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An interfering dot-probe task facilitates the detection of mock crime memory in a reaction time (RT)-based concealed information test

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ABSTRACT

The present study aimed to test the hypothesis that an interfering task in the concealed information test will help the detection of concealed memory based on participants' behavioral performance (e.g. reaction time, error rate). Here, after participants enacted a mock crime, they were introduced to a concealed information test either with or without an interfering dot-probe task. Results showed that the RT-based pure-CIT (without interference) can detect concealed memory well above chance (AUC = .88). The detection efficiency was higher (AUC = .94) in the interference-CIT based on participants' performance of the interfering task. The findings suggested that the elevation of cognitive workload could possibly increase the detection efficiency of concealed memory based on behavioral measures.

1. Introduction

Feigning memory loss or intentionally concealing information may serve to maximize one's personal benefits at the cost of another individual or society. Thus, it is critical to establish an objective test to identify a suspect's true memory status. One method that has been used to evaluate the veracity of one's statement is known as the concealed information test (Lykken, 1959, 1960; for an overview, see Verschuere, Ben-Shakhar, & Meijer, 2011). Originally developed by Lykken, the concealed information test (CIT) was designed to uncover specific crime-relevant information via physiological activities such as skin conductance responses (SCRs). Specifically, the item-of-interest (e.g. the weapon used in the murder, the place where the body was hidden, or the amount of money that was stolen) was embedded among a series of crime-irrelevant stimuli (e.g., other possible weapons that could be used). Since only the criminal possesses the crime-relevant information, the item-of-interest should elicit strong orienting responses (ORs) compared to crime-irrelevant stimuli for guilty suspects. In contrast, for an innocent person who was not involved in the crime, the crime-relevant item response should be processed in a similar way as crime-irrelevant stimuli, thus showing no differentiated responses between these two classes of stimuli. The CIT has been shown to be a valid tool for uncovering information that has personally significant meaning to an examinee (Hu, Hegeman, Landry, & Rosenfeld, 2012; Meijer, Smulders, Johnston, & Merckelbach, 2007), even when the examinee lacks a conscious recognition of that stimulus (e.g. prosopagnosia, Bauer, 1984; Tranel & Damasio, 1985), or the examinee deliberately tries to conceal the knowledge of the stimulus by lying (Ben-Shakhar & Elaad, 2003; Gamer, Kosiol, & Vossel, 2010; Rosenfeld, Hu, & Pederson, 2012; for an overview, see Verschuere et al., 2011).

In the majority of CIT studies physiological measures (both autonomic nervous system and central nervous system activities) have been used as indicators of concealed information, however, the CIT could also be used with behavioral measures such as reaction times (RTs). For instance, Farwell and Donchin (1991) found that in addition to brain activities, RTs could also be used to distinguish concealed information from irrelevant information (for using RTs as an indicator in addition to physiological measures, see also Allen, Iacono, & Danielson, 1992; Gamer, Bauermann, Stoeter, & Vessel, 2007; Gamer, 2011a;

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Gronau, Ben-Shakhar, & Cohen, 2005; Rosenfeld, 2011). However, Farwell and Donchin (1991) argued that RTs may be voluntarily controlled thus may not be a valid tool for memory detection. Seymour, Seifert, Shafto, and Mosmann (2000), for the first time, showed that RT alone is a valid and sensitive indicator for identifying concealed information with individual detection accuracy above 90%, and the RT-CIT paradigm can resist deliberate faking (also see Seymour & Kerlin, 2008). Recently, Verschuere, Crombez, Degrootte, and Rosseel (2010) directly compared the detection efficiency of RT-based CIT and polygraph-based CIT in identifying personally meaningful stimulus such as one's first name. Results suggested that RTs can differentiate probe from irrelevant items even better than skin-conductance responses (SCRs, Cohen's *d*: RTs: 1.97 vs. SCRs: 1.46).

There are arguments for including behavioral measures such as RTs in addition to physiological measure when administering the CIT. First, from a theoretical perspective, the physiological activities during the CIT may not capture all aspects of the psychological processes associated with information concealment. For instance, in the polygraph-based CIT, it has been shown that the electrodermal activity, respiratory, and cardiovascular activities are each related to slightly different aspects of orienting responses in the CIT (see Gamer, 2011b). Moreover, in addition to the dominant role of orienting responses played in the CIT, recent studies have shown that there are other mechanisms that underlie the CIT, such as response conflict/monitoring and response intention (Gamer & Berti, 2010; Hu, Wu, & Fu, 2011; Kubo & Nittono, 2009). Thus, as a classic measure of information processing and cognitive operations (Donders, 1969), RT may provide information about the sum of mental processes underlying CIT (including stimulus evaluation, conflict monitoring and resolution, response preparation, and execution) which may not be entirely measured via existing physiological measures.

Second, from an applied perspective, it has been reported that the CIT's sensitivity for detecting guilty suspects was relatively low compared to its protection for innocents (e.g. Carmel, Dayan, Naveh, Raveh, & Ben-Shakhar, 2003; Elaad, 1990, 2011). The relatively lower level of sensitivity for detecting guilty suspects in polygraph-based CITs could be due to large individual differences in physiological responses (i.e. under-arousal or non-responders, see Gamer, 2011b). This leaves room for improving the CIT's sensitivity by recoding different dependent measures that may complement each other (e.g. Ambach, Bursch, Stark, & Vaitl, 2010; Gamer, Verschuere, Crombez, & Vossel, 2008; Hu & Rosenfeld, 2012; Meijer et al., 2007; Nahari & Ben-Shakhar, 2011). Thus, as discussed above, if RTs can serve as an indicator of the sum of a series of information processing stages underlying the CIT, it may further improve the sensitivity of the CIT.

In the present investigation, we employed the RT-based CIT to further investigate its detection efficiency in identifying concealed information, especially information acquired via a mock crime. Previous RT-based CIT studies, despite their remarkable success, focused mostly on either well-rehearsed items or autobiographical information (see Seymour & Kerlin, 2008; Verschuere et al., 2010). Recently, Visu-Petra, Miclea, and Visu-Petra (2012) showed that when using pictorial stimuli from a mock crime in an RT-based CIT, RTs can accurately detect concealed information. Applications of behavioral measures in CITs using mock crime scenario are important because in the field, not every detail is elaborated on or as salient as one's autobiographical information. Thus, here we aim to further establish the validity and classification efficiency of RT-based CIT using mock crime scenarios.

Another objective of the present investigation was to increase the sensitivity of the CIT. As mentioned above, there have been several studies that have reported relatively low sensitivity of physiological activity-based CITs (e.g. Elaad, 2011). Recently, several strategies have been employed in an attempt to solve this issue. One often-adopted strategy is to record multiple physiological activities simultaneously during the CIT (e.g., skin conductance responses, heart rate, respiration line length, event-related brain potentials (ERPs), see Ambach et al., 2010; Gamer et al., 2008; Hu, Pornpattananangkul, & Rosenfeld, 2013). The hypothesis is that each measure may capture non-overlapping aspects of processes underlying the CIT (e.g. attention, memory retrieval, response monitoring, etc.). Another strategy is to use separate tasks such as the symptom validity test or the autobiographical implicit associate test in addition to the CIT (Hu & Rosenfeld, 2012; Meijer et al., 2007; Nahari & Ben-Shakhar, 2011). This strategy is based on the hypothesis that each task may add non-redundant information in identifying concealed information.

However, fewer attempts have been made to modify the CIT task itself to increase its detection efficiency (but see Ambach, Stark, Peper, & Vaitl, 2008; Ambach, Stark, & Vaitl, 2011; Rosenfeld et al., 2012). The present study aimed to increase the sensitivity of the test by embedding an interfering task within each trial of the CIT. It is hypothesized that as concealing information in the CIT has been shown to be an attention demanding task that involves executive control (Christ, Van Essen, Watson, Brubaker, & McDermott, 2009), participants would be left with fewer cognitive resources for the interfering task. In contrast, processing meaningless, irrelevant stimuli is usually not as demanding as processing personally significant stimuli (e.g. crime details for guilty participants). Thus, the interfering task within each trial of the CIT was hypothesized to increase the cognitive load for guilty participants specifically during to-be-concealed information trials, resulting in inferior performance such as increased errors and prolonged RT to the interfering task.

2. Method

2.1. Participants

Sixty-three participants were recruited through flyers and advertisements at a major university in P. R. China at a compensation rate of 10 CNY/h (approximately 1.61 USD/h). Participants were randomly assigned into either a guilty group ($N = 31$, $M_{age} = 21.6$ years, $SD = 2.88$, 20 males) or an innocent group ($N = 32$, $M_{age} = 20.8$ years, $SD = 2.16$, 17 males). Ten additional participants were excluded from analyses due to a failure to follow instructions or computer program errors. All participants had normal or corrected-to-normal vision and provided informed consents prior to the study.

2.2. Materials

Experimental stimuli were presented in words using E-Prime software on a 17″ LCD screen. Stimuli for the Concealed Information Test consisted of six probes (each referring to one aspect of the mock crime), 24 irrelevant stimuli (unrelated to the crime), and six targets that were unrelated to the crime and required a unique button press response. The irrelevant and target stimuli were matched with their probe counterpart for the number of characters and semantic meanings. Each stimulus was randomly repeated for four times, resulting in a total of 144 ($6 \times 6 \times 4$) stimuli.

For the interference task, a dot-probe task was employed. Participants were asked to judge whether a pair of dots was placed either horizontally "‥" or vertically, ":". These two versions of dots were presented randomly after the presentation of the stimuli (either target, probe, or irrelevant item) with an equal proportion of presentations of each orientation. The stimulus onset asynchrony (SOA), the time interval between the presentation of CIT-item and the dot-probe task, randomly varied from 300 to 800 ms (see Fig. 1B). This SOA was chosen because based on previous ERPs-CIT studies, it has been found that the detectable difference between probe and irrelevant occurred during this time window (e.g. Allen et al., 1992; Rosenfeld, 2011). We thus hypothesized that placing an interfering task within this time window would maximize the interference effects for guilty participants.

2.3. Procedure

After signing consent forms, the guilty group completed five phases of the study: mock crime phase, recall test phase, target word study