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DOI

[10.1016/j.jarmac.2015.11.004](https://doi.org/10.1016/j.jarmac.2015.11.004)

Publication date

2016

Document Version

Final published version

Published in

Journal of Applied Research in Memory and Cognition

License

Article 25fa Dutch Copyright Act

[Link to publication](#)

Citation for published version (APA):

Kleinberg, B., & Verschuere, B. (2016). The role of motivation to avoid detection in reaction time-based concealed information detection. *Journal of Applied Research in Memory and Cognition*, 5(1), 43-51. <https://doi.org/10.1016/j.jarmac.2015.11.004>

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Original article

The role of motivation to avoid detection in reaction time-based concealed information detection

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ARTICLE INFO

Article history:

Received 18 June 2015

Received in revised form

16 November 2015

Accepted 20 November 2015

Available online 29 November 2015

Keywords:

Memory detection

Reaction times

Lie detection

Concealed Information Test

Polygraph

Deception

ABSTRACT

Do motivated liars lie more successfully? The *motivational effort* hypothesis predicts that higher motivation effectively diminishes the chance of being detected, whereas the *motivational impairment* hypothesis predicts that the higher the motivation to go undetected, the greater the chance of being detected. We manipulated motivation in two online reaction time-based Concealed Information Test studies in which participants tried to hide their identity. Detection of concealed identity information in Experiment 1 ($n = 259$) was successful and a small financial incentive to avoid detection did not impact upon validity. Despite a greater financial incentive and a manipulation check showing that motivation was increased, Experiment 2 ($n = 233$) did not impact upon the test's validity either. A financial incentive to avoid detection did not decrease the validity of concealed information detection.

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1. Introduction

Identifying liars has intrigued people for centuries. Attempts to expose liars have known a great variety of methods and measures (e.g., voice stress analysis; Raskin, Honts, & Kircher, 2014), many of which try to differentiate between truth tellers and liars through stress. Contemporary approaches to lie-detection have adopted a different perspective and are building upon the cognitive view of deception (Vrij & Granhag, 2012). This framework is rooted in the idea that lying induces higher cognitive effort than telling the truth and advocates the exploitation of the cognitive costs involved in lying for the purpose of deception detection.

1.1. The Concealed Information Test

A well-validated paradigm that detects deception indirectly through differential cognitive processing of liars and truth tellers is the *Concealed Information Test* (CIT; Lykken, 1959; Verschuere, Ben-Shakhar, & Meijer, 2011). The CIT assumes that confrontation with critical information elicits distinct reactions in knowledgeable

participants compared to those who do not possess such knowledge (i.e. naïve participants). Imagine the robbery of a supermarket where the perpetrator was armed with a knife, demanded cash ('All you got!'), and fled the scene on a motorcycle. The investigator may use intimate knowledge of the crime in a CIT to assess the suspect on crime recognition. Such critical crime details are referred to as *probes* in the CIT. The CIT presents these probes along with stimuli of the same category that are equally plausible but unrelated to the actual crime (*irrelevants*). The investigator could ask the suspect: "What did the perpetrator say to the clerk? Was it... 'I want the money!'... 'All you got!'... 'I need cash!'... 'Big bills!'... 'Take it out!'" Denying crime involvement, the suspect is expected to overly answer NO to all the questions. Physiological responding is monitored throughout and a consistently stronger physiological reactivity to the probes than to the corresponding irrelevant items is taken as an indication of crime recognition.

1.2. Detecting concealed information through reaction times

While there is substantial empirical support for the use of physiological measures (Meijer, Klein Selle, Elber, & Ben-Shakhar, 2014), a more recent approach uses reaction times (RTs) to index concealed information. Requiring only a single computer makes an RT-based test an attractive alternative to the more complex physiology-based test. Despite initial scepticism (Farwell &

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Donchin, 1991; Gronau, Ben-Shakhar, & Cohen, 2005) a growing research base has shown that the RT-CIT successfully discriminates between knowledgeable (e.g., guilty) and naïve (e.g., innocent) participants (e.g., Seymour, Seifert, Shafto, & Mosmann, 2000; Kleinberg & Verschuere, 2015; Visu-Petra, Miclea, & Visu-Petra, 2012). Verschuere, Crombez, Degrootte, and Rosseel (2010) found that the RT-CIT might reach the same validity as the best autonomic nervous system measure, skin conductance. In order to ensure that the participants' attention is directed to the task, in addition to probes and irrelevant items, the RT-CIT also uses a third category of stimuli that require a unique behavioural response. The overt task for the participant is to make a binary decision, discriminating these 'targets' from all other stimuli. Targets serve to assure attention to the stimuli and may increase the validity of concealed information detection by obliging participants to lie to the probe (i.e., requiring a NO response to the probes). Building on the example above, the participant may be presented with several sentences, flashed one after the other on the computer screen, and instructed to answer as fast as possible with YES to a target sentence ('Don't act stupid!'), and with NO to the irrelevant sentences as well as to the probe sentence. Slower responding to the probe than to the irrelevant sentences is taken as a cue of recognition of the true crime details.

1.3. Motivation to conceal information

When comparing research settings and field applications of deception detection tests, motivation is often seen as a key factor (Hartwig & Bond, 2014). Guilty suspects in real criminal investigations have much more to win by successfully deceiving the test. The motivation to avoid detection has therefore been argued to affect the outcome of deception detection tests (Buckley, 2012; O'Sullivan, Frank, Hurley, & Tiwana, 2009; ten Brinke, Porter, & Baker, 2012). Interestingly, there are diverging theoretical perspectives on the role of motivation. On the one hand, it can be reasoned that the higher the motivation to deceive the test, the more likely it is to actually succeed in doing so (Horvath, Jayne, & Buckley, 1994). This reasoning matches a wide range of studies showing that motivation can make people invest more effort and effectively improve task performance (Muraven & Slessareva, 2003). This *motivational effort* hypothesis implies that the effects found in research settings are overestimations of the applied validity of the CIT. On the other hand, the *motivational impairment* hypothesis holds that higher motivation to deceive could paradoxically increase the test's validity (DePaulo & Kirkendol, 1989). This effect states that heightened motivation to avoid detection may actually be detrimental to what the participant is aiming to achieve, that is she is more likely to fail to deceive the test. Applied to the CIT, the increased motivation to avoid detection might increase the salience of the probe items (i.e. making them even more 'relevant' to the participant than they are anyway), so that they stand out even more amongst the irrelevant items and produce an even larger probe-irrelevant difference.

At first sight, the empirical data seem to support the motivational impairment effect. Meta-analytic research has found that greater motivation to avoid detection increased the validity of physiological concealed information detection (Meijer et al., 2014; see also Ben-Shakhar & Elaad, 2003). However, the moderating effect in the meta-analyses was based upon a between-study comparison; i.e., comparing studies that included one level of motivation (e.g., unmotivated examinees) with studies that included a different level of motivation (e.g., examinees that were financially motivated to avoid detection). These studies differed in many other aspects and the greater validity in the high motivation conditions cannot unambiguously be ascribed to motivation. Moreover, it must be noted that these studies were based on a single physiological measure, the skin conductance response. Recent studies suggest that different CIT measures may function through different

mechanisms, with skin conductance possibly being a pure measure of the orienting response and RTs reflecting response inhibition processes (Klein Selle, Verschuere, Kindt, Meijer, & Ben-Shakhar, 2015; Suchotzki, Verschuere, Peth, Crombez, & Gamer, 2014). While a number of studies found that motivation is beneficial to the detection efficiency of the CIT (Ben-Shakhar, Frost, Gati, & Kresh, 1996: Exp. 2; Elaad & Ben-Shakhar, 1989, 1997: Exp. 1; Gustafson & Orne, 1963), a substantial number of studies failed to find such an effect (Furedy & Ben-Shakhar, 1991; Liebligh, Naftali, Shmueli, & Kugelmass, 1974; Davidson, 1968; Beijik, 1980; Kugelmass & Liebligh, 1966; Day & Rourke, 1974). In sum, while motivation is reasoned to be of great importance, its impact on the SCR-based CIT may be less clear than suggested by meta-analytic research, and remains to be explored for the RT-based CIT.

1.4. The current study

We investigate the effect of motivation to avoid detection on the validity of RT-based Concealed Information Test. Using the online memory detection framework (Kleinberg & Verschuere, 2015), we were able to run well-powered studies reliably, validly and efficiently on the Internet. In Experiment 1, we used an autobiographical CIT aimed at revealing concealed autobiographical identity details. Participants in the "*knowledgeable*" conditions were presented with their identity details in the CIT and tried to hide recognition of their identity details. Half of the knowledgeable participants were promised a financial reward for successfully avoiding detection (*motivated knowledgeable*) whereas there was no such reward for the other half (*non-motivated knowledgeable*). Finally, participants in the "*naïve*" condition served as a control and they were not presented with their identity details in the CIT.

2. Experiment 1

The institutional review board of the Department of Psychology of the University of Amsterdam approved of this experiment (no. 2013-CP-3053).

2.1. Method

2.1.1. Participants

This experiment was run on the online platform *Amazon Mechanical Turk* (AMT) and we collected data of 319 participants, all of whom received a compensation of \$0.75. Data of 9 participants were not recorded properly, most likely as a result of out-dated web-browsers. Following Kleinberg and Verschuere (2015), we applied the following exclusion criteria. (1) In order to ensure that participants did not participate more than once, we recorded the participants' IP addresses and conservatively excluded data from all double IP addresses ($n = 10$). (2) We also excluded those participants that had more than 50% errors on either probes, targets, or irrelevant items because such a high error rate meant that participants were either not paying attention to the task or did not understand it ($n = 30$). (3) None of the remaining subjects had fewer than 50% of the trials left; so all participants had a large enough number of trials to be included in the analyses.

The final sample consisted of 259 participants (sample loss was 16.13%) who had been randomly assigned to one of three conditions. In the non-motivated knowledgeable condition, there were 79 participants (59% female, $M_{\text{age}} = 37.06$ years, $SD = 10.33$), in the non-motivated naïve condition 96 participants (45% female, $M_{\text{age}} = 37.69$ years, $SD = 12.05$) and in the high-motivated knowledgeable condition there were 84 participants (55% female, $M_{\text{age}} = 33.57$ years, $SD = 12.11$). Between the conditions, there was no difference in gender, $\chi^2(2) = 4.01$, $p = 0.134$. The conditions did differ in age, $F(1, 256) = 3.18$, $p = 0.043$, $f = 0.11$. We included Age

as covariate into preliminary analyses into a one-way ANOVA of Condition on the probe-irrelevant difference but neither the main effect of Age, $F(1, 253)=0.04$, $p=0.835$, $f=0.01$, nor the interaction between Age and Condition, $F(2, 253)=0.86$, $p=0.425$, $f=0.06$, were significant. As a consequence, we ruled out that age influenced the CIT effect, and decided not to include age in the main analyses.

2.1.2. Materials

The experimental task used in this experiment was written in the HTML5/JavaScript framework introduced in Kleinberg and Verschuere (2015); Verschuere and Kleinberg (2015); Verschuere, Kleinberg and Theodoridou (2015). All that was needed for participation was access to a computer with a web-browser connected to the Internet. The complete task is accessible via this link: http://www.lieresearch.com/?page_id=621. The data for both experiments can be retrieved from the Open Science Framework data repository via osf.io/c7w5v (Open Science Collaboration, 2012).

2.1.3. Procedure

This experiment was run on AMT, an online platform where participants can register to complete small tasks. We allowed AMT workers to participate who had at least a 95% approval rate of previous tasks.

2.1.4. Identity details and item selection

Upon accessing the task, participants agreed to the informed consent and were then asked to provide demographic information (age, gender, mother tongue, education, country of origin, date of birth) using drop-down menus. On the next screen they indicated three autobiographical details (*probes*): they had to choose their country of origin (e.g., Norway) from all possible countries, their date of birth (day and month, e.g., 31 May) from all possible birthdays, and their age in years from a range of 18 to 85. Additionally, they provided information about one other significant birthday, country, and age, which were subsequently excluded from the pool of items used in the remainder of the test. We chose for these three categories because in previous studies, these items had been rated as highly salient on a 1 (=not relevant at all) to 9 (=absolutely relevant) Likert scale (e.g., birthday: $M=7.28$, $SD=2.18$; origin: $M=7.44$, $SD=2.07$; age: $M=6.59$, $SD=2.31$, see Kleinberg & Verschuere, 2015). The items to be used during the experimental tasks were optimised according to the details provided and the randomly determined condition of the participant, that is a set of 18 items (consisting of 6 items per category) was generated out of an item pool of 30. This optimisation ensured that no significant items other than the probes were included in the item set. Once 18 optimised items were selected, they were randomly assigned to function as *probe*, *targets* or *irrelevants*.

2.1.5. False identity

Participants were introduced to the test and told that they had to adopt a new identity (=targets; e.g., SPAIN, 4 DECEMBER, 42). After memorisation, they proceeded to the next page and typed in their new identity. They were allowed to proceed once they had typed in all three items correctly; otherwise the memorisation and recall procedure was repeated until they passed this check.

2.1.6. Experimental manipulation

We allocated participants randomly to one of three conditions: each participant had a probability of one third to be assigned to either condition. In the non-motivated naïve condition participants were not presented their own, true autobiographical details as probe items but instead saw another set of three irrelevant items, hence the probes here are in fact irrelevants (see Meijer, Smulders, Johnston, & Merckelbach, 2007; Ben Shakhar, 2002).

In both the non-motivated knowledgeable and high-motivated knowledgeable condition, participants were presented with their true probes. The difference between these two conditions consisted of the incentive they could receive if they succeeded at hiding their true identity. Only those in the high-motivated knowledgeable condition read that upon successfully hiding their identity they would receive a financial bonus of \$1.50 (see Bradley & Warfield, 1984). Based on automated in-test scoring (d_{CIT} ; see Kleinberg & Verschuere, 2015) 56 participants from the high-motivated condition received their bonus.

2.1.7. Concealed Information Test

Participants received detailed instructions about the CIT and were instructed to endorse recognition of their new identity and deny recognition of all other items including those of their own identity. The CIT began with a step-wise practice procedure followed by the full test.

The task was to react to the question “Do you recognise this stimulus?” by pressing the e-key for YES and the i-key for NO. These instructions remained on screen during the task in white capital letters on top and on the sides of the screen, respectively. In the centre of the screen, the stimuli were displayed one at a time in black colour for exactly 1500 ms. The inter-trial interval was variably either 250, 500 or 750 ms (see Seymour et al., 2000; Noordraven & Verschuere, 2013; Verschuere et al., 2015). Reaction times were recorded up to microsecond accuracy. If the user did not respond with a key press until the response deadline (800 ms), the text TOO SLOW appeared for 200 ms in red colour, capital letters above the stimulus. If the participant reacted incorrectly, the text WRONG appeared in the same style and duration below the stimulus. Regardless of the response deadline, we recorded RTs until 1500 ms and the subsequent stimuli appeared automatically after 1500 ms if none of the response keys were pressed.

In order to allow the participants to accommodate the speed of the task, we prepared them with a stepwise practice procedure. In total, there were three practice phases, each consisting of 24 trials. Phase 1: no response deadline of 800 ms, instead the stimulus stayed on the screen until a response key was pressed. Phase 2: no response deadline of 800 ms but the stimulus disappeared after the 1500 ms interval. Phase 3: all features as in the full test, that is 800 ms response deadline, too slow message at 800 ms, and 1500 ms stimulus interval. For all of the three practice phases, we operated three passing criteria. If participants made more than 50% target errors (more or exactly 50% in the last practice phase), if the recorded RT was smaller than 150 ms in more than 20% of the trials, or if the mean RT was higher than 800 ms, they had to repeat the respective phase. After passing through the practice procedure, the participants proceeded to the full test. The number of trials for the full test was 360 (240 irrelevants, 60 probes, 60 targets), divided into 10 blocks of 36 stimuli (24 irrelevants, 6 probes, 6 targets). Within each block, the order of the stimuli was completely random. There were no breaks in between blocks.

2.1.8. Subjective ratings

The study ended with rating the categories used in this experiment (i.e., country of origin, birthday, age) according to the significance participants attached to them, along with categories that we reasoned would have lower salience (political preference, mother tongue, favourite sports, author, holiday destination, drink, celebrity, sex location, car, sex position, drug, music). On the very last page, automated individual feedback was provided on whether they successfully avoided detection.

Table 1
Mean RTs (SDs) in ms and effect sizes per stimulus and condition for Experiment 1.

	Probes	Irrelevant	CIT effect (d_{within})
Naïve	479 (41)	482 (41)	−0.12 ^a
Non-motivated knowledgeable	503 (53)	473 (44)	1.28 ^b
High-motivated knowledgeable	516 (51)	484 (47)	1.11 ^b

Note. Same superscript letters mean “no significant difference” at $p < 0.05$, different letters mean “significant difference”.

2.2. Results

2.2.1. Analysis plan

We report effect size for the ANOVA using Cohen's f , $f = \sqrt{[\eta p^2 / (1 - \eta p^2)]}$, and we used the Cohen's d s for follow up contrasts as recommended by (Lakens, 2013; Cohen, 1988). We used d_{within} and d_{between} for within-subjects and between-subjects comparisons, respectively. For individual effect sizes of the probe-irrelevant difference for each participant, we adopted the approach introduced in Noordraven and Verschuere (2013) by calculating another effect size called $d_{\text{CIT}} = (M_{\text{RT}(\text{probes})} - M_{\text{RT}(\text{irrelevant})}) / SD_{\text{RT}(\text{irrelevant})}$.

2.2.2. Item salience ratings

The three categories used in this experiment were rated as *significant* (country of origin: $M = 6.60$, $SD = 2.42$; age: $M = 6.12$, $SD = 2.31$; birthday: $M = 6.04$, $SD = 2.53$; collapsed $M = 6.25$, $SD = 2.00$). A one-sample t -tests showed that the ratings were significantly higher for the three test categories than for low salient control categories (see also Verschuere et al., 2015; Kleinberg & Verschuere, 2015); collapsed: $M = 4.14$, $SD = 1.57$), $t(508) = 13.31$, $p < 0.001$, $d_{\text{within}} = 0.99$.

2.2.3. Effect of motivation

We conducted all analyses on RTs only, because error rates were too low (<2% for probes and irrelevant) to be a valid index of the CIT effect due to floor-effects (see Seymour & Kerlin, 2008). Only correct RTs between 150 and 800 ms were included in the analysis. Table 1 shows the RTs per Stimulus and Condition. The 3 (Condition: naïve vs. non-motivated knowledgeable vs. high-motivated knowledgeable) by 2 (Stimulus: probe vs. irrelevant) mixed ANOVA revealed a significant main effect of Condition, $F(2, 256) = 4.24$, $p = 0.015$, $f = 0.13$, a significant main effect of Stimulus, $F(1, 256) = 176.83$, $p < 0.001$, $f = 0.83$, and a significant interaction between Condition and Stimulus, $F(2, 256) = 58.89$, $p < 0.001$, $f = 0.43$. Follow-up contrasts indicated that the probe-irrelevant difference for non-motivated knowledgeable participants was higher than that for naïves, $t(173) = 10.02$, $p < 0.001$, $d_{\text{between}} = 1.52$. The probe-irrelevant difference for high-motivated knowledgeable participants was higher than that for naïves, $t(178) = 9.50$, $p < 0.001$, $d_{\text{between}} = 1.42$. The two knowledgeable groups did not differ from each other, $t(161) = 0.45$, $p = 0.657$, $d_{\text{between}} = 0.07$ (Table 1).

2.2.4. Individual classification

Comparisons of mean reaction times between groups does not take into account overlap between individual results in each group (Franz & von Luxburg, 2015). In order to test how well the test outcome classified each individual we conducted receiver operating characteristics analysis and calculated the area under the curve (AUC). The AUC can range from 0 to 1, with 0.5 corresponding to performance at chance level (Hanley & McNeill, 1983). In our analysis, the criterion was the d_{CIT} (Noordraven & Verschuere, 2013) and we used the *pROC* package for R (Robin et al., 2011). The AUC was high for both the non-motivated versus naïve comparison (AUC = 0.85; 95% CI: 0.80–0.91), as well as for the high-motivated versus naïve

comparison (AUC = 0.85; 95% CI: 0.79–0.90). There was no significant difference between the two, $Z = 0.19$, $p = 0.851$.

2.3. Discussion

Experiment 1 indicated that financially motivating participants did not alter their ability to mislead the test. There are, however, four aspects that limit the quality of this finding. First, the manipulation may not have been strong enough. We therefore increased the incentive in Experiment 2. Second, Exp. 1 lacked a manipulation check preventing us from examining whether participants were indeed motivated to put extra effort in misleading the test as a product of the motivation manipulation. Third, it could be that the lack of an effect of motivation was due to the high salience of the stimuli, leading to a ceiling effect (we wish to thank an anonymous reviewer of an earlier version of this manuscript for raising this point). In Experiment 2, we therefore used stimuli of moderate to low salience. Fourth, the effect of motivation in previous studies may be related to reduced validity in low-motivated participants (e.g., examinees who are told that the test merely serves to check the functionality of the apparatus) rather than to increased motivation in high-motivated participants (i.e., those who are financially motivated to avoid detection). Experiment 2 therefore also included a low motivation condition in which we tried to lower the participants' motivation to avoid detection (see Elaad & Ben-Shakhar, 1989; Furedy & Ben-Shakhar, 1991).

3. Experiment 2

Experiment 2 included four conditions: naïve, non-motivated knowledgeable, low-motivated knowledgeable, and high-motivated knowledgeable participants. As in Experiment 1, the “knowledgeable” conditions were presented with their identity details in the CIT, with some being promised a financial reward for successfully avoiding detection (*high-motivated knowledgeable*), whereas others could not win a reward (*non-motivated knowledgeable*), and *low-motivation knowledgeable* participants being told that their participation merely served as a functionality check of a test ‘under development’. Naïve participants were not presented with their identity details in the CIT.

3.1. Method

3.1.1. Participants

Data for this experiment were collected via the online platform [crowdfunder.com](https://www.crowdfunder.com) where participants could register for this task in exchange for a compensation of \$0.75. We collected data of 302 participants initially of which 23 had to be excluded due to failure to record their data (most likely due to outdated web-browsers). (1) Data of one double IP address were removed; (2) in the error exclusion as outlined above 43 participants were excluded. (3) One participant was excluded due to too few trials left. The final sample consisted of 233 participants (28.76% female, $M_{\text{age}} = 30.72$ years, $SD = 8.05$, sample loss = 22.87%) who had been allocated to one of the following conditions: naïve ($n = 48$, $M_{\text{age}} = 32.06$, $SD = 9.30$), non-motivated knowledgeable ($n = 70$, $M_{\text{age}} = 30.59$, $SD = 7.23$), low-motivated knowledgeable ($n = 58$, $M_{\text{age}} = 29.02$, $SD = 7.05$), and high-motivated knowledgeable ($n = 57$, $M_{\text{age}} = 31.47$, $SD = 8.70$). There was no association between condition and gender, $\chi^2(3) = 1.52$, $p = 0.68$ and no difference in age between conditions, $F(3, 229) = 1.49$, $p = 0.217$, $f = 0.08$.

3.1.2. Materials

The experimental task as done by the participants can be accessed via http://www.lieresearch.com/?page_id=707.

3.1.3. Procedure

We used the same procedure as in Experiment 1, with the following differences. (1) The incentive for successful avoiding detection in the high-motivated knowledgeable condition was increased to 5.00\$ (2) A manipulation check was included asking participants two questions with regard to the motivation manipulation: “To what extent did you try to hide your personal details?” (motivation) and “To what extent did you try to beat the test?” (faking), to be rated with a number between 1 (not at all) and 100 (completely). (3) We used three categories that were autobiographical but rated as low salient in previous studies (Kleinberg & Verschuere, 2015). We chose favourite animal (e.g., CAT), favourite colour (e.g., GREEN), and favourite ice cream (e.g., VANILLA) as categories. Participant gave these details about themselves and adopted a fake identity consisting of randomly determined items in the same categories (e.g., DOG, BLUE, CHOCOLATE). (4) In addition to the three conditions of Experiment 1, Experiment 2 also included a low-motivated condition, participants read that the test was currently under development and that the purpose of the task was to examine whether the test is stable and runs without crashing. At a later point right before the test, they also read “we appreciate your help with this [...] monotonous task”. 27 participants from the high-motivated condition received their bonus.

3.2. Results

3.2.1. Motivation manipulation check

Impossible values above 100 were recoded to 100. The one-way ANOVA of Condition (non-motivated naïve, non-motivated knowledgeable, low-motivated knowledgeable, high-motivated knowledgeable) on the extent to which participants tried to hide their identity showed a significant main effect of motivation, $F(1, 230)=7.14$, $p=0.01$, $f=0.18$. The high-motivated knowledgeable condition ($M=71.25$, $SD=31.80$) tried harder to hide their identity as compared to the non-motivated naïve ($M=52.40$, $SD=36.38$), $t(103)=2.83$, $p=0.006$, $d_{\text{between}}=0.56$, non-motivated knowledgeable ($M=48.03$, $SD=36.42$), $t(125)=3.78$, $p<0.001$, $d_{\text{between}}=0.70$, and low-motivated knowledgeable ($M=46.30$, $SD=36.76$), $t(112)=3.88$, $p<0.001$, $d_{\text{between}}=0.73$. The latter three did not differ from each other.

The one-way ANOVA of Condition (non-motivated naïve, non-motivated knowledgeable, low-motivated knowledgeable, high-motivated knowledgeable) on the extent to which participants tried to beat the test did not show a significant effect, $F(1, 230)=3.21$, $p=0.07$, $f=0.12$ (naïve: $M=69.02$, $SD=31.45$, non-motivated knowledgeable: $M=71.16$, $SD=33.33$, low-motivated knowledgeable: $M=72.30$, $SD=31.97$, high-motivated knowledgeable: $M=79.91$, $SD=28.62$).

3.2.2. Item salience

Participants rated the three categories (i.e., favourite animal, favourite colour, favourite ice cream) as *significant* (collapsed: $M=5.78$, $SD=1.92$). Although still *significant*, average rating was lower than that of high-salient control categories (first name, birthday, name of mother; collapsed: $M=6.65$, $SD=2.35$), $t(462)=4.36$, $p<0.001$, $d_{\text{within}}=0.30$.

3.2.3. Effect of motivation

We used the same analysis and exclusion criteria as in experiment 1. The 4 (Condition: non-motivated naïve, non-motivated-knowledgeable, low-motivated knowledgeable, high-motivated knowledgeable; between-subjects) by 2 (Stimulus: probes vs. irrelevant; within-subjects) mixed ANOVA on RTs in milliseconds revealed main effects of Stimulus, $F(1, 229)=73.87$, $p<0.001$, $f=0.57$; and of Condition, $F(3, 229)=3.64$, $p=0.014$, $f=0.13$. These effects subsumed under the significant interaction

Table 2

Mean RTs (SDs) in ms and effect sizes per stimulus and condition for Experiment 2.

	Probes	Irrelevant	d_{within}
Naïve	494 (43)	494 (38)	0.02 ^a
Non-motivated knowledgeable	500 (43)	479 (39)	0.80 ^b
Low-motivated knowledgeable	494 (48)	477 (45)	0.60 ^b
High-motivated knowledgeable	518 (47)	500 (45)	0.79 ^b

Note. Same superscript letters mean “no significant difference”, different letters mean “significant difference”.

between Stimulus and Condition, $F(3, 229)=7.36$, $p<0.001$, $f=0.18$. The interaction indicated that the probe-irrelevant differences for the three knowledgeable motivation conditions (no, low, high) were significantly larger than the probe-irrelevant difference in the non-motivated naïve condition. Contrasts with the naïve condition: non-motivated knowledgeable: $t(116)=4.56$, $p<0.001$, $d_{\text{between}}=0.85$; low-motivated knowledgeable: $t(104)=3.33$, $p=0.001$, $d_{\text{between}}=0.65$; high-motivated knowledgeable: $t(103)=4.12$, $p<0.001$, $d_{\text{between}}=0.81$ (Table 2). The three knowledgeable conditions (no, low, high) did not differ from one another, $p's>0.05$, $r's=0.40-0.99$, $d_{\text{between}}=0.08-0.17$.

3.2.4. Individual classification

The AUC was 0.73 (95% CI: 0.64–0.82) for the non-motivated/naïve comparison; 0.67 (95% CI: 0.57–0.77) for the low-motivated/naïve comparison; and 0.73 (95% CI: 0.64–0.83) for the high-motivated/naïve comparison. There were no significant differences between the three AUCs (low-motivated/naïve compared to high-motivated/naïve: $Z=-1.40$, $p=0.162$; non-motivated/naïve compared to low-motivated/naïve comparisons: $Z=1.70$, $p=0.09$; non-motivated/naïve compared to high-motivated/naïve: $Z=-0.53$, $p=0.958$).

3.2.5. Correlational analysis

We also correlated participants' d_{CIT} scores with their motivation to hide their identity and their motivation to beat the test. We collapsed all knowledgeable participants across conditions to take into account individual differences within each condition (e.g., highly motivated participants in the non-motivated condition). Neither the motivation to hide their identity ($r=-0.00$; $p=0.91$), nor their motivation to beat the test ($r=0.08$; $p=0.27$) correlated with participants' d_{CIT} .

4. Supplementary analysis

We use a great number of trials (i.e., 360) in the Concealed Information Test, and investigated how the reliability and validity of the RT-CIT varied as a function of the test's length. There are two theoretical accounts predicting different effects of test length. One the one hand, psychometric theory predicts that more trials result in higher reliability, which may result in higher validity (Spearman, 1910; Brown, 1910). On the other hand, longer tests provide participants with more opportunity to grasp the rationale of the test and effectively avoid detection (i.e., implement countermeasures; Ben Shakhar, 2011). CIT research with physiological measures has shown incremental validity when additional blocks of trials were included (e.g. Beijk, 1980; Elaad & Ben-Shakhar, 1997; Liebllich et al., 1974). Since this has not been examined empirically for the RT-CIT, we have summarised the reliability and validity of the RT-CIT in two panel-plots. Figs. 1 and 2 display the split-half reliability, $\rho=2r/(1+r)$ (Spearman, 1910; Brown, 1910), and AUC for an increasing number of included blocks of 36 trials each (i.e., we did the analysis for all trials in block 1, next we did the analysis for all trials in block 1 and 2, etc.). These analyses refute the idea that validity would be hampered by increased test length, but

Fig. 1. Split-half reliability with successive inclusion of test blocks for Experiment 1 and 2.

rather indicate that reliability and validity increase with increased test length.

5. General discussion

5.1. The role of motivation

How does motivation to avoid detection impact upon the validity of concealed information detection? While one would intuitively expect that the more motivated liars are less likely to be caught (*motivational effort hypothesis*), the *motivational impairment effect* predicts the exact opposite, namely, that the more motivated, the easier the detection. We found no significant effect of a financial incentive to avoid detection on the likelihood of escaping detection on the RT-based CIT.

Our findings need to be interpreted alongside a number of methodological considerations. First, null findings are non-conclusive when statistical power is too low to have detected an effect if one were there. The substantial sample size used in both experiments meant that there was sufficient statistical power (power=0.96 for Exp. 1, and power=0.90 for Exp. 2) to have detected an effect of moderate size ($f=0.25$). So while we cannot exclude that there is no motivation effect at all, the current findings suggest it would likely be small, and its influence on the test outcome less dramatic than often assumed. Second, while Experiment 1 lacked a manipulation check, the manipulation check in Experiment 2 indicated that we successfully increased the motivation to avoid detection in the high motivation condition. Moreover, correlational analyses exploring individual variation in motivation across conditions also did not affect the test outcome. In sum,

methodological flaws do not evidently cause the null findings. We therefore conclude that a financial motivation to avoid detection does not have a strong impact upon the validity of the RT-CIT.

Our observation that motivation to avoid detection did not influence CIT success is at odds with meta-analytic research showing that CIT detection is more successful for motivated liars (Ben-Shakhar & Elaad, 2003; Meijer et al., 2014). We see three possible reasons for these divergent findings. First, our literature review revealed that the meta-analyses are largely based upon a between-study comparison, and that there are only few primary studies that experimentally manipulated motivation with several failing to find a significant motivation effect. This observation calls for more primary research on the role of motivation. Second, we used a different measure (RTs) than that used in the meta-analyses (skin conductance). While the SCR-CIT and the RT-CIT are conceptually similar, they may rely upon different underlying cognitive mechanisms. Skin conductance responding in the CIT has been largely related to the Orienting Response (Klein Selle et al., 2015; Suchotzki et al., 2014; Verschuere, Crombez, De Clercq, & Koster, 2004). From an orienting perspective, increased motivation may increase the salience of the concealed information and thereby augment the orienting response. It is less clear whether the RT-CIT is also driven by the orienting response. The RT-CIT may be more driven by response conflict and response inhibition (Seymour & Schumacher, 2009; Suchotzki et al., 2014; Verschuere & De Houwer, 2011). This leaves open the question why motivated liars were not more successful in inhibiting the truth. Third, the motivational effort and motivational impairment effect may both be at play, but cancel each other out. Heightened motivated to avoid detection may result in the participant being more engaged in avoiding detection (the

Fig. 2. Area under the curve with successive inclusion of test blocks for Experiment 1 and 2.

motivational effort hypothesis), which at the same time increases the saliency of the probes (the motivational impairment effect) to such an extent that the net effect is zero. Future experiments could attempt to find independent measures that can separate both effects to uncover the dynamics suggested in the current paper. The interpretation of our null-findings may contain more complexity than just the notion that motivation is not effective to avoid detection.

5.2. Test length

While the RT-CIT is typically brief (e.g., 108 trials in Seymour et al., 2000; Seymour & Kerlin, 2008; Seymour & Fraynt, 2009), the ERP-CIT in which RTs are also recorded often consists of several hundreds of trials (e.g., Farwell & Donchin, 1991). Concern could be raised that lengthier tests may increase opportunity and practice to engage into faking. Our current results do not support that concern but instead indicate that having more trials improves reliability and validity. The reliability in the first blocks was low, suggesting that little value can be attached to findings from the first blocks. In line with psychometric theory, we found that an increased number of trials benefited test reliability. This is corroborated for physiological measures by studies showing similar effects when additional blocks of trials were included (Beijk, 1980; Elaad & Ben-Shakhar, 1997; Lieblisch et al., 1974). Taken together, the lengthier test brings about a more reliable, and more valid test outcome. We therefore recommend the use of lengthier tests with at least 200 trials. Note that running a few hundred trials still only takes a few minutes because of the brief stimulus presentation duration and inter-stimulus-interval.

5.3. Limitations

A number of limitations warrant closer attention. First, with regard to the chosen methodology, our web-based research places the research in a less controlled and noisier environment than laboratory research. Note, however, that a series of studies indicates that the RT-CIT can validly be administered via the web if a range of “safeguards” is deployed including clear instructions, phasic and extensive practicing procedure, validity checks and strict passing criteria (Kleinberg & Verschuere, 2015; Verschuere & Kleinberg, 2015; Verschuere et al., 2015; for an extensive discussion of laboratory versus online testing see Houben & Wiers, 2008; Buhrmester, Kwang, & Gosling, 2011; Germine et al., 2012). Second, although we used the same motivation manipulation as previous studies, the manipulation had no strong impact upon motivation. Future research should consider other, stronger manipulations. There is a vast body of research on loss aversion (e.g. Tversky & Kahneman, 1991; Novemsky & Kahneman, 2005) indicating that people prefer avoiding losses to receiving gains. With regard to real-life applications of the CIT this is emphasised by the situation potential suspects are in: they have more to lose (e.g., their freedom) than they have to win. Motivating-with-loss therefore seems an interesting manipulation for future motivation research.

5.4. Practical applications

Using two well-powered online studies, we investigated whether motivated liars were more successful in hiding concealed information. They were not. The applied implications of this work are straightforward. RTs allow to detect concealed autobiographical

information, even when participants are financially incentivised to escape detection, with longer tests being more reliable and more valid.

Conflict of interest statement

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.1016/j.jarmac.2015.11.004>.

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