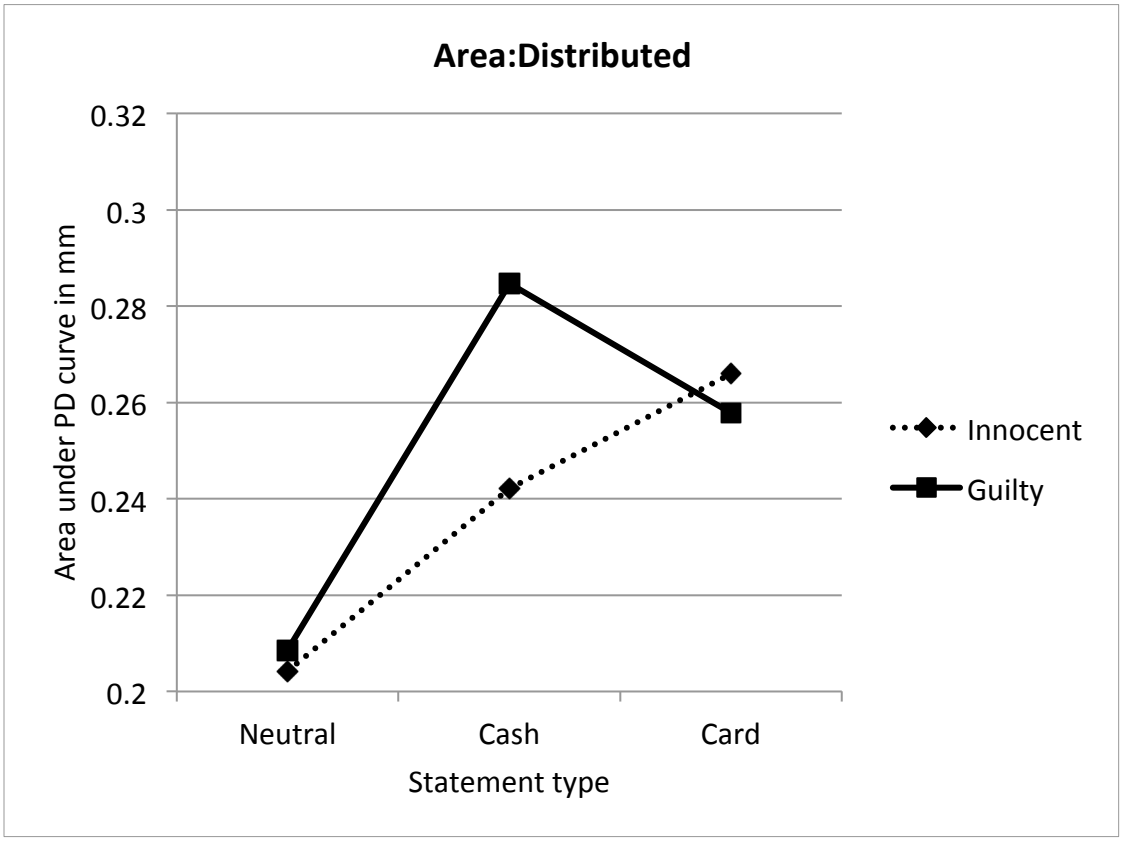

Figure 3. Area under the PD response curve to neutral, cash, and card items. a) Distributed format. b) Blocked format.

b)

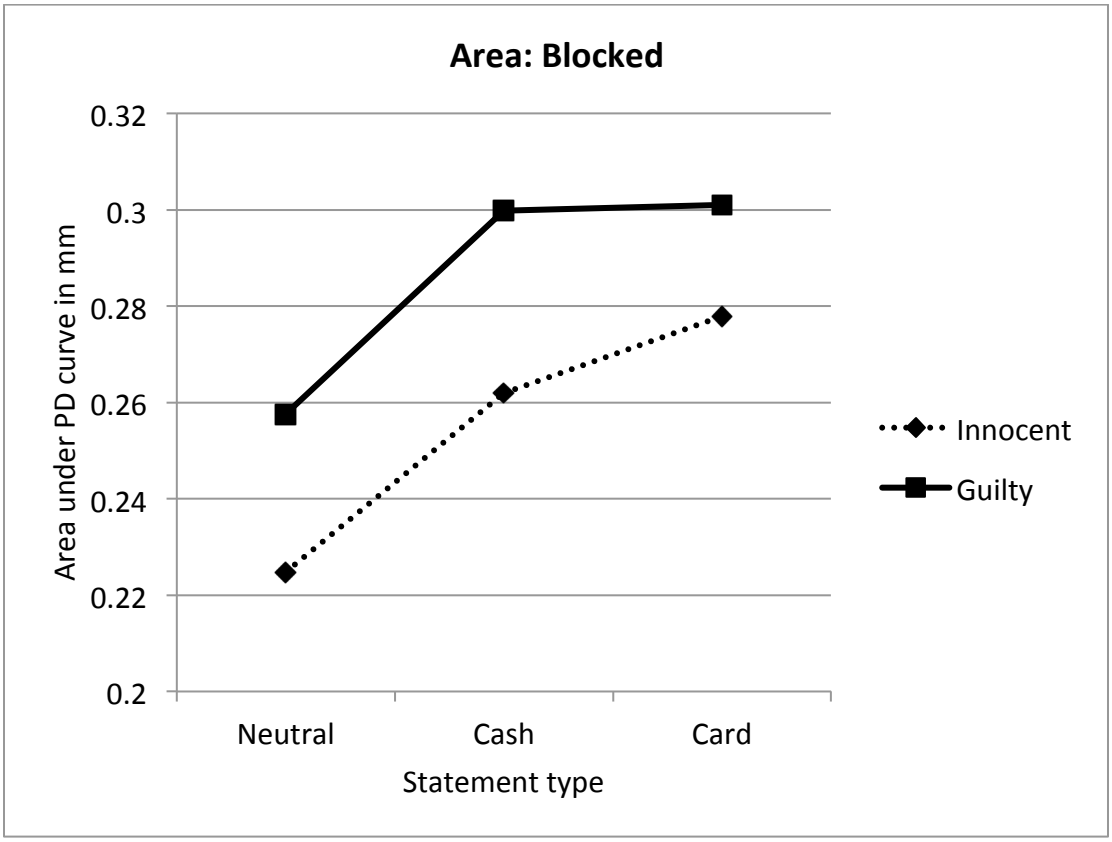

Figure 3. Continued

a)

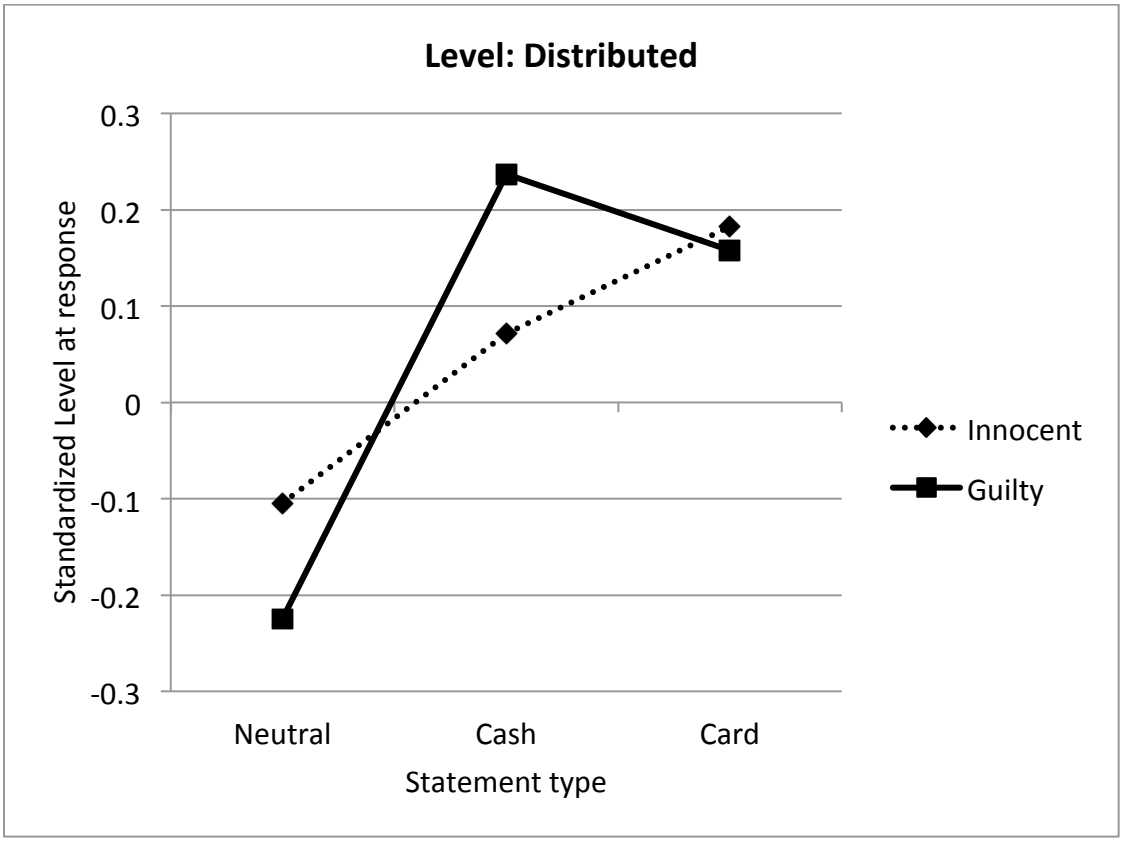

Figure 4. Standardized pupil diameter at response to neutral, cash, and card items. a) Distributed format. b) Blocked format.

b)

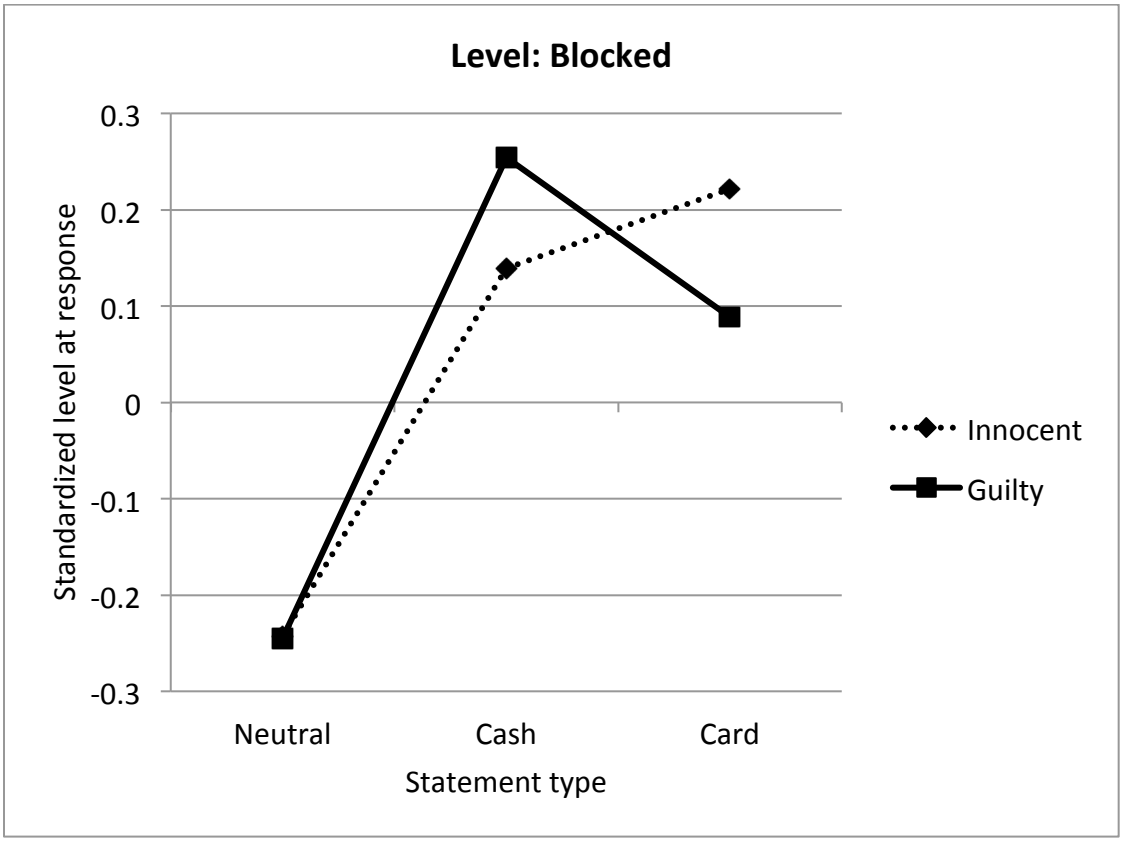

Figure 4. Continued

a)

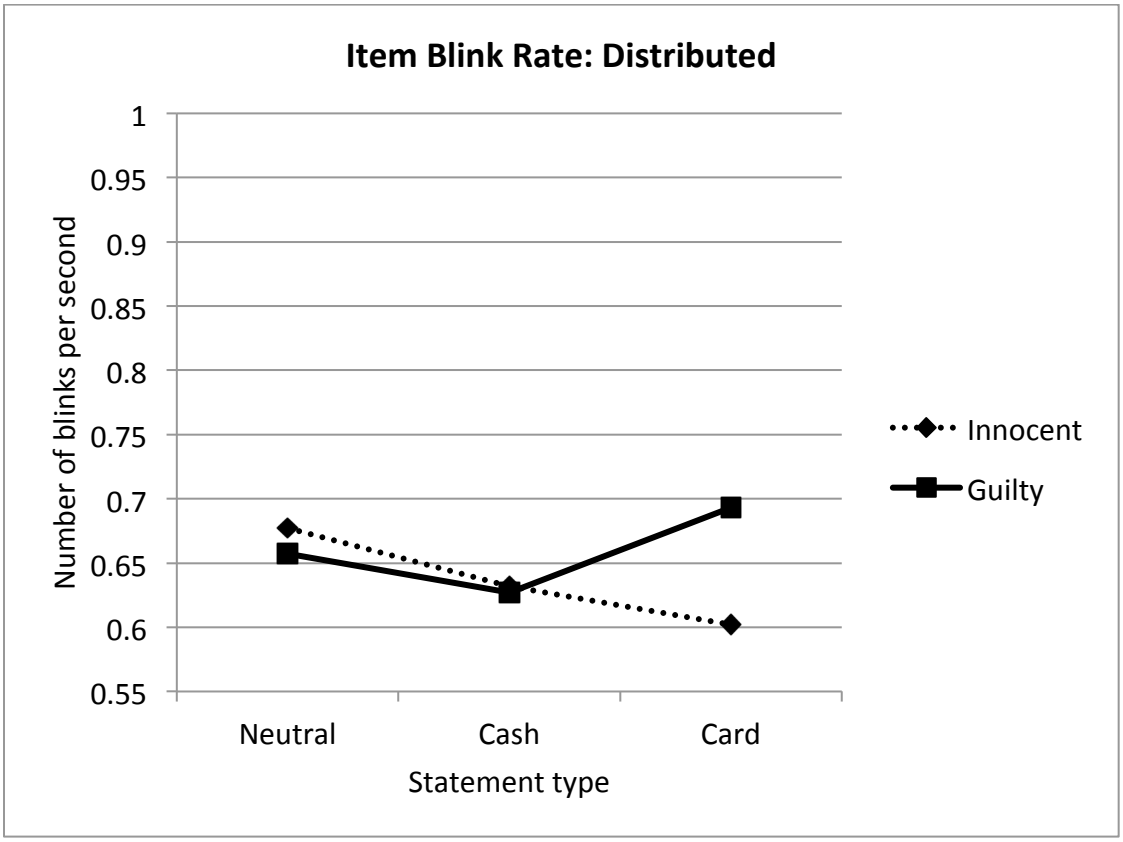

Figure 5. Number of blinks per second to neutral, cash, and card items. a) Distributed format. b) Blocked format.

b)

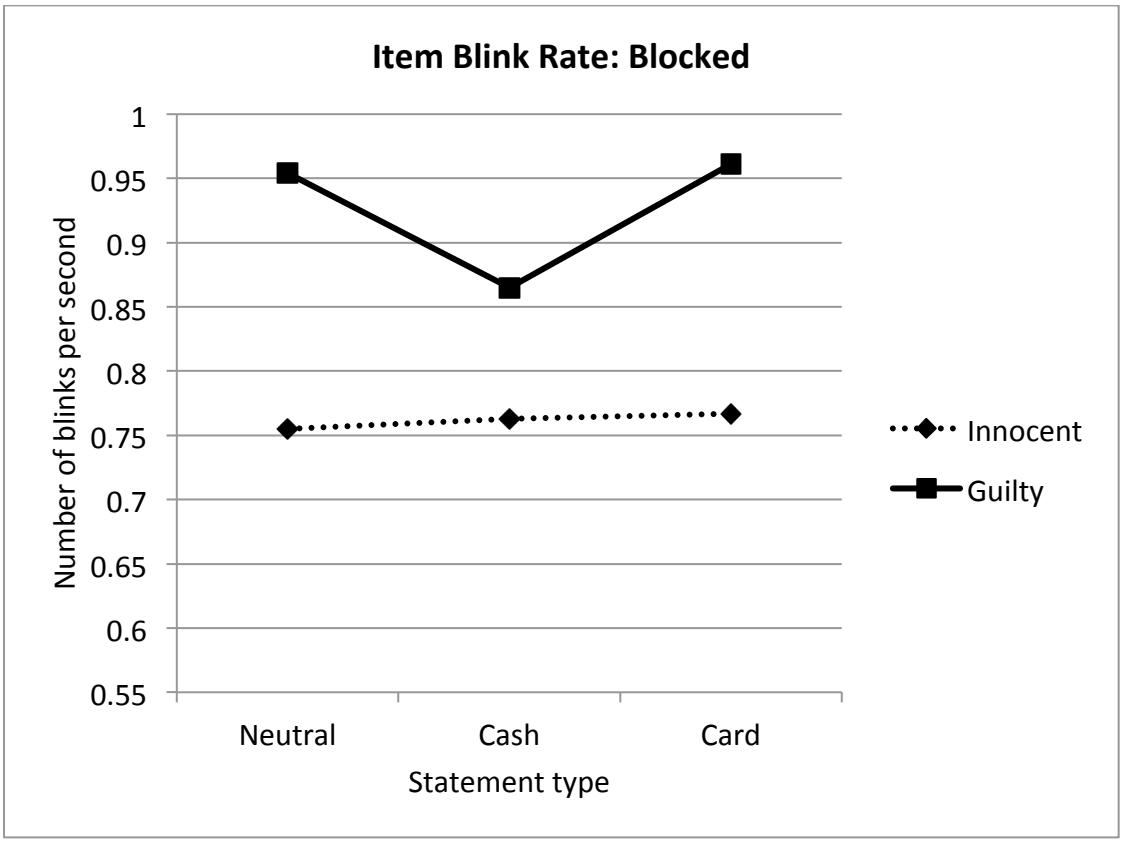

Figure 5. Continued

a)

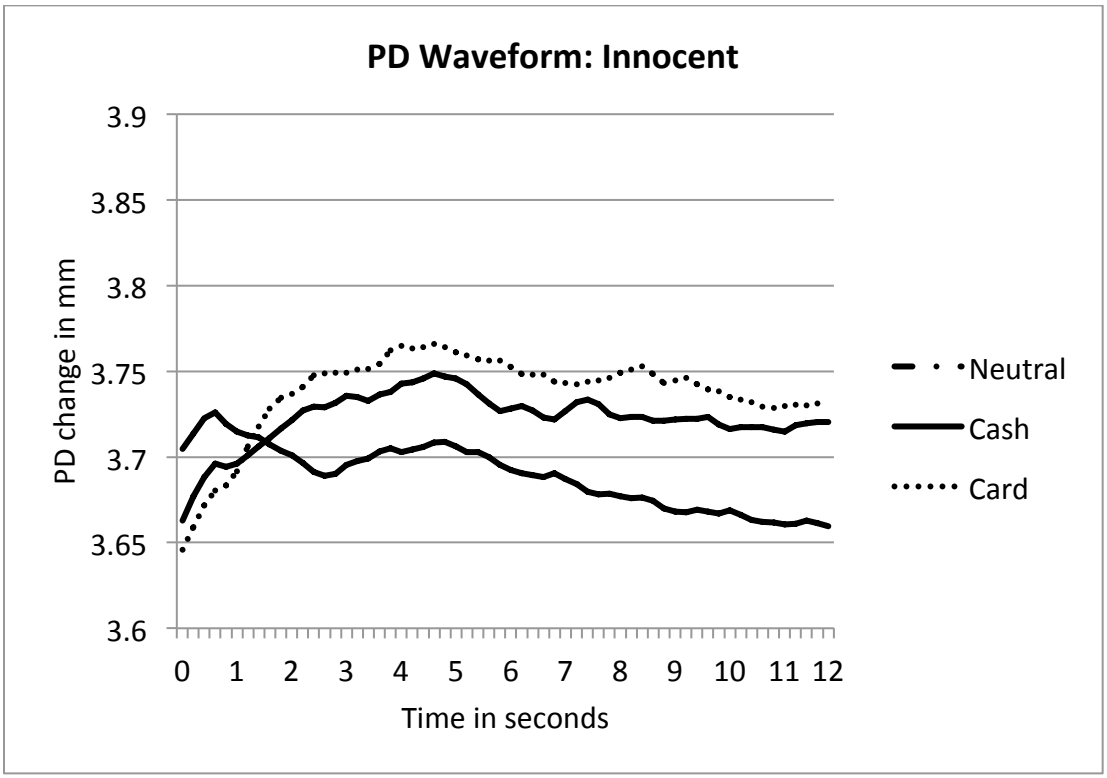

Figure 6. Pupil response to neutral, cash, and card items as a blocked unit for 12 seconds. a) Innocent participants. b) Guilty participants.

b)

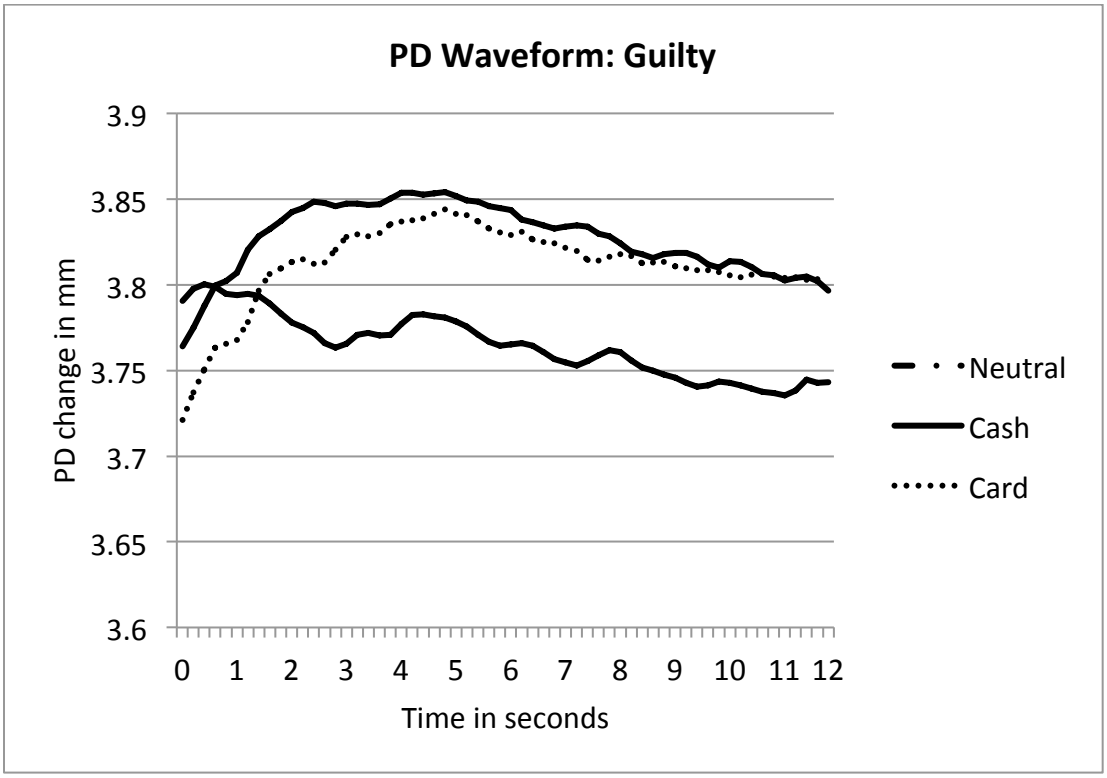

Figure 6. Continued

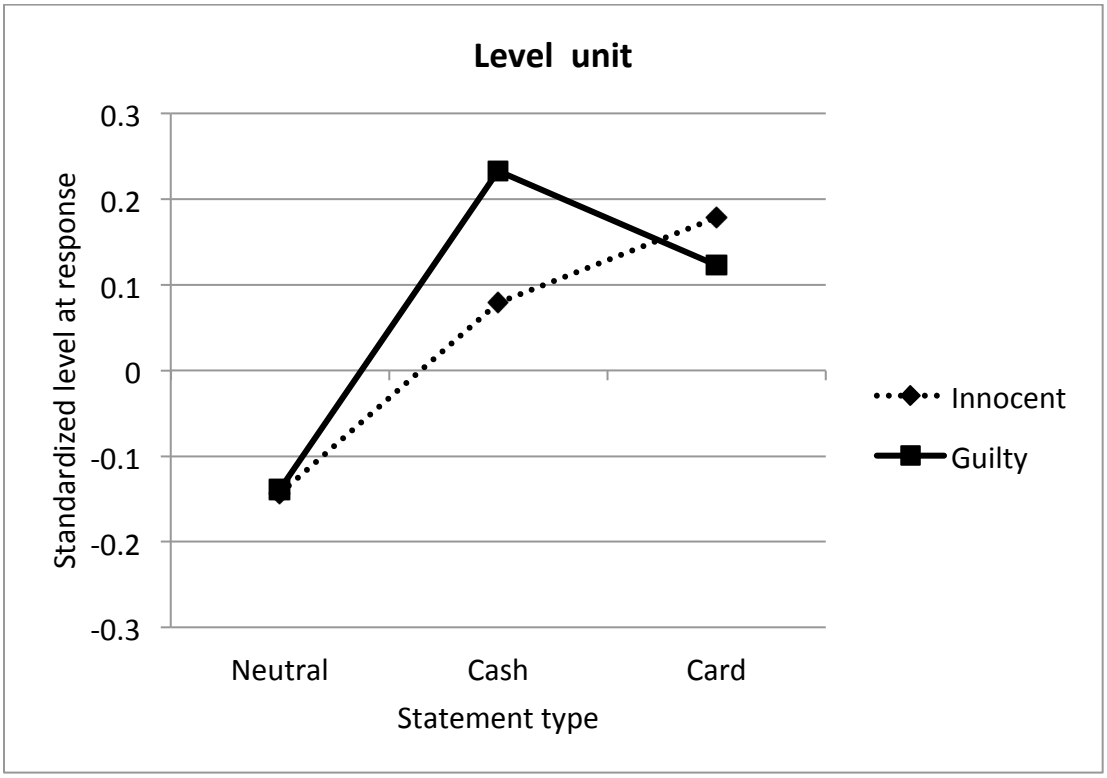

Figure 7. PD Level as blocked unit over 12 seconds.

Table 6
Reliability of ocular-motor measures for distributed and blocked presentation formats

Outcome Measure	Reliabilities			Point-biserial correlations
	Distributed	Blocked	Blocked unit	Blocked unit
RTNeutral	.848	.758	.704	.310**
RTCashCard	.329	.491	.526	-.183
RTLieTruth	.671	.703	.693	-.228
PropWrongNeutral	.924	.937	.883	.093
PropWrongCashCard	.209	.113	.330	.008
PropWrongLieTruth	.690	.738	.558	-.075
NFixNeutral	.950	.931	.968	-.228
NfixCashCard	.627	.318	.399	-.407**
NfixLieTruth	.720	.686	.706	-.268*
FirstPassNeutral	.931	.940	.965	-.216
FirstPassCashCard	.540	.167	.279	-.239
FirstPassLieTruth	.585	.535	.618	-.135
RereadNeutral	.921	.919	.952	-.323**
RereadCashCard	.397	.004	.066	-.163
RereadLieTruth	.407	.369	.430	-.133
PDAreaNeutral	.906	.912	.829	.177
PDAreaCashCard	.615	.080	.179	.139
PDAreaLieTruth	.639	.278	.219	.141
PDLevelNeutral	.869	.797	.872	.080
PDLevelCashCard	.510	.668	.741	.545**
PDLevelLieTruth	.575	.741	.745	.320**
BlinksNeutral	.935	.939	.953	.192
BlinksCashCard	.182	.130	.007	-.157
BlinksLieTruth	.101	.300	.269	-.211
NextBlinksNeutral	.705	.830	.941	.101
NextBlinksCashCard	.351	.040	.217	-.106
NextBlinksLieTruth	.381	.154	.123	-.176

Note. In the point-biserial correlations * indicates a significant correlation at $p < .05$ and ** for $p < .01$.

a)

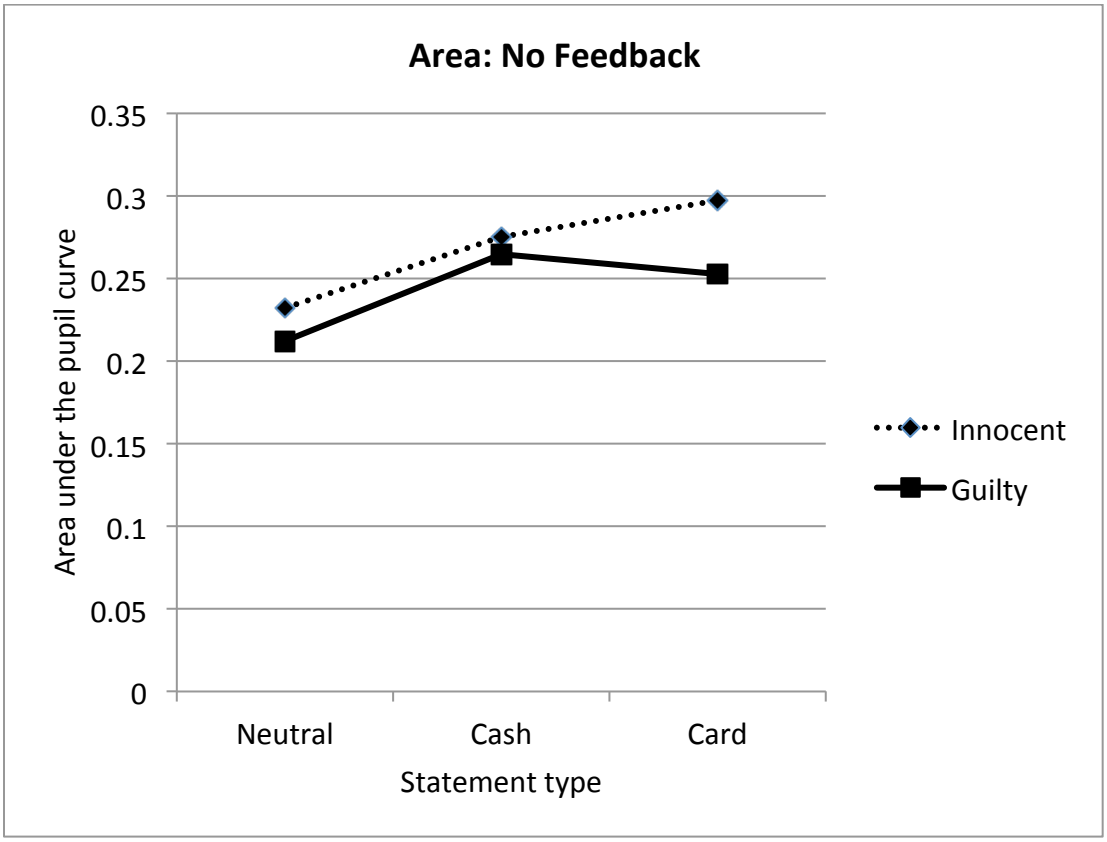

Figure 8. Area under the pupil curve for neutral, cash, and card items. a) No feedback groups. b) Feedback groups.

b)

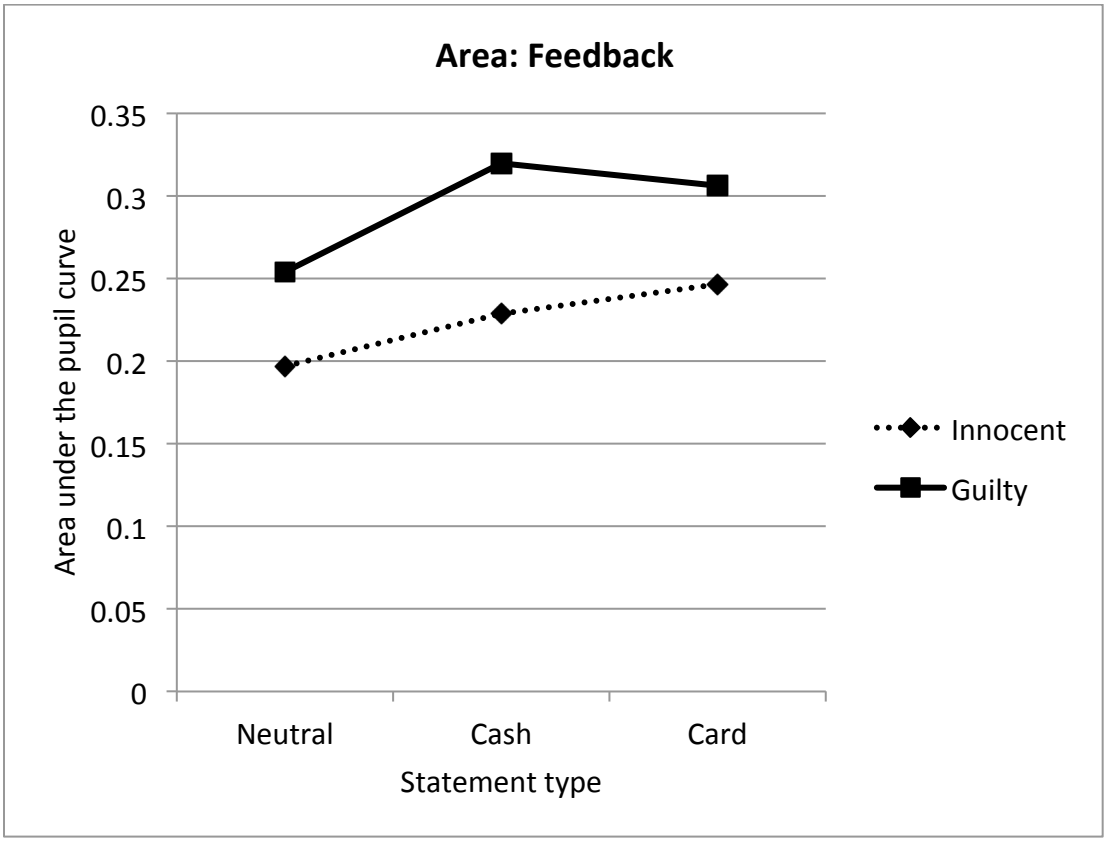

Figure 8. Continued

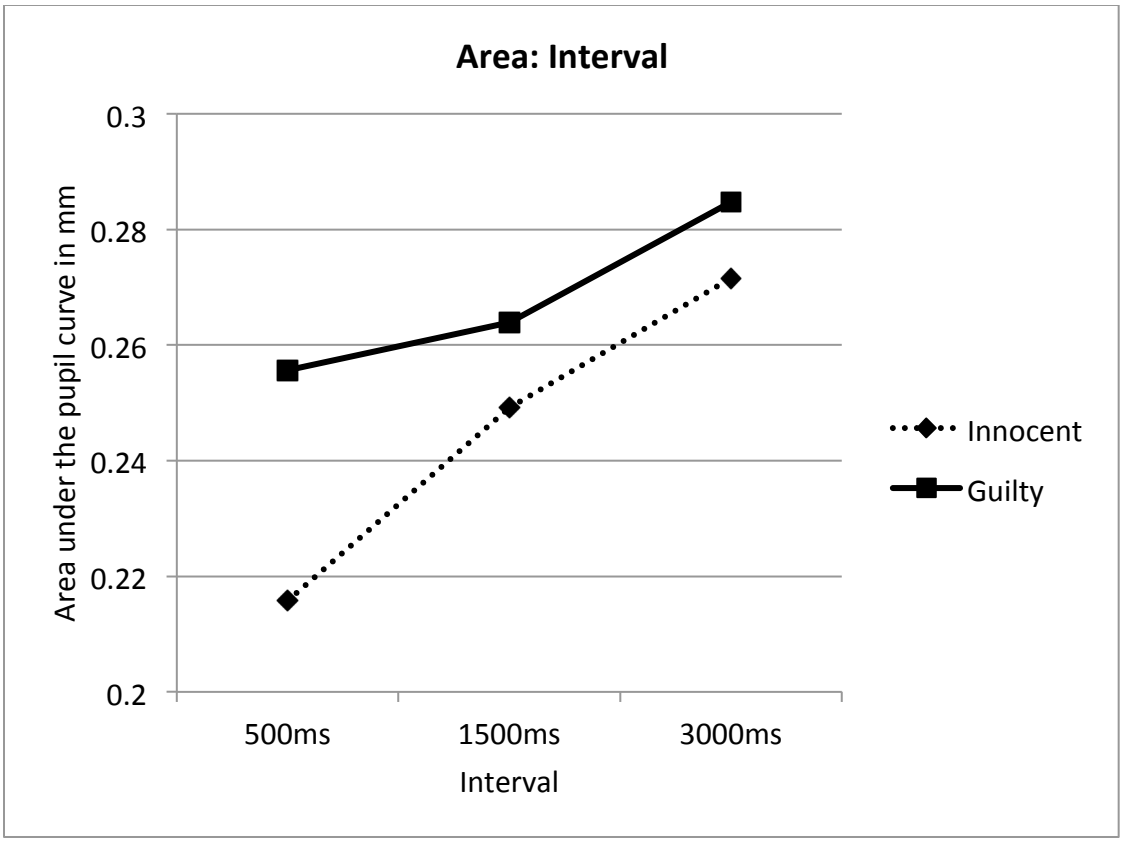

Figure 9. Area under the pupil curve for intervals.

Table 7
Multiple regression results for BIS

Outcome	Standardized Regression Coefficients		
	Guilt	BIS	Guilt X BIS
Pupil level (mm)	.024	.131	-.079
Pupil AUC (mm)	.127	-.003	-.114
Pupil level CashCard (standardized)	.596*	.051	-.048
RT (sec)	.216*	-.111	-.083
Proportion wrong (total)	.127	-.044	-.048

* $p < .05$

Table 8
Multiple regression results for BAS Reward Responsiveness

Outcome	Standardized Regression Coefficients		
	Guilt	BAS Reward Responsiveness	Guilt X BAS Reward Responsiveness
Pupil level (standardized)	.022	-.051	.047
Pupil AUC (mm)	.113	-.187*	.056
Pupil level CashCard (standardized)	.591*	-.080	-.051
RT (sec)	.214*	-.007	-.137
Proportion wrong (total)	.127	.014	-.022

*$p < .05$

Table 9
Multiple regression results for Emotionality

Outcome	Standardized Regression Coefficients		
	Guilt	Emotion	Guilt X Emotion
Pupil level (mm)	.023	.235*	-.005
Pupil AUC (mm)	.126	.115	.034
Pupil level CashCard (standardized)	.596*	.079	-.025
RT (sec)	.216*	-.109	-.101
Proportion wrong (total)	.126	.012	-.069

*$p < .05$

Table 10
Multiple regression results for Activity

Outcome	Standardized Regression Coefficients		
	Guilt	Activity	Guilt X Activity
Pupil level (mm)	.033	-.090	-.053
Pupil AUC (mm)	.138	-.140	.023
Pupil level CashCard (standardized)	.598*	-.007	-.017
RT (sec)	.211*	.048	-.056
Proportion wrong (total)	.124	.027	-.049

* $p < .05$

Table 11
Multiple regression for Sociability

Outcome	Standardized Regression Coefficients		
	Guilt	Sociability	Guilt X Sociability
Pupil level (mm)	.007	-.168*	.075
Pupil AUC (mm)	.118	-.089	.053
Pupil level CashCard (standardized)	.587*	-.088	-.045
RT (sec)	.222*	.069	-.056
Proportion wrong (total)	.123	-.033	-.075

*$p < .05$

Table 12
Multiple regression for Impulsivity

Outcome	Standardized Regression Coefficients		
	Guilt	Impulsivity	Guilt X Impulsivity
Pupil level (mm)	.009	.127	.078
Pupil AUC (mm)	.123	.032	-.043
Pupil level CashCard (standardized)	.602*	-.038	-.055
RT (sec)	.214*	.006	-.030
Proportion wrong (total)	.109	.131	.078

*$p < .05$

Table 13
Multiple regression for 2-back

Outcome	Standardized Regression Coefficients		
	Guilt	2-back	Guilt X 2-back
Pupil level (mm)	.024	.072	-.055
Pupil AUC (mm)	.125	.115	-.104
Pupil level CashCard (standardized)	.596*	.027	-.044
RT (sec)	.217*	-.125	.037
Proportion wrong (total)	.127	-.064	-.041

*$p < .05$

Table 14
Multiple regression for 3-back

Outcome	Standardized Regression Coefficients		
	Guilt	3 back	Guilt X 3 back
Pupil level (mm)	.025	-.021	-.044
Pupil AUC (mm)	.128	.031	-.145
Pupil level CashCard (standardized)	.597*	-.004	-.043
RT (sec)	.209*	-.159*	-.034
Proportion wrong (total)	.121	.580	.602

Note. An * next to the standardized regression coefficient indicates that the coefficient was significant.

Table 15
Means and SDs of Post-ODT Questionnaire for Innocent and Guilty Participants

	Innocent mean	Innocent standard deviation	Guilty mean	Guilty standard deviation	Eta-Square
Motivation	8.3	1.75	7.84	1.59	-
Concentration	6.16	2.11	5.94	1.82	-
Was study realistic	6.60	1.95	7.30	1.65	.036
Worry about speed	7.16	2.22	6.95	2.00	-
Worry about accuracy	6.93	1.81	6.58	1.69	-
Worry about cash items	4.94	1.65	5.89	1.76	.073
Worry about card items	5.43	1.81	5.23	1.70	-
Worry about passing ODT	5.15	2.12	5.88	1.61	.036

Table 16
Post-ODT Question About how the Participant Felt when they Answered Questions about the Two Thefts

	Innocent	Guilty
More anxious when answering questions about the credit card information	5 (6.3%)	4 (5.0%)
More anxious when answering questions about the $20	1 (1.3%)	22 (27.5%)
Equally anxious when answering questions about credit card information & $20	37 (46.3%)	32 (40.0%)
Wasn't concerned when answering questions about the credit card information or the $20	36 (45.0%)	22 (27.5%)

Table 17
Post-ODT question about relative importance of speed and accuracy

	No Feedback	Feedback
More important to get the correct answer than to answer quickly	20 (25.0%)	18 (22.5%)
More important to answer quickly than get every answer correct	12 (15.0%)	10 (12.5%)
Just as important to be fast as it was to be accurate	45 (56.3%)	50 (62.5%)
Did not matter if fast or accurate	3 (3.8%)	1 (1.3%)

Table 18
Point-Biserial Correlations for Distributed and Blocked.

	Distributed		Blocked	
Outcome Measure	Correlations	Reliabilities	Correlations	Reliabilities
RTNeutral	.072	.848	.169	.758
RTCashCard	**-.497**	.329	**-.341**	.491
RTLieTruth	**-.348**	.671	**-.312**	.703
PropWrongNeutral	.106	.924	.014	.937
PropWrongCashCard	.093	.209	-.043	.113
PropWrongLieTruth	-.002	.690	.025	.738
NFixNeutral	**.256**	.950	.144	.931
NfixCashCard	**-.406**	.627	**-.335**	.318
NfixLieTruth	**-.293**	.720	**-.391**	.686
FirstPassNeutral	.177	.931	.078	.940
FirstPassCashCard	**-.253**	.540	-.188	.167
FirstPassLieTruth	-.166	.585	**-.232**	.535
RereadNeutral	.154	.921	.104	.919
RereadCashCard	**-.342**	.397	-.170	.004
RereadLieTruth	-.115	.407	**-.239**	.369
PDAreaNeutral	.024	.906	.167	.912
PDAreaCashCard*	**.586**	.615	**.274**	.080
PDAreaLieTruth*	**.554**	.639	.186	.278
PDLevelNeutral*	**-.339**	.869	-.006	.797
PDLevelCashCard	**.585**	.510	**.604**	.668
PDLevelLieTruth*	**.634**	.575	**.426**	.741
ItemBlinkRateNeutral	-.022	.935	.167	.939
ItemBlinkRateCashCard	**-.388**	.182	**-.261**	.130
ItemBlinkRateLieTruth	-.191	.101	**-.289**	.300
NextItemBlinkRateNeutral*	-.200	.705	.094	.830
NextItemBlinkRateCashCard	-.088	.351	-.119	.040
NextItemBlinkRateLieTruth	-.105	.381	**-.225**	.154

Note. Any correlation greater than .22 or less than -.22 was significant at $p < .05$ (in bold). RT = standardized response time, PropWrong = proportion wrong, NFix = number of fixations, FirstPass = time spend reading, Reread = time spent rereading, PDArea = pupil diameter area under the curve, PDLevel= standardized waveform before and after response, ItemBlinkRate= number of blinks per second on each item type, NextItemBlinkRate = number of blinks per second on the item following each item type, Neutral = response for neutral items, CashCard = difference between cash and credit card items, and LieTruth = difference between cash and mean of credit card/neutral (truthful) items. An * next to the ocular-motor measure indicates that the difference between the correlations for presentation formats was significant.

Table 19
Standardized canonical discriminant function coefficients

Relevant issue	Variable	Function
Distributed	PDAreaCashCard	.510
	PDLevelLieTruth	.462
	BlinkCashCard	-.225
	RTstandardizedCashCard	-.504
Blocked	NFixCashCard	-.433
	PDLevelCashCard	.916

Table 20
Frequencies (and percentages) of cases correctly classified with discriminant analysis

		Actual Group Membership	Predicted Group Membership		Total Correct
Original			Innocent	Guilty	
	Distributed	Innocent	36 (90.0)	4 (10.0)	
		Guilty	7 (17.5)	33 (82.5)	
		Total			86.3%
	Blocked	Innocent	34 (89.5)	4 (10.5)	
		Guilty	9 (22.5)	31 (77.5)	
		Total			83.3%
Jackknifed					
	Distributed	Innocent	36 (90.0)	4 (10.0)	
		Guilty	8 (20.0)	32 (80.0)	
		Total			85.0%
	Blocked	Innocent	33 (86.8%)	5 (13.2%)	
		Guilty	9 (22.5%)	31 (77.5%)	
		Total			82.1%

Table 21
Reliability and Correlation with Discriminant Scores for Individual Difference Measures

		Correlation		
	Number of Items	Innocent	Guilty	Reliability
BIS	7	.117	-.087	.749
BAS Reward Responsiveness	5	.114	-.168	.609
Emotion	5	.129	-.068	.660
Activity	5	.109	-.097	.678
Social	5	.129	-.147	.466
Impulse	5	.07	-.109	.700
2back *d*’	3 blocks	.017	-.018	.740
3back *d*’	3 blocks	.025	-.070	.737
Realism	2	.034	-.135	.325
Concentration	2	.048	-.071	.550
Worry about speed	2	-.08	-.087	.556

Table 21 Continued

	Number of Items	Innocent	Guilty	Reliability
Worry about accuracy	2	.076	-.057	.239
Motivation	2	.122	-.113	.233
Worry about cash items	2	.144	-.048	.364
Worry about card items	2	.136	-.026	.480
Worry about passing ODT	2	.14	-.069	.627

DISCUSSION

The present study evaluated the effects of guilt, blocking, practice with or without feedback, and interevent intervals on ocular-motor and behavioral measures. Zuckerman, DePaulo, and Rosenthal (1981, 1986) proposed a four-factor theory that posits that changes in deceivers' behavior are the result of four physiological processes: physiological arousal, emotional reactions, cognitive effort, and attempted control. The present study attempted to capitalize on the multidimensional nature of deception and contribute to our understanding of the theoretical basis behind the ODT.

Presentation Format

Overall classifications yielded 86.3% accuracy for the distributed format and 83.3% for the blocked presentation. The discriminant functions for distributed and blocked presentation included both reading measures and changes in pupil size. Although the differences between the two results were not statistically significant, there were a few factors that may have contributed to the difference between the groups in accuracy rates.

There were significant differences between distributed and blocked conditions on measures of reread duration, area under the pupil response, level, and blinks per item. Examination of PD waveforms relative to statement onset revealed that changes in pupil size were diagnostic and consistent with prior research for guilty participants in the distributed format but less so for the blocked format. Although important traditional

measures of pupil response were far less diagnostic in the blocked condition, there were, nevertheless, large, diagnostic dilations of the pupil over the course of a block of statements. Indeed, a discriminant function that produced 83% correct decisions for the blocked format consisted of only two variables, the most important of which was the diameter of the participants' pupils when they responded to the statement. Participants in the distributed condition blinked less than participants in the blocked format, and prior research indicated that eye blinks are suppressed under conditions of cognitive load (Siegle, Ichikawa, & Steinhauer, 2008; Stern, Walrath, & Goldstein, 1984). Finally, participants reported that they were less able to concentrate when items were distributed than when they were blocked.

Together, the pattern of observed differences suggests that participants found it easier to read and respond to test items when the items were blocked than when they were distributed. In the blocked condition, participant's pupil reactions to individual statements were not strongly affected by statement content. For guilty participants in particular, reactions to cash and credit card items were virtually indistinguishable. Blink rates were less suppressed and participants reported it was easier to concentrate in the blocked condition. All of these effects are consistent with the idea that the blocked format was cognitively less demanding than the distributed format.

If short-term, phasic increases in pupil size following the onset of test statements are considered indications of cognitive effort, then the observed effects of deception on pupil size measured the moment participants responded to the statement may reflect the emotional impact of the stimulus. For deceptive individuals, the blocked format provided opportunities to anticipate the presentation of incriminating test items. Although these

items did not command additional cognitive resources, they did produce large tonic effects on PD level. The possibility that area under the evoked pupil response following statement onset reflects a cognitive response, whereas absolute pupil size at the response (PD level) reflects an emotional response, would explain why both measures were diagnostic for the distributed format, but only PD level was diagnostic for the blocked format. The hypothesis is consistent with the finding that emotionality as measured by the EASI was positively correlated with PD level but not area under the evoke pupil response curve (PD area). If a reduction in the interval from participant response to the onset of the next item contributes to cognitive load, then the hypothesis that PD area reflects mental effort is also consistent with the finding that the difference between guilty and innocent groups was greatest at the shortest interevent interval. Finally, being indicators of different psychological processes also would explain why the two measures often make independent contributions to discriminant functions, as they did in the present study for the distributed group.

Pre-ODT Performance Feedback

Performance feedback during the pretest practice session did not affect response times but did reduce error rates. Performance feedback also resulted in larger phasic pupil reactions to test items for guilty participants and greater differences between pupil responses to cash and credit card items for guilty participants. It does not appear that anchoring occurred because performance feedback did not affect response times. Although the feedback did not have extensive effect s on multiple outcome measures, it reduced error rates and improved the diagnostic validity of one important index of cognitive effort.

An increase in the length of the interevent interval had no effect on the diagnostic validity of any ocular-motor measure. Predictably, measurements of area under the evoked pupil response curve increased with increased interevent intervals because the reactions were less truncated by the occurrence of the next stimulus. However, the PD area measures were no more diagnostic for longer interevent intervals. Likewise, new measures of PD level and blink rates obtained with extended scoring windows for longer interevent intervals were no more diagnostic than measures previously developed for 500 ms interevent intervals.

Individual Differences

The present study tested if BIS scores were more positively correlated with ocular-motor measures from guilty than from innocent participants. In the present study, I did not find that BIS scores were related to indications of deception, which differed from results obtained previously (Patnaik, 2013). It is unclear why the results from Patnaik (2013) did not replicate. Aside from the possibility that the previous result was a Type I error or the present finding was a Type II error, it is also possible that differences between the populations in age, intelligence, education, or SES account for the failure to replicate. The regression analysis indicated that higher levels of BAS Reward Responsiveness were associated with smaller pupil reactions during the ODT. Perhaps people who are more sensitive to cues for reward were less motivated to engage in the mock crime or the ODT, both of which are likely to be perceived as challenges, if not threats. Pupil responses for people with high reward responsiveness may be smaller than those for people less sensitive to reward, but because reward responsiveness did not interact with guilt, individual differences on this measure should not affect the diagnostic

validity of the test.

The emotional attribute measured by the EASI scale seems to be measuring emotions such as fear, frustration, and anxiety due to its strong relationship with BIS (Gray, 1990; Higgins, 1997). There was no correlation between self reported emotionality and ocular-motor responses to questions about the $20, even when the data were split between presentation formats. However, results indicated that the pupil was sensitive to emotionality and sociability. An interesting relationship was that sociability was negatively correlated with concern about the relevant items and general worry about passing the test. This may have to do with the findings that the most successful liars are sociable, socially skilled, and able to appear positive and confident (DePaulo, Kirkendol, Kashy, Wyer, & Epstein, 1996). Again, however, there was no significant relationship between emotionality and discriminant scores or between sociability and discriminant scores, and, therefore, no indication that individual differences on these measures would affect ODT outcomes.

Regression results indicated that performance on the 3-back WM task was negatively correlated with response time on the ODT. Participants who were better able to maintain characters in memory and distinguish target from nontarget events responded more quickly on the ODT. However, since WM performance did not interact with guilt, I would not expect it to affect the accuracy of the ODT.

There were significant differences between innocent and guilty participants on Realism, concern about the cash items, and General Worry. Innocent participants probably did not find the study as realistic as guilty participants because they could not be sure that someone actually stole $20 or credit card information. The fact that guilty

participants were concerned about answering questions about the $20 was reflected in pupil responses and general worry about passing the test. Differences between the guilty and innocent groups' ratings of concern and worry also are consistent with the idea that emotional processes are involved in the ODT.

The results from the present study were not exactly what I had predicted. Several factors may have contributed to these results. The population that was studied in the present study better represented the population of interest in field applications than do university students. The present study had an older average age and more varied levels of education than previous ODT studies. Even though the differences in ocular-motor measures were not as evident as predicted for the feedback and interevent interval manipulations, classification accuracy was comparable to that obtained in previous ODT studies, which suggests that the validity of the test is unaffected by a number of theoretically important individual difference dimensions.

Potential Impact

The results from this experiment could have significant implications for field applications. The federal government currently relies on the polygraph to screen applicants for positions in agencies concerned with national security, intelligence, and law enforcement. The polygraph also is used periodically to test employees with security clearances. Currently, there is a large backlog of applicants and employees in most federal organizations with polygraph programs because each polygraph examination takes several hours to administer by a federal examiner who requires months of training and continuing education. In contrast, the ODT is completely automated, it can be administered in about 40 minutes, there is no need for a highly trained examiner, and the

examinee is not subjected to an adversarial interview with a trained interrogator. Importantly, most laboratory data to date indicate that the ODT is at least as accurate as the polygraph. If the ODT is to be used in field settings, any increase in accuracy will improve the quality of hiring decisions in government organization and contribute to national security.

Limitations

The present study was a laboratory experiment. The ODT may be more or less effective in field situations where participants may be more highly motivated to pass the test, but high levels of experimental control are often difficult to achieve.

Another limitation was that the sample consisted mostly of single Caucasians. This sample may have been representative of the Utah population, but generalizations to the general population may be limited. If the ODT is to be used for security screening, it is important to ensure the results generalize to the populations of interest. The mock crime procedures in the present study were designed to maximize differences between truthful and deceptive participants on ocular-motor measures. Guilty participants committed an emotionally engaging and realistic mock crime, and then they denied their involvement on a deception test that took place immediately after commission of the crime. These procedures have been found to produce physiological reactions in polygraph examinations that are indistinguishable in most respects to those obtained from suspects in actual criminal investigations (Kircher et al., 1994). Whether or not these procedures produce ODT outcomes that are representative of those obtained in the field is unknown.

Because the ODT is administered by a computer, a number of examinees could be

tested simultaneously by a single proctor. In that scenario, the participants would work alone at a workstation until they complete the test. In the present study, the experimenter sat in the same small room with the participant while they completed the ODT. Whether the presence of the experimenter in the room contributes to evaluation apprehension and whether that affects the ODT also is unknown.

Implications and Future Directions

Results from the present study, Patnaik (2013), and Cook et al. (2012) suggest that a combination of behavioral and ocular-motor measures can be used to detect deception. These results were found in a mock-crime study similar to a forensic situation, but they also have potential for use in a security screening situation. In a security screening situation, participants are asked questions about several issues, and they may or may not be deceptive about one or more issues on the test. Future work should test if there are advantages or disadvantages to adding issues to the test.

Summary

Based on the present results, it appears that the distributed format is more effective than the blocked format. Feedback during the practice session had minimal effects on ODT outcomes. There was no evidence that changes in pupil size and eye blink rates were more diagnostic of deception for longer postanswer periods. Finally, there were no indications that any of the individual difference variables moderated the effects of deception on ocular-motor measures.

APPENDIX A

PHONE SCREEN DEMOGRAPHICS

The purpose of the study is to investigate ways to detect false information. If you decide to take part in the study, you may be asked to participate in a mock, or pretend, crime. The study has been approved by the University of Utah, and there is nothing illegal about your participation in this pretend crime. A lie-detection examiner will ask you questions about your possible involvement in a mock crime. Everyone who completes the study will receive $30, but if you can convince the examiner that you are innocent, you will receive another $30 for a total of $60.

Are you interested in participating?

1. Are you fluent in English?
2. Is English your primary language?
    a. If no, what is your primary language?
3. How old are you?
4. What is your gender?
5. Are you right- or left-handed?
6. What is your marital status?
7. What race do you identify with?
8. What is the highest level of school or degree you have completed?
9. Do you wear glasses or contacts for vision correction for reading?
10. Do you have any eye, heart, or mental health issues?
11. Have you ever participated in a deception study before?
12. How did you learn about the current study?

APPENDIX B

BIS/BAS QUESTIONNAIRE

BIS/BAS Scales

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

1 = very false for me
2 = somewhat false for me
3 = somewhat true for me
4 = very true for me

1. A person's family is the most important thing in life. 1 2 3 4
2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.
1 2 3 4
3. When I'm doing well at something I love to keep at it. 1 2 3 4
4. How I dress is important to me. 1 2 3 4
5. When I get something I want, I feel excited and energized. 1 2 3 4
6. Criticism or scolding hurts me quite a bit. 1 2 3 4
7. It is hard for me to find the time to do things such as get a haircut. 1 2 3 4
8. I feel pretty worried or upset when I think or know somebody is angry at me. 1 2 3 4
9. When I see an opportunity for something I like I get excited right away. 1 2 3 4
10. If I think something unpleasant is going to happen I usually get pretty "worked up."
1 2 3 4
11. I often wonder why people act the way they do. 1 2 3 4
12. When good things happen to me, it affects me strongly. 1 2 3 4
13. I feel worried when I think I have done poorly at something important. 1 2 3 4
14. I have very few fears compared to my friends. 1 2 3 4
15. It would excite me to win a contest. 1 2 3 4
16. I worry about making mistakes. 1 2 3 4

Scoring
Items 2 and 14 are reverse-scored
BIS: 2, 6, 8, 10, 13, 14, 16
BAS Reward Responsiveness: 2, 5, 9, 12, 15

APPENDIX C

EASI QUESTIONNAIRE

EASI Questionnaire

Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please answer quickly and honestly- there are no right or wrong answers. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following five response options:

1 = strongly disagree
2 = somewhat disagree
3 = neutral
4 = somewhat agree
5= strongly agree

1. I get upset easily.	1	2	3	4	5
2. I tend to cry easily.	1	2	3	4	5
3. I tend to be irritable.	1	2	3	4	5
4. I am easily frightened.	1	2	3	4	5
5. I am somewhat emotional.	1	2	3	4	5
6. I am always on the go.	1	2	3	4	5
7. I like to be off and running as soon as I wake up in the morning.	1	2	3	4	5
8. I like to keep busy most of the time.	1	2	3	4	5
9. For relaxation I prefer quiet, inactive pastimes to more active ones.	1	2	3	4	5
10. I am very energetic.	1	2	3	4	5
11. I like to be with others.	1	2	3	4	5
12. I make friends easily.	1	2	3	4	5
13. I tend to be shy.	1	2	3	4	5
14. I am independent of others.	1	2	3	4	5
15. I usually prefer to do things alone.	1	2	3	4	5
16. I tend to be impulsive.	1	2	3	4	5
17. I find self-control difficult.	1	2	3	4	5
18. I get bored easily.	1	2	3	4	5
19. I find it difficult to resist temptation.	1	2	3	4	5
20. I tend to hop from interest to interest quickly.	1	2	3	4	5

Scoring

Items 9, 13, and 15 are reverse scored
Emotion: 1-5
Activity: 6-10
Sociability: 11-15
Impulsivity: 16-20

APPENDIX D

POST-ODT QUESTIONNAIRE

Self-report Questionnaire

The test you took had two sections. The lie detection portion of the test asked about the theft of the credit card information, and the theft of $20, and the memory portion of the test asked if a number appeared earlier in a sequence. The following questions concern only the lie detection portion of the test, NOT the memory task. The computer already has completed its analysis and decided whether you were truthful or deceptive about the theft of the card or the $20. Your answers to the following questions will have no effect on that decision. We will place your answers in a file drawer and won't analyze them until we have completed data collection from at least 168 participants. Your candid responses to the following statements will help us understand how it felt to take the test.

Choose from the following five response options:

1 = strongly disagree
2 = somewhat disagree
3 = neutral
4 = somewhat agree
5= strongly agree

8. During the test, I was anxious even though I knew it was only an experiment. 1 2 3 4 5
14. The mock crime did not seem realistic to me. 1 2 3 4 5
3. It was easy for me to concentrate during the test. 1 2 3 4 5
15. My mind wandered sometimes while I took the test. 1 2 3 4 5
2. During the test, I worried that I might fail because I wasn't answering quickly enough.
1 2 3 4 5
6. I was not concerned about answering questions quickly. 1 2 3 4 5
4. During the test, I worried that I might fail because I was making too many mistakes.
1 2 3 4 5
10. I was not concerned about occasional wrong answers. 1 2 3 4 5
1. During the test, it really did not matter to me if I passed or failed. 1 2 3 4 5
12. I tried hard to pass the test. 1 2 3 4 5
5. I felt anxious when answering questions about stealing the $20. 1 2 3 4 5
9. When I saw a question about stealing the $20, I relaxed a bit. 1 2 3 4 5
11. When I saw a question about stealing the card, I relaxed a bit. 1 2 3 4 5
13. I felt anxious when answering questions about stealing the card. 1 2 3 4 5
7. During the test, I was confident that I would pass. 1 2 3 4 5
16. During the test, I felt like I was going to fail. 1 2 3 4 5

17. Circle one option that best reflects how you felt when you answered questions about the two thefts.

a. I was more anxious when answering questions about the card.
b. I was more anxious when answering questions about the $20.
c. I was equally anxious when answering questions about the card and the $20.
d. I wasn't concerned when I answered questions about the card or the $20.

18. Circle one option that best reflects what you thought as you took the test.

a. I thought it was more important to get the correct answer than to answer quickly.
b. I thought it was more important to answer quickly than to get every answer correct.
c. I thought it was just as important to be fast as it was to be accurate.
d. I did not think it would matter if I was fast or accurate.

19. Did you use any strategies for answering the questions to appear innocent? If so, please explain.

Any other comments?

Scoring
Items in parentheses reverse scored

Realism: 8, (14)
Concentration: 3, (15)
Speed: 2, (6)
Accuracy: 4, (10)
Motivation: (1), 12
Cash: 5, (9)
Card: (11), 13
General Worry: (7), 16

APPENDIX E

TRUE/FALSE STATEMENTS

Cash Items

True
I was uninvolved in the theft of the $20 from the secretary.
The wallet in the secretary's office was untouched by me.
I did not take anything from the wallet in the secretary's office.
The theft involving the purse was not my fault.
The article from the purse was not stolen by me.
The claim that I stole twenty dollars from a secretary is incorrect.
I am innocent of taking the secretary's property from the office.
I had nothing to do with the theft of the twenty dollars.

False
I am guilty of taking something from the secretary's office
The reason the $20 is gone is because I took it
The loss of the twenty dollars is no one's fault but mine
I did not leave the office until I had taken the item that was in the purse
I am not innocent of stealing the $20 from the secretary's purse
The claim that I did not take anything from the secretary is incorrect
The secretary's property was stolen from her wallet by me
I know what happened to the item missing from the wallet.

Credit Card Items

True
I was uninvolved in the theft of the credit card information.
The computer in the professor's office was untouched by me.
I did not take anything from the professor's computer.
The stolen credit card information is not in my possession.
The credit card information was not stolen by me.
The claim that I stole credit card information is incorrect.
I am innocent of taking anything from the professor's computer.
I am not guilty of taking the credit card information.

False
I made a copy of the professor's credit card.
The USB drive in my possession contains the copied information.
The theft of the credit card number is no one's fault but mine.
I did not pass up the chance to copy the credit card information.
I am not innocent of copying the credit card information.
The claim that I made a copy of the credit card information is not wrong.
The professor's credit card information is missing because of me.
I copied the credit card information from the computer.

Neutral Items

True
Many people over the age of forty drink coffee in the morning.
Gold, silver, and copper are metals that are mined from the earth.
Many people use computers to email to family and friends.
Mount Everest in Nepal is the tallest mountain in the world.
It takes a little more than 365 days for the earth to revolve around the sun.
Cardboard is commonly used in the construction of shipping containers.
Older people frequently wear eye glasses for reading.
Most doctors argue that regular diet and exercise is an effective way to lose weight.

False
I have never ridden in an automobile, truck, wagon, or cart of any kind.
Large trucks often get better gas mileage than newer compact cars.
Looking both ways before you cross the street is never a wise thing to do.
Looking at the sun is not harmful to human eyes.
Japan is an island in the Atlantic Ocean between Africa and South America.
Beethoven was a well-known French Impressionist painter.
New Year's Day always falls on the fifteenth of January.
The Great Barrier Reef is located in the Gulf of Mexico.

APPENDIX F

CORRELATIONS BETWEEN DISCRIMINANT SCORES AND SCALE SCORES FOR INNOCENT AND GUILTY PARTICIPANTS WHO RECEIVED DISTRIBUTED OR BLOCKED FORMAT ON THE ODT

Table 22
Correlations between Discriminant scores and scale scores for innocent and guilty participants for distributed and blocked format on the ODT

			Correlation
BIS	Distributed	Innocent	.071
		Guilty	-.298
	Blocked	Innocent	.097
		Guilty	.124
BAS	Distributed	Innocent	.001
		Guilty	-.370*
	Blocked	Innocent	.116
		Guilty	-.110
Emotion	Distributed	Innocent	.085
		Guilty	.091
	Blocked	Innocent	.119
		Guilty	-.036
Activity	Distributed	Innocent	.140
		Guilty	.059
	Blocked	Innocent	-.086
		Guilty	-.147
Sociability	Distributed	Innocent	.121
		Guilty	-.236
	Blocked	Innocent	.040
		Guilty	-.135
Impulsivity	Distributed	Innocent	-.104
		Guilty	-.099
	Blocked	Innocent	.02
		Guilty	-.068
2-back Accuracy	Distributed	Innocent	-.348*
		Guilty	-.107
	Blocked	Innocent	-.216
		Guilty	-.059
2-back RT	Distributed	Innocent	-.016
		Guilty	-.296
	Blocked	Innocent	-.007
		Guilty	.057
3-back Accuracy	Distributed	Innocent	-.253
		Guilty	-.035
	Blocked	Innocent	-.073
		Guilty	-.003
3-back RT	Distributed	Innocent	-.154
		Guilty	-.293
	Blocked	Innocent	-.025
		Guilty	-.048
Motivation	Distributed	Innocent	.183

		Guilty	-.115
	Blocked	Innocent	-.141
		Guilty	-.042
Speed	Distributed	Innocent	-.212
		Guilty	-.056
	Blocked	Innocent	.131
		Guilty	-.021
Concentration	Distributed	Innocent	-.052
		Guilty	-.095
	Blocked	Innocent	-.120
		Guilty	.070
Realism	Distributed	Innocent	-.313*
		Guilty	-.187
	Blocked	Innocent	.056
		Guilty	-.122
Accuracy	Distributed	Innocent	-.194
		Guilty	-.016
	Blocked	Innocent	.151
		Guilty	.079
Cash	Distributed	Innocent	-.039
		Guilty	-.072
	Blocked	Innocent	.317
		Guilty	.139
Card	Distributed	Innocent	.030
		Guilty	.023
	Blocked	Innocent	.230
		Guilty	.157
General Worry	Distributed	Innocent	-.069
		Guilty	.105
	Blocked	Innocent	.305
		Guilty	-.050

APPENDIX G

EFFECT SIZES FOR EACH DEPENDENT VARIABLE

Table 23
Effect Sizes for Response Time

Source	Effect Size
Guilt	
Statement type	.589
Feedback	
PresFormat	
Interval	
Sex	
Guilt X Statement type	.030
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Statement type X Feedback	
Statement type X PresFormat	.050
Statement type X Interval	
Statement type X Sex	
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Interval X Sex	.031
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	
Guilt X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	

Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 24
Effect Sizes for Proportion Wrong

Source	Effect Size
Guilt	
Statement type	.276
Feedback	.053
PresFormat	
Interval	.059
Sex	
Guilt X Statement type	
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Statement type X Feedback	
Statement type X PresFormat	
Statement type X Interval	
Statement type X Sex	
Feedback X PresFormat	
Feedback X Interval	.032
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	.031
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Interval X Sex	

Guilt X Feedback X PresFormat X Interval	.035
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	.037
Guilt X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 25
Effect Sizes for Number of Fixations

Source	Effect Size
Guilt	.043
Statement type	.355
Feedback	.092
PresFormat	
Interval	
Sex	.035
Guilt X Statement type	.035
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Statement type X Feedback	
Statement type X PresFormat	.027
Statement type X Interval	
Statement type X Sex	
Feedback X PresFormat	
Feedback X Interval	.045
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	.034
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	

Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Interval X Sex	.029
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	.060
Guilt X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 26
Effect Sizes for First Pass Duration

Source	Effect Size
Guilt	
Statement type	.448
Feedback	.070
PresFormat	
Interval	
Sex	.059
Guilt X Statement type	
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Statement type X Feedback	
Statement type X PresFormat	.027
Statement type X Interval	
Statement type X Sex	.026
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	

Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Interval X Sex	
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	
Guilt X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 27
Effect Sizes for Reread Duration

Source	Effect Size
Guilt	
Statement type	.592
Feedback	.075
PresFormat	
Interval	
Sex	.030
Guilt X Statement type	
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	.042
Statement type X Feedback	
Statement type X PresFormat	.060
Statement type X Interval	
Statement type X Sex	.024
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	

Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	.028
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	.033
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	.027
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Interval X Sex	
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	.072
Guilt X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 28
Effect Sizes for Area under the Pupil Response Curve

Source	Effect Size
Guilt	
Statement type	.568
Feedback	
PresFormat	
Interval	
Sex	
Guilt X Statement type	.098
Guilt X Feedback	.060
Guilt X PresFormat	
Guilt X Interval	.034
Guilt X Sex	

Statement type X Feedback	
Statement type X PresFormat	.029
Statement type X Interval	
Statement type X Sex	
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	.021
Guilt X Statement type X PresFormat	.038
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Interval X Sex	
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	
Guilt X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 29
Effect Sizes for Level at Response Onset

Source	Effect Size
Guilt	
Statement type	.695
Feedback	

PresFormat	
Interval	
Sex	
Guilt X Statement type	.144
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Statement type X Feedback	
Statement type X PresFormat	.030
Statement type X Interval	
Statement type X Sex	
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	.039
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	.024
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	.029
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	.037
Guilt X Statement type X Interval X Sex	
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	
Guilt X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 30
Effect Sizes for PD

Source	Effect Size
Guilt	
Statement type	.507
Feedback	
PresFormat	
Interval	
Sex	
Time	.048
Guilt X Statement type	
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Guilt X Time	
Statement type X Feedback	
Statement type X PresFormat	.155
Statement type X Interval	
Statement type X Sex	.030
Statement type X Time	.429
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
Feedbac k X Time	
PresFormat X Interval	
PresFormat X Sex	
PresFormat X Time	
Interval X Sex	
Interval X Time	
Sex X Time	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	.031
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Statement type X Time	.041
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X Feedback X Time	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X PresFormat X Time	
Guilt X Interval X Sex	
Guilt X Interval X Time	
Guilt X Sex X Time	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	
Statement type X Feedback X Time	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Statement type X PresFormat X Time	.073
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	

Feedback X PresFormat X Time	
Feedback X Interval X Sex	
Feedback X Interval X Time	
Feedback X Sex X Time	
PresFormat X Interval X Sex	
PresFormat X Interval X Time	
PresFormat X Sex X Time	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Feedback X Time	
Guilt X Statement type X PresFormat X Interval	
Guilt X Statement type X PresFormat X Sex	
Guilt X Statement type X PresFormat X Time	.023
Guilt X Statement type X Interval X Sex	
Guilt X Statement type X Interval X Time	
Guilt X Statement type X Sex X Time	
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X PresFormat X Time	
Guilt X Feedback X Interval X Sex	
Guilt X Feedback X Interval X Time	
Guilt X Feedback X Sex X Time	
Guilt X PresFormat X Interval X Sex	
Guilt X PresFormat X Interval X Time	
Guilt X PresFormat X Sex X Time	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X PresFormat X Time	
Statement type X Feedback X Interval X Sex	
Statement type X Feedback X Interval X Time	
Statement type X Feedback X Sex X Time	
Statement type X PresFormat X Interval X Sex	
Statement type X PresFormat X Interval X Time	
Statement type X PresFormat X Sex X Time	
Feedback X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Time	
Feedback X PresFormat X Sex X Time	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X PresFormat X Time	
Guilt X Statement type X Feedback X Interval X Sex	
Guilt X Statement type X Feedback X Interval X Time	
Guilt X Statement type X Feedback X Sex X Time	
Guilt X Feedback X PresFormat X Interval X Sex	
Guilt X Feedback X PresFormat X Interval X Time	
Guilt X Feedback X PresFormat X Sex X Time	
Guilt X PresFormat X Interval X Sex X Time	
Statement type X Feedback X PresFormat X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Time	
Statement type X Feedback X PresFormat X Sex X Time	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Time	
Guilt X Statement type X Feedback X PresFormat X Sex X Time	
Guilt X Feedback X PresFormat X Interval X Sex X Time	

Guilt X Statement type X Feedback X PresFormat X Interval X Sex X Time	

Table 31
Effect Sizes for Item Blink Rate

Source	Effect Size
Guilt	
Statement type	.043
Feedback	
PresFormat	.041
Interval	
Sex	.034
Guilt X Statement type	.057
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Statement type X Feedback	
Statement type X PresFormat	
Statement type X Interval	
Statement type X Sex	
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	.026
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	.023
Statement type X Feedback X Sex	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	
PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Statement type X Interval X Sex	
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	
Guilt X PresFormat X Interval X Sex	

Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	.027
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

Table 32
Effect Sizes for Next Item Blink Rate

Source	Effect Size
Guilt	
Statement type	
Feedback	
PresFormat	.042
Interval	
Sex	
Guilt X Statement type	.030
Guilt X Feedback	
Guilt X PresFormat	
Guilt X Interval	
Guilt X Sex	
Statement type X Feedback	
Statement type X PresFormat	
Statement type X Interval	
Statement type X Sex	.025
Feedback X PresFormat	
Feedback X Interval	
Feedback X Sex	
PresFormat X Interval	
PresFormat X Sex	
Interval X Sex	
Guilt X Statement type X Feedback	
Guilt X Statement type X PresFormat	
Guilt X Statement type X Interval	
Guilt X Statement type X Sex	
Guilt X Feedback X PresFormat	
Guilt X Feedback X Interval	.036
Guilt X Feedback X Sex	
Guilt X PresFormat X Interval	
Guilt X PresFormat X Sex	
Guilt X Interval X Sex	
Statement type X Feedback X PresFormat	
Statement type X Feedback X Interval	
Statement type X Feedback X Sex	
Statement type X PresFormat X Interval	
Statement type X PresFormat X Sex	
Feedback X PresFormat X Interval	
Feedback X PresFormat X Sex	
Feedback X Interval X Sex	.051
PresFormat X Interval X Sex	

Guilt X Statement type X Feedback X PresFormat	
Guilt X Statement type X Feedback X Interval	
Guilt X Statement type X Feedback X Sex	
Guilt X Feedback X PresFormat X Interval	
Guilt X Feedback X PresFormat X Sex	
Guilt X Feedback X Interval X Sex	
Guilt X PresFormat X Interval X Sex	
Guilt X Statement type X Interval X Sex	
Statement type X Feedback X PresFormat X Interval	
Statement type X Feedback X PresFormat X Sex	
Statement type X Feedback X Interval X Sex	
Statement type X PresFormat X Interval X Sex	
Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval	
Guilt X Statement type X Feedback X PresFormat X Sex	
Guilt X Statement type X Feedback X Interval X Sex	.035
Statement type X Feedback X PresFormat X Interval X Sex	
Guilt X Statement type X Feedback X PresFormat X Interval X Sex	

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