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Systematic changes in tonic physiological activities during the Concealed Information Test

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ABSTRACT

Many studies on the Concealed Information Test have focused on phasic physiological changes that are temporally locked to stimulus presentation. However, little is known about changes in tonic, basal physiological levels throughout a stimulus series. This study focused on changes in tonic physiological activities during the CIT. Thirty-nine participants carried out a mock theft and subsequently received a CIT. Skin conductance, heart rate, and normalized pulse volume (NPV) were recorded. The pre-stimulus physiological level of these measures throughout the CIT series was compared across a question series with different serial positions of the relevant item. Results showed that changes in the pre-stimulus level differed depending on the serial position of the relevant item. Skin conductance declined throughout the series, but showed a transient increase after relevant item presentation. Heart rate was relatively constant throughout the series, but decreased after relevant item presentation. NPV continued to decrease until the relevant item, but increased thereafter, indicating a pattern similar to the classic Peak of Tension concept. In addition, the pre-stimulus NPV showed a significant relevant–irrelevant difference. Theoretical and practical implications of these findings are discussed.

1. Introduction

The Concealed Information Test (CIT; also known as the Guilty Knowledge Test), is a method of psychophysiological information detection used in criminal investigation (Lykken, 1959, 1960) to examine whether an examinee knows a certain detail of a crime that could only be known to a person involved in the crime. In the CIT, a polygraph examiner prepares several questions about criminal details. Each question consists of one crime-relevant item (i.e., a feature of the crime under investigation) and several crime-irrelevant items. Questions are constructed so that an individual with no information about the criminal fact would be unable to distinguish the relevant item from the irrelevant items. While sequentially presenting these items, several phasic, stimulus-locked physiological changes such as skin conductance response (SCR) and heart rate (HR) deceleration are examined (Lykken, 1959; Bradley and Janisse, 1981). If the examinee differentially responds to the relevant item (e.g., larger SCR and deceleration of HR), then knowledge about that criminal fact is inferred. This differential responding to the relevant item has been explained as an enhanced orienting response (OR) because the relevant item is significant only to a person possessing knowledge of the crime (Lykken, 1974).

While the CIT literature has focused on phasic, stimulus-locked physiological changes such as SCR and HR deceleration, changes in tonic, basal levels of physiological activities have received little attention. Tonic activity refers to the slower, long-term changes in background physiological levels. For example, Hira and Furumitsu (2009) compared the tonic level of HR and respiration rate during the CIT between guilty and innocent examinees. They analyzed these measures in arbitrarily selected periods of 1 min from the first and the last question of the CIT. The authors found that innocent persons showed a lower HR compared with guilty persons, and revealed a significant decrease over the course of the test, whereas guilty persons maintained a constant HR level. In the OR literature, on the other hand, pre-stimulus physiological level at each stimulus presentation often serves as a measure of tonic activities (Barry and Sokolov, 1993; Rushby and Barry, 2007). The present study also analyzed within individual variations at a pre-stimulus physiological level throughout a question series. If CIT examinees concealing information show systematic changes in pre-stimulus levels during the test, such changes would provide useful information that could be used to determine whether an examinee is concealing information.

The idea that CIT examinees concealing information would show systematic tonic changes is not novel, but remains to be empirically established. For example, the classic Peak of Tension (POT) test assumes

Abbreviations: ANOVA, analysis of variance; CIT, Concealed Information Test; HR, heart rate; NPV, normalized pulse volume; pHR, phasic heart rate; pNPV, phasic normalized pulse volume; POT, Peak of Tension; SCL, skin conductance level; SCR, skin conductance response.

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the presence of systematic tonic changes over a question series. The POT test can be considered a special case of the CIT (Ben-Shakhar and Elaad, 2003; Lykken, 1974), where question items are presented in a predetermined order known to examinees (Gustafson and Orne, 1964; Horvath, 1978, 1979). The central assumption of the POT test is that an examinee, knowing exactly when the relevant item will be presented, should show gradual increases in physiological levels toward relevant item presentation, followed by a sudden decrease thereafter. However, descriptions of the POT hypothesis are often insufficiently clear to be empirically tested. Moreover, despite the name 'tension' often being used as a synonym for tonic physiological level, it is uncommon to find reports of analysis of tonic activities such as SC level (SCL) in the literature. To our knowledge, no empirical study has directly tested the POT hypothesis in the form of, for example, whether the pre-stimulus SCL peaks before relevant item presentation.

Recently, a case report of field CIT suggested that the normalized pulse volume (NPV) showed a POT like change, even if the examinee did not know the order of items in advance (Yamamoto, 2010). NPV is an improved measurement of pulse volume, and its score is inversely related to peripheral vascular tone, which is controlled by cutaneous sympathetic nerves (Hirota et al., 2003; Sawada et al., 2001). In the CIT, NPV during relevant item presentation is typically lower compared with irrelevant item presentations (Hirota et al., 2003). Yamamoto (2010) observed that the mean level of NPV during 20 s after stimulus onset was larger (i.e., vasodilation) with an irrelevant item presented immediately after the relevant item, compared with an irrelevant item presented immediately before the relevant item. However, he did not analyze HR and failed to find differences in SCL during irrelevant item presentations before and after the relevant item. In addition, his observation was based on a small sample ($n = 8$). More importantly, because he analyzed post-stimulus epochs of 20 s, the observed pre- and post-relevant differences were due to a difference in phasic, post-stimulus responses rather than in tonic physiological levels.

Overall, it remains unclear whether the CIT examinee with concealed information exhibits a systematic change in tonic physiological activities throughout a question series. To address this issue, we analyzed changes in pre-stimulus SCL, HR, and NPV within a CIT sequence. Our first prediction was that if there is a systematic change in pre-stimulus levels throughout a question series, the serial position of the relevant item should affect the profile of physiological changes. For example, when the relevant item is presented at a later position in a CIT question series, the examinee may show maintenance of or increased pre-stimulus SCL. In contrast, when the relevant item is presented at a relatively early position, pre-stimulus SCL may drop rapidly after relevant item presentation. These different profiles can be confirmed by significant serial position × serial position of relevant item interaction in analysis of variance (ANOVA). Our second prediction was that if a peaking effect (i.e., pre-stimulus physiological level peaks at the relevant item) exists without prior information concerning the presentation order, the highest pre-stimulus SCL and the lowest pre-stimulus NPV would be observed before relevant item presentation. However, for pre-stimulus HR, it is difficult to make a specific prediction because anticipation of an important stimulus can be associated with decreased HR (Jennings and Van der Molten, 2005; Lacey and Lacey, 1980) or increased HR (Olbrich et al., 2011). This prediction was tested by comparing the pre-stimulus level of the relevant item with those of irrelevant items presented before the relevant item (i.e., pre-relevant items), and irrelevant items presented after the relevant item (i.e., post-relevant items).

2. Materials and methods

2.1. Participants

Thirty-nine healthy off-duty police personnel, 38 males and 1 female (age, 20–35 years old; mean age, 26.0 years, $SD = 3.22$), participated in the experiment. For practical reasons, we recruited participants from the police department, which comprised mostly men. All participants gave informed consent and received 2300 yen (approximately $23.00 USD) for participation.

2.2. Stimuli

Five items, a necklace, a ring, an earring, a broach, and a watch, served as stimuli for the mock theft. In the CIT, images of these items served as stimuli. These images were within 300 × 400 pixels and presented on a 17-inch LCD monitor with 1280 × 1024 resolution set at the height of participant's eyes, approximately 1 m from the participant. Two additional images of a tie clip and a bracelet were used as buffer items such that the bracelet appeared as the buffer item in the first, third, and fifth (last) repetitions, while the tie clip appeared in the second and fourth repetitions. This is because the first item is known to evoke an orienting response, and thus was discarded from analyses. In addition, a Japanese male voice asking question items such as "Was the stolen item a ring?", "a broach?" and so on was also prepared. These question items were presented via two loudspeakers positioned at ear height 1 m to the left and right of the participant's ears.

2.3. Physiological recording

A Digital Polygraph System (PTH-347, TEAC Inc., Tokyo, Japan) was used for recording SC, HR, and NPV. All signals were digitized using an analog-to-digital converter at 1000 Hz with 16-bit resolution.

For recording SC, two Ag/AgCl disposable electrodes (PPS-EDA, TEAC Inc., Tokyo, Japan) filled with 0.05 M NaCl electrolyte were placed on the volar side of the distal phalanges of the first and second fingers of the left hand. The electrodes were connected to a SCL/response unit that imparted a constant voltage of 0.5 V across the electrodes. The output was filtered by a low pass filter set at 5 Hz and bifurcated into SCR and SCL channels. A time constant was set at 5 s in the SCR channel. An electrocardiogram (ECG) was recorded using Ag/AgCl electrodes and a standard lead II setup. The signal was amplified with a time constant of 0.1 s and a 50 Hz band-stop filter. HR was calculated online based on R–R intervals and recorded continuously as a real-time measurement (Velden and Wölk, 1987). Finally, finger pulse volume was measured using a near-infrared light-emitting diode (LED; wavelength of 810 nm), and a photodiode was attached at opposite sides of the distal phalanges of the third finger of the left hand. NPV was calculated online every cardiac cycle and recorded as a real-time measurement similar to HR (Sawada et al., 2001).

2.4. Procedure

After providing written informed consent, each participant was taken to an electrically and acoustically shielded experimental chamber and asked to draw a lot to determine their role in the experiment. Participants were informed that the lots could indicate either a "criminal" or "innocent" role, but, unknown to participants, all lots designated the criminal role. The participants were instructed that if they were assigned to the criminal role, they were to steal one of five envelopes containing the item from the drawer case in the chamber, and conceal it in his or her clothes or bag after the experimenter left the chamber. They were also told that, if the lot assigned the "innocent" role, they should wait in the room for a few minutes and then leave without taking any of the items. After instruction, the experimenter left the participant in the chamber and the participant performed the mock theft.

Following the mock-theft, the CIT was administered. The participant was then instructed that the test would be conducted to examine whether he or she had stolen an item from the drawer. The participant was asked to try to prove his or her innocence through the test. The CIT question series consisted of six items including one buffer item. The instructions mentioned what items would be presented during