# EYE MOVEMENTS AND OTHER COGNITIVE CUES TO REHEARSED AND UNREHEARSED DECEPTION WHEN INTERROGATED ABOUT A MOCK CRIME

**Jeffrey J. Walczyk, Diana A. Griffith, Rachel Yates, Shelley Visconte, and Byron Simoneaux**
**Louisiana Tech University**

Accurate lie detection is crucial for fighting terrorism and for advancing justice. New theoretically-undergirded methods are needed to replace the polygraph-based Control Question Test (National Research Council, 2003). We tested a promising one in a mock crime, *Time Restricted Integrity-Confirmation* (Walczyk et al., 2005), which selectively induces cognitive load on liars. Also, for the first time, the effects of rehearsal, a likely load-reducing countermeasure, were assessed on the cognitive cues of response times, answer wordiness and consistency, eye movement, and pupil dilation. After "stealing" money during a job interview, participants were randomly assigned to either a truth telling, an unrehearsed lying, or a rehearsed lying condition and then were interrogated. Among the important findings were that truthful answers to multiple-response questions (versus yes/no) were quicker than deceptive answers. Liars had wordier answers, especially when rehearsed, and more inconsistencies. Truth tellers had the fewest eye movements and rehearsed liars had the most, suggesting that liars may be able to reduce cognitive load by briefly breaking eye contact with another. Discriminant analyses revealed liar-truth teller classification accuracies from 67% to 84%, with few false positives.

*Keywords*: deception and cognition, cognitive lie detection, eye movements and lying

Although occasionally used in investigations, the results of polygraph-based lie detection exams are largely inadmissible in criminal court cases (Lykken, 1998). In particular, the validity of the Control Question Test (CQT), the questioning paradigm used most often, was criticized on several grounds in a 2003 report by the National Research Council. The criticism relevant here is that the CQT is not based on a valid theory of deception. Rather, it is grounded on the dubious assumption that dishonesty produces more sympathetic nervous system arousal than honesty. In response, innovative cognitive approaches to lie detection have been proposed recently that attempt to make lying more difficult than truth telling (e.g., Vrij, Fisher, Mann, & Leal, 2008; Walczyk et al., 2005), but lack a strong theoretical foundation (Vrij, Granhag, & Porter, 2010a). The development of well-specified, validated cognitive accounts of deception might provide foundations for emerging cognitive lie detection technologies that overcome this criticism.

In this article, we advance theoretical understanding of the cognition of deception and refine a technique that induces cognitive load (i.e., increases demand for attention and working memory) selectively on liars. Doing so can amplify the cues to deception (Vrij

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et al., 2008; Walczyk et al., 2005) and might furnish the criminal justice system with new forensic tools. We tested *Time Restricted Integrity-Confirmation* (TRI-Con; Walczyk et al., 2005) for the first time in a mock crime experiment. Also, the act of preparing and rehearsing deception before interrogation with liars is likely to attenuate cognitive load, a fact that developers of load-inducing approaches have largely overlooked (see Vrij et al., 2010a for a review). For the first time, we examined the effects of rehearsal on the cognitive cues of response time, answer wordiness and consistency, eye movements, and pupil dilation.

Researchers have long inquired about the cognition of deception (e.g., McCornack, 1997; Zuckerman, DePaulo, & Rosenthal, 1981) and recently have sought to advance cognitive lie detection (Gombos, 2006; Sporer & Schwandt, 2006; Vrij, Fisher, Mann, & Leal, 2006; Walczyk, Roper, Seemann, & Humphrey, 2003). A cognitive account of deception relevant to lie detection is the *Activation-Decision-Construction Model* (ADCM) of Walczyk and colleagues (2003; 2005; 2009), which is the theoretical foundation of TRI-Con. The ADCM analyzes the act of answering questions deceptively into three components. First, a question heard or read activates the "truth" from long-term memory (LTM), usually automatically. Second, based on the truth and social context, a decision to lie may occur, usually to advance liars' interests. Truthful answering then will be actively inhibited, especially when well-practiced. Third, a context-appropriate lie is constructed, constrained to be internally coherent, plausible, and advance the liar's goals. Often, memories of actual life experiences or scripts are recalled from LTM and modified in working memory for this purpose (Leins, Fisher, & Ross, 2013; Malone, Adams, Anderson, Ansfield, & DePaulo, 1997; Sporer & Schwandt, 2006, 2007; Walczyk et al., 2003). Once ready, the lie can be disclosed to the target. One caveat, work by Loftus (2007) and others shows that memory errors are common for witnessed events. Consequently, retrieved "truths" may not be entirely accurate, which is not a problem. The ADCM concerns deceptive representations of what individuals believe is true.

Elements of the ADCM have been supported. Walczyk et al. (2003) found when participants answered general questions deceptively that most reported that the truth entered working memory automatically and interfered with lying, consistent with the activation and decision components. Walczyk, Mahoney, Doverspike, and Griffin-Ross (2009) demonstrated that individuals lying about well practiced truths had the greatest difficulty due to a Stroop-like interference compared to lying about truth recently encoded. In having participants answer questions about various aspects of their lives either deceptively or truthfully, Walczyk et al. (2005) showed that the act of deciding to lie adds to cognitive load, and constructing a lie imposed greater load than truth telling, as predicted.

The rehearsal of deception is addressed by the ADCM (Walczyk et al., 2009). Practicing deceptive answers transforms "decide to lie" to "remember to lie." The question serves as the memory cue. "Lie construction" becomes "lie recall," followed by appropriate tweaking to fit the social context. The extended practice of deceptive answering can lower cognitive load below that of truth telling (Greene, O'Hair, Cody, & Yen, 1985; O'Hair, Cody, & McLaughlin., 1981). Slight rehearsal, though, may impose the same or even higher cognitive loads (Walczyk et al., 2009). When insufficiently practiced, lying is a

novel response. Recalling it will require more explicit searching than truth retrieval, which is usually automatic (Solso, 2001). Finally, the opportunity to rehearse lies allows them to be more detailed and verbally elaborate than unrehearsed lies or perhaps even truths.

We now expand the ADCM to account cognitively for eye movements in lying, a new potential cue. Eye saccades and fixations typically occur automatically, but can be intentional (Rayner, 1998). By the ADCM, controlling eye movements allows liars to reduce cognitive load in two ways. First, a heavy load is imposed by having to generate a novel, deceptive answer that satisfies multiple constraints. In such cases, eyes will be fixated on a non-distracting stimulus (e.g., a white wall) so that attention can be easily focused on memory retrieval and other internal processes (Doherty-Sneddon, Burce, Bonner, Longbotham, & Doyle, 2002; Doherty-Sneddon & Phelps, 2005; Glenberg, Schroeder, & Robertson, 1998). Second, experiencing high levels of anxiety can impose load and reduce available cognitive resources (Beilock & Carr, 2005; Eysenck, 1992), which occurs in high stakes lying (e.g., a murder suspect under police interrogation, Vrij, 2000) and with identity-relevant lies. The latter are told to protect liars' positive images (DePaulo et al., 2004; Vrij, 2000). When telling such lies and when eye contact is expected, more eye movement is predicted as individuals break eye contact to reduce anxiety (Vrij, Mann, Leal, & Fisher, 2010b), which will also increase the cognitive resources to lie well (Beilock & Carr, 2005; Eysenck, 1992).

***Inducing Cognitive Load by Reducing the Rehearsal of Lying***

Unrehearsed liars convey the richest cues to deception, such as frequent and long pauses (Bond & DePaulo, 2006; Littlepage & Pineault, 1985). Rehearsal-reducing approaches to lie detection try to catch examinees off guard, for example, by asking unanticipated questions about spatial details of an alibi (Vrij et al., 2009). TRI-Con, another such approach, surprises examinees with questions and adds load to lying in other ways suggested by the ADCM (Walczyk et al., 2005). Specifically, (a) before questioning, examinees are prompted about the focus of the questions to follow (e.g., "The next 11 questions concern your relationship with the suspect."). By priming relevant episodic memories, prompting reduces the need for truth tellers to search memory explicitly to answer honestly, making response time and other indices of cognitive load clearer cues to deception. (b) The specific questions are not disclosed until asked during an exam to reduce the rehearsal of lies. (c) Questions should be answerable with one or two words, which makes ascertaining the time needed to respond clear compared to longer answers. Response time is an important cue to deception. (d) Examinees are instructed to answer as quickly as possible to limit their chance to generate lies. (e) Under TRI-Con, logically interrelated questions are asked to increase the cognitive load of unprepared liars and provoke contradictions. Recall that during the ADCM's construction component, liars seek to generate lies that are internally coherent. (f) When possible, examinees should be instructed to maintain eye contact with another, which can cause lies to manifest as slower speech (Vrij et al., 2010b).

Although TRI-Con seeks to minimize it, the rehearsal of deception is not entirely preventable and is a likely load-reducing countermeasure (Lykken, 1998). Still, few studies have examined the effects of rehearsal on cues (DePaulo et al., 2003). For instance, in

a recent meta-analysis of nonverbal cues to deception, Sporer and Schwandt (2007) sought to include rehearsal as a moderator but "found too few studies that had manipulated this variable to allow meaningful comparison" (p. 9). The rehearsal of deceptive answering lowers response times and inconsistencies compared to unrehearsed lying (Walczyk et al., 2009), but much more research is needed on its effects on these and other cognitive cues.

***The Present Study***

Walczyk et al. (2005, 2009) tested TRI-Con using response time and inconsistencies as cues. This research expands on their findings by testing the utility of eye data combined with other cognitive cues under TRI-Con and, importantly, evaluates the effects of rehearsal on all of these cues in the quasi-authentic context of a mock crime. Rehearsal is likely in high stakes lying before perpetrators are interrogated (Vrij, 2000), and may be detectable.

In a mock crime adapted from Gronau, Ben-Shakhar, and Cohen (2005), our participants adopted the role of an applicant for "research associate" in the psychology department. The interviewer asked routine questions and then left her office briefly mid-interview. Interviewees then stole money from her desk. Following the interview, they were interrogated in an eye tracking laboratory after being instructed to answer all questions truthfully or answer theft-related questions deceptively unrehearsed or deceptively following rehearsal. The cognitive indices were chosen carefully, each assessing important aspects of cognitive load. Response time and pupil dilation are direct measures of cognitive load or the extent of processing (Solso, 2001). The wordiness and consistency of answers are the outputs of processing (DePaulo et al., 2003). By the ADCM, movement of the eyes allow examinees to reduce cognitive load either by fixating on a neutral stimulus to minimize environment distraction (Glenberg et al, 1998) or by breaking eye contact to lower anxiety (Vrij et al., 2010b).

Lie detection accuracy can be enhanced by establishing behavioral base rates of truth telling to compare with suspected deceptive responding for each cue (Bond & DePaulo, 2006). In this research, *general questions*, answered truthfully by all participants, provided ground-truth benchmarks. *Relevant questions* addressed misconduct that might have occurred during the interview and were answered deceptively or truthfully. *Control questions* were all other interview-related questions answered truthfully, providing different ground-truth benchmarks. We implemented Walter's (1996) recommendation to control for individual differences in behavioral base rates by subtracting means of general questions or control questions from means of relevant questions to see which made better ground-truth benchmarks (see Vrij et al., 2010a). Four hypotheses and justifications appear below, one for each cue except inconsistencies, which is a well-established sign of deception (Granhag & Hartwig, 2008).

**H1: Unrehearsed liars will take longer than rehearsed liars; truth tellers will answer the quickest.** Studies show that unrehearsed lying takes longer than truth telling (see DePaulo et al., 2003; Seymour, Seifert, Shafto, & Mosmann, 2000), and rehearsal can reduce the time to lie (Greene et al., 2005; O'Hair et al., 1981; Walczyk et al., 2009). Per

the ADCM, the slight rehearsal of this study should not lower response time below that of truth tellers.

**H2: Rehearsed liars will have wordier answers than unrehearsed liars, and both will be wordier than truth tellers.** Reflecting both anxiety and cognitive load, deceptive answers can be wordier than truthful ones (DePaulo et al., 2003; Harrison, Hwalek, Raney, & Fritz., 1978). Although we found no studies of the effects of rehearsal on the wordiness of deceptive answers given under time restriction, the ADCM predicts that rehearsal will allow examinees to prepare more elaborate, wordier lies.

**H3: When telling identity-relevant lies, unrehearsed liars will move their eye more than rehearsed liars, who will move them more than truth tellers.** For those assigned to the lying conditions, the lies were high in identity-relevance (DePaulo et al., 2004). Liars had to cover their own "criminal misdeeds" while maintaining eye contact with a stranger. Vrij et al. (2010b) found that such instructions increased cognitive load on liars and resulted in more cues to deception. Researchers videotaped examinees and later coded for the extent of sustained eye contact. We measured precisely eye movements with an eye tracker as participants answered. Instructions to maintain eye contact should increase load by elevating anxiety and self-monitoring in liars. As a load and anxiety reducing countermeasure, liars are expected to break eye contact, manifesting as more eye movements. Unrehearsed liars should do so the most. Under less cognitive load due to having prepared lies, rehearsed liars will move eyes less frequently, but more than truth tellers.

**H4: Unrehearsed liars will have more pupil dilation than rehearsed liars, with truth tellers demonstrating the least dilation.** Studies have demonstrated more pupil dilation with lying, likely due to its greater cognitive load and anxiety (Bradley & Janisse, 1979; Dionisio, Granholm, Hillix, & Perrine., 2001; Heilveil, 1976; Lubow & Fein, 1996; Zuckerman, DeFrank, Hall, Larrance, Rosenthal, 1979; Webb, Honts, Kircher, Bernhardt, & Cook, 2009), which the ADCM also predicts. Studies have not examined how rehearsal affects pupil dilation for deceptive answers. It is expected to be lower than that of unrehearsed liars.

## METHOD

### *Participants*

A total of 138 college students were recruited from psychology classes and received extra credit. The sample was 107 white (76%), 24 black (17%), and 7 Latino (5%); 74 were female (54%). The mean age was 21.43, *SD* = 2.47. All spoke English fluently.

### *General Procedure*

This research was approved by the university's IRB. Participants were tested individually, each session lasting about 30 minutes. There were two experimenters, a greeter and an examiner. Each performed dual roles. After obtaining informed consent, the greeter handed a hardcopy of the instructions to participants and read them aloud. She instructed participants to adopt the role of an applicant for "research associate" and told them they

would be escorted to the office of the "Research Director" for the interview. They were told that if at any time the interviewer left the office, they were to act as opportunistic thief, rifle through her desk, steal any money, then finish the interview on her return. After, they were taken to the interview. The interviewer followed a script by first introducing herself and then asking appropriate questions (e.g., What was your last job?). Following the fifth question, she excused herself and indicated she would be back shortly, a cue to participants to search through her desk. Each drawer contained an envelope marked with an A, B, or C, each with different contents (A-$5, B-rubber bands, C-paper clips) and were located in such a way that envelope A would likely be found last. Upon returning, the interviewer finished the interview, escorted participants to outside the eye tracking lab, and went inside to run the eye tracker.

The greeter instructed all participants to continuously maintain eye contact during the interrogation, answer questions quickly (consistent with TRI-Con guidelines) and answer the general questions truthfully. Participants then were randomly assigned to one of three conditions. *Truth tellers* were further instructed to answer all questions about the interview truthfully. *Unrehearsed liars* were told to answer questions about the interview truthfully, except those about going through the desk or stealing the money, and to make sure all answers were logically consistent. Inherent to rehearsing before interrogation is having prior exposure to or guessing the questions to be asked so that lies can be prepared (Lykken, 1998). Accordingly, *rehearsed liars* received the same instructions as unrehearsed liars but received a copy of the nine relevant questions and were given three minutes for preparing lies. Pilot testing on eight college students otherwise uninvolved in this research revealed this time to be adequate. Allowing liars to read rather than listen to questions prevented liars from forgetting them because they were always visible. Such rehearsal is ecologically valid in that polygraph examiners typically preview questions with examinees before testing (Lykken, 1998). Next, the greeter ushered participants into the eye tracking lab and sat directly in front of them, made direct eye contact and reminded participants to do the same as needed, which occurred rarely. Following the exam, the greeter retrieved the pilfered money outside the lab. All participants had "stolen" it. Lastly, a post-experiment questionnaire and debriefing were administered.

***Sets & Categories of Questions***

Two sets of questions were written, *general* and *interview*. Some questions of each set were yes/no; others were multiple-response. All 36 appear in the Appendix and are answerable with a word or two. Some pairs were written to be logically interrelated (see Appendix). The 17 general questions probed information about participants or general knowledge. Boldfaced questions concern facts that could be verified to ensure compliance with instructions to answer truthfully. The 19 interview questions addressed what happened during the interview, details of the office, or probed potential misconduct. For the statistical analyses, three *categories of questions* are defined: *general questions*, *control question* (interview questions not probing misconduct, and *relevant questions* (probing misconduct and italicized in the Appendix). Participants of the two lie conditions lied to the relevant questions alone. Audacity version 1.3.8, an open source audio recording and

editing software (http://audacity.sourceforge.net), was used to record the instructions that preceded each question set, the prompts for the questions, and the 36 questions. A woman recorded these in a clear, loud voice. A JAVA program presented the prompts, followed by the appropriate questions in their order of appearance in the Appendix.

***Eye Tracking Laboratory (ETL) 400 and the Interrogation Task***

The ETL 400 Tabletop Remote Infrared eye tracking system (ISCAN, Inc., Woburn, MA) assessed pupil dilation and eye movements. It measured examinees' precise focal point on the calibration stimulus, known as the Point of Regard. A Dell desktop computer ran the JAVA program, which presented the instructions and questions, recorded answers, and stored response times as measured to the millisecond by a voice key. Participants wore a microphone headset. Any noise following the question, usually the answer, caused the voice key to trip, the timing loop to end, and a beep. When the noise was not the answer, then the recording allowed answer response times to be determined using Audacity software.

Participants' chins were positioned on a head stand exactly 18" in front of the camera, the latter beneath their view. They maintained eye contact with the greeter, who sat four feet in front of them. The ETL 400 was first calibrated using the four corners on a rectangle 29" wide by 23" tall on the wall behind the greeter. The eye tracker imposed a virtual coordinate system of pixels corresponding to the center of participants' fovea. The origin was in the upper, left hand corner (horizontal=0, vertical=0). The bottom, right had maximum coordinates (horizontal=511, vertical=511). The greeter sat such that her eyes were about in the middle of the rectangle. Throughout, the ETL 400 took 60 "snapshots" of the right eye per second. In each, the pupil dilation and Point of Regard were measured. Statistics for pupil dilation and eye movements of Tables 3 through 5 are expressed in pixels. For each test question, the eye data we analyzed started with the beginning of the question and terminated when the voice key tripped, that is, for the full *question-answer event*. The mean pupil dilation during that interval was used. Per the recommendation of ISCAN, Inc., the *SD* of changes in Point of Regard was determined for each question-answer event to index eye movement. A smaller *SD* indicates more stationary eyes.

***Transcribing Recordings, Checking Consistency & Compliance, & Tallying Words***

A graduate assistant (GA) transcribed all recordings. Rarely were answers inaudible. Transcriptions were then coded for the number of inconsistencies within a question set. An inconsistency occurred if the second answer of an interrelated pair was implausible if the first one was assumed true. For example, one participant answered "B" to question 24 "If any, which envelope, A, B, or C, had the money?" and then answered "No" to question 33, "Did you open up any envelopes in the desk?", an obvious inconsistency. The first question might have been answered "I don't know" to avoid it. To check inter-rater reliability, copies of 40 randomly selected transcriptions were independently coded by the GA and by another GA. Pearson correlations between inconsistency totals for the general and interview questions were .77 and .86, respectively, large enough to justify the first GA coding all others on her own (Anastasi & Urbina, 1997). Her total interview inconsistency scores are used in the discriminant analyses. Next, the GA used the transcriptions to tally the number of words needed to answer each question, which included words repeated, di-

gressions, and interjections. Yes/no questions were sometimes answered with two or more words (e.g., "Of course not!").

The transcriptions were checked for whether all participants answered truthfully the boldfaced general questions. No one answered more than two incorrectly and with few inconsistencies. Instructions were generally followed. Also, a post-experiment questionnaire in hardcopy listed the 19 interview questions with instructions to answer them truthfully. Across conditions, the mean number of interview questions answered correctly was 16.56, $SD$ = 1.45. Students occasionally did not encode a detail or forgot it. Clearly participants had truths in memory. Moreover, comparing the questionnaires with the transcriptions, we determined that participants generally answered truthfully the control questions except for the occasional "I don't know." Data for the latter and for control questions answered with lies (< 3% of questions across liars) were treated as missing. All truth tellers answered relevant questions honestly or with "I don't know." All rehearsed liars answered relevant questions deceptively. Unrehearsed liars occasionally answered relevant question truthfully (< 5% of questions), and data was treated as missing.

***Summarizing Data for Each Category of Question***

For each question-answer event, there was a response time, a mean for pupil dilation, an eye movement *SD*, and a total word count. These data were summarized for hypothesis testing as follows. Because yes/no and multiple-response questions differ in their syntactic constraints on permissible responses, Walczyk et al. (2005) recommend analyzing the data of each question type separately, which we did. Within each of the three question categories (e.g., relevant), the mean pupil dilation for yes/no questions was determined, as well as for multiple-response questions. Within each question category and question type, the mean eye movement *SD* and the mean wordiness were determined. Because response times tend to be positively skewed (Solso, 2001), the median response time within each question category and question type was used.

## RESULTS

The main statistical procedure was a 2 (question type) x 3 (lie condition) mixed ANOVA. When significant main effects occurred for lie condition, which were only expected for relevant questions, the Studentized-Newman-Keuls procedure showed which means were significantly different. Effect sizes (Cohen's *d*, Hays, 1994) are reported in the tables. ANOVA results for simple main effect tests following an interaction are only reported if significant. Finally, for each cue below, the first analysis conducted included gender as a factor. No main effects for gender were found, nor gender-related interaction. Thus, we collapsed across gender for all analyses. An $\alpha$ of .05 was used throughout, except where otherwise noted.

***H1: Response Time***

Statistics for response times appear in Table 1. Condition *N*s are boldfaced, with no missing data. For the relevant questions, multiple-response questions took longer than yes/no questions, $F(1,135) = 104.40$, $p = .001$, $\eta = .436$ (yes/no $M = 482.26$, multiple-response

*M* = 765.18, Cohen's *d* = .91). Lie condition had a significant effect, $F(2,135) = 3.12$, $p = .048$, $\acute{\eta} = .044$, with a significant interaction, $F(2,135) = 4.64$, $p = .011$, $\acute{\eta} = .064$. Truth tellers were faster than unrehearsed liars for multiple response questions, $F(2,135) = 4.59$, $p = .012$.

Table 1
*Statistics for Response Times (in milliseconds)*

| | Lie Condition | | | | | | |
|---|---|---|---|---|---|---|---|
| | Truth Telling | | Unrehearsed Lying | | Rehearsed Lying | | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | Means signif. diff. [*Cohen's d*] |
| Yes/No Questions | | | | | | | |
| General | 545 | 159 | 539 | 159 | 588 | 287 | none |
| Control | 531 | 276 | 622 | 325 | 625 | 329 | none |
| Relevant | 471 | 171 | 513 | 285 | 461 | 231 | none |
| Rele.-Gen. | -74 | 156 | -25 | 251 | -127 | 201 | none |
| Rele.-Cont. | -60 | 227 | -109 | 307 | -163 | 248 | none |
| | ***N*** | **44** | | **47** | | **47** | |
| S-N-K # | 1 | | 2 | | 3 | | |
| Multiple-response Questions | | | | | | | |
| General | 670 | 187 | 634 | 189 | 715 | 274 | none |
| Control | 588 | 305 | 691 | 346 | 710 | 475 | none |
| Relevant | 638 | 238 | 881 | 358 | 767 | 498 | 1-2[.81]* |
| Rele.-Gen. | -32 | 199 | 247 | 355 | 52 | 365 | 1-2[1.01],2-3[.54] |
| Rele.-Cont. | 49 | 287 | 189 | 353 | 58 | 333 | none |
| | ***N*** | **44** | | **47** | | **47** | |
| Mean # | 1 | | 2 | | 3 | | |

* Cohen's *d* appears bracketed to the right of any pair of means that are significantly different in Tables 1 through 4.

Walters (1996) and Bond and DePaulo (2006) argued that lie detection accuracy increases if behavioral baselines for each cue are established during known truthful responding for comparison with suspected deception. Per the recommendation of Walczyk et al. (2005), for response times and other cues, four new means for each participant were calculated using general questions and control questions as ground-truth baselines. Relevant-general adjusted means involved subtracting general question means from relevant ques-

tion means separately for yes/no and multiple-response questions. Relevant-control means were calculated by subtracting control means from relevant means for each question type. Adjusted means appear in Table 1. For the relevant-general adjusted means, a main effect was found for question type, $F(1,135) = 30.25$, $p = .001$, ή = .183 (yes/no $M = -75.61$, multiple-response $M = 91.86$, $d = .61$), and for lie condition, $F(2,135) = 9.12$, $p = .001$, ή = .119. There was a significant interaction, $F(2,135) = 4.96$, $p = .008$, ή = .068. Unrehearsed liars took significantly longer to answer than truth tellers and rehearsed liars for multiple-response questions, $F(2,137) = 9.27$, $p = .001$. In the case of relevant-control adjusted means, a main effect for question type was observed, $F(1,135) = 36.02$, $p = .001$, ή = .211 (yes/no $M = -112.39$, multiple-response $M = 100.14$, $d = 71$), but no effect for lie condition, $F,135) = 2.23$, $p = .112$, nor interaction, $F(2,135) = 2.44$, $p = .091$.

To recap, unrehearsed liars took longer to answer relevant multiple-response questions than truth tellers. Multiple-response question response times adjusted by general questions were the best cues, distinguishing unrehearsed liars from truth tellers and rehearsed liars. Therefore, Hypothesis (H1) had partial support.

***H2: Wordiness***

Statistics for answer wordiness appear in Table 2. For general questions, a question type main effect occurred, $F(1,135) = 298.24$, $p = .001$, ή = .688 (yes/no $M = 1.04$, multiple-response $M = 1.40$, $d = 1.04$). There was a marginally significant effect for lie condition, $F(2,135) = 2.86$, $p = .061$, and a significant interaction, $F(1,135) = 4.56$, $p = .012$, ή = .063. Truth tellers and rehearsed liars were slightly less wordy than unrehearsed liars for multiple-response questions, $F(2,135) = 4.41$, $p = .014$. Since general questions were answered honestly by everyone, these findings are anomalous. For control questions, multiple-response questions required more words, $F(1,135) = 6.197$, $p = .014$, ή = .044 (yes/no $M = 1.38$, multiple-response $M = 1.59$, $d = .15$). There was also a main effect for lie condition, $F(2,135) = 3.27$, $p = .041$, ή = .046. Truth tellers were more succinct than rehearsed liars, also anomalous given that all answered them truthfully. Finally, for the crucial relevant questions, multiple-response questions elicited more words, $F(1,135) = 97.17$, $p = .001$, ή = .419 (yes/no $M = 1.59$, multiple-response $M = 2.75$, $d = .55$). There was a main effect for lie condition, $F(2,135) = 7.92$, $p = .001$, ή = .105, and an interaction, $F(2,135) = 7.26$, $p = .001$, ή = .103. Truth tellers answered more succinctly yes/no questions, $F(2,135) = 3.46$, $p = .034$, and multiple-response questions, $F(2,135) = 11.24$, $p = .001$, with larger effect sizes for the latter. Therefore, Hypothesis 2 (H2) was generally supported.

Table 2
*Statistics for the Wordiness of Answers*

| | Lie Condition | | | | | | |
|---|---|---|---|---|---|---|---|
| | Truth Telling | | Unrehearsed Lying | | Rehearsed Lying | | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | Means signif. diff. [*Cohen's d*] |
| Wordiness for Yes/no Questions | | | | | | | |
| General | 1.10 | .29 | 1.02 | .12 | 1.01 | .27 | none |
| Control | 1.11 | .17 | 1.33 | .95 | 1.73 | 2.09 | 1-3[.54] |
| Relevant | 1.14 | .19 | 1.80 | 2.12 | 1.95 | 2.37 | 1-2[.57], 1-3[.63] |
| Rele.-Gen. | .04 | .38 | .77 | 2.13 | .94 | 2.45 | 1-2[.58], 1-3[.64] |
| Rele.-Cont. | .03 | .38 | .47 | 1.42 | .21 | 2.30 | none |
| Wordiness for Multiple-response Questions | | | | | | | |
| General | 1.30 | .39 | 1.52 | .32 | 1.37 | .34 | 1-2[.62], 2-3[.45] |
| Control | 1.26 | .45 | 1.65 | .86 | 1.82 | 1.56 | 1-3[.56] |
| Relevant | 1.53 | .77 | 3.03 | 2.25 | 3.62 | 2.83 | 1-2[.99], 1-3[1.16] |
| Rele.-Gen. | .23 | .68 | 1.51 | 2.26 | 2.25 | 2.87 | 1-2[.87], 1-3[1.14] |
| Rele.-Cont. | .27 | .59 | 1.38 | 1.79 | 1.79 | 2.04 | 1-2[.93], 1-3[1.15] |
| | ***N*** | **44** | | **47** | | **47** | |
| | | 1 | | 2 | | 3 | |

As with response times, adjusted wordiness means were calculated by subtracting yes/no and multiple-response general or control means from the corresponding relevant means and appear in Table 2. For the relevant-general means, question type was significant, $F(1,135) = 40.46$, $p = .001$, $\acute{\eta} = .231$ (yes/no $M = .58$, multiple-response $M = 1.35$, $d = .61$). A main effect for lie condition, $F(2,135) = 7.01$, $p = .001$, $\acute{\eta} = .094$, was accompanied by an interaction, $F(1,135) = 6.79$, $p = .001$, $\acute{\eta} = .093$. Truth tellers answered yes/no questions with marginally significantly fewer words than liars of either condition, $F(2,137) = 3.03$, $p = .052$. Truth tellers answered multiple-response questions with significantly fewer words than liars too, $F(2,137) = 10.08$, $p = .001$, but effect sizes were larger with the latter. Regarding the relevant-control adjusted means, question type mattered, $F(2,135) = 42.94$, $p = .001$, $\acute{\eta} = .241$ (yes/no $M = .20$, multiple-response $M = 1.16$, $d = 1.02$). As expected, lie condition counted, $F(2,135) = 6.79$, $p = .002$, $\acute{\eta} = .085$. The question type-lie condition interaction was significant, $F(2,135) = 5.75$, $p = .004$, $\acute{\eta} = .079$. For multiple-response questions only, truth tellers were less wordy than liars of either condition $F(2,135) = 10.67$, $p = .001$. Relevant-general adjusted means make better cues.

***H3: Lying and Eye Movement***

Table 3 summarizes eye movements. For the general questions, there was a significant main effect for lie condition, $F(2,122) = 4.07$, $p = .020$, $\acute{\eta} = .062$. Although everyone answered truthfully, truth tellers had fewer eye movements than either lie condition. For relevant questions, no effect occurred for question type, $F(1,125) = .35$, $p = .554$, nor was there an interaction, $F(2,125) = 1.35$, $p = .262$. The lie condition effect was insignificant, $F(2,125) = 1.25$, $p = .290$.

Four adjusted eye movement means were calculated for each participant (see Table 3). No effect for question type occurred for the relevant-general means, $F(1,121) = .28$, $p = .600$, nor interaction, $F(2,121) = 1.28$, $p = .281$. However, there was a significant effect for lie condition, $F(2,121) = 3.19$, $p = .042$, $\acute{\eta} = .046$. Truth tellers had fewer relative eye movements than rehearsed liars. The relevant-control analysis did not produce an effect for question type, $F(1,122) = .79$, $p = .375$, nor interaction, $F(2,122) = 2.70$, $p = .071$. But, lie condition had a significant impact, $F(2,122) = 3.89$, $p = .023$, $\acute{\eta} = .060$. A significant difference occurred between unrehearsed liars and rehearsed liars. Eye movement means adjusted by general or control questions may distinguish rehearsed liars from the other conditions.

Table 3 shows that the observed truth teller eye movement means are usually smaller than those of the other conditions, consistent with Hypothesis 3 (H3). Even so, a significant lie condition main effect only occurred for eye movements of general questions answered honestly by all participants and for adjusted eye movements of relevant questions, partially supporting H3.

***H4: Lying and Pupil Dilation***

Table 4 shares the summary statistics for pupil dilation. For relevant questions, question type did not have an effect, $F(2,135) = .43$, $p = .513$, nor lie condition, $F(2,135) = .84$, $p = .435$. Consequently, no adjusted means were calculated. Hypothesis (H4) went unsupported.

***Exploratory Discriminant Analyses: Combining Cues***

Two exploratory discriminant analyses assessed the collective potential of all the cognitive cues for distinguishing truth tellers from rehearsed and unrehearsed liars. Lie condition was the grouping variable. The first analysis included all three lie conditions. Means of all cues adjusted by general questions, as well as eye movements adjusted by control questions, were the independent variables, per Walters' (1996) recommendation, along with total inconsistency for interview questions. Table 5 shows that inconsistency means are low, suggesting that liars generally followed instructions to answer interrelated questions consistently. The largest mean is for rehearsed liars and may reflect their preparation of lies for relevant questions without having prepared consistent answers for control questions. *N*s for the discriminant analyses were reduced by including only participants with complete data for all nine variables. One-way ANOVAs compared condition means. Given the exploratory nature of these analyses, a less conservative $\alpha$ of .10 was chosen to maximize power. Six variables (italicized rows of Table 5) were significant and were used

in estimating the first discriminant function. The model was significant, *Wilks' Lambda* = .84, $p$ =.001; 67% of the sample was accurately classified, 33% expected by chance. The false positive rate (6.8%; truth tellers misclassified liars) was half the rate of false negatives (13.6%; liars misclassified truth tellers).

Table 3
*Statistics for Eye Movements (in pixels)*

| | Lie Condition | | | | | | |
|---|---|---|---|---|---|---|---|
| | Truth Telling | | Unrehearsed Lying | | Rehearsed Lying | | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | Means signif. diff. [*Cohen's d*] |
| Yes/No Questions | | | | | | | |
| General | 42 | 36 | 63 | 44 | 64 | 38 | 1-2[.53],1-3[.59] |
| ***N*** | | **41** | | **42** | | **42** | |
| Control | 57 | 32 | 73 | 42 | 57 | 34 | none |
| ***N*** | | **41** | | **43** | | **43** | |
| Relevant | 49 | 36 | 61 | 45 | 60 | 38 | none |
| ***N*** | | **41** | | **43** | | **44** | |
| Rele.-Gen. | 6.3 | 32 | 0.1 | 29 | -3.0 | 38 | 1-3[.26] |
| ***N*** | | **41** | | **42** | | **41** | |
| Rele.-Cont. | -8.2 | 27 | -12.1 | 26 | 5.1 | 24 | 2-3[.68] |
| ***N*** | | **40** | | **43** | | **43** | |
| | | 1 | | 2 | | 3 | |
| Multiple-response Questions | | | | | | | |
| General | 42 | 35 | 60 | 47 | 65 | 38 | 1-2[.44],1-3[.63] |
| ***N*** | | **41** | | **42** | | **42** | |
| Control | 54 | 33 | 70 | 47 | 58 | 35 | none |
| ***N*** | | **41** | | **43** | | **43** | |
| Relevant | 52 | 35 | 65 | 41 | 56 | 31 | none |
| ***N*** | | **41** | | **43** | | **44** | |
| Rele.-Gen. | 10.6 | 24 | 6.6 | 40 | -8.6 | 32 | 1-3[.68] |
| ***N*** | | **41** | | **42** | | **41** | |
| Rele.-Cont. | -1.8 | 19 | -4.6 | 21 | -1.4 | 20 | 2-3[.16] |
| ***N*** | | **40** | | **43** | | **42** | |
| | | 1 | | 2 | | 3 | |

Table 4
*Statistics for Pupil Dilation (in pixels)*

| | Lie Condition | | | | | | |
|---|---|---|---|---|---|---|---|
| | Truth Telling | | Unrehearsed Lying | | Rehearsed Lying | | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | Means signif. diff. [*Cohen's d*] |
| Yes/No Questions | | | | | | | |
| General | 64 | 20 | 68 | 18 | 68 | 17 | none |
| Control | 64 | 23 | 68 | 18 | 69 | 17 | none |
| Relevant | 63 | 24 | 67 | 20 | 67 | 17 | none |
| ***N*** | **44** | | **47** | | **47** | | |
| | 1 | | 2 | | 3 | | |
| Multiple-response Questions | | | | | | | |
| General | 65 | 24 | 68 | 17 | 67 | 17 | none |
| Control | 63 | 22 | 67 | 18 | 68 | 17 | none |
| Relevant | 62 | 22 | 67 | 18 | 68 | 18 | none |
| ***N*** | **44** | | **47** | | **47** | | |
| | 1 | | 2 | | 3 | | |

For the second analysis, the full rehearsal-reducing potential of TRI-Con was assumed by excluding rehearsed liars. One-way ANOVAs on the nine cues of Table 5 between truth tellers and unrehearsed liars produced four significant models: relevant-general multiple-response question response times, both adjusted wordiness measures, and total inconsistencies. A discriminant analysis using these four Independent Variables (IVs) produced a significant model, *Wilks' Lambda* = .67, $p$ =.001; 84% of the sample was accurately classified, 50% expected by chance. The false positives rate was low (1%) compared to the false negative rate (15%). Both these analyses show the lie detection potential of multiple cognitive cues under TRI-Con, with few false positives.

Table 5
*Lie Condition Means and ANOVA Results for Cues Usable in the Discriminant Analyses*

| | Lie Condition | | | | |
|---|---|---|---|---|---|
| | Truth Telling | Unrehearsed Lying | Rehearsed Lying | | |
| | *M* | *M* | *M* | *F* | *p* |
| Adjusted Response Times | | | | | |
| Relevant-General Yes/no | -78.81 | -23.87 | -99.51 | 1.39 | .251 |
| *Relevant-General Multiple-resp.* | *-31.59* | *233.26* | *24.40* | *8.77* | *.001** |
| Adjusted Wordiness | | | | | |
| *Relevant-General Yes/no* | *.01* | *.62* | *.85* | *2.39* | *.096* |
| *Relevant-General Multiple-resp.* | *.29* | *1.30* | *2.25* | *7.91* | *.001* |
| *Total Interview Inconsistencies* | *.00* | *.34* | *.59* | *2.97* | *.055* |
| Adjusted Eye Movements | | | | | |
| Yes/no | | | | | |
| Relevant-General Yes/No | 7.01 | 1.32 | -2.64 | .78 | .458 |
| *Relevant-Control Yes/no* | *-9.46* | *-10.00* | *5.91* | *4.92* | *.009* |
| Multiple-response | | | | | |
| *Relevant-General* | *10.03* | *5.84* | *-10.11* | *3.72* | *.027* |
| Relevant-Control | -2.38 | -4.17 | -1.85 | .14 | .870 |
| ***N*** | | **37** | **41** | **37** | |

* - Variables of italicized rows, *p* values < .10, used in first discriminant analysis.

## DISCUSSION

To avoid a major pitfall of the polygraph-based Control Question Technique, cognitive lie detection efforts should be based on well-specified, validated theoretical accounts of deception, which can inform when indices of cognitive load make reliable cues (NRC, 2003). TRI-Con (Walczyk et al., 2005), based on the ADCM, is a rehearsal-reducing technique that induces cognitive load selectively on liars. Its ability to uncover deception following a mock crime was tested. The cues assessed important aspects of cognitive processing. Response time and pupil dilation are direct measures of cognitive load (Solso, 2001). The wordiness of answers and their consistency are processing outputs (DePaulo et al.,

2003). Per the expanded ADCM, breaking eye contact, as shown through eye movements, is a cognitive load and anxiety reducing behavior. Finally, because of its threat as a load-reducing countermeasure and the scarcity of studies including it, the rehearsal of lying was manipulated to assess its effects on multiple cognitive indices. The present analyses suggest the individual and collective value of most of them in distinguishing truth tellers from rehearsed and unrehearsed liars, especially after adjusting for truthful behavioral base rates. The wordiness of answers was the single best cue.

***H1: Response Time***

Response time is a useful cue to deception (see DePaulo et al., 2003; Seymour et al., 2000). This study adds to the literature by showing that multiple-response questions can elicit better cues than yes/no questions in the quasi-authentic forensic context of a mock crime. Walczyk et al. (2003) found that lying to yes/no questions was easier than lying to multiple-response questions, according to participants' self-reports of how lies were constructed. For the former, liars switched their answer from yes to no or vice versa, whatever opposed the truth. For multiple-response questions, more thought was given to the plausibility of answers given their greater range of permissible responses. Similarly, in this research, due to fewer syntactic constraints on answers, multiple-response questions likely imposed higher cognitive load on liars and amplified cues to deception (DePaulo et al., 2003; Vrij et al., 2010a).

Importantly, relevant multiple-response means adjusted by general questions distinguished unrehearsed liars from truth tellers and rehearsed liars. This replicates the results of Walczyk et al. (2009), for whom unadjusted response times failed to discriminate truth tellers from liars, but adjusted response times did and supports Walters' (1996) and Bond and DePaulo's (2006) suggestion of adjusting for individual differences in behavioral base rates.

The brief rehearsal of this research lowered the cognitive load of adjusted multiple-response questions, as indexed by response time, below that of unrehearsed lying (see Table 1). Consistent with the ADCM, slight rehearsal was insufficient to lower load below that of truth tellers. Clearly rehearsal must be considered as a countermeasure for cognitive lie detectors (Miller & Stiff, 1993). In future research, the extensive rehearsal of lying may be shown to lower cognitive load below that of truth tellers (Greene et al, 1985; O'Hair et al., 1981).

***H2: Wordiness***

Liars can be wordier than truth tellers, often embellishing their messages to appear believable (e.g., Harrison et al., 1978; Weiler & Weinstein, 1972). Does this extend to short answers given under TRI-Con? Hypothesis 2 was well supported across question types. Surprisingly, though all responded to them truthfully, answers to general multiple-response questions of unrehearsed liars were wordier than the answers of truth tellers and rehearsed liars, and truth tellers answered control questions with fewer words than rehearsed liars. Regarding why, we suspect that it is because those assigned to the lie conditions knew before their interrogations that they would be lying. The general questions were asked first

to familiarize participants with the procedure and to obtain ground-truth baselines. Liars' greater wordiness may have been due to higher anxiety and cognitive load at the prospect of lying (DePaulo et al., 2003). Such findings are intriguing by suggesting that the "intent to deceive" can spill over to truthful responding early on in an exam, but must be replicated.

Answers to relevant questions of rehearsed liars were the wordiest of the three conditions. Answering under the time pressure of TRI-Con discourages wordiness (Walczyk et al., 2005). Even so, consistent with the ADCM, rehearsed liars prepared longer answers for later recall. Wordy answers given under time pressure may be a telltale sign of rehearsed deception. Despite the significant group differences in general and control answer wordiness, an encouraging finding is that the relevant-general adjusted means still largely supported Hypothesis 2. Truth tellers were less wordy than either lie condition. Answer wordiness under TRI-Con is a promising cue.

***H3: Eye Movements***

Although lying often entails decreased body movements as liars try to appear relaxed (Buller & Burgoon, 1996; Ekman, 1997; Zuckerman et al., 1981), we predicted the opposite with the eyes. Due to high motivation and cognitive load over telling identity-relevant lies (DePaulo et al., 2004; Vrij et al., 2010b), we expected liars to break eye contact more often than truth tellers as an anxiety and load reducing countermeasure. This would manifest as greater eye movements, a possibility not examined by Vrij et al (2010b). Just as the wordiness of multiple-response general questions of truth tellers was less than that of unrehearsed liars, although general questions were answered truthfully, fewer eye movements occurred for truth tellers than for liars with both question types. Both wordiness and eye movements suggest that anxiety and higher cognitive load are induced by the "intent to lie," at least at the beginning of an exam, not just while lying. Greater eye movements also may reflect gaze aversion out of shame or discomfort at the prospect of lying (Keltner & Harker, 1998). Also in support, though group differences were not always significant across question categories of Tables 3, the smallest unadjusted eye movement means were typically with truth tellers. Hypothesis 3 was partially supported with the adjusted relevant question means. Rehearsed liars were significantly different from the other two conditions, findings that are interpreted when the discriminant analyses are discussed.

***H4: Pupil Dilation***

The greater pupil dilation hypothesized for lying was not observed. Even so, lying often entails more dilation, indicative of high cognitive load and anxiety (e.g., Bradley & Janisse, 1979; Dionisio et al., 2001; Heilveil, 1976; Lubow & Fein, 1996; Webb et al., 2009; Zuckerman et al., 1979). Importantly, Table 4 shows that truth tellers had the smallest observed dilation means across lie conditions for each question category. A reason for the insignificant findings is that dilation may be the most confounded index of cognitive load of this experiment, reflecting also anxiety, surprise, and other emotional states (Stern, Ray, & Quigley, 2001). The novelty of the procedure (e.g., sustained eye-to-eye contact) may have been sufficiently arousing to have overshadowed any modest cognitive load effects due to lying. Based on other research, this cue may prove useful to cognitive load-inducing techniques as they are refined.

***Implications of the Exploratory Discriminant Analyses for Lie Detection***

Using adjusted responses times and total inconsistencies as cues in discriminant analyses, Walczyk et al. (2009) found classification accuracies of truth tellers, rehearsed liars, and unrehearsed liars above chance. Because there are no unequivocal cues to deception, multiple cues are needed to optimize lie detection accuracy (Bond & DePaulo, 2006; DePaulo et al., 2003). We extended Walczyk et al. (2009) findings to a forensically-relevant mock crime and added eye data and wordiness as converging cues. Two discriminant functions were estimated, one with all three lie conditions and another on unrehearsed liars and truth tellers alone that assumed the full rehearsal-reducing potential of TRI-Con. The cues discriminated liars from truth tellers, with 67% accuracy for all three lie conditions and 84% accuracy for only two. Encouraging findings for TRI-Con are also the low rates (6.8, 1%) of false positives, which are a serious concern with the CQT (NRC, 2003). Comparing the two analyses, the cues that distinguished truth tellers from rehearsed liars differed interestingly from those discriminating truth tellers from unrehearsed liars. Wordiness and inconsistency (see Table 5) distinguished both lie conditions from truth tellers. However, response times of multiple-response questions distinguished truth tellers from unrehearsed liars. Eye movements discriminated rehearsed liars from truth tellers and unrehearsed liars.

Vrij et al. (2010a) noted that behavioral cues accompanying suspected deception must be compared with appropriate instances of ground-truthful responding, but research was lacking regarding what is appropriate for cognitive lie detection. In response, we compared behavioral cues adjusted by ground-truth general questions unrelated to the mock crime with these cues adjusted by ground-truth control questions related to the mock crime. For multiple-response question response times and wordiness, adjustments with general questions discriminated across lie conditions the best. With eye movements, the results were mixed. For multiple-response questions, general question means provided the best adjustments. Hypothesis 3 held that the eye data would discriminate among all three conditions. Table 5 shows that rehearsed liars had eye movements below general questions compared to the other conditions.

According to the ADCM, fixating the eyes on a neutral background supports internal processing, such as retrieving an answer previously prepared, as did our rehearsed liars to multiple-response questions (see Glenberg et al., 1998). Eye movements, in this case, are distracting. For yes/no questions, adjustments with control question means produced the best discrimination. Rehearsed liars had eye movements elevated compared to control question means, whereas the other two conditions fell below. Since they are generally easier to answer deceptively (Walczyk et al., 2003), for yes/no question liars may have been able to reduce cognitive load and lower anxiety by briefly breaking eye contact (Vrij et al., 2010b), another load reduction mechanism of the ADCM. In other words, the difficulty of the question may influence which action of the eyes most reduces cognitive load for rehearsed liars. More difficult items require eyes fixed to support internal processing for exact recall. For items imposing less cognitive load, breaking eye contact reduces load by lowering anxiety. This account must be confirmed in future research. For instance, will lies low in identity-relevance but heavily constrained (e.g., requiring much thought to ensure

internal consistency) entail eyes more fixated, as predicted by the ADCM, compared to easier lies? Overall, adjustments with general questions yielded the best cues and have the advantage of eliciting readily verifiable truths.

Given the 84% accuracy of the second discriminant function, if interrogators can reasonably discount rehearsal as a countermeasure with the guidelines of TRI-Con, then high lie detection accuracies may occur. When rehearsal cannot be discounted, high accuracies are still possible if research can uncover more cues for distinguishing truth tellers from rehearsed liars. Rehearsal's role as a countermeasure to cognitive lie detection is under-researched (Sporer & Schwandt, 2006; 2007; Vrij et al., 2010a). Adjusted eye data, adjusted wordiness, and inconsistency are promising converging cues for ferreting it out.

A few limitations are noteworthy. Our "liars" were not as motivated as actual perpetrators under police interrogation. Future research can enhance motivation by offering monetary rewards for lying well. Still, highly motivated liars often are easiest to detect (DePaulo et al., 2003), providing rich cues. In a review of studies of the lie detection abilities of police officers, O'Sullivan, Frank, and Hurley (2009) found that accuracy was highest when the lies witnessed involve high stakes for the liar. TRI-Con also might uncover deception most accurately when liars are highly motivated. Moreover, our sample was predominately Caucasian, mostly female (54%), and comprised of college students from middle to upper middle-class backgrounds, not representative of the target population of felony suspects (Vrij, 2000). Thus, the results should be generalized cautiously.

## CONCLUSION

The present findings suggest the following. First, longer response times to multiple-response questions, answer wordiness, and inconsistencies are associated with unrehearsed deceptive answering. Second, wordiness, inconsistencies, and elevated or depressed eye movements can point to rehearsed deceptive answering. Third, eye movements and wordiness can spill over into truthful responding early in an exam when there is an "intent to deceive." Fourth, by the ADCM, the focus of the eyes can facilitate lying in two ways. Fixating eyes on a non-distracting stimulus facilitates internal processing such as recalling a lie previously prepared (Glenberg et al, 1998), or the cognitive load caused by anxiety can be reduced by breaking direct eye contact when the task of lying is easier (Vrij et al., 2010b). Both mechanisms for load reduction were evident in the eye movements of Table 5. Fifth, cues adjusted by ground-truthful behavioral base rates support more accurate lie detection than unadjusted cues. General questions worked the best overall. Future research is warranted to advance theoretically-undergirded, load-inducing lie detection as well as to deepen understanding of the role of the eyes in managing cognitive load during deception with the ultimate goal of furnishing the criminal justice system with new lie detection tools.

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## APPENDIX

General and Interview Questions

| | |
|---|---|
| GENERAL QUESTIONS | Question pairs involving inconsistencies: 5<br>1-15, 2-14, 4-9, 6-16, 11-13 |

1) **Is Independence Day celebrated during August?**
2) **Is it possible for a person to be burned when operating an oven?**
3) What is your last name?
4) What is your age?
5) What is your biological mother's first name?
6) **In what city is the White House located?**
7) You received your GED or graduated from high school in what year?
8) What is your gender?
9) Were you born before the year 1979?
10) What is your race?
11) Are you a freshman?
12) **Is our current president's first name Leo?**
13) Are you a student?
14) **Can an oven get hot?**
15) **On what date does the United States celebrate Independence Day?**
16) **Is Los Angeles the location of the White House?**
17) **What is the name of the Louisiana state capital?**

| | |
|---|---|
| INTERVIEW QUESTIONS | Question pairs involving inconsistencies: 8<br>19-28, 20-27, 20-31, 24-33, 26-29, 26-34, 29-34, 30-33 |

18) Did you enter the psychology staff member's office downstairs within the past hour?
19) Was there a framed picture on the desk?
20) *How many envelopes did you find in the desk drawers?*
21) Was there a computer monitor on the desk?
22) What was the gender of the person taking you downstairs?
23) About how many minutes did the psychology staff member leave the room?
24) *If any, which envelope, A, B, or C, had the money?*
25) Were there any plants in the office?
26) *Did you take money from that office?*
27) *Did you go through the psychology staff member's desk?*
28) What was the picture of on the desk?
29) *What did you take from the office?*
30) *What did the other envelopes contain?*
31) *How many envelopes did you find?*
32) What color were the walls painted?
33) *Did you open up any envelopes in the desk?*
34) *How much money did you take out of the office?*
35) Was there a clock on the wall above the desk?
36) Did you find a wallet in the office?

* **Boldfaced general questions have verifiable truths**. *The relevant questions are italicized.*