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The Concealed Information Test in the Laboratory Versus Japanese Field Practice: Bridging the Scientist–Practitioner Gap

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Whereas the Concealed Information Test (CIT) is heavily researched in laboratories, Japan is the only country that applies it on a large scale to real criminal investigations. Here we note that important differences exist in CIT design, data-analysis, and test conclusions between these two settings. These differences can be ascribed to using the CIT in the laboratory to judge the overall presence or absence of crime-related knowledge (examinee-focused), while using it in the field to assess recognition of individual pieces of crime-related knowledge (question-focused). The question-focused approach is one way to increase the usefulness of the CIT and is a key factor that allows Japanese law enforcement to apply the CIT to real criminal investigations. We hope this review can help bridge this apparent scientist–practitioner gap by encouraging critical reflection on the benefits and pitfalls of examinee- vs. question-based approaches, and by encouraging question-focused laboratory-based research that has direct relevance to Japanese field practice.

Keywords: polygraph examination, concealed information test, memory detection

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Polygraphy is one of the most important and controversial topics in applied psychophysiology. Polygraph testing refers to the recording of physiological signals—typically skin conductance, respiration, and cardiovascular responses—that can provide useful information during the course of criminal investigations. The Comparison Question Test (CQT) is the most commonly applied polygraph method around the world for detecting deception, although it is not the method used by Japanese police. It compares physiological responses to specific, accusatory questions (e.g., Did you steal money from the cashbox last Friday night?) to control questions

that are deliberately formulated to be more vague (e.g., In the first 25 years of your life, have you ever done anything illegal?). Stronger physiological responses to the accusatory questions are interpreted as a sign of deception. Yet, the rationale and validity of the CQT have been heavily challenged for decades (National Research Council, 2003). In particular, there is concern that those telling the truth may also show stronger physiological responses to these questions, resulting in a high rate of false-positive outcomes. Another less contested polygraph method is the Guilty Knowledge Test (GKT; Lykken, 1959), now commonly referred to as the Concealed Information Test (CIT; Verschuere, Ben-Shakhar, & Meijer, 2011). The CIT does not assess deception, but rather assesses the presence of crime-related memories. In this review paper, we focus on the methodological features of the CIT in laboratory studies and field application to help bridge the gap between research and practice.

The Concealed Information Test

The CIT first appeared in the psychophysiology literature in Lykken's 1959 seminal paper. The basic concept underlying the CIT was phrased as follows:

> Use of physiological measurements to detect not lying, but the presence of "guilty knowledge" requires only the more reasonable assumption that a guilty person will show some involuntary physiological response (e.g., GSR) to stimuli related to remembered details of his crime. (p. 385)

Thus, if an examinee is involved in a crime, he or she should know details of the crime that are unknown by the innocent, and this knowledge will cause different physiological responses to the crime-relevant stimuli than to other stimuli. Based on this rationale, Lykken designed a test consisting of six multiple-choice questions. Participants in a mock-crime experiment were read questions such as:

"Where did the thief hide the stolen watch? Was it (a) in the men's room, (b) on the coat rack, (c) in the office, (d) on the windowsill, (e) in the locker?"

The items were chosen so that an examinee with no knowledge of the crime would be unable to discriminate the relevant item (e.g., the locker) from among the irrelevant ones. During the presentation of these questions, electrodermal activity was recorded. A score of 2 was given if the crime-related item in a question elicited the largest physiological response and a score of 1 was given if it elicited the second largest response. Otherwise a score of 0 was given. The scores were summed up across questions. Because there were six questions, the overall score could range from "a perfect innocent" score of 0 to "a perfect guilty" score of 12. A total score of 6 or less was used to classify the examinee as "innocent" and a total score greater than six signified "guilty". With 100% specificity (no false-positives), and 88% sensitivity (12% false-negatives), the experiment was a great success.

Subsequent studies have modified the original CIT in efforts to increase its validity (Ben-Shakhar, 2012; Meijer, Selle, Elber, & Ben-Shakhar, 2014; Verschuere et al., 2011; Verschuere & Meijer, 2014). For example, whereas early studies were solely based on skin-conductance responses, additional measures such as respiratory activity (Timm, 1982), heart rate (Verschuere, Crombez, de Clercq, & Koster, 2004), and finger-pulse volume (Elaad & Ben-Shakhar, 2006) have been demonstrated as effective CIT measures and

are now often included in the test, sometimes with variations. Studies have also shown that participants with concealed information typically respond to the crime-relevant item with larger electrodermal activity, lower respiratory activity, heart rate deceleration, and peripheral vasoconstriction (Elaad & Ben-Shakhar, 2006; Meijer et al., 2014). These physiological changes are typical of orienting responses (Verschuere et al., 2004). The relevant alternatives are significant only for knowledgeable individuals, and significant stimuli elicit enhanced orienting responses (e.g., Gati & Ben-Shakhar, 1990; Lykken, 1974; Sokolov, 1963). CIT accuracy has also been studied, and several reviews have reported that the average correct detection rates (i.e., sensitivity) ranged from 76% to 88%, whereas average correct rejection rate (i.e., specificity) ranged from 83% to 97% (Ben-Shakhar & Furedy, 1990; Lykken, 1998; MacLaren, 2001). Two meta-analyses (Ben-Shakhar & Elaad, 2003; Meijer et al., 2014) have also demonstrated high detection-efficiency estimates for the CIT.

Field-use of the CIT has been limited. Despite support from scientific studies, it is often thought to be inapplicable (Podlesny, 1993; Vrij, 2008). For example, because the CIT focuses on knowledge only known to the criminal, leakage of crime-related information by the police, media, or attorneys makes it difficult to formulate the proper questions (Ben-Shakhar & Elaad, 2003; Ben-Shakhar, Gronau, & Elaad, 1999). If innocent people know critical details of the crime, detecting such knowledge makes little contribution to a criminal investigation or leads to a waste of time and resources. In this context, Japan is the exception in its practical use of the CIT. The large-scale use of the CIT in Japan may not be related to Japanese law enforcement being better able to withhold information from the public (see e.g., Furedy, 2009), as much as it is a different way of using the CIT that makes it easier to apply.

Japanese Field Use of the CIT

The CIT is used to assess an examinee's memory about a criminal case. As in laboratory studies, the Japanese field CIT is composed of multiple-choice questions (Matsuda, Nittono, & Allen, 2012; Osugi, 2011). There are two variants of the Japanese field CIT: The known-solution CIT and the searching CIT. The known-solution CIT asks whether an examinee knows a specific detail about the crime that law enforcement have identified. Suppose that a tie has been identified by law enforcement as the weapon used to strangle someone, and that this fact had not been disclosed to the public. A known-solution question about the weapon could be: "What was the murder weapon? Was it (a) a rope, (b) a scarf, (c) a tie, (d) a lamp cord, (d) necklace, (e) a stocking?"

This specific CIT assesses whether the examinee knows that the tie was the murder weapon, but does not go beyond this fact to assign overall guilt based on this knowledge. The searching CIT is also used to examine whether an examinee recognizes a specific item as relevant to the crime-related fact in question, but contrary to the known-solution CIT, law enforcement does not know the correct answer. In these cases, the investigators will select plausible options, hoping that the correct item is included among the choices. The investigators will also typically include an open alternative (i.e., "something else") to avoid having all answers be incorrect. Using the same example as above, a differential response to the tie would suggest that it was the weapon used in the crime. In this way the searching CIT can provide clues about crime details that law enforcement have not

yet discovered. The known-solution CIT and searching CIT are often combined within a single case.

In Japan, the CIT typically consists of four to six questions (Kobayashi, Yoshimoto, & Fujihara, 2009). Each question is repeated three to five times, with the choices given in different orders. Physiological measures include skin conductance, respiratory activity, heart rate, and normalized pulse volume (i.e., improved measurement of pulse volume; Hirota et al., 2003; Sawada, Tanaka, & Yamakoshi, 2001). The examiner judges whether a specific item consistently elicits larger physiological responses than the other items (Osugi, 2011). This judgment is based on visual inspection of graphs and descriptive statistics derived from the physiological recordings. If an examinee's responses are similar to all items, the examiner infers that the examinee does not recognize any item as being related to the crime. However, the examiner would infer that the examinee does recognize a specific item as related to the crime if differential responses to that item are observed. To form the final conclusion, the examiner takes into account additional factors such as the examinee's physiological reactivity, environmental factors (e.g., noise), artifacts (e.g., physical movement or deep breathing), and reasonable alternative arguments for certain items (e.g., recognition of relevant item for reasons unrelated to the crime).

Differences Between Laboratory Research and Japanese Field Practice

The use of the CIT in laboratory-based studies and Japanese criminal investigations differs notably. First, in Japanese criminal investigations, each question is repeated at least three times. This repetition serves to increase reliability, and allows assessment of whether stronger responses to the crime-relevant item appear systematic across repetitions. In contrast, the laboratory CIT typically uses none or few repetitions of individual questions. For example, about half of the 80 studies included in the meta-analysis by Ben-Shakhar and Elaad (2003) presented questions only once, indicating that question repetition was not considered a requirement in these studies. Instead, laboratory researchers prefer using multiple questions more than repeating individual questions, reasoning that repetition of the same question is more error-prone (Meijer et al., 2014). For instance, if a crime relevant item happens to be more salient, familiar, or arousing to an examinee, it might always evoke a stronger response than the crime irrelevant items, and repeating the question will not remedy the problem.

Second, while Japanese polygraphers working on real criminal investigations aggregate repetitions of a single question, but never across different questions (Matsuda et al., 2012), laboratory researchers aggregate different questions when scoring the physiological signals. Indeed, Lykken (1959) scored the CIT by summing up scores across questions, and this remains the standard practice in laboratory research today.

Third, the test conclusion in laboratory studies are different from that of the Japanese CIT used in the field. Based on the aggregated responses across different questions, laboratory studies come to a single conclusion of "knowledgeable (guilty)" or "unknowledgeable (innocent)". Thus, the conclusion in laboratory research refers to whether the examinee has knowledge about the crime. In contrast, Japanese CIT practitioners provide conclusions for each separate question. For example, when a CIT in a Japanese theft case contains three questions that ask when it happened, where it happened, and what was stolen, the conclusion could be that the examinee seems to

know the when and the where but not the what, rather than simply that the examinee knows something.

This list is probably not exhaustive, but it covers the key differences that are related to the different conceptualizations of the CIT as outlined in the next section.

Conceptualizing Guilty Knowledge

How can we understand the differences between laboratory-based studies and the Japanese application of the CIT? We think it is helpful to frame these differences within a slightly different conceptualization of the notion of guilty knowledge.

Lykken (1959) introduced the notion of guilty knowledge to psychology to describe knowing facts of a crime that are only known to the criminals. In his seminal paper, he concluded that the concealed information test provided a means "to determine guilt" (p. 388). Likewise, the title of the paper—*The GSR in the Detection of Guilt*—refers to determining whether the examinee is guilty. In such a conceptualization, multiple questions are equivalent in the sense that they all contribute to the overall judgment of guilty knowledge. The test conclusion is based upon averaging across the different questions. That the suspect reacts to some questions but not others is considered noise. Note that aggregating across different questions restricts the conclusions polygraph examiners can make because it can no longer be specified what the examinee knows and does not know, particularly when questions are presented only once. Here, the CIT seems to serve a single overall goal, to determine whether the examinee has knowledge of the crime. Thus, the CIT in laboratory-based research is examinee-focused.

The concept of guilty knowledge is conceptualized differently in Japanese field practice, and refers to knowledge of specific detail of the crime (i.e., a specific CIT question). In Japanese field practice, each question has its own significance with the reasoning that different questions represent different aspects of the crime (e.g., time, place, victim, accomplices). Japanese polygraph examiners are required to provide separate conclusions for each question, and do not aggregate questions to derive a single outcome. Thus, the CIT in Japanese field practice is question-focused.

The CIT in Japanese field practice can therefore be considered an information-gathering approach. As such, it can even be meaningfully applied when guilt is already known. Suppose a hypothetical case where law enforcement arrested a man for a theft and the suspect confesses that he did it alone. The investigators may have doubt as to whether the man performed the crime alone or if he had an accomplice. In this case, a CIT that asks about the number of people involved in the crime may be informative (e.g., Did you perform the theft (a) with one accomplice, (b) with two accomplices, (c) with three accomplices, (d) with more than three accomplices. The purpose of this type of searching-CIT is not to determine guilt, but rather to gain further information.

What Could Laboratory-Based Research Learn From Japanese Field Practice?

Identifying the different ways in which the CIT is conceptualized might help elucidate the differences between research and practice. For instance, knowing the different ways that guilty knowledge is conceptualized should help Japanese

practitioners understand why laboratory-based studies often aggregate scores across multiple questions – a practice uncommon to Japanese practitioners. Further, researchers may have wondered why Japanese police investigators are reluctant to provide hit rates from their field tests. This may be more understandable when one considers that such statistics involve an overall judgment as to whether guilty knowledge is present (examinee-focused) rather than the question-by-question (question-focused) judgments common in Japanese field tests. For example, Ogawa, Matsuda, and Tsuneoka (2013) planned a mock theft experiment in which 36 Japanese polygraphers served as examiners (see also Matsuda, Ogawa, Tsuneoka, & Verschuere, 2014, for further detail). Results indicated an 86% sensitivity and a 95% specificity after exclusion of inconclusive decisions (cf. Elaad, Ginton, & Jungman, 1992). These figures, however, reflect correct classification rates of a single detail of the crime and could be readily misinterpreted by laboratory researchers that typically report the correct classifications of examinees.

The question-focused approach might help encourage CIT implementation outside of Japan. The limited field use of the CIT in many countries has often been related to the difficulty in preparing sufficient questions (Podlesny, 1993, 2003). Lykken (1988) suggested that six or more questions is optimal for a CIT, yet Podlesny (1993, 2003) argued that developing such a CIT is only feasible in a small portion of cases. In contrast, the question-focused CIT has no minimum number of questions. Additionally, using searching CIT questions further broadens the way CIT can be used because developing searching CIT questions is often possible when preparing known-solution CIT questions is difficult. In searching CIT, each question must be treated separately. Notably, Japanese practitioners typically use a mixture of known-solution CIT and searching CIT within a single case. In contrast, laboratory-based research has typically used either the known-solution CIT or the searching CIT (for recent laboratory studies on the searching CIT see Breska, Ben-Shakhar, & Gronau, 2012; Meijer, Bente, Ben-Shakhar, & Schumacher, 2013; Meijer, Smulders, & Merckelbach, 2010; Meixner & Rosenfeld, 2011).

We hope that our analysis will provide impetus for new research. Studies departing from the question-focused perspective may not be easily applicable to the CIT as used in Japan. Scientists can increase the applied value of their research in several ways. Foremost, Japanese field practice is more likely to incorporate laboratory conclusions that are based upon studies that treat individual CIT questions as the unit of analysis. This implies repetition of individual questions and not aggregating across different questions.

What Could Japanese Field Practice Learn From Laboratory-Based Research?

Laboratory-based research has provided the scientific foundation for how the CIT is used in the field. For example, the polygraph system used in Japan employs the 0.5 V constant voltage circuit following the recommendation by Fowles et al. (1981). It also uses a laboratory-based data-analysis procedure such as a standardization to reduce inter-repetition variance in physiological measures (Ben-Shakhar, 1985). However, although Japanese field practice has certainly been inspired by laboratory research, it should critically reflect upon how laboratory research can be used to further improve the situation in the field.

The choice to aggregate across multiple questions in laboratory-based research is based on the concern that using single questions can inflate false positive errors. In the question-focused approach, the innocent examinee may consider the critical item in one question to be more salient or more plausible. In such a case, repeating the question does not solve the problem because the increased physical responses of an innocent examinee may be the result of a bias in the test rather than being noise that can be ignored. The examiner confirms these possibilities during pre and post- test interviews by explicitly asking the examinee how they felt about the items. However, when using several questions, it is unlikely that the innocent person considers *all* critical items to be more salient or more plausible. Therefore, even if questions are treated separately, presenting multiple questions should prevent errors during an investigation such as a mistaken arrest. Ogawa et al. (2013) reported 5% as the false-positive rate in question-based analysis. However, when four questions are administered, the probability that all answers are false-positives is greatly reduced to 0.054%.

Laboratory research has provided convincing evidence that several measures, not currently used in Japan, are valid. These include finger-pulse line length (Elaad & Ben-Shakhar, 2006; Vandenbosch, Verschuere, Crombez, & de Clercq, 2009) and non-autonomic measures such as reaction time (Kleinberg, Verschuere, & Theocharidou, 2015; Seymour & Fraynt, 2009; Seymour & Kerlin, 2008; Seymour, Seifert, Shafto, & Mosmann, 2000; Verschuere & Ben-Shakhar, 2011), and the P300 event related potential recorded from the brain by EEG (Farwell & Donchin, 1991; Rosenfeld et al., 1988). We are not saying that these measures are ready to be used in the Japanese field. But proposing new measures and new techniques is one of the most important contributions of laboratory-based studies, as are the follow-up studies that assess the validity of these new procedures before implementing them in the field.

More importantly, Japanese field practice should develop a more valid and objective scoring method. In current Japanese field practice, physiological recordings are evaluated through visual inspection (Osugi, 2011). One may argue that human judgment is vulnerable to biases (Dawes, 1979), and an objective scoring system would produce results that are more impartial, reliable, and ultimately more valid (Matsuda et al., 2012). Current practitioners may argue that subjective scoring allows them to incorporate important information that is not captured in current objective scoring systems. This is illustrated in a case report by Yamamoto (2010) where an examinee confessed his knowledge to 4 out of 5 questions during the interrogation held after the polygraph test. For each of the 4 questions, the examinee consistently reacted to the critical items with increased vasodilation at the fingertip. Such a response directly opposes predictions made by laboratory-based research (i.e., vasoconstriction), and might have been missed by computerized scoring systems. Subjective scoring is often more valid than computerized scoring. Using Lykken scoring of Ogawa et al.'s (2013) data, Matsuda, Ogawa, and Tsuneoka (2015) found a sensitivity of 68% and a specificity of 96%. Human judgment, however, was better with 86% sensitivity and 95% specificity. This lower sensitivity in the Lykken scoring may have resulted from the inclusion of non-responding participants or from ignoring individual differences in responsive measures. Moreover, the Lykken scoring system was designed for the known-solution CIT and cannot simply be applied to the searching CIT. Clearly, more sophisticated models are needed for analyzing physiological measures both for known-solution and searching CIT questions.

An Agenda for Future Research

Research is needed for future development of the field CIT. An important topic in future CIT studies should be how the criminal perceives and remembers criminal events. Such studies have important practical implications for developing questions. For example, recent studies have suggested that central features such as the weapon are much better remembered than peripheral items such as a picture on the wall (Carmel, Dayan, Naveh, Raveh, & Ben-Shakhar, 2003; Gamer & Berti, 2012; Nahari & Ben-Shakhar, 2010). In addition, eyewitness research provides valuable information to practitioners regarding which facts are likely to be remembered and which are not. Additionally, eyewitnesses and perpetrators might have memories of events with different characteristics, and much needs to be learned about what criminals are likely to remember. Ongoing efforts should be dedicated to establishing theoretical bases of the Concealed Information Test. Good theory will provide the conditions, measures, and populations in which the technology will work (Verschuere & Ben-Shakhar, 2011). For example, one might ask about processes responsible for the atypical responses found by Yamamoto (2010). Only basic and applied studies are able to answer these questions. In this context, laboratory studies will be extremely useful for the practical use of the CIT.

Practitioners should try to inform researchers about practical issues they confront in the field. For instance, when developing a field CIT, there is currently no consensus as to whether the examinee's stated answer should be used as an option in the CIT. Suppose the examinee claims to have committed a theft alone, but law enforcement thinks there may have been two or three accomplices. Clearly, the 'two accomplices' and 'three accomplices' options should be included, but how is the 'no accomplices' option handled? As this is what the examinee claims, it is likely to evoke a response, irrespective of its truth-value. Excluding it as an option may seem strange to the examinee. Current field practice has several ways of handling this issue, such as excluding the option from the test or including it in the test but excluding it from the analyses. Laboratory research may tell us how these different procedures affect detection efficiency. For example, inclusion might not necessarily harm detection efficiency, as this is somewhat similar to a study in which detection efficiency was unaffected by including target items to which participants had to respond by pressing a key (Ben-Shakhar et al., 1999; Elaad, 1997). Laboratory studies that employ methods more closely related to those used in the Japanese field CIT will strengthen the scientific basis of the field application.

Conclusion

As the overall aim of this paper was to promote further development of the CIT, we have highlighted the differences in how the CIT is used in laboratory-based studies vs. Japanese criminal investigations. In laboratory-based studies, CIT questions have often been integrated to derive a single, unified outcome of 'knowledgeable' versus 'unknowledgeable' (examinee-focus), whereas Japanese polygraph examiners treat each CIT question as a unit of analysis (question-focus). This difference is not trivial, as it poses different constraints on the CIT method (e.g., the need to have a sufficient number of questions does not hold from the individual question approach), requires different methods for data analysis (e.g., aggregating across questions), and leads to very different test conclusions (i.e., knowledge present or absent vs. recognition of

specific pieces of crime-related information). We hope this paper will foster a better understanding of how the CIT is applied in laboratory-based studies and in Japanese criminal investigations. As such, this paper might encourage laboratory-based studies that can be more readily translated to Japanese field application. Importantly, we hope the present paper will stimulate CIT field application outside Japan and encourage reflection by Japanese practitioners on how the CIT can be optimally applied.

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