

Increasing Cognitive Load to Facilitate Lie Detection: The Benefit of Recalling an Event in Reverse Order

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Published online: 13 August 2007

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Abstract In two experiments, we tested the hypotheses that (a) the difference between liars and truth tellers will be greater when interviewees report their stories in reverse order than in chronological order, and (b) instructing interviewees to recall their stories in reverse order will facilitate detecting deception. In Experiment 1, 80 mock suspects told the truth or lied about a staged event and did or did not report their stories in reverse order. The reverse order interviews contained many more cues to deceit than the control interviews. In Experiment 2, 55 police officers watched a selection of the videotaped interviews of Experiment 1 and made veracity judgements. Requesting suspects to convey their stories in reverse order improved police observers' ability to detect deception and did not result in a response bias.

Keywords Verbal and nonverbal cues to deception · Lie detection · Cognitive load

With current concerns over security, it is becoming increasingly important to discriminate between suspects who lie versus those who tell the truth. Nevertheless, a substantial empirical base shows that laypeople and even trained investigators (e.g. police) are often poor at discriminating between liars and truth tellers (Vrij 2000, 2004, in press). Obviously, liars' behaviour often does not differ

much from truth tellers' behaviour—at least not as we currently measure them—and so the task of discriminating between them is quite difficult. One reason for observers' poor discriminatory performance, we believe, is that they take a passive approach to the task of detecting deception. That is, observers simply monitor liars' and truth-tellers' naturally occurring behaviours during an interview and look for various non-verbal and verbal cues to distinguish between them. Clearly, these discriminatory signs are not so obvious. We suspect that observers could improve their deceit-detection performance by taking a more active approach to the task, and specifically by introducing a manipulation that will magnify the differences between liars and truth tellers. By definition, anything that magnifies the difference between liars and truth tellers should enhance our ability to discriminate between the two—assuming, of course, that we can measure these magnified differences. In this article we introduce such an intervention that we expect to magnify the differences between liars and truth tellers: Asking interviewees to report their stories in reverse order. We argue that this will be particularly debilitating for liars, because their cognitive resources have already been partially depleted by the cognitively demanding task of lying. As a result, we expected that more non-verbal and verbal differences would emerge between liars and truth tellers in the reverse order interviews than in the chronological interviews (Experiment 1), which should facilitate the observers' task of discriminating between them (Experiment 2).

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Cognitive Demand

One reason why differences in non-verbal and verbal cues occur between liars and truth tellers is that lying can be

cognitively more demanding than truth telling (DePaulo et al. 2003; Zuckerman et al. 1981). Several aspects of lying contribute to this increased mental load. First, formulating the lie itself may be cognitively taxing. Second, liars are typically less likely than truth tellers to take their credibility for granted (DePaulo et al. 2003; Gilovich et al. 1998; Kassin 2005; Kassin and Gudjonsson 2004; Kassin and Norwick 2004; Vrij et al. 2006d). As such, liars will be more inclined than truth tellers to monitor and control their demeanour so that they will appear honest to the lie detector (DePaulo and Kirkendol 1989), which should be cognitively demanding. Third, because liars do not take credibility for granted, they may monitor the *interviewer's* reactions more carefully in order to assess whether they are getting away with their lie (Buller and Burgoon 1996; Schweitzer et al. 2002). Carefully monitoring the interviewer also imposes cognitive load. Fourth, liars may be preoccupied by the task of reminding themselves to act and role-play (DePaulo et al. 2003), which requires extra cognitive effort. Fifth, liars have to suppress the truth while they are lying and this is also cognitively demanding (Spence et al. 2001). Finally, whereas activating the truth often happens automatically, activating a lie is more intentional and deliberate, and thus requires mental effort (Gilbert 1991; Walczyk et al. 2003, 2005).

Obviously, lying is not always more cognitively demanding than truth telling (McCornack 1997). Perhaps the six reasons given as to *why* lying is more cognitively demanding could give us insight into *when* it is more cognitively demanding. That is, lying is more cognitively demanding to the degree that these six principles are in effect. For example, lying is likely to be more demanding than truth telling only when interviewees are motivated to be believed. Only under those circumstances can it be assumed that liars take their credibility less for granted than truth tellers and hence will be more inclined than truth tellers to monitor their own behaviour and/or the interviewer's reactions. Second, for lying to be more cognitively demanding than truth telling, liars must be able to retrieve their truthful activity easily and have a clear image of it. Only when liars' knowledge of the truth is easily and clearly accessed will it be difficult for them to suppress the truth. On the other side of the equation, truth tellers also need to have easy access to the truth for the task to be relatively undemanding. If truth tellers have to think hard to remember the target event (e.g. because it was not distinctive or it occurred long ago), their cognitive demands may exceed the cognitive demands that liars require for fabricating a story.

In experimental studies researchers ensure that interviewees are motivated (typically by giving a reward for making a credible impression) and that the target event is easily retrieved (typically by interviewing the suspects

shortly after informing them about the target event). In those experiments lying has been found to be more demanding than truth telling in various settings. Participants who have directly assessed their own cognitive load report that lying is more cognitively demanding than truth telling. This occurred when lengthy, elaborative responses, were required (Granhag and Strömwall 2002; Hartwig et al. 2006; Strömwall et al. 2006; Vrij et al. 2001b, 2006d; Vrij and Mann 2006; White and Burgoon 2001), and also when short responses were sufficient (Caso et al. 2005; Vrij et al. 1996, 2006b). In fMRI deception research, lying and truth telling is differentiated only by the act of pressing either a "lie" or "truth" button. Nevertheless, participants' brain activity reveals that lying is more cognitively demanding than truth telling (Spence et al. 2004).

In forensic settings, we can reasonably assume that interviewees will be motivated, but we cannot assume that interviewees will always be able to retrieve the target event easily, as this should vary from one case to another. Analyses of police interviews with real-life suspects, however, suggests that lying is often more cognitively demanding than truth telling in the forensic setting. First, in those police interviews, lies were accompanied by increased pauses, decreased blinking, and decreased hand and finger movements, all of which are signs of cognitive load (Mann et al. 2002; Vrij and Mann 2003). Second, police officers who saw videotapes of these suspect interviews reported that the suspects appeared to be thinking harder when they lied than when they told the truth (Mann and Vrij 2006).

Magnifying the Differences between Liars and Truth Tellers

Although liars should experience more cognitive load than truth tellers, the differences between liars and truth-tellers may be relatively small, and perhaps not readily discernable by observers (DePaulo et al. 2003; Zuckerman et al. 1981). Our goal, therefore, was to magnify the differences between liars and truth tellers. Vrij et al. (2006b, in press) suggested that this might be accomplished by devising an interview protocol that posed excessive cognitive demands on the suspects (e.g. recalling events in reverse order). The underlying assumption is that cognitively demanding interviews (reverse order) will be particularly debilitating for liars, whose cognitive resources have already been partially depleted by the cognitively demanding task of lying. This is analogous to the finding in the cognitive-attention literature that information processing in the primary task is slower in dual-task conditions than in single-task conditions (Briggs et al. 1972).

Either of two mechanisms of attention might account for the expected finding, that liars will be particularly debilitated

in the demanding interview protocol (reverse order recall). One possible mechanism is that the cognitive demands of lying and describing an event in reverse order are drawn from a common, limited pool of cognitive resources. When the cognitive resources required to perform two demanding tasks exceed the limit of attention, there will be a breakdown in performance, the so-called divided-attention (e.g. Johnston et al. 1970). Such a breakdown, or system overload, is more likely to occur when the two tasks are each cognitively demanding than when one of the tasks is relatively simple or well practiced (recalling in chronological order). A second possible attention mechanism suggests that performing two tasks simultaneously entails shifting attention rapidly between the two tasks (Broadbent 1957). The more cognitively demanding a task is (reverse order recall), the more attentional time it demands, thereby leaving less attention devoted to the second task. Ultimately, the less attention that is devoted to a task, the poorer performance will be (Kahneman 1973). We do not attempt to discriminate between these two attentional mechanisms, as both predict that liars should be particularly debilitated in the more demanding reverse-order interview protocol.

We selected reverse order recall as the interview protocol to increase cognitive demand because (a) it runs counter to the natural forward-order coding of sequentially occurring events (Gilbert and Fisher 2006; Kahana 1996) and (b) it disrupts reconstructing events from a schema (Geiselman and Callot 1990). Empirical support that reverse order recall is, in fact, resource-demanding derives from a time-sharing study showing that performance on a concurrent psycho-motor task declines when the memory list is recalled in reverse order recall rather than in forward order (Johnston et al. 1970). Although the reverse-order strategy has been used for other purposes (as a memory enhancing technique within the Cognitive Interview, Fisher and Geiselman 1992), we used it here only because of its high cognitive demand.

Verbal and Non-verbal Cues of Cognitive Load

We examined several verbal and non-verbal cues that are associated with cognitive load.

Verbal Cues

Describing events in detail is typically more cognitively challenging for liars than for truth tellers (Köhnken 1996, 2004; Vrij 2000, 2005). Liars may lack the imagination to invent many details, or they may find it difficult to fabricate a detailed story that sounds plausible. Verbal lie detection tools that assess the number of details mentioned by interviewees, such as Criteria-Based Content Analysis

(Vrij 2005) and Reality Monitoring (Masip et al. 2005), distinguish between general categories of details and more specific types of details. In the present experiment we examined only general categories of details: Visual details (details about what someone saw), auditory details (details about what someone heard), and contextual embeddings (details about locations, “the stool was underneath the table” and details about time, “about one minute later...”). Since we assume that lying is more cognitively demanding than truth telling, and that telling a story in reverse order is more cognitively demanding than telling a story in chronological order, we hypothesised that liars would include fewer visual, auditory and contextual embedding details in their stories than truth tellers, and that this would occur mainly in the reverse order condition.

The final verbal cue we examined, a cue belonging to the RM tool, was cognitive operations. This category varies in its definition among Reality Monitoring researchers (Masip et al. 2005). Here we define cognitive operations to refer to evidence in the narratives of various cognitive activities, such as thoughts or reasonings (“I must have had my coat on, as it was very cold that night”) and cognitive suppositions of sensory experiences, e.g. “She seemed quite clever” (Vrij et al. 2007). Since cognitive operations refer to cognitive activities, we could expect cognitive operations to be more frequent in situations when people carry out many cognitive activities, as in situations with high cognitive load. We thus predicted that liars would include more cognitive operations into their accounts than truth tellers, and particularly in the reverse order condition.

Vocal Cues

We examined several vocal cues that are associated with cognitive load. Research has demonstrated that increased latency (time lapse between question and beginning of the answer), more pauses (between words or sentences), more speech hesitations (use of speech fillers such as “um”, “uh”, “er” etc), more speech errors (grammatical errors, stutters, false starts etc.) and a slower speech rate are all associated with cognitive load (Goldman-Eisler 1968; Smith and Clark 1993; Sporer and Schwandt 2006). We therefore predicted that, in comparison to truth tellers, liars would (a) display longer latency periods, (b) demonstrate more pauses, speech hesitations and speech errors, and (c) speak slower. Furthermore, these patterns would occur particularly in the reverse order condition.

Visual Cues

Research has indicated that people tend to decrease several kinds of movements when they have to think hard (Ekman

1997; Ekman and Friesen 1972). This decrease occurs because cognitive demand results in a neglect of body language, reducing overall animation. We looked at several types of movements: Illustrators (gestures that accompany speech), hand/finger movements (movements of hand and fingers without arms being moved), eye blinks, leg and foot movements, and chair swivelling, and predicted that liars would show fewer illustrators, hand/finger movements, eye-blinks, leg/foot movements and chair swivels than truth tellers, and particularly in the reverse order condition.

We looked at two more visual cues: Gaze aversion and self-adaptors (scratching the head, wrists etc.). We did not formulate hypotheses regarding those two cues because we did not expect them to be associated with deception in our experiment. Nevertheless we examined those two cues because people typically believe that they are associated with deception (Strömwall et al. 2004; Vrij et al. 2006a). Gaze aversion is associated with cognitive load. People tend to look away when they think hard, because looking someone in the eye is too distracting when load is experienced (Doherty-Sneddon et al. 2002). Despite being associated with cognitive load, gaze aversion does not appear to be related to deception (DePaulo et al. 2003). People typically believe that looking away makes a suspicious impression, and liars therefore avoid looking away in an attempt to appear credible (Hocking and Leathers 1980; Vrij 2000). Self-adaptors are not associated with cognitive load; rather, they are associated with experiencing negative emotions (such as fear). Self-adaptors tend to increase when certain negative emotions are experienced (Ekman 1985/2001), but they are typically not associated with deception (DePaulo et al. 2003). Perhaps they are not related to deception for the same reason why gaze aversion is not related to deception. People believe that fidgeting makes a suspicious impression, and therefore liars avoid fidgeting in order to appear credible.

Experiment 1

Method

Participants

A total of 80 undergraduate students participated: 40 males and 40 females. Their average age was $M = 20.88$ ($SD = 3.89$) years.

Procedure

The experiment took place at a Students' Union in a British university. Undergraduates were recruited under the guise of participating in an experiment about 'telling a

convincing story' with the possibility of earning £15. The participants signed an informed consent form, and then were randomly allocated to the truth telling condition or the deception condition.

The 40 truth tellers participated in a staged event in which they played a game of Connect 4 with a confederate (who posed as another participant). (Connect 4 is a popular two-player game where players drop counters into a slotted grid to achieve, and simultaneously prevent their opponent from achieving, four of their counters in a row). During the game they were interrupted twice, first by another confederate who came in to wipe a blackboard and later by a third confederate who entered looking for his or her wallet. Upon finding the wallet, this latter confederate then claimed that a £10 note had gone missing from it. The participant was then told that s/he would be interviewed about the missing money. We used the same event as Vrij et al. (2006c, d) and Vrij et al. (2007).

The 40 liars did not participate in this staged event. Instead, they were asked to take the £10 from the wallet, but deny having taken this money in a subsequent interview. They were told to tell the interviewer that they played a game of Connect 4 just as the truth tellers had. The liars were then presented with a document containing the following information about the staged event that the truth tellers had participated in.

'You enter the room to find another participant, 'Sam', and the two of you play Connect 4 alone together for a while. You sat where you are sitting now and the other participant sat opposite you. You had a general conversation with the other participant as you played, until the other participant's mobile phone rang and they excused themselves and left the room, leaving you alone for a minute or so. When they returned you continued playing the game. Then someone else entered the room, made a comment about you playing the game, wiped the mathematical formulas that you can see off the board and then left. You continued playing the game when someone else entered the room looking for his/her wallet. The wallet which you can see in front of you, is found somewhere around the room (up to you to decide where – it was varied in the scenario). You continue playing the game when the experimenter came back in, with the wallet-owner, and informs you both that some money had gone missing from the wallet and you are both to be interviewed.'

In summary, the liars did not engage in any of the activities the truth tellers were engaged in (playing Connect 4, etc.). Instead, the liars took the money out of the wallet, hid it somewhere on their person, and pretended that they had been engaged in the truth tellers' activities. They therefore

lied about the entire scenario, including taking £10 from the wallet. The procedure reflects a situation where a liar is familiar with the event s/he described but lacks the experience of true participation in that event.

Both liars and truth tellers were told that if they convinced the interviewer that they did not take the money, they would receive £10 for participating in this study. If they did not convince the interviewer, they would instead have to write a statement about what actually occurred. The participants were then brought to the interview room where they were interviewed by a uniformed, male, British police officer. The interviewer was blind to the participants' condition (truth telling or lying). The interviewer started the interview by saying “£10 has gone missing from a wallet in the room next door and I have to find out whether or not it was you who took it”. After several introductory questions, the actual interview commenced. Participants were asked to explain in as much detail as possible what happened when they played Connect 4. The following instructions were given by the interviewer to participants in the non-instructed condition, and participants in the reverse order condition. The parts denoted in italics were identical for both and hence have not been repeated here. The interviewer asked the 20 liars and 20 truth tellers in the non-instructed condition:

“Please tell me, in as much detail as possible, what happened when you were in the room with Sam just now. Mention all details, all conversations that took place, and give as much information as you can about everyone who entered the room, however irrelevant it may seem. I will only be asking this one question. You will have this one opportunity to give me as much information as you can possibly remember. Therefore, please tell me as much as you possibly can, as I will use all the information you give me to decide whether or not I think you are telling me the truth. If you are unsure what I want you to do then tell me now.”

The 20 liars and 20 truth tellers in the reverse order condition heard the following first two sentences in place of the first sentence above:

“I want you to tell me everything that happened in the room just now with Sam, but in reverse order. Therefore you should start your story with entering this room, and end it with how you came to be in the room next door with Sam....”

After the interview the police officer gave each participant a questionnaire, which he or she completed in another room. Participants were asked the following three manipulation checks: (i) to what extent they were motivated to appear convincing during the interview, (ii) what they

thought the likelihood was of getting the £10, and (iii) what they thought the likelihood was of being made to write a statement. Answers were given on Likert scales ranging from (1) very unlikely to (7) very likely. To ensure that all participants were paid the same amount (£10), the experimenter told them that the police officer had been convinced by their story.

Verbal and Non-verbal Coding

The interviews were videotaped and transcribed, and these transcripts were the basis for all verbal coding. We had previously trained two people to code visual cues, auditory cues, contextual embeddings, cognitive operations, and chronological productions. The two raters individually coded the statements from the present study. They were both blind to the hypotheses under investigation, to the staged event, and to the experimental condition. One rater coded all the statements and a second rater coded a random sample of 40 statements (50% of the total). The two raters coded per interview the frequency of occurrence of visual details (e.g. “He walked over to the whiteboard” contains three visual details); auditory details (e.g. “She said to sit down” contains one auditory detail); contextual embeddings (e.g. “We started playing” is one temporal detail and “And then the pieces fell on to the floor” contains one spatial detail); cognitive operations (e.g. “She seemed quite clever” contains one cognitive operation); and chronological production (the number of times the order of event in the narrative differed from the chronological order of the event, typically indicated by the participant by saying “Before that...”, “Prior to that...”). The frequency scores of the two raters correlated highly with each other for each of the verbal cues (visual details, $r = .97$; auditory details, $r = .80$; contextual embeddings, $r = .72$; cognitive operations, $r = .90$; and chronological production, $r = .92$).

Coding of vocal cues and all visual cues occurred on the basis of the videotapes, except for the coding of speech hesitations and speech errors, which occurred on the basis of the transcripts. We had used these coding schemes in numerous experiments, including Mann et al. (2002), Vrij (2006), Vrij et al. (1996, 1997, 2000, 2001a, b, 2004), and Vrij and Winkel (1991, 1992). Another two raters individually coded the videotapes. These raters were also blind to the hypotheses under investigation, to the staged event, and to the experimental condition. One rater coded all the transcripts/videotapes and a second rater coded a random sample of 16 transcripts/statements (20% of the total). The following cues were coded: Latency period (a noticeable pause of a second or more between the interviewer asking the question and the interviewee responding with an answer, bearing in mind that in this experiment only one question was asked, $r = .83$); pauses (a noticeable pause of

a second or more in the interviewee's monologue, $r = .91$); speech hesitations (frequency of saying 'ah' or 'mm' between words, $r = 1.00$); speech errors (frequency of word or sentence repetition, sentence change, sentence incompleteness, and slips of the tongue, $r = .87$); illustrators (frequency of arm and hand movements which were designed to modify and supplement what was being said, $r = .97$); hand and finger movements (frequency of movements of the hands or fingers without moving the arms, $r = .94$); eye blinks (where the eye shuts briefly but completely for a blink, $r = .97$); leg and foot movements (frequency of movements of feet or legs. Simultaneous movements of feet and legs were scored as one movement, $r = .98$); chair-swivels: (participants sat on a swivel chair; we counted each time the chair was propelled one way or another by the participant, $r = .87$); gaze aversion (number of seconds for which the participant looked away from the interviewer, $r = .98$); self-adaptors (frequency of scratching the head, wrists, etc. Rubbing one's hands together were not coded as self-adaptors but as hand and finger movements, $r = .76$). Speech rate was defined as the number of words (calculated with the word count in Word divided by length of answer in seconds). All visual and vocal cues except speech hesitations and speech errors were adjusted for the duration of the interview and were calculated per minute of interview. Speech hesitations and speech errors were calculated per 100 words.¹

The average length of the interviews was $M = 170.15$ s ($SD = 80.1$). To examine differences in length of interview as a function of the experimental condition a 2 (Veracity) \times 2(Order) ANOVA was carried out. The analysis revealed a significant main effect for Order, $F(1, 76) = 5.93$, $p < .05$, $\eta^2 = .07$ reflects that the Reverse Order interviews lasted longer ($M = 191.42$, $SD = 79.9$) than the control interviews ($M = 148.88$, $SD = 76.4$). None of the other main or interaction effects were significant, all F s $< .89$, all p s $> .35$.

Results

Manipulation Checks

Four 2 (Veracity) \times 2(Order) ANOVAs were conducted with the four manipulation checks as the dependent variables. The ANOVA regarding chronological production

¹ We did not calculate the verbal cues per minute of speech because we believe that this changes the nature of the verbal cues. That is, the number of details mentioned in a statement is different from the number of details mentioned per 100 words, because the latter refers to the conciseness of presenting information whereas the former does not. When we included the duration of answer as a covariate in our analysis, the results for the verbal cues showed the same pattern as presented in the main text.

revealed one significant effect, a main effect for Order, $F(1, 76) = 349.66$, $p < .01$, $\eta^2 = .82$. Participants in the Reverse Order condition recalled their stories less chronologically ($M = 6.08$, $SD = 2.04$) than participants in the control condition ($M = .13$, $SD = .33$). In fact, all participants recalled their stories in reverse order after being instructed to do so. By comparison, participants in the control condition hardly ever recalled non-chronologically.²

The experimental manipulations did not affect the participants' motivation (all F s $< .61$, all p s $> .43$). The vast majority of participants (80%) reported that they were motivated to appear convincing during the interview (a score of 5 or higher on the 7-point scale).

The ANOVA regarding the likelihood of receiving an incentive of £10 resulted in main effects for Veracity, $F(1, 76) = 14.05$, $p < .01$, $\eta^2 = .16$, and Order, $F(1, 76) = 7.06$, $p < .01$, $\eta^2 = .09$. Truth tellers were more convinced that they would receive the incentive ($M = 4.78$, $SD = 1.8$) than liars ($M = 3.40$, $SD = 1.7$) and participants in the control condition were more convinced that they would receive the incentive ($M = 4.58$, $SD = 1.7$) than the participants in the Reverse Order condition ($M = 3.60$, $SD = 1.8$). Those results suggest that truth tellers thought that they performed better than liars and that participants in the control condition thought that they performed better than participants in the Reverse Order condition.

The ANOVA regarding receiving a penalty (writing a statement) revealed a main effect for Order, $F(1, 76) = 4.74$, $p < .05$, $\eta^2 = .03$. Participants in the Reverse Order condition thought it more likely to receive a penalty ($M = 4.23$, $SD = 1.6$) than participants in the control condition ($M = 3.48$, $SD = 1.6$). This finding again suggests that participants in the control condition thought that they performed better than participants in the Reverse Order condition. In summary, the participants were motivated to be convincing, and participants in the Reverse Order condition in particular thought that they performed worse than participants in the control condition.

Hypotheses-Testing

A 2 (Veracity) \times 2(Order) MANOVA was conducted with the 16 verbal, vocal and visual cues as dependent variables. The Veracity main effect, $F(16, 61) = 4.20$, $p < .01$, $\eta^2 = .52$, and Veracity \times Order interaction effect, $F(16, 61) = 2.46$, $p < .01$, $\eta^2 = .39$ were significant, whereas the Order main effect was not, $F(16, 61) = 1.22$, $p = .28$.

² Perhaps one would expect liars to break up their stories in larger chunks than truth tellers, as this is probably easier to do. Indeed, truth tellers told their stories less chronologically ($M = 6.65$, $SD = 2.0$) than liars ($M = 5.50$, $SD = 2.0$), $F(1, 38) = 3.36$, $p < .01$, one-tailed, $\eta^2 = .08$. As such, the tendency to comply with the request to tell the story in reverse order could be used as an indirect tool to detect deceit.

Of interest for the hypotheses is the Veracity × Order interaction effect. At a univariate level significant effects emerged for auditory details, $F(1, 76) = 11.07, p < .01, \eta^2 = .13$; speech rate, $F(1, 76) = 4.62, p < .05, \eta^2 = .06$; hand/finger movements, $F(1, 76) = 6.11, p < .05, \eta^2 = .07$; and leg and foot movements, $F(1, 76) = 7.52, p < .01, \eta^2 = .09$. Marginally significant effects emerged for contextual embeddings, $F(1, 76) = 3.75, p = .057, \eta^2 = .05$, and speech hesitations, $F(1, 76) = 3.77, p = .069, \eta^2 = .06$.

Table 1 depicts the findings for the Reverse Order and control conditions separately. In the Reverse Order condition, liars mentioned fewer auditory details than truth tellers. Liars also included more speech hesitations in their statements, spoke at a slower speech rate and moved their legs and feet more than truth tellers. In the control condition only one significant finding emerged: Liars moved their hands and fingers less than truth tellers. Although the Veracity × Order interaction effects for cognitive operations, speech errors and eye blinks were not significant, they did significantly discriminate between truth tellers and liars in the Reverse Order condition but not in the control condition. In the Reverse Order condition, liars included more cognitive operations and more speech errors in their speech than truth tellers, as well as blinking more.

Discussion

The findings supported our prediction that liars would display more signs of cognitive load than truth tellers, and particularly in the Reverse Order condition. In the Reverse Order condition liars included fewer auditory details and contextual embedding details and more cognitive operations in their stories than truth tellers, three signs of cognitive load. Furthermore, liars made more speech

hesitations, spoke with a slower speech rate, and made more speech errors than truth tellers, which are three more signs of cognitive load. Liars, however, did not just reveal more signs of cognitive load than truth tellers. They also made more leg and foot movements than truth tellers and blinked more. These are signs of nervousness, rather than signs of cognitive load. It thus appears that the instruction to tell a story in reverse order not only made the participants have to think harder, but it also made them more nervous. Participants’ perceptions that they perform worse in the Reverse Order condition than in the control condition (as indicated by their expectation of being less likely to receive an incentive and more likely to receive a penalty) may have contributed to their anxiety.

Participants in the control condition showed only one cue to deceit: Liars moved their hands and fingers less than truth tellers. This cue has emerged as a sign of deceit in many of our previous studies (e.g. Akehurst and Vrij 1999; Caso et al. 2006; Vrij 1995, 2006; Vrij and Mann 2001; Vrij and Winkel 1991; Vrij et al. 1996, 1997, 2000, 2001a, 2004) and is, in our deception research, one of the most consistent cues to deceit. Yet, very few other researchers examine those movements (DePaulo et al. 2003). A decrease in hand/finger movements could be a sign of cognitive load, but could also be a sign of trying to make a convincing impression on others. That is, liars will attempt to control their behaviour and will avoid making movements that they believe look suspicious, and making hand/finger movements could be one cue that liars believe look suspicious. It is also possible that the reduction in hand/finger movements was caused by a combination of cognitive load and attempts to control behaviour.

In summary, we examined 16 non-verbal and verbal cues. Of these, we expected 14 cues (all except gaze and self-adaptors) to emerge as cognitive cues to deceit,

Table 1 Verbal, vocal and visual cues as a function of veracity for the reverse order and control conditions separately

	Reverse order				<i>F</i> (1, 38)	η^2	Control condition				<i>F</i> (1, 38)	η^2
	Truth		Lie				Truth		Lie			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Auditory details	9.00	4.6	5.35	3.6	7.62***	.17	6.25	4.2	8.85	4.2	3.80	.09
Contextual embeddings	18.95	7.3	12.15	5.9	10.51***	.22	17.05	10.3	17.10	7.4	.00	.00
Speech hesitations	4.54	2.6	5.96	2.0	3.86*	.09	4.36	2.2	3.99	2.0	.32	.01
Speech rate	163.62	29.2	142.13	13.7	5.15**	.12	162.84	21.0	169.02	32.9	.50	.01
Hand/finger	11.78	9.8	15.41	13.1	.98	.02	14.55	8.7	7.33	6.4	8.84***	.19
Leg/foot	5.21	5.3	13.80	16.9	4.68**	.11	14.97	21.1	6.28	5.8	3.15 (.08)	.08
Cognitive operations	1.75	2.0	4.35	4.6	5.30**	.12	2.05	3.9	3.65	3.4	1.93	.05
Speech errors	1.26	0.7	1.91	1.2	3.87*	.09	1.45	1.2	1.51	1.2	.02	.00
Eye blinks	17.38	9.7	27.07	12.7	7.34***	.16	19.56	9.1	24.75	12.1	2.34	.06

* $p < .05$, one-tailed test; ** $p < .05$, two-tailed test; *** $p < .01$, two-tailed test

particularly in the high cognitive load condition (Reverse Order). In the high cognitive load condition six of the 14 cues emerged as cognitive cues to deceit, whereas in the low cognitive load condition (control) only one such cue emerged. Six out of 14 cues (43%) may not be seen as strong support for our hypothesis, but it is a high percentage compared to other studies: In most studies where a substantial number of cues have been examined (see DePaulo et al. 2003, and Vrij 2000, for reviews) fewer than 43% of the investigated cues actually emerge as cues to deceit. Our findings are even more striking considering the task we set our liars. Because we told our liars what the truth tellers had experienced during the staged event, we provided liars with a wealth of visual details that they could incorporate into their stories. As a result, differences in visual details between liars and truth tellers did not arise. If we had not coached our liars so thoroughly, the predicted difference that is typically found (Vrij 2005) between liars and truth tellers in mentioning visual details may have occurred. Also, the extensive coaching of liars may have made the task of lying somewhat easier for them, and this may explain why the expected differences in latency period, pauses and speech errors did not emerge. To be sure, we cannot explain why the differences between liars and truth tellers show up for some measures but not for others. The real concern, however, is whether observers can discriminate between liars and truth tellers more effectively when stories are told in Reverse Order. Experiment 2 addresses this issue.

Experiment 2

The fact that reverse order interviews reveal more cues to deception than control interviews does not automatically imply that observers will be able to discriminate better between truths and lies in reverse order interviews. Successful discrimination depends on whether observers interpret the diagnostic cues correctly. Lack of detail, increases in speech hesitations and speech errors, slower speech rate and an increase in movements (some of the cues that differentiated liars from truth tellers in the reverse order interviews), all create the impression of suspicion (Strömwall et al. 2004; Vrij et al. 2006a). Therefore, we were hopeful that observers could differentiate between truths and lies in the reverse order interviews. In contrast, the situation appears gloomier for the control interviews. Only one cue, a decrease in hand/finger movements, differentiated liars from truth tellers in these interviews, and this cue is typically not associated with deception. In fact, observers believe that liars make *more* movements than truth tellers (Strömwall et al. 2004; Vrij et al. 2006a). Observers might therefore be using the wrong decision-making strategy when judging the control interviews and

might associate an increase in movements with deception rather than truth telling. This would result in judging truthful stories as deceptive and deceptive stories as truthful.

We also examined whether interviewees gave the impression that they were nervous or thinking hard. Since several of the cues that differentiated liars from truth tellers in the reverse order interviews were signs of cognitive load (lack of detail, more speech hesitations, more speech errors, and slower speech rate) or perhaps nervousness (increase in leg/foot movements and eye blinks), we predicted that in the reverse order condition liars would give the impression of thinking harder and being more nervous than truth tellers. Given the lack of cues that differentiated liars from truth tellers in the control interviews, we did not expect liars and truth tellers to differ from each other in terms of giving the impression of having to think hard or being nervous in the control interviews.

Method

Participants

The participants were 55 British police officers: 33 males and 22 females. The largest group (62%) were general uniformed officers, with the remaining 38% being specialised in CID (Criminal Investigations Department). None of the participants had received training in lie detection (such training does not exist in England and Wales). Their average age was $M = 30.60$ years ($SD = 8.4$). All of the police officers except one were Constables. The remaining participant was a Sergeant. Their average length of service in the police was $M = 2.81$ years ($SD = 6.2$). When asked to indicate on a 5-point Likert scale how experienced they considered themselves in interviewing ($M = 1.76$, $SD = 1.2$), 76% rated themselves as 'inexperienced' (a score of 1 or 2 on the 5-point Likert scale) whereas 12% declared themselves as 'experienced' (a score of 4 or 5 on the 5-point Likert scale). When asked to indicate on a 5-point Likert scale how motivated they were to perform well on the task, 77% reported themselves as fairly or highly motivated (a score of 4 or 5 on the 5-point Likert scale, $M = 4.02$, $SD = .8$).

Procedure

The study took place at training colleges with police constabularies in the South of England. Between seven and fifteen participants were tested simultaneously. This variation in group size reflected only the number of officers that trainers were willing to release from class at that time. It did not in any way affect the conduct of the experiment. The videotaped interviews ('clips') were shown on a large

screen (approximately 2m x 1m), in a large classroom that would have enabled twenty participants to have seen the screen clearly, sitting far enough apart so as not to see each other's answers. Participants were given questionnaires and asked to complete the first section relating to the details discussed in the Participants section above. They were then informed that they were about to see a selection of clips of students who were either lying or telling the truth about a scenario that involved the theft of money from a wallet. The scenario involved their playing a game of Connect 4 with another participant (actually a stooge) whilst various people entered or exited the room. Truth tellers had actually participated in this event, and truthfully had not taken any money; liars were merely informed about the event, and had actually taken the money from the wallet. The experimenter did not tell the participants how many clips they would see, or what percentage were truths or lies, so as to avoid participants calculating how many truths and lies they were actually being shown, and hence deliberately trying to achieve a certain number of truth/lie responses. Instead they were informed that although they would not be told how many clips they would see, there would not be as many clips as were in their questionnaire. They were told that after each clip the tape would be stopped, and when everybody had completed all questions on the questionnaire relating to that clip, the next clip would be shown. 31 officers saw 12 interviews told in reverse order and 24 officers saw 12 interviews told in chronological order. Those 24 interviews were a random sample of the interviews from Experiment 1. Of the 12 interviews seen by each observer, six interviewees lied and six told the truth.

In the experimental condition, prior to watching the reverse order interviews the participants were informed that the students that they were about to see have been asked to explain everything that happened in reverse order, so they will be reporting their story backwards.

After watching each clip the observers were asked to answer three questions: (i) Do you think that the suspect is telling (dichotomous answer, the truth/a lie), (ii) To what extent does the person in the video look as if he/she is having to think hard?, and (iii) To what extent does the person in the video look nervous? Answers were given on 7 point Likert scales ranging from (1) not at all to (7) extremely. The study took about 1 h to conduct.

Accuracy was measured by calculating the percentage of correct veracity judgements given by each participant in judging the truthful clips (truth accuracy) and deceptive clips (lie accuracy). The impressions of having to think hard and being nervous were measured by calculating the average cognitive load and nervousness scores allocated to liars and to truth tellers.

Results

Overall Accuracy, Lie Accuracy and Truth Accuracy

The overall accuracy scores ranged from a low of 17% (one participant in the control condition) to a perfect 100% (one participant in the Reverse Order condition) with an average of $M = .53$ ($SD = .17$). This average percentage did not differ significantly from the level of chance (.50), $t(54) = 1.22$, $p = .23$. The truth accuracy ($M = .54$, $SD = .21$) and lie accuracy ($M = .52$, $SD = .21$) were almost the same and did not differ significantly from each other, $F(1, 54) = .21$, $p = .64$. Neither truth accuracy nor lie accuracy differed significantly from chance, both t s < 1.28 , both p s $> .20$.

Hypothesis-Testing

A 2 (Veracity) \times 2(Order) mixed ANOVA was conducted with Veracity as the within-subjects factor, Order as the between-subjects factor, and accuracy as the dependent variable. The analysis revealed a significant Order effect, $F(1, 53) = 6.98$, $p < .05$, $\eta^2 = .12$. None of the other main effects or interaction effects were significant, all F s < 2.81 , all p s $> .10$. Accuracy in the Reverse Order condition ($M = .58$, $SD = .16$) was superior to accuracy in the control condition ($M = .46$, $SD = .17$). Accuracy in the Reverse Order condition was above the level of chance, $t(30) = 2.73$, $p < .05$, whereas accuracy in the control condition did not differ from chance, $t(23) = 1.12$, $p = .27$.

The data were separated into truth and lie accuracy scores. The Reverse Order condition resulted in $M = .56$ ($SD = .22$) truth accuracy and $M = .60$ ($SD = .20$) lie accuracy, whereby both truth accuracy $t(30) = 14.14$, $p < .01$, and lie accuracy score, $t(30) = 2.68$, $p < .05$ were significantly above the level of chance. The control condition resulted in $M = .50$ ($SD = .20$) truth accuracy and $M = .42$ ($SD = .19$) lie accuracy, whereby the lie accuracy score was significantly below the level of chance, $t(23) = 1.97$, $p < .05$. Lie accuracy in the Reverse Order condition (60%) was significantly higher than lie accuracy in the control condition (42%), $F(1, 53) = 10.53$, $p < .01$, $\eta^2 = .17$; truth accuracy did not differ significantly between the two conditions, $F(1, 53) = 1.26$, $p = .26$.

A 2 (Veracity) \times 2(Order) mixed MANOVA was conducted with Veracity as the within-subjects factor, Order as the between-subjects factor, and the impressions of having to think hard and nervousness as dependent variables. This analysis revealed a significant Veracity effect, $F(2, 52) = 15.61$, $p < .01$, $\eta^2 = .38$, a significant Order effect, $F(2, 52) = 6.37$, $p < .01$, $\eta^2 = .20$, and a significant Veracity \times Order interaction effect, $F(2, 52) = 23.71$, $p < .05$, $\eta^2 = .48$. At a univariate level, both

Veracity \times Order interaction effects were significant: Cognitive load ($F(1, 53) = 38.02, p < .01, \eta^2 = .42$) and nervousness ($F(1, 53) = 18.03, p < .01, \eta^2 = .26$). Since these two Veracity \times Order interaction effects are more informative than either of the two Veracity and Order main effects, only the Veracity \times Order interaction effects will be discussed further.

In the control condition, liars and truth tellers did not differ from each other in terms of giving the impression of having to think hard or being nervous, but in the Reverse Order condition they did, as can be seen in Table 2. Liars gave the impression of having to think harder and being more nervous than truth tellers.

Discussion

This experiment (Experiment 2) demonstrated that instructing participants to tell their stories in reverse order facilitates lie detection. Police officers who observed the stories told in reverse order were better at detecting lies (60% accuracy) than those who observed stories told in chronological order (42%). Also, the 60% lie accuracy obtained in the Reverse Order condition was significantly better than could have been expected by chance, whereas the 42% lie accuracy obtained in the control condition was significantly below chance level.

The improvement in lie detection as a result of asking interviewees to tell their stories in reverse order did not occur at the expense of the ability to detect truths. Truth detection accuracy was somewhat higher in the Reverse Order condition (56%) than in the control condition (50%) although the difference was not significant. However, total accuracy (lie and truth accuracy combined) in the Reverse Order condition (58%) was significantly higher than the total accuracy obtained by observers in the control condition (46%). The total accuracy obtained in the Reverse Order condition was also significantly above the level of chance, whereas the total accuracy in the control condition did not differ from chance.

We acknowledge that the accuracy scores are not high, even in the Reverse Order condition. Note that we told our liars (see Experiment 1) what truth tellers had actually experienced during the staged event. This may make lying somewhat easier than in situations where liars have to invent all the details themselves. However, as in many experimental studies, it is the statistical difference between experimental conditions that is important rather than the absolute level of accuracy scores.

We initially assumed that liars would have to think harder than truth tellers, and in particular when recalling in reverse order. Indeed, in this condition in particular liars gave the impression of having to think harder than truth tellers (Experiment 2). Liars also gave the impression of being more nervous than truth tellers in the Reverse Order condition (Experiment 2), which fits well with the findings of Experiment 1, that liars made more movements than truth tellers in the Reverse Order condition. We believe that the unexpected challenge of having to tell their stories in reverse order made liars nervous. Although we did not predict that liars would be more nervous than truth tellers in the Reverse Order condition (Experiment 1), the finding that liars displayed more nervous behaviours in the Reverse Order condition than truth tellers (Experiment 1) perhaps facilitated lie detection in the Reverse Order condition in Experiment 2 because observers typically think that liars show more nervous behaviours.

General Discussion

We started this article by noting the paucity of attempts to actively magnify the differences between liars and truth tellers. In this article we attempted to fill this gap and empirically tested an interview style designed to enlarge the non-verbal and verbal differences between liars and truth tellers: Instructing interviewees to recall their stories in reverse order. We predicted that this would be particularly debilitating for liars, because their cognitive resources

Table 2 Impression liars and truth tellers made on the observers in the reverse order condition and the control condition

Reverse order condition	Truth tellers		Liars		$F(1, 30)$	η^2
	M	SD	M	SD		
Having to think hard	3.75	.7	4.89	.7	90.35**	.70
Looking nervous	3.69	.6	4.48	.7	49.59**	.62
Control condition	Truth tellers		Liars		$F(1, 23)$	η^2
	M	SD	M	SD		
Having to think hard	3.95	.9	3.72	.7	1.36	.05
Looking nervous	3.56	.7	3.59	.7	.04	.00

* $p < .05$; ** $p < .01$

have already been partially depleted by the cognitively demanding task of lying. These predictions were supported. The reverse order interviews contained many more cues to deceit than the control interviews, and the instruction to convey stories in reverse order improved police observers' ability to detect deception.

We believe that the present findings are useful for professional lie detectors, and can be adapted for police interviews. Asking interviewees to report their stories in reverse order is already practiced in police interviews in several countries including the UK and US (Milne and Bull 1999, 2003), albeit in interviews with cooperative witnesses rather than suspects. Cooperative witnesses are requested to tell their stories in reverse order because it facilitates recalling more accurate information than conventional interview techniques (Geiselman et al. 1986; Köhnken et al. 1999). The present findings demonstrate that this technique could also be used in suspect interviews to facilitate truth and lie detection.

One possible limitation of this study is that police officers may be uncomfortable in a real investigation to request suspects to describe events in reverse order. It has been noted, for example, that British police have generally not used the reverse-order instruction of the Cognitive Interview (Fisher and Geiselman, 2002) when interviewing cooperative witnesses (Kebbell et al. 1999). We believe that a reason for this reluctance is that the police typically use a predetermined structure in which, in their view, the reverse-order instruction does not really fit. However, police may feel more comfortable using the technique when interviewing suspects, where the interview is more dynamic and is less likely to follow a predetermined structure. Indeed, we have been told by several American investigators who used the reverse-order instruction when interviewing suspects, that suspects frequently gave themselves away with obviously non-credible stories that were replete with inconsistencies.

Our new approach to lie detection is not restricted to asking interviewees to recall their stories in reverse order: Numerous other requests that make the interview setting cognitively more challenging should have a similar effect. For example, interviewees could be instructed to look the interviewer in the eye while reporting their activities. Constantly maintaining eye contact while talking is cognitively demanding (Beattie 1981), because it can be distracting (Doherty-Sneddon et al. 2002; Doherty-Sneddon and Phelps 2005). As we found in the present experiments, it could thus result in cues to deceit and facilitate lie detection.

Whether our predictions about the effects of holding constant eye contact on deception and lie detection will hold true will need to be experimentally tested. In addition, we have no doubt that there are other additional requests

that could be made in interview settings that would make the settings more demanding for the liar. We hope that our work inspires researchers to further develop the cognitively based lie detection method introduced in this article.

Acknowledgements This project was sponsored by a grant from the Economic and Social Research Council (RES-000-23-0292).

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