



**Deception, the polygraph, and psychopathy:  
The role of orienting in the Concealed Information Test**

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## *INTRODUCTION*

Although thousands of polygraph tests are performed each year, detection of deception using the polygraph (“lie detector”) remains controversial. Polygraph tests need to meet the same criteria as other psychological tests in order to be regarded scientific. Most importantly, polygraph tests need to be accurate and have a good theory (National Research Council, 2003). Three main polygraph techniques exists: the Relevant/Irrelevant Question Technique, the Control Question Technique and the Concealed Information Test. A critical review of the literature shows that the Relevant/Irrelevant Question Technique does not meet either criterion, and the Control Question Technique lacks a scientifically supported theory. The Concealed Information Test, on the other hand, has good accuracy and a well developed theory. Still, the theory of the Concealed Information Test needs further empirical verification. This is the main aim of the present dissertation.

## Background

Junk or science? Ever since its introduction, now more than 100 years ago, this question forms the essence of the debate on the validity of the polygraph (“lie detector”). The debate was recently recaptured with the When Ho Lee case (Aftergood, 2000). This Los Alamos nuclear scientist was accused of espionage, but cleared by a polygraph test conducted by the FBI in 1984. However, Lee’s visits to China in 1986 and 1988 brought him back under suspicion of the FBI. Two more polygraph tests followed, one in 1998 by the Department of Energy, and one in 1999 by the FBI. Unfortunately, interpretation of the test results were inconsistent and a vivid debate arose on whether Lee did or did not pass the polygraph. With the When Ho Lee case, the utility of systematically testing nuclear scientists and security officials with the polygraph was questioned. This led the Department of Energy to request the prominent National Research Council for a review of the scientific evidence on the polygraph (National Research Council, 2003). The Council argued that, in order to be regarded scientific, polygraph tests need to meet the same criteria as other psychological tests. Most importantly, polygraph tests need to be accurate (criterion validity) and have a good theory (construct validity). According to the report of the National Research Council, no polygraph test is sufficiently valid to be used for systematically screening large populations, in which a low base rate of deception can be expected. I can only agree with this conclusion, but I will argue that this conclusion does not hold for the validity of the polygraph regarding specific-incident (e.g., after a crime) testing. I will describe the most important polygraph techniques (i.e., the Relevant/Irrelevant Question Technique, the Control Question Technique, and the Concealed Information Test), and discuss their criterion and construct validity regarding specific-incident testing. I will argue that both the Control Question technique and the Concealed Information Test have good criterion validity, but that only the Concealed Information Test has good construct validity. Still, further empirical research trying to falsify the test theory is needed. I will describe how the present dissertation has tried to fulfil this need.

## **PHYSIOLOGICAL DETECTION OF DECEPTION AND THE POLYGRAPH**

Physiological detection of deception has a long history. One of the earliest written reports goes back to 900 B.C, and describes how the ancient Hindu tried to detect deception by looking for signs of blushing on the suspects' face (Ben-Shakhar & Furedy, 1990). It is told that African Bedouins requested their crime suspects to lick at a hot iron bar, reasoning that only the deceptive suspect would burn his/her tongue. According to Ford (1995), during the West-European inquisition, heretics were asked to chew on "truth-bread" when questioned. If deceptive, the suspect would have a dry mouth and find it difficult to spit the bread out. Polygraph tests are based upon a similar assumption, that lying is accompanied by different bodily responses than truth telling. The polygraph is a device that is able to measure small changes in bodily reactions very accurately. Whereas the first polygraph only picked up changes in blood pressure (Marston, 1917), measures of skin conductance and respiration were added early on by other researchers. Several polygraph techniques have been developed, of which the Relevant/Irrelevant Question Technique, the Control Question Technique and the Concealed Information Test are the most important. These techniques make use of the same physiological measures, but differ in the questions asked during the interrogation.

### **Relevant/Irrelevant Question Technique**

The oldest and simplest polygraph technique is the Relevant/Irrelevant Question Technique (R/IR; Larson, 1922), developed from Marston's blood pressure test. In the R/IR, a comparison is made between physiological responses on relevant (e.g., "Do you know who kidnapped the prime minister?") and irrelevant questions (e.g., "Is your first name Jean-Luc ?"). Stronger physiological responses to the relevant questions as compared to the irrelevant questions are



regarded as indicative of guilt. Scoring of the R/IR is typically done by global, impressionistic and unstandardized inspection of the responses (Raskin & Honts, 2002). Standardized, numerical scoring systems have been developed for the scoring of the Control Question Technique (Kircher & Raskin, 1988), and these could, however, also be used to score the responses of the R/IR. Physiological responding on each relevant question, then, is compared with responding on the preceding control question. If the examinee responded more strongly to the relevant question, a score between  $-1$  (slightly stronger) and  $-3$  (much stronger) is assigned, depending on the strength of responding. Values between  $+1$  and  $+3$  are assigned if the examinee reacted more strongly to the control questions, and a zero-score is obtained whenever there is no clear difference between the control and relevant question. Scores are summed across questions, physiological measures, and test repetitions. Summed scores below a certain cutoff (e.g.,  $-6$ ) are interpreted as indicating deception, scores around  $0$  (e.g., between  $-6$  and  $+6$ ) as inconclusive, and scores above a certain threshold (e.g.,  $+6$ ) as indicating truth telling.

The accuracy of polygraph test has most often been examined in laboratory research using the mock crime procedure (Kircher, Horowitz, & Raskin, 1988). This procedure consists of allocating participants randomly to either the “innocent” or the “guilty” condition. Participants enacting the guilty condition are requested to commit a mock crime, and participants simulating the innocent condition are not involved in this mock crime. Participants from both conditions are instructed to try to appear innocent during a subsequent polygraph interrogation. Based upon this polygraph examination, the examiner makes a judgment on whether the participants was lying or not. This judgment can be correct or incorrect, resulting in four possible combinations of actual truthfulness and the polygraph test outcome: true positive (deception detected), false negative (undetected deception), true negative (identified innocent), and false positive (false accusation). The sensitivity concerns the accuracy in judging the deceptive participants, and the specificity regards the accuracy in classifying the innocent participants.

There is only one high quality study published in a peer-reviewed journal that examined the criterion validity of the Relevant/Irrelevant Technique. Horowitz,

Kircher, Honts, and Raskin (1997) recruited 30 participants from the community and assigned them randomly to either the guilty or the innocent condition. Participants enacting the guilty condition, were instructed to steal a ring from a desk in a nearby room. Participants in the innocent condition were informed about the mock theft, but did not enact it. Three relevant and three neutral questions were repeated five times during the subsequent polygraph test, while measuring skin conductance, heart rate, blood volume, finger pulse amplitude, and thoracic and abdominal respiration. Participants from both conditions were promised a financial reward if they were able to appear innocent. In this study, deception was detected in all guilty participants. Detection accuracy for the innocents, however, was less favorable: 73% of the innocents were falsely accused, and only 20% of the innocents were correctly identified (the remaining 7% were inconclusive). Though subject to methodological shortcomings, the study by Horvath (1988) found similar results, with 100% false positives. These studies clearly show that the accuracy of the Relevant/Irrelevant Question Technique is unacceptable.

Regarding construct validity, a qualitative difference in physiological responding between lying and truth telling was originally assumed in the R/IR. That is, a unique lie response on the relevant questions was expected in deceptive individuals. However, this physiological nose of Pinocchio is yet to be found, and will probably never be found<sup>1</sup>. Ample research has shown that different stimuli can lead to the same physiological responses, and that the same stimulus can lead to different physiological responses. For example, concealing crime information leads to enhanced frontal brain activity (Langleben et al., 2002), but so does solving crossword puzzles. A picture of a spider, on the other hand, will lead to a decrease in heart rate in most individuals, but to an increase in heart rate in spider phobics (Fredrikson, 1981). In the absence of a unique lie response, it has been suggested to compare physiological responses on the relevant questions

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<sup>1</sup> Currently, brain imaging measures are being used to scan the brain for deception. Media reports of this research seem to suggest that these techniques will be able to demonstrate the “lie response” in the brain (e.g., see <http://news.bbc.co.uk/2/hi/health/4051211.stm>). This, however, is most unlikely.

with the neutral questions. No strong theoretical proposals have been made. It was rather assumed that only the guilty examinee will feel guilty, anxious or worried about the relevant questions (Marston, 1917). However, stronger physiological responses on the relevant questions in the R/IR technique cannot be unequivocally interpreted as an indication of guilt. These reactions can also be found in the innocent simply because the relevant questions are more threatening than the control questions. The study of Horowitz et al. (1997) indeed demonstrated that nearly all examinees, guilty or innocent, responded more strongly to the relevant questions than to the neutral questions.

In sum, the R/IR does not meet the necessary psychometric standards that a psychological test requires. There are surprisingly few validity studies for a test that exists more than 100 years. The few published reports have demonstrated that the accuracy of the R/IR does not exceed chance. Moreover, both proponents and opponents of the polygraph have long agreed that the theory of the R/IR is inflated and outdated (Podlsney & Raskin, 1978). It is quite worrisome, then, that this test is still being used by U.S. security agencies, with possibly tremendous consequences for the examinees (National Research Council, 2003).

### **Control Question Technique**

The Control Question Technique (CQT; Reid, 1947) was developed to meet the critics about the R/IR by using arousal-evoking rather than neutral control questions. The CQT consists of three phases. The main aim of the first or pretest phase is to convince the suspect of the extreme high accuracy of the polygraph and to discuss the formulation of the questions. The relevant questions (e.g., “Do you know who kidnapped the prime minister?”) are formulated in such a way that the suspect can unambiguously answer with “no” to all of them. The control questions are deliberately formulated more vague and general, for example “Have you ever taken anything that did not belong to you?” or “Have you ever done anything illegal?”. The examinee is maneuvered into answering “no” on these questions by suggesting that a positive answer would be indicative of guilt (Honts, 1994; Raskin & Honts, 2002). The second or test phase, is the actual

polygraph examination where physiological responses to the relevant and control questions are measured. A number of irrelevant questions (e.g., “Is your first name Jean-luc?”) are also included, but the crucial comparison involves the physiological responses on the crime-related relevant questions and the arousal-evoking control questions. A deceptive status (guilty vs. innocent)  $\times$  question type (relevant vs. control) interaction effect is expected. Innocent examinees are expected to show the largest reactions to the control questions, because they can confidently deny commission of the crime, but will be uncertain or worried about their answers to the control questions. Guilty examinees are expected to respond more strongly to the relevant questions, because these are most important to them. Thus, stronger physiological responses to the control questions are interpreted as indicative of truth telling, and stronger reactions to the crime questions are taken as indicative of deception. During the third or posttest phase, the test results are scored, most often using a numeric system, and the examinee is confronted with the test results.

Data on the criterion validity have been reviewed by several authors. Kircher et al. (1988), for example, have reviewed 14 studies using the mock crime procedure and found that 74% of the guilty and 66% of the innocent participants were correctly classified with 8% false negatives and 12% false positives. Ben-Shakhar and Furedy (1990) included 9 mock crime studies in their review and found that 80% of the guilty and 63% of the innocent participants were correctly classified with 7% false negatives and 15% false positives. It has been argued that these statistics may be biased (by the base rate of deceptive versus innocent participants and the number of inconclusive test outcomes), and are difficult to interpret. A measure of accuracy that is not subject to these problems is the receiver operating characteristic curve (ROC). This curve plots the true positive rate against the false positive rate, and the area under the curve ( $a$ ) reflects the detection efficiency. The value of  $a$  lies between 0 and 1, with .50 indicating performance at chance level. Using this approach, the National Research Council (2003) found a median accuracy index  $a$  of .85 across 37 mock crime studies. Thus, these reviews confirm that the accuracy of the CQT is well above chance. It further appears that commonly applied decision thresholds are somewhat

biased against the innocent, with a false positive rate around 12-15% (Kircher et al., 1988; Ben-Shakhar & Furedy, 1990).

Although the results of the reviews are remarkably consistent, they have been interpreted in opposing ways. Proponents argue that these results provide an underestimation of the actual accuracy. They argue that augmenting the stakes in actual polygraph examinations will result in higher accuracy (Kircher et al., 1988). Opponents argue that the results are an overestimation because an actual polygraph examination will never meet the perfect laboratory conditions (Lykken, 1998). One way of resolving this issue is to examine the test accuracy in the field, where stakes are higher. In field research, the relationship between polygraph test outcome and an independent criterion of guilt, most often confession, has been examined. Ben-Shakhar and Furedy (1990) reviewed 9 field studies and found that 84% of the guilty and 72% of the innocent participants were correctly classified with 13% false negatives, and 23% false positives. Raskin and Honts (2002) were more selective, and included only four field studies in their review. They calculated that 89% of the guilty, and 59% of the innocent suspects were correctly classified, with 1% false negatives and 12% false positives. The accuracy raised to 95% for the guilty and 96% of the innocent participants when looking at the judgments made by the original examiners, and inconclusive were excluded. Across 7 field studies, the National Research Council (2003) found an accuracy index  $a$  of .89. Taken together, these data show that the CQT is slightly more accurate in field compared to laboratory settings (National Research Council, 2003).

It should be noted that the validity of this research has been challenged. The biggest problem with laboratory research using the mock crime procedure is its lack of ecological validity (Lykken, 1998; National Research Council, 2003). Indeed, it is unlikely that laboratory research can mimic the emotional and motivational characteristics of high stake real-life examinations. Field research does not face this problem, but absolute determination of deception status ("ground truth") is impossible. Most often, confession has been used as the criterion to determine whether the suspect was guilty or not. However, this criterion is far from absolute (e.g., the occurrence of false confessions; Kassir, 1997), and might produce inflated accuracy figures due to biased sampling

(Patrick & Iacono, 1991). It is reasoned that a deceptive test outcome leads police investigators to search for confirming evidence (e.g., by trying to elicit a confession). However, guilty suspects who obtained a truthful test outcome might go undetected because less investigation effort is invested in them. The case of Aldrich Ames illustrates this problem. Ames was a CIA agent who passed classified information during 10 years to the Soviet Union. Ames reportedly passed several polygraph tests (Aftergood, 2000), which may have been the reason why Ames was long undetected, despite clear indications of his misconduct (Lykken, 1998). Rather than concluding that the accuracy of polygraph tests simply can not be determined (e.g., Patrick & Iacono, 1991), I favor the more constructive approach of combining the data from analogue and field research.

Although the CQT has an accuracy well above chance, it has received critics on ethical and methodological grounds (Ben-Shakhar & Furedy, 1990). An important ethical objection is that the pretest of the CQT involves deception by the examiner. Several authors have expressed their concern about lying authority figures (Kassin, 1997). A methodological concern is the lack of standardization of the test procedure: control questions are shaped during the pretest phase; the duration of the test procedure can vary from one to several hours; and numerical scoring involves the subjective decision of determining whether the differences between control and relevant questions are “noticeable”, “strong” or “dramatic”. As pointed out by Rosenfeld (1995, 1997), a number of these critiques concern inappropriate practices of some examiners, and/or do not apply for more recent adaptations of the CQT, such as the Directed Lie Technique (see Raskin & Honts, 2002). I will, therefore, restrict my discussion of the CQT to the construct validity of the test.

An important weakness of the CQT is its a-theoretical basis. The technique is based on a set of assumptions rather than scientific principles. For example, in order for the innocent to react more strongly to the control questions, the suspect has to be convinced that the polygraph has an accuracy close to 100%, and that enhanced responding to the control questions results in a deceptive outcome. In

fact, both statements are untrue, and it seems implausible that each examinee can be convinced of these lies. It could be argued that the research on the test accuracy has demonstrated the plausibility of the assumptions (Elaad, 2003). However, this research has also shown that not all examinees show differential responding between relevant and control questions (i.e., they have an inconclusive test outcome), and some show a pattern that is opposite to the test assumptions (i.e., they have a false positive or a false negative test result). In order to determine why the test assumptions do not hold for all examinees, one needs to have clear insight into the mechanisms that relate the polygraph questions to the physiological responses. Unfortunately, virtually no attention has been given to the psychophysiological mechanisms in the CQT. Davis (1961) named three possible mechanisms by which deception may lead to enhanced physiological responsivity: fear of punishment (cf. “Anti Climax dampening” or “Psychological Set”; Matte & Grove, 2001), mental conflict, or conditioned reaction. These hypotheses face a number of problems. First, they are unspecified and vague. For example, anti-climax dampening “involves the inter-relationship of two issues, questions or topics, in close proximity to each other, where the more important, bothersome or stimulating issue suppresses or completely eliminates emotional response to the other issue, question or topic which the person might have responded to had the other strong issue, question or topic not been present” (Backster, 1960, in Matte & Grove, 2001). Second, these hypotheses have not been tested empirically. Given their vague formulation, some may not even be testable. Third, these hypotheses have difficulty in explaining results of experiments that found accurate detection in the absence of negative consequences (e.g., Bradley & Janisse, 1981).

A testable and specified account was formulated by Raskin (1979). Raskin argued that the physiological responses are best explained in terms of the defensive reflex (Sokolov, 1963). This reflex secludes the organism, in order to protect it from aversive stimuli. As such, the defense reflex is closely linked to fight/flight responding. The test theory, then, holds that the more threatening a question is, the stronger the defensive responding will be. For the innocent, the control questions are supposed to pose the biggest threat, while this would be the relevant questions for the guilty suspect. The defense reflex hypothesis would

predict that the more threatening a polygraph test is experienced, the better the detection efficiency. The (slightly) higher accuracy figures obtained in the field compared to the laboratory could be interpreted as confirming evidence. Other predictions, however, were not confirmed. First, no differences in physiological responding between psychopathic and non-psychopathic prisoners were found (Raskin & Hare, 1978; Patrick & Iacono, 1989), no correlation between anxiety and detection efficiency was found (Honts, Raskin, & Kircher, 1986, in Ben-Shakhar & Furedy, 1990), and threat of shock did not enhance detection efficiency (Bradley & Janisse, 1981). Second, defensive responding is associated with cardiac acceleration (Sokolov, 1963; Graham & Clifton, 1966) and hyperventilation (Duan, Winters, McCabe, Green, Huang, & Schneiderman, 1996; Van Diest, Winters, Devriese, Vercamst, Han, Van de Woestijne, & Van den Bergh, 2001), which is therefore expected to occur in the CQT. However, the opposite pattern, that is cardiac deceleration and respiratory suppression, has often been observed in the laboratory (Podlesney & Raskin, 1978; Raskin & Hare, 1978). These cardio-respiratory indices are components of the orienting reflex, not the defensive reflex. One possibility, then, is that orienting might explain physiological responding (Kleiner, 2002). According to the National Research Council (2003), the orienting hypothesis contradicts current practice. In sum, the mechanism driving physiological responding in the CQT is unknown.

To conclude, there is considerable evidence that the CQT performs well above chance. However, the construct validity is problematic. First, test assumptions are questionable and certainly do not hold for all examinees. Second, the psychophysiological mechanism connecting the polygraph questions and the physiological responses is unknown. The National Research Council (2003) has argued that a polygraph test without a sound theory is problematic, because no firm predictions can be made on how the test will perform in individuals, examiners or situations that have not yet been tested. To that extent, strong confidence in the CQT is unwarranted.



### **Concealed Information Test**

“The real use of the [...] method is therefore probably confined to those cases in which it is to be found out whether a suspected person knows anything about a certain place or man or thing (Münsterberg, 1908, pp. 137)”. Harvard Professor Münsterberg, who was the first to introduce the polygraph into the US, was also the first to acknowledge its limitations and to point to an alternative method. The idea behind this method was as elegant as simple: the guilty suspect has knowledge about the crime that only the culprit can have. When later confronted with this knowledge, the culprit will recognize it and is likely to show a bodily response to it. The innocent on the other hand will react similarly to all alternatives. About half a century after Münsterberg launched this idea, Lykken (1959) experimentally tested it using the Concealed Information Test (CIT; also named the “Guilty Knowledge Test”). The CIT consists of a series of questions, each having one correct and several incorrect items. In a murder case, for example, one might question the suspect about how the victim was murdered (“Do you know whether the victim was ...hung? ...shot? ....suffocated? ...drown? ...poisoned?”), the location where the victim was found, how the murderer got away, etc. If the examinee systematically responds more strongly to the correct items than to the control items, he/she is supposed to have secret information about the crime. To the perspective of the innocent, all answers are homogenous, making it unlikely that the innocent will systematically react stronger to the correct answers. The CIT is usually scored as originally proposed by Lykken (1959). Physiological responses to the relevant answers are compared with the control answers for each question. A score of 2 is assigned if the relevant answer elicited the largest response, 1 if it elicited the second largest response, and 0 for any other response. Responses are summed across questions, response measures, and test repetitions, and a score between 0 and T is obtained, with T being the maximum score. A score below  $(T/2)+1$  results in an innocent test outcome, whereas a score above  $T/2$  results in a guilty test outcome, and usually there is no inconclusive zone. For example, a threshold of 5 is used in a single repetition of a CIT with 5 questions using skin conductance as the sole measure.

The accuracy of the CIT has mainly been examined in laboratory research. Apart from the mock crime procedure described above, researchers have used three other procedures to create concealed information in the laboratory: a chosen card, code words and autobiographical information (Ben-Shakhar & Elaad, 2003). Common across procedures, is the fact that certain information is made relevant for the subsequent polygraph test. In a card test, the participants is asked to chose one card from a pile (each with a number between 1 and 10), and the participants is questioned on the number that was written on the card. In the code word paradigm, concealed information consists of a number of stimuli (usually words, but pictures can also be used), which the participants has to memorize. Finally, the third variant uses autobiographical information, such as the name or phone number of the examinee, as concealed information. Research on studies examining the accuracy of the CIT have been reviewed by several authors. An important difference in interpreting and comparing the results with the studies on the CQT, is that the scoring system used in the CIT does not include an inconclusive category. Ben-Shakhar and Furedy (1990) reviewed 10 studies and found that the CIT classified 84% of the guilty and 94% of the innocent examinees correctly. Reviewing 22 studies, MacLaren (2001) found an accurate judgment for 76% of the guilty, and 83% of the innocent participants. Most recently, the NRC selected 13 mock crime studies and found an accuracy index  $a$  of .88. In a very thorough meta-analysis, Ben-Shakhar and Elaad (2003) reviewed 80 studies and found a very similar mean accuracy index  $a$  of .80, .74, .84, and .87 for studies using the card test, the code word, the autobiographical or the mock crime procedure, respectively. Because of the high number of studies included, these authors were able to perform moderator analyses. This analyses revealed that the mock crime procedure produced the highest accuracy. Furthermore, the CIT was more effective if participants were instructed to give a verbal deceptive (“no”) response to the questions, were motivated to appear innocent, and the test consisted of 5 or more questions. Ben-Shakhar and Elaad selected 10 mock crime studies that met these ideal conditions and found a mean accuracy index  $a$  as high as .95. In terms of percentage correct, this implies that 83% of the guilty and 96% of the innocent participants were correctly classified

(Ben-Shakhar, personal communication, May 2004). This laboratory research, therefore, confirms that the CIT has good criterion validity.

Unfortunately, less is known about how the CIT performs in the field. The lack of field studies is due to the fact that field polygraph examinations are almost exclusively performed with the CQT. The CIT has been applied on a large scale only in Israel and Japan. Two Israeli field studies (Elaad, 1990, Elaad, Ginton, & Jungman, 1992), reported that 94% of the innocent and 65-76% of the guilty examinees were correctly classified. Elaad argued that because of the low mean number of questions in his studies (1.8 and 2), the data might underestimate the true field accuracy of the CIT. This explanation is challenged by the report that similar detection rates are found in Japan (Nakayama, 2002), where five or more questions are usually formulated (Hira & Furumitsu, 2002). These data suffer, however, from methodological shortcomings (Nakayama, 2002), and were not subjected to peer-review. Although far from conclusive, the field data indicate that the specificity is similar to that observed in the laboratory, but that the sensitivity is somewhat lower. Most likely, this is due to guilty suspects who did not notice or remember certain details. Supporting evidence for this idea was found in a study by Carmel, Dayan, Naveh, Raveh, and Ben-Shakhar (2003), who manipulated the type of mock crime procedure (standard vs. more realistic) and the time between the crime and test (immediate vs. delayed). The accuracy of .84 in the immediate standard mock crime, declined to .68 in the delayed realistic mock crime procedure.

Regarding the test theory, Ben-Shakhar and Furedy (1990) have argued that cognitive, rather than emotional factors are most likely to explain the physiological responses to concealed information. Research has shown that concealed information elicits enhanced physiological responses compared to control information, even if the examinee does not give an overt answer, is unlikely to experience strong emotions (either anxiety, guilt or shame), or is not particularly motivated to appear innocent (Ben-Shakhar & Elaad, 2003). An influential cognitive account was proposed by Lykken (1974), who argued that enhanced orienting explains differential responsivity in the CIT. The orienting reflex is a complex of behavioral, physiological and brain responses elicited by novel and/or significant stimuli (Sokolov, 1963). Novel stimuli elicit orienting

because they do not fit in the organisms mental model of the surrounding world. The organism orients towards novel stimuli in order to analyze them more thoroughly. After a period, these stimuli will be taken into the new mental model and orienting will be inhibited (habituation). For example, a car that passes your window will probably draw your attention. However, if you live next to a motorway, this sound will be adopted in your mental model and orienting will no longer take place. However, not only novel, but also familiar stimuli can elicit orienting, provided they are in some way relevant to the organism. Your own name, for example, is likely to draw your attention, even when your paying attention to other stimuli (Moray, 1959). Lykken (1974) reasoned that concealed information will elicit enhanced relevance-orienting, only in knowledgeable individuals. Only for them, the correct answer has a special meaning and will lead to enhanced physiological responding. For persons without knowledge about the crime under investigation, all items should be homogeneous, thereby minimizing the chance of distinct responding to the crime details.

Building on the orienting theory, Ben-Shakhar formulated his dichotomisation theory (1977). The theory postulates that knowledgeable participants in a CIT make a basic dichotomisation between two stimulus categories: concealed vs. control information. It is further assumed that the strength of responding to a stimulus depends on habituation of stimuli within that category, but not of stimuli in the other category. For the innocent, all stimuli are neutral, and responses will quickly habituate. The guilty suspect, on the other hands, will differentiate relevant from neutral stimuli. Because neutral stimuli are presented more often, they will habituate faster than the relevant stimuli, leading to differential responding. Note that the dichotomisation theory explains responding solely in terms of (relative) novelty. The theory predicts that increasing the number of stimuli in one category reduces the magnitude of responding to those stimuli, but leaves the magnitude of responding to stimuli of the other category unaffected. Using the card procedure, it was indeed found that increasing the number of unchosen cards (leading to habituation of the unchosen, but not the chosen stimuli), resulted in better detection efficiency (Lieblich, Kugelmass, & Ben-Shakhar, 1970). Ben-Shakhar (1977) could also demonstrate that generalization

of habituation occurs within stimulus categories. With  $c$  representing the chosen and  $u$  representing the unchosen category, it was predicted that the same detection efficiency would be obtained in the series  $u_1, u_2, u_3, c, u_4, u_5, u_6, u_7$  (1 chosen, and 7 different unchosen cards) and  $u_1, u_1, u_1, c, u_1, u_1, u_1, u_1$  (1 chosen, and 1 unchosen card presented 7 times). Very similar detection efficiency was indeed found. However, several findings could not be explained by the dichotomisation theory. Infrequently presented chosen items (1 chosen vs. 7 unchosen) elicited greater responses than infrequently presented unchosen cards did (1 unchosen vs. 7 chosen). This suggests that responsivity is not only determined by relative novelty, but also by relevance (Ben-Shakhar, 1977). Relevance appeared an even a more potent factor in eliciting orienting than relative novelty (Ben-Shakhar, 1994). Furthermore, participants do not only pay attention to the relevant/neutral dimension. Ben-Shakhar and Gati (1987) demonstrated that a more complex comparison of common and distinctive features is performed. These conflicting data urged for a reformulation of the theory, and a feature matching theory of both relevance and novelty was proposed (Gati & Ben-Shakhar, 1990). Most importantly, the model holds that the *features* of incoming stimuli are compared with the *features* of previous stimuli on both novelty and relevance, independently. Subsequent research (e.g., Ben-Shakhar & Gati, 2003; Ben-Shakhar, Gati, & Salamon, 1995) generally confirmed that stimulus responsivity is determined by the degree to which it has common and distinctive features with previously presented stimuli (novelty) and the degree to which it matches previously presented relevant stimuli (relevance). It should be clear that this feature matching theory extends Sokolov's orienting theory, rather than replaces it.

Taken together, the evidence shows that relevance is the crucial factor in determining differential reactivity in the CIT. When relative novelty is ruled out by using an equal proportion of relevant and neutral stimuli, concealed information still elicits enhanced responding (Ben-Shakhar, 1977). The main difference between concealed and control information is their difference in relevance. Thus, "...for the guilty subject only, the 'correct' alternative will have special significance, and added 'signal value' which will tend to produce a stronger orienting reflex than that subject will show to other alternatives

(Lykken, 1974, p. 728)". Novelty will contribute to responding, but is not necessary.

There is good evidence for the orienting theory on concealed information. First, concealed information is associated with the physiological responses that are known to be associated with the orienting response. Thus, the orienting account can explain why concealed information is accompanied by an increase in skin conductance (Lykken, 1959), respiratory suppression (Timm, 1982), an increase in p300 amplitude (Rosenfeld, Cantwell, Nasman, Wojdac, Ivanov, & Mazzeri, 1988), and an increase in pupil dilation (Lubow & Fein, 1996). It should be noted, however, that these physiological responses are not uniquely related to orienting. Second, physiological responding to concealed information shares several characteristics of the orienting response. The orienting response is known to generalize to similar stimuli (generalization), to decline with repeated presentation (habituation), and re-appear after a novel stimulus has been presented (dishabituation). Habituation of responding has been demonstrated in several studies using the CIT (e.g., Ben-Shakhar, Frost, Gati, & Kresh, 1996). Generalization of responding was also demonstrated in the CIT. For example, Ben-Shakhar et al. (1996) found that physiological responding to concealed information presented in one modality (e.g., verbal) generalized to other modalities (e.g., pictorial). Using the code word procedure, Ben-Shakhar and Gati (1987) further demonstrated that the strength of responding to a stimulus was linearly related to the degree it resembled the concealed information stimulus. In contrast to the predictions resulting from the orienting theory, however, research with the CIT has failed to demonstrate dishabituation (e.g., Ben-Shakhar, Gati, Ben-Bassat, & Sniper, 2000). Third, Sokolov (1963) argued that the purpose of the orienting reflex is to allow a more thorough processing of the orienting-eliciting stimulus. Thus, enhanced recall of concealed versus control information could be expected. Indirect evidence was found in a study by Waid, Orne, Cook, and Orne (1978). Participants were asked to memorize a list of words and instructed to inhibit responding to these code words during the subsequent polygraph examination. Memory for the *control* words was assessed after the examination. It was found that remembered words had a higher probability of

eliciting reaction, and a positive correlation between the number of recalled words and detection efficiency was found. More direct evidence was found in later studies (e.g., Iacono, Boisvenu, & Fleming, 1984; Carmel et al., 2003), which demonstrated that better recall of concealed information was associated with better detection efficiency. Still, factors other than orienting (e.g., arousal; Bradley, Greenwald, Petry, & Lang, 1992) could account for these findings. Taken together, orienting theory is able to explain most results that were obtained with the CIT.

In sum, the CIT (mean accuracy  $\sim .88$ ) performs well above chance, slightly higher than the CQT (mean accuracy  $\sim .85$ ). Furthermore, in contrast to the CQT, the test assumptions follow a clear logic. Importantly, the well specified orienting theory is likely to explain the physiological responses to the polygraph questions. However, alternative theories and differential predictions needs to be examined empirically. The present dissertation aims to do that.

### **Present research**

The criterion validity of the CIT has been demonstrated empirically in laboratory research. Confidence in this polygraph technique would be strengthened by empirical research on the construct validity. In the present dissertation, I have examined whether the physiological reactivity to concealed information is due to enhanced relevance orienting.

There are two important qualifications to the concealed information procedures that I have used in the present research. First, participants were never instructed to give a verbal answer to the items. Typically, participants are asked to answer “no” to all questions, thus lying on questions containing concealed information. This procedure might itself produce physiological reactivity (Furedy, Davis, & Gurevich, 1988). Trying to avoid that factors other than relevance-orienting could explain my research findings, participants were, therefore, not asked to give a verbal response. Second, I used an equal proportion of concealed information and control information items, whereas most researchers have used a

1 by 4 proportion. When presenting concealed information items less frequently than the control information items, relative novelty might also explain physiological reactivity (Gati & Ben-Shakhar, 1990). In order to avoid that relative novelty could explain my research finding, concealed information and control information items were presented equally often. Using a CIT without verbal answering and a equal proportion of concealed and control information, should, therefore, allow a stringent test of the relevance-orienting hypothesis.

In the present dissertation, three main research questions were examined. In Chapter I, I examined whether concealed information demands attention. Several authors have favoured an information processing view on orienting (Öhman, Hamm, & Hugdahl, 2000). They have argued that the main function of the orienting reflex is to interrupt ongoing behaviour and to reallocate attention towards the orienting-eliciting stimulus. If psychophysiological responding to concealed information is due to orienting, concealed information should demand attention. Reaction-time interference was used to measure attention allocation. The idea was that the more concealed information would demand attention, the less attention could be allocated to other tasks, leading to reaction-time slowing on a secondary task. Chapter I examined whether concealed information is more attention demanding than control information. Additionally, it was investigated whether this effect was due to the enhanced relevance of the concealed information items. I predicted that concealed information would demand more attention, not only compared to unfamiliar non-relevant information, but also compared to familiar non-relevant information. Results of three experiments were clearly in line with these predictions. However, the differences between concealed information and familiar irrelevant information were small and not always significant. One explanation for these small differences, was that I was not entirely successful in creating known, “non-relevant” items. In Chapter II, I therefore made another attempt to create familiar, non-relevant items.

The allocation of attention to concealed information (Chapters I and II) could also be explained by the defensive reflex. Indeed, aversive stimuli that normally elicit defensive responding also demand attention (Eccelston & Crombez, 1999).



Not only the behavioral, but also physiological responses (e.g., enhanced skin conductance responses) may be considered correlates of the defensive reflex, instead of the orienting reflex. One can imagine that polygraph questions are experienced as threatening and that a suspect will respond defensively. By measuring heart rate, the research described in Chapter III, provided a critical test for both hypotheses. Using a mock crime procedure, participants were presented with concealed information and control information. In line with previous research, larger skin conductance responses and greater reaction-times to a secondary probe were expected. The crucial measure, however, was heart rate. I investigated whether concealed information was accompanied by a decrease in heart rate, indicative of orienting, or by an increase in heart rate, indicative of defensive responding.

Finally, in Chapters IV and V of this dissertation, I examined whether physiological responding to concealed information was moderated by psychopathic traits. It has been frequently demonstrated that psychopathy is associated with reduced skin conductance responding (Lorber, 2004). However, some authors have argued that psychopathy may also be associated with enhanced physiological responding in some response measures (e.g., heart rate; Arnett, 1997) or under some conditions (e.g., when rewarded; Raine, 1997). In Chapter IV, I tested this hypotheses in a group of undergraduates, who scored either very low or very high on psychopathic traits. Participants were presented with concealed information and control information while heart rate and skin conductance was measured. There were two tests, one in which participants could win, and one in which they could loose money. I reasoned that high psychopathic undergraduates would show reduced skin conductance responding when risking to loose money, but might show enhanced cardiac responding when able to win money. The results did not support these predictions. Rather, concealed information elicited enhanced skin conductance and greater cardiac deceleration across groups and across tests. However, a methodological shortcoming of this study was that the role of psychopathy was investigated in a sample of undergraduates. In Chapter V, I therefore examined the role of psychopathy in a sample of male offenders from a high-security prison.

I end my dissertation with a general discussion of my research. First, I will summarize the most important results. Next, I will discuss theoretical and applied implications of my research. Finally, I will point out the limitations of my research and formulate guidelines for future research.

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# CHAPTER 1

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## ORIENTING TO GUILTY KNOWLEDGE<sup>85</sup>

The Guilty Knowledge Test (GKT; Lykken, 1959) assesses whether suspects conceal information about a crime (“guilty knowledge”). Previous studies have demonstrated larger physiological reactions to guilty knowledge compared to unknown information. In three experiments, we investigated whether guilty knowledge also demands attention. During an alleged polygraph examination, participants were presented with to-be-detected pictures (“guilty knowledge”), non-significant, familiar pictures (“mere knowledge”), and previously unseen pictures (“neutral information”) for 250 ms in a modified dot probe task. In all three experiments, probe responses were slower on guilty knowledge trials as compared to the neutral trials. Results are discussed in terms of an information processing view on orienting to guilty knowledge.

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## **INTRODUCTION**

Psychophysiological detection of deception is widely used in law enforcement in the US and several other countries around the world. "Lie detection" by the polygraph is most commonly performed with the Control Question Technique (CQT; Reid, 1947). In this technique a comparison is made between the psychophysiological responses of a suspect to crime relevant questions (e.g., "Did you kill X last Friday?"), to arousing control questions (e.g., "Have you ever stolen something?"), and to neutral questions (e.g., "Is today Wednesday?"). When larger responses are found on crime-relevant than on control questions, the suspect is assumed to be lying. Arguing that the aim in applied settings is to assess guilt rather than lying, Lykken (1959) developed the Guilty Knowledge Test (GKT). The GKT detects the possession of knowledge about an event (e.g., a crime) that a person cannot or does not want to reveal. In the GKT, psychophysiological activity is registered during a series of multiple-choice questions, each having one correct answer. For example, if the victim in a murder case wore a dress with a salient colour, a typical question might be: "The victim wore a dress with a specific colour. If you are the murderer you know the colour of the dress. Was it (a) blue, (b) green, (c) red, (d) black or (e) white?". The core assumption of the GKT is that the correct answer has a special meaning only for the knowledgeable participant. Therefore, only this participant will show enhanced psychophysiological responding to the correct answer. The guilty knowledge test has been shown to be very accurate under laboratory conditions (for a recent review see MacLaren, 2001).

### ***Orienting to significant stimuli underlies the "guilty knowledge effect"***

Several models have been proposed to explain the mechanisms underlying the GKT (Ben-Shakhar, 1977; Gati & Ben-Shakhar, 1990; Lykken, 1974; Waid & Orne, 1981). Of substantial influence is the idea that the orienting response (OR) accounts for the enhanced responding to the correct answer (Lykken, 1974). The OR is a conglomerate of behavioral and physiological responses, which is

elicited when a stimulus is novel or has been changed. However, familiar stimuli can also elicit an OR if they have relevance or “signal value” (Sokolov, 1963). Building upon these ideas, Lykken (1974) has argued that guilty knowledge adds signal value to the correct answer in the GKT, contributing to an enhanced orienting response as compared to the incorrect answers. In two experiments using a card version of the guilty knowledge paradigm<sup>3</sup>, Ben-Shakhar (1994) showed that guilty knowledge has an added signal value. In this study, “guilty knowledge” was manipulated by asking students to choose one out of eight figures and to memorize it. Participants were told that an attempt would be made to detect which figure they had selected. The electrodermal response was measured while participants looked at a sequence of stimuli. This sequence consisted of several control stimuli followed by one test stimulus, which could be a guilty knowledge or neutral stimulus. In addition to guilty knowledge, novelty was manipulated by varying the extent to which the test stimulus resembled the preceding control stimuli. It was shown that both guilty knowledge and novelty contributed independently to the electrodermal orienting response.

### ***Orienting is associated with allocation of attention***

If the psychophysiological responses to guilty knowledge items can be conceived of as a component of the orienting response, it is reasonable to assume that attentional processes are also involved. Indeed, several authors have proposed an information processing view on orienting (Graham, 1979; Kahneman, 1973; Öhman, 1992; Sokolov, Spinks, Näätänen, & Lyytinen, 2002; Wagner, 1978). They have argued that the main function of the OR is to enhance information

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<sup>3</sup> In more than 40 years of experimental research on the GKT, a variety of procedures has been used (for a review see Ben-Shakhar & Furedy, 1990). Participants have been asked to memorize a list of words, to choose a card, to watch a videotaped crime, or to execute a mock crime. Common across studies, participants acquire *knowledge*, which is in some way *relevant* in the experimental set-up. In line with this research, we use the term “guilty knowledge” in the present study. However, it should be noted that we do not intend to make any assumptions concerning the emotional state of the participant.



processing, which is not only achieved by directing the senses to the stimulus, but also by allocating attention towards it.

The relationship between the orienting response and the allocation of attention has most often been studied using a secondary task paradigm. In an early study, Dawson, Schell, Beers, and Kelly (1982) measured response latency on an auditory secondary-task signal, while participants attended primarily to visual stimuli that signaled the absence or the occurrence of an aversive electroshock. The results clearly showed that participants responded more slowly to auditory probes that were presented during the signals for threat than to probes that were presented during the safety signals. Of particular interest for our study was the finding of a close relationship between the skin conductance orienting response and the allocation of attention (see also Filion, Dawson, & Schell, 1994). Dawson et al. (1982) suggested that interference of performance on a secondary task can be used to assess resource allocation to orienting stimuli. Subsequent research has shown that both novel and significant stimuli are associated with allocation of attention as measured by task interference on a concurrent reaction time task (for a review see Siddle, 1991).

### ***Objectives and predictions of the present study***

This paper investigates whether guilty knowledge demands attentional resources. Using a guilty knowledge paradigm similar to Ben-Shakhar (1994), participants were led to believe that we would try to detect which pictures they had memorized in the beginning of the experiment. During an alleged polygraph examination, participants performed a probe classification task similar to Bradley, Mogg, Falla, and Hamilton (1998). Each trial started with a central fixation cross, followed by a pair of pictures presented one above the other. Each pair consisted of one neutral and one critical picture, which varied according to previous experience the participant had with it. This critical picture could be a previously unseen ("neutral trial"), a non-significant familiar ("mere knowledge trial") or a to-be-detected picture ("guilty knowledge trial"). After 250 ms, a reaction time probe (: or ..) replaced one of the two pictures and participants were

required to classify the probes by pressing one of two response keys. There were three research objectives in the present study.

First, we wanted to investigate whether guilty knowledge leads to task interference in the probe classification task. As it has been shown that an orienting stimulus can slow performance on a probe position task (Meyer, Niepel, Rudolph, & Schützwohl, 1991), we predicted that probe reaction times will be slower during guilty knowledge trials as compared to neutral trials.

Second, we wanted to disentangle the effects of familiarity and relevance in the GKT. In research on the GKT, the control condition usually consists of neutral information. However, as guilty knowledge differs from neutral information in both familiarity and relevance, clear-cut conclusions about the underlying mechanism of the GKT are difficult to reach. Therefore, we added a set of non-significant familiar pictures (“mere knowledge items”). If the signal value of the guilty knowledge items is critical, we expect that task interference will be larger during guilty knowledge trials than during mere knowledge trials. To our knowledge, this study is the first to include mere knowledge items as a within-subjects variable.

Third, we wanted to investigate attentional avoidance from guilty knowledge. In anxiety research, the probe classification task has been used to examine attentional shifts towards/away from threatening stimuli (Mogg & Bradley, 1998). In order to examine spatial attention, a distinction is made between congruent and incongruent trials. Congruent trials are those in which the critical picture and the probe appear in the same location, whereas their location differs on incongruent trials. These trials allow to assess whether participants spatially shift their attention towards/away from a critical stimulus. Spatially shifting attention towards a stimulus (‘vigilance’) is expected to result in faster RTs on congruent trials than on incongruent trials. Shifting attention away (‘avoidance’) would result in slower RTs on congruent as compared to incongruent trials. We hypothesized that participants will shift their attention away from guilty knowledge in order to avoid detection.

## EXPERIMENT 1

In Experiment 1, we investigated whether guilty knowledge demands attention. Using a probe classification task similar to Bradley et al. (1998), we examined (1) whether guilty knowledge leads to task interference, (2) whether this task interference is specific to guilty knowledge, and (3) whether participants spatially shift attention away from guilty knowledge.

### ***METHOD***

#### ***Participants***

Forty-six undergraduate psychology students (39 women) of the Ghent University took part in the experiment in partial fulfillment of course requirements. Mean age was 18.7 years ( $SD = 2.0$ ; range 18-30). All participants had normal or corrected-to-normal vision.

#### ***Materials***

Forty-eight pictures were selected from the International Affective Picture System (IAPS; Lang, Öhman, & Vaitl, 1988). This is a standardized collection of emotion eliciting, color pictures that were rated by large groups of North-American participants on valence, dominance and arousal. These ratings were validated for experimental use in a Flemish sample of undergraduate students (Verschuere, Crombez, & Koster, 2001). Based upon the normative ratings, 48 pictures of neutral valence and low arousal were selected. Sixteen of these pictures were used in practice and buffer trials preceding the test trials.

The experimental stimuli (mean height = 50 mm; mean width of 65 mm) used in the probe classification task stemmed from three categories: (a) guilty knowledge: five stimuli that were memorized and made relevant through instructions, (b) mere knowledge: five stimuli that were memorized, but had no

further relevance and (c) neutral information: six stimuli that had not been previously seen by participants. Each of these 16 stimuli was combined with a neutral picture from the same semantic category, resulting in a total number of 16 stimulus pairs.

### ***Apparatus***

Stimuli were presented on a S710 Compaq Deskpro computer using the Inquisit Millisecond software package (Inquisit 1.28, 1998), run with Windows 98. Inquisit has a millisecond accuracy of stimulus presentation and response timing (De Clercq, Crombez, Buysse, & Roeyers, 2003). Participants were seated approximately 60 cm from the 17-inch color SVGA screen.

### ***Procedure***

Participants were tested individually in a sound attenuated room. They were informed that they took part in a “lie detection experiment”. Participants were given ten pictures and asked to memorize them. After five minutes, there was a free recall test in which participants were instructed to describe the content of the pictures. The pictures were then returned again to the participant for a final brief look. Thereafter, participants were informed that a second experimenter would try to detect five of the ten pictures she/he had memorized. The experimenter selected a fixed set of pictures and gave the participants another three minutes to memorize these pictures. After the pictures were handed back to the first experimenter, a second experimenter entered the room, who informed participants on the use of the lie detection test. The second experimenter remained in the room during the entire test. Participants were told that the polygraph would be used to detect the memorized information. In line with previous research (e.g., Waid, Orne, Cook, & Orne, 1978) motivational instructions were given. Participants were told that, despite its high accuracy, very mature and intelligent people are able to beat the polygraph. Electrodes for the registration of electrodermal responding were connected to the left hand, but there was no actual measurement of electrodermal activity.

Next, standard instructions for the probe classification task were given. Participants were required to press one of two buttons - a red one at the left ('q') and a blue one at the right ('5') - as quickly and accurately as possible to classify the probe: vertical (:) or horizontal (..). Each trial began with a fixation cross, presented during 1400 milliseconds in the middle of the screen, followed by a picture pair for 250 milliseconds. One picture of the pair was presented above and one beneath the central fixation cross. The distance between their exterior edges was 50 mm. Time between picture offset and probe onset was 14 ms. The probe remained on the screen until a response was made. After an intertrial interval of 200 ms, the next trial began.

Participants practiced the probe classification task during 12 trials. Next, there were two buffer and 128 experimental trials that were presented in a new random order for each participant. Each of the 16 stimulus pairs was presented eight times, while location of the critical stimulus, location of the probe and the type of probe were counterbalanced in these trials.

After the probe classification task, participants rated the 32 different pictures from the experimental trials on valence and arousal by the Self-Assessment Manikin (SAM; Lang, 1980). SAM provides an easy understandable graphic 9-point scale for both dimensions. Valence ranges from a happy (9) to a unhappy figure (1). Similarly, the figure ranges from an excited (9) to a relaxed figure (1) for arousal. Pictures of this rating task were presented in a fixed random order one by one on the screen.

## **RESULTS**

### **Reaction time data**

Trials with errors were discarded (3.5% of the data) and RT data that deviated more than three standard deviations from the individual mean RT were excluded as outliers (1.78%). Percentages of incorrect responses during the guilty knowledge, mere knowledge and neutral trials were 3.9%, 3.0%, and 3.5%, respectively. Only data from participants who had no more than 20% trials lost

due to errors and outliers were taken in account for further analysis. Based upon these criteria, one participant was excluded from further analysis (22.6% loss of data). The statistical analysis was conducted with 92.76% of the original data. As an estimate of effect size, the percentage of variance ( $PV$ ) is reported. Following Cohen (1988), a  $PV$  of .01, .10 and .25 was used as thresholds to define small, medium and large effects, respectively. Finally, we report Greenhouse-Geisser corrections (with adjusted degrees of freedom) whenever the sphericity assumption was violated (Mauchly's Test of Sphericity;  $p < .05$ ).

The overall mean RT was 557 ms ( $SD = 67$ ). RTs were first analyzed using a repeated measures analysis of variance (ANOVA) with trial type as a within-subject variable with three levels (guilty knowledge/mere knowledge/neutral). This analysis showed a significant main effect of trial type,  $F(2,88) = 5.66$ ,  $\epsilon = .86$ , corrected  $df(1.73, 76.01)$ ,  $p < .01$ ,  $PV = .11$ . In a further analysis, one-tailed simple contrasts were used to test our hypotheses. These tests showed that RTs were slower on guilty knowledge trials, as compared to both mere knowledge,  $F(1, 44) = 6.56$ ,  $p < .05$ ,  $PV = .13$ , and neutral trials,  $F(1, 44) = 7.51$ ,  $p < .05$ ,  $PV = .15$ .

*Table 1. Mean Response Latencies to Probes (in ms; Standard Deviations in Parentheses) for Different Trial Types in all Three Experiments.*

	Trial type		
	Guilty knowledge	Mere knowledge	Neutral
Experiment 1	563 (77)	555 (66)	552 (63)
Experiment 2	600 (112)	596 (105)	589 (95)
Experiment 3	555 (76)	550 (66)	547 (70)

Attentional shifting of was investigated using a 2 (trial type: guilty knowledge/mere knowledge) x 2 (congruence: congruent/incongruent) repeated measures ANOVA. In line with the analysis regarding general task interference, there was a significant main effect of trial type,  $F(1,44) = 4.59$ ,  $p < .05$ . The critical interaction of Trial Type x Congruence did not reach significance,  $F(1,44) = 2.82$ ,  $p = .10$ . Mean RTs for congruent vs. incongruent presentations

were 560 ( $SD = 77$ ) and 566 ( $SD = 80$ ) for guilty knowledge trials, respectively, and 558 ( $SD = 64$ ) and 553 ( $SD = 74$ ) for mere knowledge trials. The main effect of congruence was also not significant,  $F < 1$ .

#### *Valence and arousal ratings*

Results from the self-report scales for valence and arousal indicated that pictures from all three trial types were rated as neutral ( $4 \leq \text{valence} \leq 6$ ) and low arousing ( $\text{arousal} \leq 4$ ). There were no significant differences in the arousal ratings of the guilty knowledge as compared to the mere knowledge or the neutral items. The mean valence of the guilty knowledge pictures was significantly more positive than both the mere knowledge items,  $t(43) = 4.66, p < .01$ , and the neutral items,  $t(41) = 5.95, p < .01$ . The valence ratings of the mere knowledge items and the neutral items did not differ significantly,  $t(41) < 1$ . Mean valence and arousal ratings for each trial type are given in Table 2.

*Table 2. Mean Ratings of Valence and Arousal (Standard Deviations in Parentheses) for Different Types of Stimuli in Experiments 1 and 2*

Self report dimension	Trial Type		
	Guilty knowledge	Mere Knowledge	Neutral
Experiment 1			
Valence	5.95 (0.87)	5.12 (1.13)	5.07 (0.83)
Arousal	3.47 (1.40)	3.42 (1.42)	3.54 (1.36)
Experiment 2			
Valence	5.54 (0.92)	5.45 (0.91)	5.14 (0.85)
Arousal	3.80 (1.45)	3.85 (1.31)	4.00 (1.19)

## **DISCUSSION**

The results of Experiment 1 can be readily summarized. First, participants were slower in responding to probes on guilty knowledge trials, as compared to the neutral trials. This finding is consistent with the idea that guilty knowledge elicits a signal OR, and therefore demands attention. Second, participants reacted slower to probes during the guilty knowledge trials than to probes during the mere knowledge trials. This indicates that the response slowing is due to the signal value of the guilty knowledge pictures. Third, no significant differences were found on the congruently vs. incongruently presented guilty knowledge trials. Thus, no evidence was found for the idea that participants tried to shift attention away from the guilty knowledge pictures.

## **EXPERIMENT 2**

The primary purpose of Experiment 2 was to replicate the findings obtained in Experiment 1, and to assess their generalizability using a procedure similar to that applied by Elaad and Ben-Shakhar (1989, Experiment 2). In Experiment 2,



participants were asked to choose one of two envelopes that determined which would be the to-be-detected items. It was expected that this procedure would increase the personal relevance of the guilty knowledge items.

## ***METHOD***

### ***Participants***

Fifty-two undergraduate psychology students (45 women) of the Ghent University took part in the experiment in partial fulfillment of course requirements. Mean age was 18.8 years ( $SD = 1.2$ , range 17-22). All participants had normal or corrected-to-normal vision.

### ***Procedure***

The procedure was similar to that of Experiment 1, except for the way in which pictures became guilty or mere knowledge items. After memorizing all 10 items during 5 minutes, participants were asked to choose one of two envelopes and carry out the instructions that were typed on a card.

The instructions urged participants to pick the set of to-be-detected pictures and to remove the remaining pictures<sup>4</sup>. Participants were instructed to pick five numbered pictures from the envelope (“guilty knowledge”) and to remove the other five (“mere knowledge”). They were told that the removed pictures were of no further relevance for the experiment, but that the second experimenter would try to detect which pictures they had chosen from the envelope. To be sure they knew which were the chosen items, they were instructed to memorize them for an extra 2 minutes. When this period was over, the first experimenter left and the second experimenter entered the room. Another procedural difference in Experiment 2 was that the manipulation check was formalized in that the verbal description of the pictures was written down by the experimenter.

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<sup>4</sup> The actual allocation of the stimuli to the mere knowledge or guilty knowledge type was manipulated by the experimenter. For half of the subjects, IAPS pictures 1270, 2500, 5020, 5990, and 7040 served as guilty knowledge items and 1670, 2190, 2210, 5500, and 5520 served as mere knowledge items (as in Experiment 1), whereas the reverse was true for the remaining participants.

## **RESULTS**

### **Manipulation check**

All participants remembered at least 7 out of 10 pictures correctly. Mean number of correctly remembered pictures was 9.33 ( $SD = 0.81$ ). Among the pictures that participants could not immediately recall, there were 19 (54.3%) guilty knowledge and 16 (45.7%) mere knowledge pictures.

### **Reaction time data**

Trials with errors were discarded (6.2% of the data) and RT data that deviated more than three standard deviations from the individual mean RT were excluded as outliers (1.57%). Guilty knowledge trials contained 6.7% incorrect responses, whereas the mere knowledge and neutral trials had 5.8% and 6.0% incorrect responses. None of the participants had more than 20% trials lost due to errors and outliers. The analysis was conducted with 92.35% of the original data.

The overall mean RT was 595 ms ( $SD = 102$ ). Repeated measures ANOVA with trial type (guilty knowledge/mere knowledge/neutral) as a within subjects variable showed a significant main effect of trial type,  $F(2, 102) = 3.10$ ,  $p < .05$ ,  $PV = .06$  (see Table 1). Simple contrasts showed that the RTs to the probes during guilty knowledge trials were significantly slower than during neutral trials,  $F(1, 51) = 5.17$ ,  $p < .05$ ,  $PV = .09$ . The difference between the guilty knowledge and mere knowledge trials was however not significant,  $F(1, 51) < 1$ .

A 2 (trial type: guilty knowledge/mere knowledge) x 2 (congruence: congruent/incongruent) repeated measures ANOVA showed no significant main or interaction effects, all  $F$ s  $< 1$ . Mean RTs were 600 ms ( $SD = 119$ ), 599 ( $SD = 112$ ) for congruent and incongruent guilty knowledge trials; 596 ms ( $SD = 105$ ) and 598 ms ( $SD = 112$ ) for congruent and incongruent mere knowledge trials.

*Ratings of valence and arousal*

As in Experiment 1, pictures from all three trial types were rated as neutral and low arousing. The mean valence of the guilty knowledge pictures was significantly more positive, as compared to the neutral items,  $t(50) = 2.30$ ,  $p < .05$ . Although the guilty knowledge pictures were rated relatively more positive in both Experiment 1 & 2, they were rated as *neutral* in both Experiments ( $4 \leq \text{valence} \leq 6$ , see Verschuere et al., 2001). There were no other significant differences between the guilty knowledge, mere knowledge and neutral pictures for self-reported valence and arousal (see Table 2).

**DISCUSSION**

Results of Experiment 2 partially replicated the results of Experiment 1. First, as in Experiment 1, participants were slower on guilty knowledge as compared to neutral trials. This finding corroborates our idea that guilty knowledge demands attention, and therefore slows down the performance on the probe classification task. Second, the difference between the guilty knowledge and mere knowledge items could not be replicated. There might be several reasons for this. One possibility is that in a context of lie detection, the mere knowledge items also acquired some signal value. Participants might have not believed that the mere knowledge items were not relevant. Third, in agreement with Experiment 2, no evidence for attentional avoidance was found.

**EXPERIMENT 3**

Experiment 3 was designed to optimize the difference in relevance between the guilty knowledge and the mere knowledge pictures. This was achieved in two ways. First, the mere knowledge items were memorized at the end of an immediately preceding, seemingly unrelated experiment. In this way, pictures were memorized in a neutral context and should not be interpreted as task-relevant. Second, in order to make the possession of guilty knowledge more

personally relevant, the polygraph test was presented as a test for emotional intelligence. Participants were told that only persons with high emotional intelligence would be able to control their emotions while viewing the guilty knowledge items. It was assumed that such a cover story would further increase personal relevance in undergraduate psychology students.

## ***METHOD***

### ***Participants***

Fifty-four undergraduate psychology students (46 women) of the Ghent University took part in the third experiment in partial fulfillment of course requirements. Mean age was 18.7 ( $SD = 0.9$ , range 18-21). All participants had normal or corrected-to-normal vision.

### ***Procedure***

There are two main differences with the previous experiments. First, the mere knowledge items were memorized in an immediately preceding experiment to avoid that they would be perceived as task-relevant (and thus gain signal value). This experiment was presented as part of a validation study of the IAPS pictures. Participants learned the mere knowledge pictures during 3 minutes, and they were asked to describe them. This procedure also allowed an equal memorization duration for the mere and guilty knowledge items, whereas in Experiments 1 and 2 participants had more time to learn the guilty knowledge pictures than the mere knowledge pictures. Second, a cover story was set up to enhance personal relevance of the guilty knowledge items. Participants were told that we were investigating whether emotional intelligence could predict who succeeds in first year psychology. They were asked to memorize five pictures and to try to control their emotions when viewing these pictures in the following polygraph test. Being able to control their emotions would result in a high EQ-score. Finally,

there was only one experimenter in Experiment 3, and - due to time constraints - there were no valence and arousal ratings.

## **RESULTS**

### ***Manipulation check***

Fifty-one of the 54 participants correctly described all 10 pictures ( $M = 9.94$ ,  $SD = 0.23$ ). The three remaining participants remembered 9 pictures correctly. Two participants could not recall a mere knowledge picture, while one participant could not recall a guilty knowledge picture.

### ***Reaction time data***

Trials with errors were discarded (4.9% of the data) and RT data that deviated more than three standard deviations from the individual mean RT were excluded as outliers (1.6%). There were 4.9% incorrect responses during the guilty knowledge, 5.0% during the mere knowledge and 4.7% during the neutral trials. No participants had an unacceptable percentage of trials lost due to errors and/or outliers. The analysis was conducted with 93.58% of the original data.

The overall mean RT was 550 ms ( $SD = 69$ ). Repeated measures ANOVA with trial type as a within-subject variable revealed a significant main effect of trial type,  $F(2, 108) = 3.49$ ,  $\varepsilon = .84$ , corrected  $df(1.68, 90.54)$ ,  $p < .05$ ,  $PV = .06$ . Mean RTs and their corresponding  $SD$ s are reported in Table 1. Simple contrasts showed that this effect was due to a lengthening of RTs during guilty knowledge trials, as compared to the responses to probes during the neutral trials,  $F(1, 54) = 9.53$ ,  $p < .05$ ,  $PV = .15$ . Although in the predicted direction, the difference between the guilty knowledge and the mere knowledge trials failed to show significance,  $F(1, 54) = 2.23$ ,  $p = .07$ .

The differentiation between congruent and incongruent trials in the  $2 \times 2$  ANOVA did not show any significant results, all  $F$ s  $< 1$ . Mean RTs for congruent vs. incongruent presentations were 555 ( $SD = 80$ ) and 556 ( $SD = 76$ ) for guilty

knowledge trials, respectively, and 548 ( $SD = 71$ ) and 552 ( $SD = 68$ ) for mere knowledge trials.

### ***DISCUSSION***

The results of Experiment 3 provide further evidence for the information processing view on orienting to guilty knowledge. First, participants were slower in classifying probes on guilty knowledge trials as compared to neutral trials. Second, in line with Experiment 1, the results of Experiment 3 showed that participants tended to be slower on guilty knowledge trials as compared to the mere knowledge trials. Since this difference failed to reach significance, it seems premature to draw strong conclusions regarding the role of the mere knowledge pictures. Third, congruence had no significant influence on the results. This finding contradicts the idea that participants tried to avoid detection by spatially shifting attention away from the guilty knowledge pictures.

### ***GENERAL DISCUSSION***

In three experiments, we examined whether guilty knowledge demands attention, and therefore leads to interference of performance on a probe classification task. Participants were led to believe we were trying to detect five out of 10 recently memorized pictures using a modified version of the polygraph (“guilty knowledge items”). The five remaining pictures were presented as irrelevant (“mere knowledge items”). During the alleged polygraph examination, we were interested in how fast participants responded to probes that followed trials containing the guilty knowledge, mere knowledge, or previously unseen pictures (“neutral items”).

The results of our experiments firmly support the idea that guilty knowledge demands attention. In each experiment, probe responses were slower on guilty

knowledge trials than on neutral trials. This “guilty knowledge effect” had a medium effect size. These findings are consistent with the information processing view on orienting to guilty knowledge, which states that guilty knowledge elicits a signal-OR and therefore demands attentional resources. Our results are also consistent with previous studies that have shown slower responses to guilty knowledge items compared to irrelevant items in participants who acquired this knowledge during a mock-crime (Farwell & Donchin, 1991; Seymour, Seifert, Shafto, & Mosman, 2000). In these experiments an oddball task was used, in which participants were asked to differentiate stimuli as being either “targets” or “irrelevant” by pressing one of two buttons. Targets were previously presented stimuli of low probability to which participants were instructed to respond by pressing one of two buttons. On all other stimuli, participants were asked to react by pressing the “irrelevant”-button. However, guilty knowledge stimuli were embedded among the irrelevant category. It was found that only participants who had acquired this knowledge in a preceding mock crime were slower in classifying the guilty knowledge stimuli as being irrelevant.

It is unclear whether mere knowledge can account for the guilty knowledge effect. Arguing that orienting to significant stimuli underlies the guilty knowledge paradigm, we expected more task interference during guilty knowledge trials as compared to mere knowledge items. The results of Experiment 1 confirmed this prediction, as probe responses on guilty knowledge trials were larger than on mere knowledge trials. However, this effect could not be replicated in Experiments 2 & 3, although it was in the predicted direction. To increase statistical power we decided to pool the data from all three experiments in an overall ANOVA with trial type as the within and experiment as a between subjects variable. The ANOVA revealed a main effect of experiment,  $F(2,149) = 4.50$ ,  $p < .05$ , with participants in Experiment 2 reacting slower than those in Experiments 1 and 3. There was no interaction between experiment and trial type,  $F(4, 298) < 1$ . Of importance was the significant main effect of trial type,  $F(2, 298) = 10.52$ ,  $p < .05$ ,  $PV = .07$ . Simple contrasts revealed that probe responses on guilty knowledge trials were longer in comparison to responses on both the mere knowledge,  $F(1, 149) = 6.42$ ,  $p < .05$ ,  $PV = .04$ , and the neutral

trials,  $F(1, 149) = 19.58$ ,  $p < .05$ ,  $PV = .12$ . This analysis confirms that a small but reliable difference exists between the guilty and mere knowledge trials. One possibility for the difficulty to find a difference between the guilty knowledge and the mere knowledge trials may be the difficulty in creating familiar *non-significant* items. Most likely, the mere knowledge items acquired some signal value, although less so than the guilty knowledge items. Because this was the first study to use mere knowledge items as a within-subjects control condition, further research is needed to elucidate the role of the mere knowledge items.

No evidence was found for the idea that participants shifted attention either towards or away from guilty knowledge. Arguing that participants may try to avoid detection by spatially shifting their attention away from the guilty knowledge pictures, slower responses on congruent vs. incongruent trials were expected. However, none of the experiments supported this hypothesis. There was only a general interruption of attentional performance on guilty knowledge trials, with no indication of spatial shifting of attention. Still, it is possible that attentional avoidance may occur with longer exposure durations (e.g., Bradley et al., 1998).

In the polygraph literature there are two important theoretical approaches: On the one hand an emotional-motivational view, assigning a central role to fear and/or guilt (Podlesny & Raskin, 1977), and on the other hand a cognitive approach (e.g., Gati & Ben-Shakhar, 1990), stressing the role of memory and/or attention. In the present study, we proposed an experimental approach to examine the fundamental processes displayed in the detection of information. Tentatively, we argue that an information processing view on orienting can help to understand a wide variety of seemingly unrelated data obtained with the guilty knowledge paradigm. This cognitive view on orienting may in an integrative way explain why the possession of guilty knowledge can be reliably detected by both peripheral (e.g., skin conductance responses, Lykken, 1959) and central physiological measures (e.g., P300, Farwell & Donchin, 1991), as well as behavioral measurements (e.g., reaction times, Seymour et al., 2000). Bringing in a cognitive view on orienting in the guilty knowledge paradigm might provide a



theoretical framework that allows a more complete understanding of the physiological detection of guilty knowledge.

There is a number of limitations to the current research. First, this study was conducted in undergraduates in the context of a theoretical framework on orienting to guilty knowledge. Therefore, we do not know whether these findings generalize to other populations and applied settings. Second, we did not obtain physiological recordings, which would have allowed us to examine the relationship between the behavioral and the physiological indicators of the orienting response. Third, several alternative explanations can be put forward. One might argue that the interference on guilty knowledge trials is due to a defensive reflex. The purpose of this reflex is to protect the organism from aversive stimuli (Graham, 1979). Although we found no evidence that the guilty knowledge pictures were seen as aversive, future studies may include autonomic measures, such as heart rate, to allow a direct comparison between orienting and defensive responses. Therefore, combining cognitive measures with psychophysiological recordings provides a promising tool to investigate the relationship between orienting and attention in the guilty knowledge paradigm.

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# CHAPTER 2

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## **BEHAVIORAL RESPONDING TO CONCEALED INFORMATION: EXAMINING THE ROLE OF RELEVANCE ORIENTING<sup>1</sup>**

The concealed information test uses physiological responses to assess whether someone possesses information. The theory of this test holds that enhanced responding to concealed information is based upon memory, orienting and attention. Specifically, it has been argued that concealed information elicits enhanced orienting due to its relevance. In the present study, we used a reaction-time task in order to test this hypothesis. Fifty undergraduates were presented with concealed information, familiar but non-relevant information and unfamiliar information in a probe classification task. No differences in reaction-times were found. However, participants made more errors in this task after presentation of concealed information, compared with both familiar non-relevant and unfamiliar information. Results provide support for the idea that relevance orienting underlies the concealed information test.

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<sup>1</sup> Verschuere, B., Crombez, G., Koster, E. H. W., & Van Baelen, P. (submitted). Behavioral responding to concealed information: Examining the role of relevance orienting.

## INTRODUCTION

In January 1984, the dead body of Julie H. was found near a railway. Julie H. had been abducted, raped and murdered. Though the police suspected James B. G. of the murder, they did not have the evidence to convict him. The break-through in this investigation came only 15 years later, when James B. G. took part in an evoked potential based concealed information test. During this test, James B. G. was presented with a series of items, which he had to classify as fast as possible as belonging to a previously memorized list of words (relevant) or not (irrelevant). Among the irrelevant items, some crime details were embedded (e.g., an object that the murderer took from the victim, the location where the body was dropped,...). An analysis of the suspect's brain wave responses showed that the suspect differentiated the crime details from the truly irrelevant items. When confronted with these results, the suspect confessed and was later found guilty on the murder of Julie H (see [www.brainfingerprinting.com](http://www.brainfingerprinting.com)).

Seemingly successful applications of the “lie detector” are often heard arguments in discussing whether legal authorities should admit lie detection tests as legal evidence. This, however, is not a solid argument to most academics, who would prefer to see empirical data on the psychometric properties of the test under discussion. Obviously, an essential condition is its accuracy. Concerning the concealed information test, there is now ample evidence from the laboratory that one can become an accurate decision in at least 85% of the cases (see Ben-Shakhar & Furedy, 1990; MacLaren, 2001). Another important condition is whether the test has a good theoretical foundation, allowing it to make meaningful predictions on test outcome (National Research Council, 2003). The present study was set up to test the underlying theory of the concealed information test.

Basically, the concealed information test or guilty knowledge test (Lykken, 1974) consists of relevant and irrelevant items. In criminal investigations, the relevant items are details of the crime under investigation, and the irrelevant items are plausible, but incorrect alternatives. While the suspect attends to these items, physiological responses are measured. The test assumptions hold that for the

innocent all items are equally likely, and therefore, no differential pattern of responding will be observed. The guilty suspect on the other hand is assumed to recognize and consequently respond more strongly to the relevant items. Research has generally confirmed that the relevant items elicit a marked change in physiological responses in the guilty suspect only (for a review, see Ben-Shakhar & Elaad, 2003). Lykken (1974) has argued that these physiological reactions are the result of enhanced orienting to concealed information due to its relevance. That is, only for the guilty suspect, the crime details are more relevant than the control items, and will therefore elicit larger orienting responses. Whereas research on the concealed information test has mainly looked at physiological responses, behavioral measures (e.g., reaction-times) may provide an easily feasible and additional source of information. Reaction-times in the detection of concealed information have mainly been studied in so called oddball tasks, as described in the case study above (for a review see, Rosenfeld, 2002). This paradigm involves asking participants to classify stimuli in two categories: relevant/irrelevant. Because the relevant items are presented less frequently than the irrelevant items, larger reaction-times are found on these items. The crucial manipulation is that concealed information items are embedded within the irrelevant category and participants have to classify them as irrelevant. It has been consistently found that classifying concealed information is less accurate and slowed down compared to the irrelevant information (e.g., Seymour, Seifert, Shafro, & Mosmann, 2000). Although this paradigm might be useful in the detection of concealed information, it does not provide a stringent test of the orienting hypothesis. First, because concealed information items are presented less frequently than irrelevant items, the response slowing might be due to the relative novelty of the concealed information items. It is well known that novel stimuli can elicit orienting (Gati & Ben-Shakhar, 1990). Second, the larger reaction-times might also be due to the fact that participants have to classify the clearly relevant concealed information items as "irrelevant". Thus, a Stroop-like stimulus-response conflict is likely to contribute to enhanced responding to concealed information. Third, concealed information and irrelevant items not only differ in relevance, but also in familiarity. This confound makes it

impossible to differentiate between mere recognition and relevance orienting. Larger reaction-times on concealed information items in the oddball task can be attributed to relevance, stimulus-response conflict, relative novelty, familiarity or a combination of one or more of these factors. Thus, the data obtained with the oddball paradigm can not be regarded as hard evidence for the relevance-orienting hypothesis.

In order to examine the theory of the concealed information test, new reaction-time paradigms are needed. One alternative is the dot probe task, which has been previously adopted to examine orienting to concealed information (see Verschuere, Crombez, & Koster, 2004). In this task, two stimuli are simultaneously presented, and a target (e.g., “..” or “:”) replaces one of both stimuli after a short time period. Participants are asked to decide as fast as possible whether they saw two horizontally or two vertically presented dots. Some trials consist of two unfamiliar stimuli, while in other trials one unfamiliar stimulus is paired with a concealed information item. In three experiments, we found that participants were slower on concealed information trials, as compared to the trials containing only unfamiliar items. Furthermore, in order to differentiate between familiarity and relevance, we created trials in which one unfamiliar and one familiar non-relevant item was presented. As predicted, slower reaction-times were found on concealed information trials as compared to these familiar non-relevant trials. As such, this finding provides unique evidence for the idea that enhanced responding to concealed information is due to its relevance. However, the observed findings were small, and not always significant. The authors reasoned that this could have been due to the fact that they were not entirely successful in creating familiar, non-relevant items. Because of the high theoretical relevance, an attempt was made in this study to create familiar, non-relevant items. We predicted stronger orienting responses to concealed information items as compared to both the familiar non-relevant as well as to the unfamiliar items. A second objective of this study was to investigate the role of motivation. Several studies have investigated the influence of motivation on physiological responding to concealed information. In general, it was found that heightened motivation to deceive the test can contribute to the enhanced responding to concealed information (Ben-Shakhar & Elaad, 2003). Similarly, we reasoned that motivating participants could lead to stronger orienting responses to concealed information in the dot probe task.

## ***METHOD***

### ***Participants***

Fifty undergraduate psychology students (41 female, 9 male) of the Ghent University took part in the experiment as partial fulfillment of course requirements. Mean age was 18.22 years ( $SD = 0.76$ ; range 17-21). Written informed consent was obtained from all participants. The study was approved by the ethical committee of the Ghent University.

### ***Materials***

In order to create concealed information, familiar non-relevant, and unfamiliar trial types, we selected 30 close-up pictures from familiar persons (politicians, actors,...) and 35 pictures from unfamiliar persons. An attempt was made to select neutral pictures. In a pilot study, valence, arousal and familiarity of the selected pictures were assessed. Fifteen undergraduate students (12 female; mean age = 19.94 years,  $SD = 1.51$ ) were asked to rate the 65 pictures on familiarity on a 5-point scale (1 = not familiar at all, 5 = highly familiar). They were also asked to name the person. Furthermore, participants rated the pictures on valence and arousal using the Self-Assessment Maniken (SAM; Lang, 1980). The SAM provides an easily understandable figure ranging from unhappy (= 1) to happy (= 9) for valence, and from calm/unaroused (= 1) to excited/aroused (= 9). Pictures (mean height = 74 mm; mean width = 52 mm) that were rated as being neutral ( $3.5 \leq \text{valence} \leq 6.5$ ) and low arousing ( $\text{arousal} \leq 5$ ) were selected for experimental use. Six pictures that received a score of 4 or more on the familiarity scale and were correctly named by at least 85 % of the participants, were selected as familiar pictures. Twelve pictures that received a familiarity rating lower than 2 and were not named by any participant, were selected as unfamiliar pictures. That way, neutral pictures differing only in familiarity were selected. Through the experimental setup (see Procedure Section), half of the familiar pictures gained relevance, leading to the three stimulus categories: unfamiliar (12 pictures), familiar non-relevant (3 pictures), and familiar relevant stimuli ("concealed information"; 3 pictures).



### ***Apparatus***

Participants were seated approximately 60 cm from the 17-inch color screen. Stimuli were presented on a Compaq Deskpro computer using the Inquisit Millisecond software package (Inquisit 1.32, 2002), which measures reaction-times with high precision (Declercq, Crombez, Buysse, & Roeyers, 2003).

### **PROCEDURE**

Participants were welcomed by the experimenter and they were informed that they took part in a lie detection experiment. Participants were asked to choose an envelope, containing a list with the names of 3 familiar persons. They were further instructed to memorize the 3 names and explained that recognition of the memorized persons would be assessed in a lie detection test later in the experiment. Thus, these 3 items served as “concealed information”, and the 3 remaining familiar items served as “familiar non-relevant information”. The actual allocation of the familiar pictures to the relevant or non-relevant stimulus category was controlled by the experimenter in order to allow counterbalancing across individuals from both groups (low vs. high motivation). A manipulation check was performed, serving two purposes. First, by presenting participants with all pictures before the actual experiment begun, we aimed to diminish novelty-orienting to all pictures, and to enhance the relevance of the concealed information items. Second, recognition of the concealed information could be assessed. During the manipulation check, the 3 concealed information, the 3 familiar non-relevant and the 3 unfamiliar persons were each presented 3 times in a random order. Participants were asked to press one key when recognizing a person from the concealed information list, and to press another key for all other persons. After the manipulation check, electrodes for the registration of electrodermal responding were connected to the left hand, but there was no actual measurement of electrodermal activity. This was done to prevent participants from focusing on and strategically responding to the response-time measurement. During the subsequent concealed information test, participants were asked to try to conceal recognition of the concealed information items. Participants allocated to the low motivation condition, were informed that the experiment served to test new polygraph equipment. Participants in the high motivation condition, were

told that only intelligent people were able to beat the polygraph, and that they could win 50 euro when they had successfully mislead the polygraph test (see Gustafson & Orne, 1963).

The concealed information test was a modified probe classification task (see e.g., Bradley, Mogg, Falla, & Hamilton, 1998; Verschuere et al., 2004). Participants were presented with 12 practice and 144 experimental trials. Each trial started with a fixation cross for 1400 ms, followed by a picture pair, presented one above the other for 250 ms. The distance between the exterior edges of the pictures was 40 mm. One picture of the pair was either a concealed information, a familiar non-relevant, or an unfamiliar picture; the other picture of the pair was always an unfamiliar picture. A pair of dots was presented nearly immediately (one refresh rate, ca. 14ms) after picture offset on the location of one of both pictures. Participants were asked to classify as fast as possible whether the dots were horizontally (..) or vertically (:) positioned. The dots remained on the screen until a response was made. The next trial began 200 ms later.

## **RESULTS**

Data were analyzed using a 2 x 3 mixed analysis of variance (ANOVA) design with motivation (low vs. high) as the between-subjects and trial type (concealed vs. familiar non-relevant vs. unfamiliar information) as the within-subjects factor<sup>2</sup>. Both reaction-times and proportion of errors are analyzed in this way.

Percentage of variance (*PV*) is reported as an estimate of effect size. A *PV* of .01, .10 and .25 was used as thresholds to define small, medium and large effects,

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<sup>2</sup> Usually, a distinction between congruent and incongruent trial presentations is made in the dot probe task. Congruent trials are those in which the critical picture and the probe appear in the same location, whereas their location differs on incongruent trials. This analysis allows to examine spatial shifts of attention (see Mogg & Bradley, 1998). However, previous research with this paradigm has failed to find an effect of concealed information on spatial attention (Verschuere et al, 2004). We ran additional analyses with trial congruency as a factor, but again, no evidence for attentional shift were found.

respectively (Cohen, 1988). We report Greenhouse-Geisser corrections (with adjusted degrees of freedom) whenever the sphericity assumption was violated (Mauchly's Test of Sphericity;  $p < .05$ ).

### ***Manipulation Check***

Participants categorized 99% ( $SD = 4$ ; range 78-100%) of the pictures correctly. This indicates that participants could easily distinguish concealed information from the other items.

### ***Reaction time data***

Trials with errors were discarded (4.14% of the data) and RT data that deviated more than 3 standard deviations from the individual mean RT were excluded as outliers (1.7%). The statistical analysis was conducted with 94.2% of the original data. The overall mean RT was 669 ms ( $SD = 135$ ). The ANOVA showed that no effects of either trial type, motivation, or the motivation by trial type interaction reached significance (all  $F$ 's  $< 1$ ). Mean RT's for the concealed information, familiar non-relevant, and unfamiliar information were 683 ( $SD = 131$ ), 681 ( $SD = 140$ ), and 679 ( $SD = 132$ ) respectively, in the high motivation group. Mean RT's in the low motivation group were 659 ( $SD = 134$ ), 656 ( $SD = 141$ ), and 653 ( $SD = 142$ ) for the concealed information, familiar non-relevant, and unfamiliar information, respectively.

### ***Error analysis***

The 2 x 3 ANOVA revealed a significant main effect of trial type,  $F(2, 96) = 6.75$ ,  $\epsilon = .88$ , corrected  $df(1.75, 84.08)$ ,  $p < .01$ ,  $PV = .12$ . Percentages of incorrect responses during the concealed information, familiar non-relevant information and neutral trials were 5.4% ( $SD = 4.37$ ), 3.5% ( $SD = 3.14$ ), and 3.6% ( $SD = 3.84$ ) respectively. Simple contrasts, confirmed that participants made more errors after concealed information, as compared to both familiar non-relevant information,  $F(1, 48) = 11.66$ ,  $p < .001$ ,  $PV = .20$ , and unfamiliar information,  $F(1, 48) = 6.95$ ,  $p < .01$ ,  $PV = .13$ . No effects with motivation as a factor reached significance, all  $F$ 's  $< 1.4$ . Mean error proportion for the concealed information, familiar non-relevant, and unfamiliar information were

5.4% ( $SD = 4.0$ ), 4.3% ( $SD = 2.9$ ), and 4.2% ( $SD = 3.9$ ) respectively, in the high motivation group. Mean error proportion in the low motivation group were 5.5% ( $SD = 4.8$ ), 2.6% ( $SD = 3.2$ ), and 3.1% ( $SD = 3.8$ ) for the concealed information, familiar non-relevant, and unfamiliar information, respectively.

### ***DISCUSSION***

The present study was designed to provide a test of the underlying theory of the concealed information test. Specifically, we examined whether relevance-orienting can account for enhanced responding to concealed information. Two main findings result from the present research. First, concealed information interrupted task performance, as compared to unfamiliar as well as to familiar, non-relevant information. These effects were evident in the error proportion, but not in reaction-times. Second, the level of motivation did not alter behavioral responding to concealed information.

Error analysis demonstrated that concealed information interrupted task performance, as compared not only with unfamiliar, but also with familiar non-relevant information. This confirms that concealed information elicited enhanced orienting, due to its relevance. The behavioral data therefore provide unique support for the orienting theory of the concealed information test. During a concealed information test, concealed information is primed in the short-term memory as relevant (Gati & Ben-Shakar, 1990). New incoming stimuli are automatically compared with the relevant items. If this comparison results in a match, an orienting reflex is elicited. This reflex entails interruption of ongoing behavior and allocation of attention to the relevant information resulting in impaired performance on a secondary task. In contrast to previous research with this paradigm, this effect was only present in the accuracy, but not in the speed of responding. This could be due to a speed-accuracy trade-off (see e.g., Dennis & Evans, 1996), with participants sacrificing accuracy for fast responding. Both response slowing and diminished accuracy can, however, be meaningfully interpreted within the same theoretical framework.

The observed effect of concealed information on the error proportion had a moderate effect size. Previous research, using the oddball task, has usually found large effects of concealed information. Methodological modifications to examine the orienting account may have diminished effect sizes. In response to the shortcomings of the oddball task, the dot probe paradigm in this study, (1) used an equal proportion of concealed information and control stimuli, (2) required a speeded response to a physically separated target, rather than to the stimulus itself, and (3) included a category of familiar, non-relevant stimuli. Though these adjustments were considered necessary to answer the theoretical research question in the present study, they are most likely responsible for the relative smaller effects observed in this study. In support of this argumentation is the finding that other reaction-time paradigms have also led to smaller and less robust effects. Using a modified stroop task, Gronau, Ben-Shakhar, and Cohen (in press), found significant lengthening of reaction-times in only one of two experiments. Locker and Pratarelli (1997) did not observe any differential responding between concealed and control information in a lexical decision task. In yet another reaction-time variant (Verschuere, Crombez, Declercq, & Koster, 2004), participants were asked to respond as fast as possible to a secondary tone probe while watching concealed and control information. Although probe detection was slower during concealed information than on control information, the observed differences did not reach significance. At present, only the oddball task has produced strong and replicable reaction-time slowing. As argued above, we argue that this is due to additional factors (e.g., stimulus-response conflict, relative novelty,...) that contribute to responding to concealed information in this paradigm.

The level of motivation did not moderate the behavioral responding to concealed information in the present study. In real-life polygraph examinations, participants are typically strongly motivated to obtain a truthful test outcome. Although it is impossible to mirror this level of motivation in the laboratory, several studies have examined the role of motivation. Several studies have found that heightened motivation to deceive the test resulted in increased effectiveness of the concealed information test. On the other hand, many researchers failed to replicate this effect (for a review see Ben-Shakar & Elaad, 2003). It seems that motivation can

contribute to responding to concealed information, but at present it remains unclear how and when.

To summarize, our data provide further support for the orienting theory of the concealed information test. This study joins an increasing group of studies that used reaction-times to examine responding to concealed information. As only some of these studies have found robust effects of concealed information on the speed and/or accuracy of responding, research on the necessary and sufficient conditions for the reaction-time variant of the concealed information test is needed.

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# CHAPTER 3

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## **AUTONOMIC RESPONDING TO CONCEALED INFORMATION: DIFFERENTIATING ORIENTING AND DEFENSIVE RESPONSES<sup>1</sup>**

A mock crime experiment was conducted to examine whether enhanced responding to concealed information during a polygraph examination is due to orienting or defensive responding. Thirty-six undergraduate students enacted one of two mock crimes. Pictures related to both crimes were presented while heart rate, magnitude of the skin conductance response, and reaction times to a secondary probe were measured. Compared to control pictures, participants showed greater heart rate deceleration and enhanced electrodermal responding to pictures of the crime they had committed. Probe reaction times did not differ significantly between crime and control pictures. The present findings support the idea that the orienting reflex accounts for the enhanced responding to concealed information. Theoretical and practical implications of the orienting account are discussed.

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<sup>1</sup> Reprinted from *Psychophysiology*, 41, Verschuere, B., Crombez, G., De Clercq, A., & Koster, E. H. W., Autonomic responding to concealed information: Differentiating orienting and defensive responses, 461-466, copyright 2004.



## INTRODUCTION

In this study we examined whether orienting can account for enhanced physiological responding to concealed information during a polygraph examination. During the concealed information test (CIT; first described by Lykken [1959] and named by him the “guilty knowledge test”<sup>86</sup>), participants are presented with a series of multiple choice questions, each having one correct (crime-relevant) and several incorrect items. For example, if the crime under investigation involved a bank robbery, a concealed information question could be: “If you have committed the robbery, than you know in what kind of car the robbers got away. Was the car (a) a yellow Toyota, (b) a grey Honda, (c) a red Opel, (d) a green Renault or (e) a blue Peugeot?”. If the interrogee systematically responds more strongly to the correct item than to the control items, he/she is supposed to have secret information about the crime. Using five or more concealed information questions, each embedded within an appropriate set of control items, it is unlikely that an innocent suspect will systematically react stronger to the correct answers. Reviews of the concealed information test have pointed out that this test is very accurate under controlled laboratory conditions (Ben-Shakhar & Elaad, 2003; MacLaren, 2001).

Despite the accuracy of the concealed information test, two questions remain largely unanswered. First, the effectiveness of this test in field situations is unknown. Out of more than 100 articles on the concealed information test, only two have examined the applicability of the concealed information test in real-crime situations (Elaad, 1990; Elaad, Ginton, Jungman, 1992). Both studies confirmed the high specificity of the concealed information test, in that the innocent suspect has a small chance of being mistakenly classified as “guilty”. However, results on the sensitivity were less positive: only between 65% and 76% of the guilty suspects were classified correctly. One reason for the low sensitivity may be owing to the small number of questions used. Both studies used an average of 1.8 to 2 concealed information questions, whereas five or more questions are recommended. In a recent meta-analysis, Ben-Shakhar and

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<sup>86</sup> We prefer the term Concealed Information Test, because this paradigm has interesting applications outside the forensic practice. For example, the CIT has been used as an implicit test of recognition in patients suffering from amnesia (Verfaellie, Bauer, & Bowers, 1991).

Elaad (2003) demonstrated that the number of questions is the most important factor moderating the accuracy of the concealed information test. Second, the underlying theory of the concealed information test has not been systematically investigated. Research aimed at understanding the processes underlying physiological detection of deception is scarce (NRC, 2002). Yet, the concealed information test may only be regarded as scientific evidence in the court if its theoretical foundations prove to stand the test of falsification (Ben-Shakhar, Bar-Hillel, & Kremnitzer, 2002). It has been argued that enhanced orienting accounts for the differential responsivity to concealed information (Lykken, 1974). The present study reviews the available evidence for and provides a direct test of the orienting-hypothesis.

The orienting reflex (OR) plays a crucial role in information processing. According to Sokolov (1963), during the repeated processing of sensory information a mental model of the surrounding world is gradually built. All incoming sensory information is then compared to that model. If a mismatch between the neuronal model and the incoming stimulus is detected, a novelty-OR is elicited. If the stimulus matches the existing model, the OR is inhibited, and habituation takes place. An exception to this process occurs whenever stimuli are tagged as significant. Then, a match between the stimulus and the mental representation will elicit a significance-OR. Notwithstanding some exceptions, extensive research has generally produced data in support of Sokolov's comparator model (Öhman, Hamm, & Hugdahl, 2000). Following this model, it is reasonable to assume that presentation of crime information will elicit a significance-OR in guilty individuals. Only for them, the correct answer has a special meaning and will lead to enhanced physiological responding. For persons without knowledge about the crime under investigation, all items should be homogeneous, thereby minimizing the chance of distinct responding to the crime details. Indeed, elaborate research has demonstrated that innocent persons have only a small chance of reacting consistently stronger to the correct items in the concealed information test (MacLaren, 2001).

Reviewing the literature, we found five arguments suggesting that enhanced orienting may be the active mechanism of the concealed information test. First, both physiological and behavioral indicators of the OR have been shown to be useful in detecting concealed information. Using the skin conductance response, Lykken (1959) was able to differentiate most guilty from innocent subjects (90% correct classifications). This finding has been replicated numerous times across different laboratories (see Ben-Shakhar & Elaad, 2003). Other physiological and behavioral measures are also able to distinguish knowledgeable from uninformed participants: Amongst these are pupil dilation (Lubow & Fein, 1996), event-related potentials (Rosenfeld, Cantwell, Nasman, Wojdacz, Ivanov, & Mazzeri, 1988), and reaction times (Verschuere, Crombez, & Koster, 2004). These measures can be usefully integrated within an orienting framework. Second, a core feature of the OR is that the magnitude of the response diminishes with repeated presentation. Likewise, habituation of the skin conductance response has been frequently reported in research on the concealed information test. For example, Ben-Shakhar, Frost, Gati, and Kresh (1996) reported a marked decrease in responsivity from the first to the second presentation of concealed information. Third, OR-generalization was demonstrated in the concealed information test. For example, in the study by Ben-Shakhar et al. (1996), undergraduates were asked to memorize the details of a crime and to hide possession of this knowledge in a subsequent concealed information polygraph test. In four experiments, they examined to what extent OR-generalization takes place to stimuli that were semantically related to the crime details. Partial generalization was found between the crime stimulus and its synonym or its semantic superordinate. Complete generalization occurred when the crime stimulus was presented in a different sensory modality (i.e., word-picture). Fourth, although emotional (e.g., anxiety) and motivational variables (e.g., the motivation to deceive) may increase physiological responding to concealed information, several studies have shown that recognition of concealed information is sufficient to create differential responding. This indicates that the concealed information test is based on cognitive rather than emotional/motivational factors (Ben-Shakhar & Furdey, 1990). And fifth, Verschuere et al. (2004) recently demonstrated that the concealed information effect is related to the significance of the concealed information stimuli. In order to disentangle the effects of familiarity and significance in the concealed information test, we created a condition existing of familiar, non-significant stimuli ("mere knowledge items"). In three experiments, we found greater reaction time-slowness to concealed information compared to mere knowledge items.

Again, this finding is supportive for the idea that orienting to significant stimuli is the underlying mechanism of the concealed information test.

Despite the arguments in support of the OR-hypothesis, alternative theories and differential prediction have not been investigated. Until now, all theoretical proposals for the concealed information test have been formulated in terms of orienting. However, enhanced responding to concealed information, might also be explained in terms of the defensive reflex (DR). The purpose of this reflex is to protect the organism from aversive stimuli (Sokolov, 1963). In the context of lie detection, it is plausible that a guilty suspect will seclude oneself from (stimulus rejection), rather than orient towards (stimulus intake) crime details. Therefore, the behavioral and physiological responses to concealed information stimuli, may be considered correlates of the DR instead of the OR. The OR-DR dichotomy needs however some qualification. First, though the DR seemingly contrasts sharply with the OR, it has nevertheless been proven difficult to distinguish both responses (Graham, 1979; Turpin, 1986). Both systems share several response components (e.g., skin conductance response), while other components have been much debated (e.g., peripheral and central vascular responses). Heart rate has however been proposed as an easily measured and reliable criterion to distinguish both response systems (Graham & Clifton, 1966). Orienting was identified with heart rate deceleration, whereas defensive responding was argued to be associated with acceleration. Although challenged by some (e.g., Barry & Maltzman, 1985), extensive research supports this hypothesis (see e.g., Cook & Turpin, 1997). Second, Lang, Bradley and Cuthbert (1997) have argued that defense involves stages of responding, obtaining physiological responses consistent with orienting with moderate activation of the defense system. We elaborate on their defense cascade model in the Discussion Section.

### **Objectives and Predictions of the Present Study**

The aim of the present study is to investigate whether the concealed information test is based upon orienting or defense. In order to differentiate between both reflexes, heart rate was measured. Furthermore, electrodermal responses and probe reaction times were also measured. Using a mock crime procedure, all participants committed one of two mock crimes and were unaware of the other crime. The mock crime consisted either of stealing 10 euro or committing exam fraud. The subsequent concealed information test was a modification of the secondary reaction time paradigm. This procedure has proven to be a useful tool for the combined examination of physiological responding and the allocation of attention (for a review, see Siddle, 1991). In the present study, participants were shown pictures of both crimes while heart rate and electrodermal responding were measured. Secondary auditory probes were presented from time to time, and response latencies in tone detection were registered. We predicted that crime pictures would lead to enhanced electrodermal responding and slowing of probe detection. Of most importance to this study, was the heart rate. According to the OR-hypothesis, heart rate was expected to decelerate in response to crime pictures in participants with crime knowledge. In contrast, the DR-hypothesis would predict heart rate acceleration.

## **METHOD**

### **Participants**

Thirty-six first year psychology students (29 women, 7 men) at Ghent University took part in the experiment in partial fulfillment of course requirements.

## Stimuli

The experimental stimuli were 12 digital color pictures (height = 95 mm; width = 127 mm), consisting of 6 crime-details of each crime. Details on which pictures served as crime details are underlined in the Procedure section.

## Apparatus

The experiment was conducted in a sound-attenuated, darkened laboratory, that was connected via intercom and one-way vision screen to an adjacent control room. A Lablinc V Coulbourn recorded skin conductance and heart rate. Skin conductance was measured using a constant voltage (0.5V) coupler, and Ag/AgCl electrodes (0.8 cm diameter) filled with KY-jelly that were attached on the thenar and hypothenar eminences of the left hand. Heart rate was obtained by attaching a photoelectric transducer to the left index finger. The skin conductance and heart beat signals were recorded on a second PC, equipped with a Scientific Solutions Labmaster DMA card, running VPM software (Cook, 1997).

All stimuli were presented using Inquisit 1.33 (2002). The auditory stimulus was a 1000Hz tone, presented during 500 ms at 71 dB by means of a headphone. Participants were seated approximately 50 cm from the screen.

## Procedure

Participants were informed by a first experimenter that they took part in a lie detection experiment and were provided with information about use and validity of the polygraph ("lie detector"). Next, they were asked to choose one of two envelopes, which allocated them to either the theft group or the exam fraud group.

Participants enacting the *theft* ( $n = 18$ ) were instructed to enter a nearby room using a key with a toy-keyring. Access to the room is known to be only permitted to professors. In this room they had to look for a grey coat and to steal 10 euro out of a red wallet inside that coat. Participants were asked to leave the grey

gloves that they had used, before returning to the laboratory. Participants simulating the *exam fraud* ( $n = 18$ ) were asked to gain access to a storage room on another floor using a key with a red keyring. In this room they had to open a suitcase, which contained a file. They were asked to open this green file, copy the answers of the red exam form. Before returning to the laboratory, participants were asked to leave a drink which they had taken with them. Participants in both groups were instructed to try to appear innocent in the following polygraph examination.

A second experimenter, who was unaware of participants condition, explained that the polygraph would be used to detect recognition of crime details. In line with previous research (Gustafson & Orne, 1963), motivational instructions on self-esteem were given: it was told that despite its high accuracy, intelligent people are able to beat the polygraph. Prior to the attachment of the electrodes, participants were requested to wash their hands. Once physiological recordings were attached, there were two phases before the concealed information test began. First, four visual stimuli (a seal, participant's own name, a bloody, and an erotic picture) and one auditory stimulus (white noise, 71dB) were presented to optimize measurement of heart rate and skin conductance. Thereafter, all pictures ( $n = 12$ ) that were to-be-presented in the concealed information test were displayed for 2500 ms in random order. Participants were asked to simply look at all the pictures. This was done in order to diminish novelty OR's to the control stimuli during test phase. Furthermore, this phase aimed to ensure that participants could discriminate crime from control pictures, enhancing the significance-OR to the crime pictures.

### **Concealed Information Test**

Participants were told that their primary task was to beat the polygraph by trying to conceal recognition of crime pictures. They were further informed in a cover story that we examined the effect of mental load on the validity of the polygraph. Therefore, they had to press the space bar on a standard keyboard as fast as possible whenever they heard a tone. The concealed information test started with a buffer item (picture of a pen). Thereafter, 24 pictures (12 of each crime) were presented in the middle of the screen during 2500 ms, with inter-stimulus

intervals (ISIs), from 15 to 25 seconds. The auditory probe was presented on half of the pictures, either 250, 500 or 750 ms after picture onset; the remaining half of the pictures were presented without probe (“unprobed”). Pictures were presented in one of four fixed semi-random orders, restricted by following rules: (1) the first picture in each block was unprobed, (2) there could be no more than three consecutive probed (vs. unprobed) pictures, and (3) no more than three consecutive crime (vs. control) pictures. In addition to the probes presented during the pictures, there were twelve probes presented randomly during the ISI, but not within 5 seconds before or after a picture. Probe detection was practiced in 30 trials just before the concealed information test. A total of 24 reaction-time tones were presented during the concealed information test. Physiological recordings were obtained only during the probe-free trials. Finally, two digit trials (i.e., a random number between 1 and 10) were presented for 1 second during the ISI. Presentation was random, with the restriction that the digits were not displayed within 5 seconds prior or after the pictures. To assure participants attention was focused on the screen, they were asked to name these digits out loud.

#### *Memory Check*

Immediately after the concealed information test, memory for crime pictures was assessed in a short classification task. Participants were asked to classify pictures truthfully as guilty or innocent by pressing the letter ‘s’ for guilty (“schuldig” in Dutch) and the letter ‘o’ for innocent (“onschuldig” in Dutch) pictures respectively. The pictures for this rating task were presented at random one by one in the middle of the screen.

#### *Scoring, Response Definition, and Analysis.*

The results of three dependent variables are reported: second-by-second change in heart rate, magnitude of electrodermal responding, and probe response latency. The psychophysiological data were analyzed using Psychophysiological Analysis



(PSPHA), a software program that we developed for the off line analysis of psychophysiological data

PSPHA was used to detect the R-peaks and to calculate the distance between them. An artifact detection procedure was applied with PSPHA to detect erroneous detection and/or missing beats. The former was defined as IBI's less than 400 ms (150 bpm) or intervals that were shorter than 70% of the mean of the surrounding IBI. The latter was defined as IBI's greater than 1500 ms (40 bpm) or intervals that were greater than 130% of the mean of the surrounding IBI's. The correction procedure consisted of splitting the prolonged IBI's and merging the shortened IBI to the previous IBI. Trials containing more than 2 corrected IBI's were excluded as artifacts. Ten IBI's (0.17%) needed correction and one trial was omitted from further analyses. Prior to analysis, the interbeat intervals (IBI) were converted to heart rate in beats per minute (bpm) per real-time epoch (1sec). Mean bpm in the 5 seconds preceding picture onset were compared to the mean bpm in the 5 second period after picture onset. The mean of the 5-sec prestimulus period was subtracted from each poststimulus period, allowing a second-by-second analysis.

The maximal skin conductance change (with a minimum of  $0.05\mu\text{S}$ ), starting between 1 and 5 seconds after picture onset, was analyzed. In order to normalize the data, they were square root transformed prior to statistical analysis.

Reaction times (RT's) were expressed as change scores (cfr., Dawson et al., 1982). We subtracted the mean reaction time to probes during the inter trial interval from the mean reaction time on probes during pictures. A positive change score indicates a slower probe response on the pictures, compared to the mean reaction time during the inter trial intervals. A negative change score, indicates faster probe responding during the pictures.

A .05 significance level was employed in all statistical tests, and Greenhouse-Geisser corrections (with adjusted degrees of freedom) are reported where appropriate. As an estimate of effect size, the percentage of variance (*PV*) is reported. Following Cohen (1988), *PV*'s of .01, .10 and .25 were used as thresholds to define the effects as small, medium, or large, respectively.

## RESULTS

### *Memory Check*

Results of the memory check confirmed that the crime pictures were correctly recognized and remembered. Participants classified 99% of the pictures correctly.

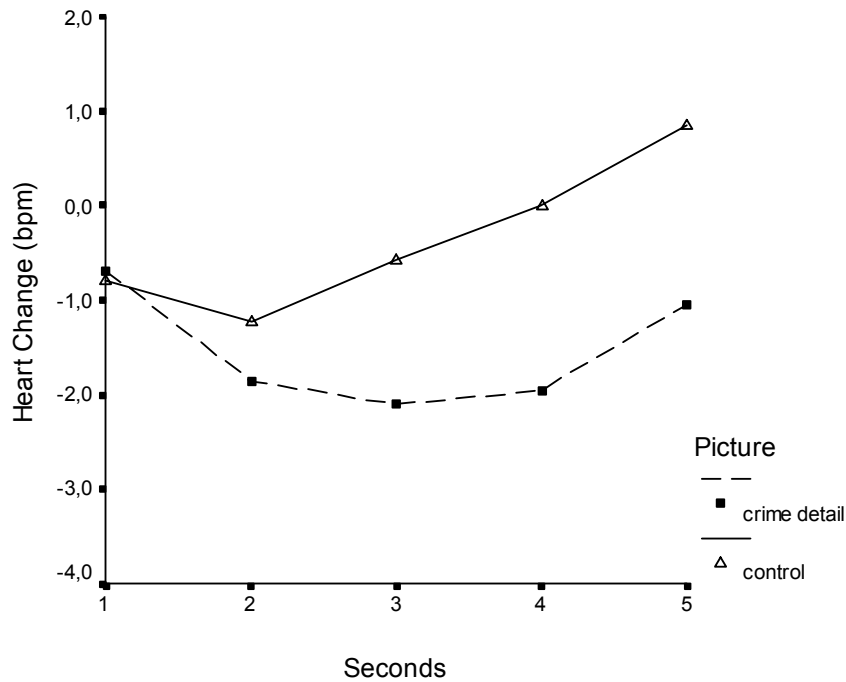
### **Heart Rate**

Prestimulus heart rate averaged 86 bpm. A 2 (picture: crime/control) x 5 (second: sec1-5) multivariate analysis of variance (MANOVA) was used to analyze the heart rate data. There was a significant main effect of both second,  $F(4, 32) = 12.15$ ,  $p < .05$ ,  $PV = 0.60$ , and picture,  $F(1, 35) = 4.16$ ,  $p < .05$ ,  $PV = .10$ , confirming that a larger heart rate deceleration to pictures containing crime details ( $M = -1.52$  bpm;  $SD = 0.44$ ) as compared to control pictures ( $M = -0.34$  bpm;  $SD = 0.43$ ) was found (see Figure 1). There was no significant effect of Picture x Second,  $F(4, 32) = 1.75$ , ns.

### *Skin Conductance*

A paired  $t$ -test was performed to compare the magnitude of the skin conductance response on crime and control pictures. This analysis revealed that crime pictures ( $M = 1.19$ ,  $SD = 0.19$ ) elicited larger responses than control pictures did ( $M = 1.14$ ,  $SD = 0.15$ ),  $t(31) = 2.15$ ,  $p < .05$ ,  $PV = .15$ .

*Figure 1. Effect of picture type (crime detail/control) on second-by-second change in heart rate (in bpm).*



### Reaction Time Data

RT-data faster than 150 ms or slower than 2000 ms were excluded from analysis (<1% of the total data set). Mean RT on the probes during the ISI was 559 ( $SD = 121$ ). RT change scores (RTC) were analyzed using picture (crime/control) and probe position (250/500/750) as within-subject variables in the ANOVA. This analysis revealed a significant main effect of probe position,  $F(2,68) = 5.81$ ,  $p < .01$ ,  $PV = .15$ , with greater RTC slowing in late compared to early probe positions. Furthermore, though RTC's at the middle and the late interval were greater to crime compared to control pictures, neither the main effect of picture nor the Picture x Probe Position effect reached significance. Mean RTC's for the crime pictures were 43 ( $SD = 147$ ), 29 ( $SD = 139$ ), and -9 ( $SD = 115$ ), respectively at the early, middle and late probe position. For the control pictures, mean RTC's the early, middle and late probe position were respectively 46 ( $SD = 103$ ), 9 ( $SD = 129$ ), and -26 ( $SD = 124$ ).

## DISCUSSION

The present study investigated whether the detection of concealed information is based upon orienting or defensive responding. Using a concealed information test, participants who enacted a mock crime were presented with crime and control pictures while heart rate, skin conductance, and probe reaction-times were measured. While both the OR and the DR are associated with larger electrodermal responding and slowing of probe responding, these reflexes may be reliably differentiated by heart rate (Graham, 1979). Specifically, heart rate deceleration is taken as an index of orienting, while defensive responding is associated with heart rate acceleration.

Results of this study showed that crime pictures elicited greater heart rate deceleration than control pictures, supporting the orienting account. Direction, latency, and magnitude of this cardiac change reflect typical orienting reaction (Graham, 1979; Öhman et al., 2000; Turpin, 1986). It should be noted that the present study is not the first to examine cardiovascular activity to concealed information. A few studies have measured heart rate in order to investigate whether it provides a valid index of concealed information (e.g., Bradley & Ainsworth, 1984; Bradley & Janisse, 1981; Podlesny & Raskin, 1978). These studies showed that, although better than chance level, heart rate was less effective than the skin conductance response in distinguishing guilty from innocent subjects. Given the theoretical scope of our research, the present study differs in two important aspects from these studies. First, while previous studies have only reported a global index of differential cardiac activity, we provided a second-by-second change in heart rate. Second, previous studies have presented crime and control items in a 1 by 4 proportion, leading to a confound of novelty and significance (Dawson, Schell, & Fillion, 2000). That is, since the crime items are presented less often, relative novelty may contribute to the differential reactivity. Clearly this does not pose a problem in applied settings where one wishes to maximize the chance of differential responding. But, an equal number of crime and control pictures seems preferable when examining the underlying processes of enhanced responding to concealed information. Using this methodological setup, this study provided the opportunity to differentiate between orienting and defensive responding. As predicted, all pictures were

accompanied with a decline in heart rate, and this deceleratory response was greater in crime compared to control pictures.

Skin conductance and reaction-times were also obtained in this study. First, larger electrodermal responding to pictures containing crime details compared to control pictures was observed, thereby replicating previous studies. While very large effects are typical in mock crime studies (an average Cohens'  $d$  of 2.09; Ben-Shakhar & Elaad, 2003), the present effect had a medium effect size. This finding corroborates the idea that relative novelty contributes to enhanced responding in the concealed information test. Second, we predicted that probe reaction-times would be slower on crime pictures as compared to control pictures. While results were in the predicted direction at the middle and the late probe position, these differences failed to reach significance. Although this finding is at odds with previous studies using reaction times (Farwell & Donchin, 1991; Seymour et al., 2000; Verschuere et al., 2004), differences in methodology may account for the lack of significant findings. While several methodological differences can be listed, two seem most relevant. First, because we also measured autonomic measures, only a very small number of reaction time trials was used. Increasing the number of trials might decrease both the variance in reaction times and the likelihood of reacting stronger to control stimuli. Second, while previous research has presented probes in the same sensory modality as the concealed information and control stimuli, we used auditory probes presented during visual stimuli. The use of different modalities might have reduced the interference effect in this study. Future research may examine the possibilities and boundaries of reaction times in the detection of concealed information.

Taken together, the present findings are in line with a cognitive explanation of enhanced responding to concealed information. The correct answers in the concealed information test are significant only to the knowledgeable subject. When such stimulus is detected, ongoing behavior is interrupted and attention is allocated to the significant stimulus. Different measures can and have been used to tap from this process of detection, interruption and reallocation of attention. Thus, the cognitive view on orienting can integratively explain the increase in p300-amplitude, electrodermal responding, heart rate deceleration, reaction-times and pupil size in response to concealed information.

Despite the clear theoretical focus of this study, there are some potential practical implications. First, the present data further supports the idea that the concealed information test is a theoretically sound polygraph technique (Ben-Shakhar et al., 2002). Second, an important critique on this test is the difficulty of creating a sufficient number of concealed information items. Lykken (1998) has argued that the use of pictures enlarges the flexibility of the concealed information test. The present study illustrates that modern technology makes it very easy to set up a pictorial version of the concealed information test. However, the validity of this pictorial variant remains to be tested. Third, the framing of the concealed information test in cognitive rather than emotional processes, further enhances the applicability of the test. While lying and motivation to deceive the test can enhance the efficacy of the concealed information test, they are not necessary conditions. This implies that there is no reason why this test would not be applicable in psychopaths. Psychopathic individuals are characterized by a marked emotional deficit, lacking empathy, anxiety and feelings of guilt. While this is exactly what traditional lie detection is based upon, the present data support the idea that the concealed information test is not conditional upon emotional distress. Furthermore, a recent review of the literature on autonomic responsivity in psychopaths (Arnett, 1997), showed that there is yet no evidence for reduced orienting in psychopathy. In contrast, it was hypothesized that psychopathy may be characterized by greater sensitivity to orienting stimuli. Thus, the present analysis leads us to conclude that a polygraph investigation using the concealed information test should work equally well, and perhaps even better, in psychopaths.

In the present study, we used a mock crime procedure under motivational instructions. While this laboratory procedure resembles field situation most closely (Ben-Shakhar & Elaad, 2003), it remains different. With increasing threat, the physiological activation to crime stimuli might shift from orienting to defensive action. Lang et al. (1997) theorized that the difference between orienting and defense is not dichotomous, but rather that it is dynamically related to the aversiveness of stimulation. At a low-aversive stimulation level, more attention is given to novel/significant stimuli compared to known/neutral stimuli.

This is the typical OR, producing distinct autonomic changes, among which heart rate deceleration and an increase in skin conductance responding. With increasing levels of threat, orienting transits to defensive activation to prepare to organism for basic fight/flight responses. Similarly, the nature of physiological responding during a polygraph examination may depend on the arousal value of the relevant items. Raskin (1979) reasoned that defensive responding can be expected to occur in polygraph tests consisting of direct, accusatory questions (e.g., control question technique), but is less likely in the concealed information test. However, given the highly threatening nature of the crime stimuli in a real-life, high-stake criminal investigation, one might expect defensive responding. In each case, it seems worthwhile to examine whether physiological responding to concealed information follows the defensive cascade from the laboratory to the field..

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# CHAPTER 4

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## **THE EFFECTS OF PUNISHMENT, REWARD AND PSYCHOPATHIC TRAITS ON AUTONOMIC RESPONDING TO CONCEALED INFORMATION<sup>1</sup>**

The role of psychopathic personality traits on the physiological detection of concealed information was investigated in a college sample. A large sample of undergraduate students ( $N = 432$ ) filled in Carver and White's (1994) BIS/BAS Scales. Students evidencing a weak BIS/strong BAS were defined as the high psychopathic group ( $n = 16$ ), and students evidencing a strong BIS/weak BAS were allocated to the low psychopathic group ( $n = 16$ ). Participants were instructed to try to conceal recognition of personal information and were informed that their performance would result in either winning or losing money. Overall, participants displayed enhanced orienting to concealed information. No effects of psychopathic traits or reward/punishment were found.

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<sup>1</sup> Verschuere, B., Crombez, G., De Clercq, A., & Koster, E. H. W. (submitted). The effects of punishment, reward, and psychopathic traits on autonomic responding to concealed information.

## INTRODUCTION

Trying to conceal information often results in enhanced physiological responding. The concealed information polygraph test (or guilty knowledge test; Lykken, 1957) measures these physiological changes and allows to make a solid decision on whether someone is trying to hide information. In criminal investigations, the concealed information test may therefore be used to examine whether a suspect possesses secret information about a crime. An important topic for applied forensic purposes is whether psychopathic individuals also show enhanced physiological responding to concealed information. Unfortunately, research on the moderating role of psychopathic traits on the physiological detection of deception has led to inconsistent results (Balloun & Holmes, 1979; Gudjonsson, 1982; Honts, Kircher, & Raskin, 1985; Raskin & Hare, 1978; Patrick & Iacano, 1989; Verschuere, Crombez, Koster, & Declercq, submitted; Waid, Orne, & Wilson, 1979a, b). In all studies, participants were instructed to try to beat the polygraph, but studies differed strongly in the way participants were motivated to do so. For example, in the study by Raskin and Hare (1978), participants who were able to obtain an innocent test outcome were monetarily rewarded. Patrick and Iacano (1989) on the other hand, threatened their participants by stating that individual test outcome could penalize the whole [prisoners] group. Divergent results could, however, be expected from these motivational manipulations, because psychopaths are autonomically *hypo*responsive to punishment, but *hyper*responsive to reward (see Arnett, 1997). In the present study, we therefore manipulated the consequences (reward/punishment) within high and low psychopathic individuals and investigated their moderating influence on physiological responding to concealed information.

It is often argued that psychopaths will show reduced responding on polygraph tests, because they are characterized by a lack of fear. Laboratory research has indeed confirmed that psychopaths do not show normal fear responses. Processing of negative stimuli in psychopaths is not accompanied by the same physiological responses as in normals. For example, when looking at aversive pictures, psychopaths do not show enhanced startle responding (Patrick, Bradley,

& Lang, 1993) and evidence reduced electrodermal responding (Herpertz et al., 2001). These data have led several authors to theorize that psychopathy originates from a deficit in the neurophysiological fear system. This brain system has been called the behavioral inhibition system (BIS; Gray, 1987). The BIS is sensitive to cues for punishment, nonreward, as well as novelty. It inhibits behavior that might lead to aversive outcomes and is accompanied by the feeling of anxiety. According to Gray, differences in BIS sensitivity explain individual differences in anxiety proneness. At one extreme, individuals in risk of anxiety disorders may be found, whereas psychopathic individuals may be found at the other extreme of the continuum. Thus, a weak BIS might explain why psychopathic individuals show reduced autonomic responding to aversive stimulation.

Psychopaths are not only insensitive to punishment cues, Gorenstein and Newman (1980) argued that they are also hyperresponsive to rewarding stimulation. Empirical support for this position comes from research showing that psychopathic prisoners evidence greater heart rate responsivity than nonpsychopathic prisoners in reaction time task when financially rewarded (Arnett, Smith, & Newman, 1997). Gorenstein and Newman (1980) reasoned that psychopathy might result from a heightened activation of the behavioral activation system (BAS). The BAS is the brain system that is responsible for approach behavior and is sensitive to cues for reward and nonpunishment. Activation of the BAS is related to feelings of positive affect. In terms of individual differences in personality, extreme underactivation of the BAS may result in depressive disorders, whereas extreme activation of the BAS may underlie the psychopathic personality. According to Newman and colleagues, enhanced BAS sensitivity can explain why psychopaths show enhanced cardiac responding to reward cues.

The weak BIS and the strong BAS hypotheses were integrated by Arnett (1997) in his motivational imbalance theory. This theory holds that psychopathy is characterized by both a low sensitivity to punishment (weak BIS) and a heightened sensitivity for reward cues (strong BAS). Building on the work of

Fowles (1980), the theory predicts that a weak BIS should be apparent in reduced electrodermal activity, while enhanced heart rate activation indexes a strong BAS. Abnormal autonomic responding in psychopathic individuals is assumed to vary according to the kind of stimulation. That is, psychopathic individuals are expected to show reduced electrodermal responding to punishment cues, but enhanced cardiac responding to reward cues. Applied to polygraph testing, which relies on these autonomic measures, divergent results can therefore be expected when test performance results in reward or punishment.

In the present study, we tested these predictions in a concealed information polygraph test. Participants were selected from a large group of undergraduate students on self-reported measures of behavioral inhibition and behavioral activation using Carver and White's (1994) BIS/BAS Scales. Undergraduates who evidenced a weak BIS/strong BAS were defined as the high psychopathic group, while those who evidenced a strong BIS/weak BAS were allocated to the low psychopathic group. Previous research with undergraduates selected in this way, has found deficits similar to those found in clinical psychopaths. For example, undergraduates with high psychopathic traits show deficient punishment learning (Honk, Hermans, Putman, Montagne, & Schutter, 2002) and are less accurate in recognizing fearful facial expression as compared with low psychopathic undergraduates (Montagne et al., in press). Undergraduates can, therefore, be meaningfully allocated to a high and low psychopathic group. In the present study, participants from both groups were asked to hide recognition of personal information while electrodermal and cardiac responding was measured. Consequences of test performance were manipulated in two tests: participants could either win money by successfully hiding personal information (reward-CIT) or lose money when performing badly (punishment-CIT). It was hypothesized that, in comparison to the low psychopathic group, the high psychopathic group would show (1) enhanced cardiac responding during the reward-CIT, and (2) reduced electrodermal responding to concealed information during the punishment-CIT.

## METHOD

### Participants

Participants were selected from a larger pool of undergraduate psychology students of the Ghent University ( $N = 432$ ). Sixteen participants who scored in the upper quartile of the BIS and the lower quartile of the BAS scale, and 16 participants who scored in the lower quartile of the BIS and the upper quartile of the BAS scale participated in the present study. Female:male ratio was 11:5, and 14:2 respectively,  $\chi^2(1) = 1.65$ , ns. Groups did not differ in mean age,  $F < 1$ . Subjects earned course credits for participation.

### Material

The BIS/BAS Scales (Carver & White, 1994) consist of 20 items that are rated on a 4-point scale, ranging from “I totally agree” to “I totally disagree”. Seven items (e.g., I have very few fears compared to my friends) form the BIS scale, and 13 items form the BAS Scales. The latter can be subdivided in three related scales: Drive (4 items, e.g., When I want something, I usually go all-out to get it), Reward responsiveness (5 items, e.g., It would excite me to win a contest), and Fun Seeking (4 items, e.g., I crave excitement and new sensations). The Dutch translation of the BIS/BAS Scales has good psychometric properties (Franken, Muris, & Rassin, in press).

### Procedure

The experiment was conducted in a laboratory that was designed for psychophysiological research. Participants were welcomed by an experimenter, who was blind to group membership. Our study was approved by the ethical committee from the Ghent University, and written informed consent was obtained from all participants. At the beginning of the experiment, participants were asked to name personally relevant names (e.g., names of family members) in a short questionnaire, and filled in the BIS/BAS Scales for a second time in order to assess test-retest reliability (2-4 month interval).

Participants were asked to wash their hands, where after physiological equipment was attached. A Lablinc V Coulbourn recorded the skin conductance and heart rate signals. Two 0.8 cm diameter Ag/AgCl electrodes, were filled with KY-gelly and attached to the thenar and hypothenar eminences of the participant's left hand in order to measure skin conductance. The skin conductance signals were processed using the V71-23 isolated skin conductance coupler, and subsequently digitized at 100 Hz. Three Ag/AgCl electrodes were filled with KY-gelly and placed in lead-II placement to obtain an electrocardiogram. One electrode was attached to the right forearm, one to the left leg, with the ground electrode on the left forearm. Cardiac signals were processed with the V75-04 bioamplifier, digitized at 500 Hz.

The polygraph examination consisted of two concealed information tests (CIT) for each participant. Participants received 5 € from the experimenter, and they were informed they could augment or loose this sum of money, depending upon their performance on the polygraph test. In the reward-CIT, they could win an extra 5 € if they were able to hide recognition of personal information in at least 75% of the presentations. In the punishment-CIT, they could loose 5 € if they were unable to hide recognition in at least 75% of the presentations. In this way, participants were told they could earn 0, 5, or 10 €. In fact, all participants were paid 5 € in a debriefing session at the end of the study.

Each test consisted of a buffer name, 4 personal (participant's first name, participant's last name, first name of the father, first name of the mother) and 4 control names. The order of the tests (punishment-CIT/reward-CIT) was counterbalanced across individuals and across groups. All names were presented for 6 seconds, separated by an inter-stimulus intervals (ISI) ranging from 26 to 30 seconds. Two digit trials (e.g., a random number between 1 and 10) were also presented for one second in each test. To assure participants attention was focused on the screen, they were asked to name these digits aloud. Digit presentation was random, with the restriction that the digits were not displayed within 16 seconds prior or 5 seconds after the stimuli.

### ***Response scoring and analysis***

The psychophysiological data were analyzed using Psychophysiological Analysis (PSPHA), a software program that we developed for the off line analysis of psychophysiological data. PSPHA was used to detect the R-peaks in the ECG-signal and to calculate the distance between them. Prior to analysis, the interbeat intervals (IBI) were converted to heart rate in beats per minute (bpm) per real-time epoch (1sec). Mean bpm in the 3-second period preceding picture onset were compared to the mean bpm in the 6 second period after picture onset. The mean of the prestimulus period was subtracted from each poststimulus period, allowing a second-by-second analysis. For skin conductance, the maximal skin conductance change (with a minimum of  $0.05\mu\text{S}$ ), starting between 1 and 5 seconds after picture onset was calculated using PSPHA. The magnitude of the electrodermal responses were square root transformed prior to the analyses. Hypotheses for each dependent variable were analyzed using multivariate analysis of variance (MANOVA) with repeated measures treated as variates. We report percentage of variance (PV) as a measure of effect size. Following Cohen (1988), a PV of .01, .10 and .25 was used as thresholds to define small, medium and large effects, respectively.

## **RESULTS**

### ***BIS/BAS Scales***

Test-retest reliability (2-4 month interval) was high for the BAS Scale: .81,  $p < .01$ , which is comparable to normative data in prior studies (e.g., Johnson et al., 2003). As expected, the psychopathic group ( $M = 45.88$ ,  $SD = 3.72$ ) scored significantly higher on the BAS Scale compared to the control group ( $M = 37.63$ ,  $SD = 3.83$ ),  $F(1, 31) = 38.21$ ,  $p < .001$ . Pearson product correlation between the two administrations of the BIS Scale were rather low: .51,  $p < .01$ . Nonetheless, the psychopathic group ( $M = 19.44$ ,  $SD = 1.29$ ) still scored significantly lower than the control group ( $M = 23.50$ ,  $SD = 2.31$ ),  $F(1, 31) = 16.65$ ,  $p < .001$ .



### *Heart Rate*

The heart rate data were analysed using a mixed MANOVA with group (2 levels: psychopathic group/control group) as the between-subjects factor, and stimulus (2 levels: concealed/control information), second (6 levels: sec1-6), and test (2 levels: reward/punishment) as the within-subjects factors. There was a significant main effect of second,  $F(5, 19) = 3.44, p < .01, PV = .47$ . More importantly, there was a significant main effect of stimulus,  $F(1, 23) = 11.23, p < .01, PV = .33$ , confirming that concealed information elicited a greater decline in heart rate ( $M = -1.10; SD = 2.25$ ) than control information did ( $M = 0.40; SD = 1.47$ ). There were no significant effects with either test or group as a factor, all  $F < 1.85$  (see Table 1).

### *Skin conductance*

Magnitude of the skin conductance responses were analyzed using a mixed MANOVA with group (2 levels: psychopathic group/control group) as a between-subjects factor, and test (2 levels: reward/punishment) and stimulus (2 levels: concealed/control information) as the within-subjects factors. The only significant finding was the main effect of stimulus,  $F(1, 29) = 26.47, p < .001, PV = .48$ , evidencing that concealed information ( $M = 0.44, SD = 0.36$ ) elicited larger skin conductance responses than control information ( $M = 0.27, SD = 0.28$ ), irrespective of group or test, all  $F < 1$  (see Table 1).

*Table 1. Autonomic Responses to Concealed and Control Information in Low and High Psychopathic Individuals*

	Reward CIT	Punishment CIT
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	Concealed Information <i>M (SD)</i>	Control Information <i>M (SD)</i>	Concealed Information <i>M (SD)</i>	Control Information <i>M (SD)</i>
<i>SCR</i>				
Low Psychopathic	.41 (.45)	.21 (.33)	.42 (.37)	.26 (.29)
High Psychopathic	.49 (.35)	.32 (.35)	.48 (.36)	.33 (.30)
<i>HR</i>				
Low Psychopathic	-.78 (3.04)	.68 ( 1.76)	-.73 (2.55)	-.03 (1.68)
High Psychopathic	-1.52 (2.09)	.24 (1.78)	-.64 (3.06)	.14 (2.14)

## DISCUSSION

In this study, we examined whether psychopathic traits, as assessed by the BIS/BAS Scales, and consequences of test outcome (reward/punishment) moderate autonomic responding to concealed information. Our study generated two interesting findings. First, concealed information elicited larger electrodermal and cardiac responding than control information did. Second, and contrary to expectations, no moderating influence of either psychopathic traits or consequences of test outcome affected autonomic responding.

Trying to conceal information resulted in larger skin conductance responses and a greater decline in heart rate, relative to control information. This pattern of responding indicates concealed information elicits greater orienting reflexes, thereby supporting the orienting theory on concealed information. Reviewing the scientific evidence on the physiological detection of deception, the National Research Council (2003) argued that polygraph tests need to satisfy two important psychometric properties: accuracy and construct validity. While extensive laboratory research previously confirmed the high accuracy of the concealed information test (Ben-Shakhar & Elaad, 2003), there is now considerable evidence for the construct validity of the concealed information test (see Verschuere, Crombez, Koster, & Declercq, 2004). Specifically, orienting theory can explain behavioral, autonomic and electrophysiological responding to concealed information.

Enhanced orienting to concealed information was observed, irrespective of the consequences of test outcome. Because we counterbalanced test order (reward-CIT vs. punishment-CIT), one could argue that habituation (reduced responding over tests) attenuated or even eliminated the effect of polygraph test type. This is, however, unlikely because previous research with the present paradigm has shown that – despite overall habituation – the differential responding between concealed and control information remains similar across two examinations (Verschuere et al., submitted). Though unlikely, we ran additional analyses to rule out this possibility. Separate MANOVA's was run for the electrodermal and the cardiac data from the first block only with test outcome (punishment/reward)

as a between-subjects variable. These analyses confirmed that participants evidenced enhanced responding to concealed information, irrespective of test outcome. Thus, our study failed to show an effect of motivation in the concealed information test. In fact, this is not an isolated finding, as several researchers have failed to find motivational effects (see Ben-Shakhar & Elaad, 2003). Our study differed from these studies in that we examined motivational effect in relation to individual differences, but still, no effect of motivation was found. Ben-Shakhar and Elaad (2003) concluded that heightened motivation is associated with enhanced responding to concealed information. Our data are, however, in line with other reviews (National Research Council, 2003; MacLaren, 2001) that were more skeptical on the role of motivation.

Finally, psychopathic traits did not moderate responding to concealed information in our study. Before discussing the implications of this finding, we need to deal with methodological artifacts that might explain this null finding. First, test-retest correlation for the BAS scales was moderately high, but low for the BIS scale. A look at the scores on both scales shows that participants scored less extreme from the first to the second examination. This is a well-known statistical phenomenon, called 'regression to the mean', which affects scores on retesting so that they are closer to the population mean (see e.g., Streiner, 2001). The reason that the BAS scale was more stable than the BIS Scale is probably due to its larger number of items. Since participants still differed highly significantly on the re-examination, it is unlikely that this effect erased individual differences on the polygraph test. Second, we used the BIS/BAS Scales to allocate participants to a low or high psychopathic group. Although the BIS/BAS Scales were not originally developed as a measure of psychopathy, several authors have theorized that underactivation of the BIS and the overactivation of the BAS underlie psychopathic traits (see e.g., Carver & White, 1994). Research in psychopathic prisoners (Book & Quinsey, 2004; for a review see Arnett, 1997) and more recently in undergraduates tends to support this position (Van Honck et al., 2002; Montagne et al., in press). Surely, we do not imply that our participants can be considered psychopaths, but empirical evidence supports the idea that participants evidencing a weak BIS/strong BAS have psychopathic personality

traits. Third, recent research has questioned whether high psychopathic individuals show higher heart rate reactivity compared to low psychopathic individuals. In a large meta-analysis, Lorber (2004) examined among others, the relationship between psychopathy and electrodermal and cardiac task reactivity. As expected, psychopathy was related to reduced electrodermal task reactivity. However, there was no relationship between heart rate reactivity and psychopathy. Thus, whereas these findings strengthen the prediction of reduced skin conductance orienting, they raise doubt on whether enhanced cardiac responding could have been found.

Some studies (Waid et al., 1979a,b) have previously found that psychopathic traits moderate physiological responding to concealed information in a non-clinical population. Our study could not replicate this finding. At present, it remains unclear why only some studies could demonstrate differential responding. One possible explanation for the inconsistent findings, is that only individuals scoring on the extreme side of the psychopathic trait dimension, show abnormal responding during a concealed information test. Some recent data support this position, as psychopathic prisoners were found to show reduced orienting to concealed information (Verschuere et al., submitted). Because of the important implications for applied purposes, this topic definitely needs further examination in order to draw more strong conclusions.

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# CHAPTER 5

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## **PSYCHOPATHIC TRAITS AND AUTONOMIC RESPONDING TO CONCEALED INFORMATION IN A PRISON SAMPLE<sup>1</sup>**

We examined the role of psychopathic traits on physiological responding during a concealed information polygraph test among prison inmates ( $n = 40$ ). The Psychopathic Personality Inventory (Lilienfeld & Andrews, 1996) was used to assess psychopathic traits. Cardiac, electrodermal and respiratory responses were measured while participants were presented with personal and control names and asked to conceal recognition of personal information. We first piloted the present concealed information test in a sample of undergraduates ( $n = 27$ ). Enhanced orienting to concealed information compared to control information was observed in both prisoners and undergraduates. However, prisoners scoring high on the Impulsive Antisociality factor of the Psychopathic Personality Inventory (PPI-II) exhibited reduced electrodermal responding. This finding indicates that the sensitivity of the concealed information test may be decreased in antisocial offenders.

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## INTRODUCTION

How do psychopathic individuals respond to the polygraph (“lie detector”)? Clearly, the answer to this question has important implications for authorities relying on polygraph tests in criminal investigations. While most clinicians and layman undoubtedly think that psychopathic individuals are able to beat the polygraph, research is inconclusive. In general, polygraph-supported interrogations are conducted with (variants of) the control question technique. In this test, a comparison is made between physiological responses on relevant questions (e.g., “Did you steal a Ferrari on the 6<sup>th</sup> of July?”) and arousal-evoking control questions (e.g., “Prior to the 6<sup>th</sup> of July, did you ever take anything that did not belong to you?”). It is assumed that the guilty suspect will react more strongly to the relevant questions, while the innocent is assumed to react more strongly to the control questions. Raskin and Hare (1978) were the first to demonstrate that the control question polygraph test detects deception in psychopaths as accurately as in non-psychopaths (for a critique see Lykken, 1978). Subsequent research has replicated this finding (Honts, Raskin, & Kircher, 1985; Patrick & Iacono, 1989). The control question technique has, however, received severe critiques on both logical and ethical grounds (see e.g., Ben-Shakhar & Furedy, 1990).

The concealed information test or guilty knowledge test (Lykken, 1959) has been proposed as a scientifically valid alternative to the traditional control question test (Ben-Shakhar, Bar-Hillel, & Kremnitzer, 2002). The concealed information test examines deceit more indirectly and looks much like a multiple choice examination. The suspect is questioned on knowledge about a crime that only the guilty suspect can have. Building on the example above, the suspect could be asked: “If you are the thief, you would know what the owner of the car left on the front seat. Was this a coat?...a laptop?...a sandwich?...a pack of cigarettes?...a hat?”. Several questions of this kind are formulated, and if the suspect systematically reacts stronger to the correct alternative, it is assumed that the suspect has concealed information about the crime under investigation. The accuracy of the concealed information test has been extensively examined and it has been demonstrated that it performs well above chance (National Research

Council, 2003). Based upon his quantitative meta-analysis, MacLaren (2001) estimated that the concealed information test provides an accurate judgment for 83% of the “innocent”, and 76% of the “guilty” participants. Furthermore, the concealed information test relies on sound theoretical grounds. Lykken (1974) has argued that the enhanced physiological responding to concealed information is based upon the orienting reflex (OR; Sokolov, 1963). The OR is a complex of behavioral and physiological responses elicited by either new or significant stimuli. For the guilty suspect, the correct answers are significant and will therefore elicit greater orienting reflexes as compared to the incorrect answers. From the perspective of the innocent suspect, all answers in the concealed information test are homogeneous, leading to a  $1/n$  chance of reacting more strongly to the correct alternative (with  $n$  being the number of answer possibilities). Several predictions resulting from this hypothesis have been tested, and have provided strong support in favor of the orienting account (Verschuere, Crombez, Declercq, & Koster, 2004).

An important question is to what extent psychopathic individuals react in a similar way to concealed information. A few studies have examined whether the accuracy of the concealed information test is moderated by antisocial behavior, a concept related to psychopathy. In an experiment by Balloun and Holmes (1979), undergraduate students had the chance of cheating on an intelligence test and were subsequently questioned on their cheating behavior using a concealed information test. Participants were allocated to a low or high antisocial group, based upon their score on the psychopathic deviate scale of the Minnesota Multiphasic Personality Inventory (Hathaway & McKinley, 1943). Using skin conductance responses, no differences in detection rate were found between high and low antisocial individuals. In two other studies (Waid, Orne, & Wilson, 1979a, b) undergraduates, half of which had enacted a mock crime, were engaged in a concealed information test. In both studies, the socialization scale of the California Psychological Inventory (Gough, 1956) was administered. The findings of both experiments contradicted those of Balloun and Holmes (1979) in that less socialized participants showed smaller skin conductance reactions to the relevant items and that a relatively higher number of guilty low socialized

participants were incorrectly judged as being truthful. Finally, Gudjonsson (1982) used a card version of the concealed information test in a sample of normal and psychiatric patients. He found no correlation between the socialization scale and concealed information test accuracy based on skin conductance responses.

The relationship between psychopathy and physiological detection of concealed information remains unclear. Results are inconsistent and conclusions from these studies are restricted by methodological shortcomings. First, all studies used non-incarcerated subjects. Because lower levels of psychopathic traits can be expected in the normal population compared to the prison population, this method is sub-optimal to find individual differences. Second, the validity of the psychopathy measures in these studies have been criticized. Both the psychopathic deviate and the socialization scale assess antisocial behavior, but not the affective-interpersonal features of psychopathy. Indeed, psychopathy is commonly conceptualized as two-dimensional. The first dimension consists of affective-interpersonal features, such as superficial charm, lack of empathy, affective shallowness, egocentricity, lying, and manipulativeness; the second dimension comprises antisocial behavior such as juvenile delinquency, aggressive behavior, and irresponsibility. The best-validated instrument of psychopathy (i.e., the Psychopathy Checklist or PCL; Hare, 1991) assesses both dimensions. Using a large sample of prison inmates, Harpur, Hare, and Hakstian (1989) have demonstrated that both the psychopathic deviate scale and the socialization scale are moderately related to the antisocial factor, but are uncorrelated to the affective-interpersonal dimension of the Psychopathy Checklist. This led the authors to conclude that both scales provide an incomplete picture of the psychopathic personality. In order to encompass both critiques, we measured both dimensions of psychopathy in a sample of prison inmates. Psychopathic personality traits were assessed using the Psychopathic Personality Inventory (Lilienfeld & Andrews, 1996). A total score can be derived from this 187-item questionnaire that can be interpreted as a global measure of psychopathy. The Psychopathic Personality Inventory, however, differs from other self-report measures of psychopathy in that it measures several aspects of the psychopathic personality along 8 subscales: impulsive nonconformity, blame

externalization, Machiavellian egocentricity, carefree nonplanfulness, stress immunity, social potency, fearlessness and coldheartedness. Importantly, recent factor analytic work (Benning, Patrick, Blonigen, Hicks & Iacono, in press; Benning, Patrick, Hicks, Blonigen, & Krueger, 2003) has shown that the Psychopathic Personality Inventory comprises the two-dimensional structure of psychopathy, similar to that of the Psychopathy Checklist. The first factor (PPI-I), labeled “Fearless Dominance”, consists of the subscales stress immunity, social potency and fearlessness. The second factor (PPI-II), labeled “Impulsive Antisociality”, consists of the subscales impulsive nonconformity, blame externalization, machiavellian egocentricity, and carefree nonplanfulness.

In this study, we assessed psychopathic traits in prison inmates and investigated their relationship with physiological responding to concealed information. To the best of our knowledge, our study is the first to examine the moderating role of psychopathic features on responding to concealed information in a prison sample. We used a personal items variant of the concealed information test, in which participants viewed personal (e.g., participant’s first name) and control names on the computer screen and were instructed to hide recognition of personal information. For comparison purposes, a pilot study was first performed in undergraduate students. Next, applying the personal items concealed information test to a sample of prison inmates, we examined whether responding to concealed information was moderated by the Fearless Dominance and/or the Impulsive Antisociality factor of the Psychopathic Personality Inventory.

## **PILOT STUDY**

### **METHOD**

#### **Participants**

Twenty-seven undergraduate students (23 female) of Ghent University took part as partial fulfilment of course requirements. Mean age was 18.63 years ( $SD = 1.32$ )

#### **Procedure**

The experiment was conducted in a sound-attenuated, darkened laboratory, which was connected via an intercom and a one-way vision screen to an adjacent control room. Participants were informed about the procedure and goal of the study and signed an informed consent form. Participants filled in a short questionnaire, which asked to name personally important individuals (e.g., parents, siblings, friends, (ex-)partner(-s),...). Prior to the attachment of the electrodes, participants were requested to wash their hands.

Participants were informed that they were going to take part in a lie detection experiment and they were asked to try to beat the polygraph by hiding recognition of personal information. Participants were seated approximately 50 cm from the screen. The concealed information test consisted of two blocks of 8 names. Each block started with a buffer name, followed by 4 personal and 4 control names in one of 4 fixed random orders. Stimulus presentation was random in these orders, with the exception that (a) half of them started with a personal name, and the other half with a control name, and (b) there were not more than three consecutive presentations of one stimulus type (personal or control). For each block, participants were randomly allocated to one out of the 4 randomization orders. Personal names (first name, last name, first name of the father and first name of the mother) were selected from the questionnaire that was assessed earlier in the session. Control names were selected prior to the experiment, but checked (and if necessary changed) in order to assure that they did not resemble any of the names from the questionnaire. All names were

presented in the middle of the screen during 6 s, with an inter-stimulus intervals (ISI) ranging from 26 to 30 s. Each block also contained two digit trials (i.e., a random number between 1 and 10) that were presented for 2.5 s. The digits were presented at a fixed pseudorandom position during the ISI, so that the digits did not appear within 10 s after stimulus onset or 16 s prior to stimulus onset. To assure participants attention was focused on the screen, they were asked to name these digits out loud.

### **Recording and scoring of psychophysiological signals**

All stimuli were presented by a first PC using Inquist software (2002). A Labline V Coulbourn recorded skin conductance, heart rate and respiration. Psychophysiological signals were stored on a second PC, equipped with a Scientific Solutions Labmaster DMA card, running VPM software (Cook, 1997). The psychophysiological data were analyzed using Psychophysiological Analysis (PSPHA; Declercq, Verschuere, Crombez, & De Vlieger, submitted), a software program that we developed for the off line analysis of psychophysiological data.

Skin conductance was measured using a constant voltage (0.5V) coupler, and Ag/AgCl electrodes (0.8 cm diameter) filled with KY-jelly that were attached on the thenar and hypothenar eminences of the left hand. Skin conductance was digitized at 10 Hz. Using PSPHA, we calculated the maximal skin conductance change (with a minimum of 0.05 $\mu$ S), starting between 1 and 5 s after stimulus onset (Dawson, Schell, & Filion, 2000).

Heart rate activity was obtained by a photoelectric transducer, attached to the left index finger. Heart rate was digitized at 500 Hz. PSPHA was used to detect the peaks and to calculate the distance between them. An artifact detection and correction procedure was applied with PSPHA using established procedures (Cheung, 1981). Less than 1 % of the heart rate data needed editing. Prior to analysis, the interbeat intervals (IBI) were converted to heart rate in beats per minute (bpm) per real-time epoch (1sec). Mean bpm in the 3 s preceding stimulus onset were compared to the mean bpm in the 6 s period after stimulus onset.

Respiration was measured using a single strain gauge attached around the thorax. Respiration moved the air in the elastic tube and these variations were picked up by a pressure sensor. The difference in pressure was converted to voltage and digitized at 250 Hz. In line with applied research on the physiological detection of deception, we calculated respiration line length (Timm, 1982). The length of the respiration line was measured starting from stimulus onset up to 8 s later and expressed in milliseconds. Timm has pointed out that the length of the respiration line might be disproportionally affected by the start of measurement. For example, starting at the end of a slowly declining expiratory curve or at the beginning of the rapidly ascending inspiratory curve would produce different line lengths for the same time interval. In order to deal with this problem, each respiration line length was calculated as the mean of 10 respiration line lengths: from stimulus onset to 8 s later, from 0.1 s after stimulus onset to 8.1 s after stimulus onset, from 0.2 s to 8.2 s after stimulus onset, etc.

We calculated within-subject *Z* scores, in order to enhance the comparability of the physiological responses between individuals. The *Z* scores were computed relative to the participant's mean and standard deviation (Ben-Shakhar, 1985). In order to further enhance comparability between response measures, we multiplied the *Z* scores for respiration line length and cardiac reactivity by -1, because concealed information is associated with smaller values in these measures (e.g., cardiac and respiratory suppression). In this way, larger *Z* scores indicated enhanced responding for all measures.

## RESULTS

Hypotheses for each dependent variable were tested using multivariate analysis of variance (MANOVA) with repeated measures treated as variates. We report percentage of variance (*PV*) as a measure of effect size. Following Cohen (1988), a *PV* of 1, 10 and 25% was used as thresholds to define small, medium and large effects, respectively.

### *Skin conductance*

A 2 (stimulus: concealed vs. control information) x 2 (block: block1 vs. block2) repeated measures MANOVA was performed to analyse the magnitude of the skin conductance response. This analysis revealed a main effect of stimulus,  $F(1, 22) = 20.88, p < .001, PV = .44$ , confirming that skin conductance responses were larger in response to concealed information compared to control information (see Table 1). Furthermore, a significant main effect of block,  $F(1, 26) = 23.86, p < .001, PV = .48$ , revealed that there was overall habituation from the first to the second block. The Stimulus x Block effect was not significant,  $F = 1.14$ .

### *Heart Rate*

A 2 (stimulus: concealed vs. control information) x 2 (block: block1 vs. block2) MANOVA was used to analyze the heart rate data. There was a significant main effect of stimulus,  $F(1, 26) = 10.03, p < .001, PV = .28$ . This finding revealed that the decline in heart rate was larger in response to concealed information than to control information (see Table 1). No effect with block as a factor was significant,  $F$ 's  $< 1.77$ .

### *Respiration*

A 2 (stimulus: concealed vs. control information) x 2 (block: block1 vs. block2) repeated measures MANOVA was performed to analyse the length of the respiration line. As expected, the respiration line length was shorter after concealed information than after control information,  $F(1, 26) = 11.62, p < .01, PV = .31$  (see Table 1). No effect with block as a factor was significant,  $F$ 's  $< 2.17$ .

### *Detection efficiency*

Although the present polygraph test was not primarily designed to detect concealed information at the individual level, we also calculated the detection efficiency of the concealed information test. In line with the recommendations by the National Research Council (2003), we used an approach that was adopted from signal detection theory. We calculated a receiver operating characteristic



(ROC) curve. The area under the curve ( $a$ ) reflects the detection efficiency of the concealed information items across all possible cutoff points. The value of  $a$  lies between 0 and 1, with .50 indicating that the distribution from the concealed information items and the control items do not differ from each other. The area under the curve with the corresponding 95% confidence interval (Bamber, 1975) for each measure in each block can be found in Table 1. Inspection of Table 1 shows that the detection efficiency ( $a$ ) was about .63 to .72 in the first block, and declined to .55 to .66 in the second block.

## DISCUSSION

Trying to conceal personal information elicits a predictable pattern of physiological reactions. Specifically, it was found that concealed information elicits larger skin conductance response, a greater decline in heart rate and a shortening of the respiration line length, as compared to control information. Effect sizes of the differences between concealed and control information were large for all physiological measures. The data from this pilot study therefore indicate that the present personal items concealed information test is adequate to test our main hypothesis in a less standardized (e.g., prison) situation.

## MAIN STUDY

### METHOD

#### Participants

Participants were forty male prisoners of the Central State Prison Leuven (Belgium), a maximum security prison of about 250 long-sentenced prisoners. Mean age was 39 years ( $SD = 11$ ; range: 21-72). Eighty-five percent of the participants was of Belgian origin, with 15 % of the participants having a different ethnic origin (North African:  $n = 3$ , and Mid-Eastern:  $n = 3$ ). About one third of the prisoners had a sentence between 4 and 10 years, one third between

10 and 30 years, and one third was convicted for life time. Mean years of formal education was 10 ( $SD = 2$ ; range 6 – 15 years). Participants were paid the equivalent of one hour prison labor (2 euro).

### **Material**

The Psychopathic Personality Inventory was used to assess psychopathic traits. Respondents indicated how much each item applied to them on a 4-point scale ranging from 1 (= false) to 4 (= true). Following Benning et al. (2003), we calculated the two factor scores by averaging the mean of the standardized subscale scores, because the subscales are based on a different number of items. This Z-transformation assured that the scores of the different subscales were weighted equally. The Psychopathic Personality Inventory has good to excellent psychometric properties: internal consistency and test-retest reliability of the total score is high in both undergraduates (respectively .90 and .95; Lilienfeld & Andrews, 1996) and (female) offenders (respectively .94 and .92; Chapman, Gremore, & Farmer, 2003). The Psychopathic Personality Inventory was translated into Dutch by four researchers, who were all experts in the domain of psychopathy (Jelicic, Merckelbach, & Candel, in press). In a sample of Dutch undergraduates ( $n = 127$ ), the Dutch translation had similar internal consistency (.92) and test-retest reliability (.99;  $n = 35$ ) for the total score.

### **Procedure**

The method was identical to that described in the pilot study, except that heart rate was obtained using three electrodes placed in the standard lead II configuration: the negative electrode was placed just below the right clavicle, the positive electrode on the left lower rib, and the ground electrode placed on the right lower rib. Heart rate was filtered (band pass: 8-40 Hz) and digitized at 500 Hz.

## RESULTS

### *Psychopathic Personality Inventory*

Thirty-seven participants (92%) turned in a completed Psychopathic Personality Inventory. Internal consistency (Cronbach's  $\alpha$ ) in the present sample was high for the total score (.89), as well as for the Fearless Dominance factor (.84) and the Impulsive Antisocial factor (.89). Mean total score in the present sample was 350 ( $SD = 40$ ; range: 270-428). The two factors of the Psychopathic Personality Inventory were uncorrelated,  $r = .17$ ,  $p = .32$ .

### **Concealed Information Test**

Within-subject  $Z$  scores were used for all analyses, except when analyzing the relationship of psychopathic traits and overall stimulus reactivity. Here, raw physiological responses were used, because standardization would eliminate individual differences. Again, mean  $Z$  scores were multiplied by -1 for respiratory and cardiac reactivity.

#### **Skin conductance**

A 2 (stimulus: concealed vs. control information)  $\times$  2 (block: block1 vs. block2) repeated measures MANOVA was performed to analyse the magnitude of the skin conductance response. This analysis revealed a main effect of stimulus, which was highly significant,  $F(1, 39) = 41.30$ ,  $p < .001$ ,  $PV = .51$ . This finding demonstrated that concealed information elicited larger responses than control information did (see Table 1). Furthermore, the Stimulus  $\times$  Block interaction was significant,  $F(1, 39) = 9.13$ ,  $p < .01$ ,  $PV = .19$ , which indicates that the difference in skin conductance responses between concealed and control information declined from the first to the second block. Finally, the main effect of block proved to be significant,  $F(1, 39) = 6.58$ ,  $p < .05$ ,  $PV = .14$ , indicating that there was an overall decline in responsivity from the first to the second block.

*Table 1. Means (and standard deviations) of the physiological responses to concealed and control information in the undergraduate and the prisoners sample; area under the ROC-curve with corresponding 95 % confidence interval in each block.*

	Block 1			Block 2		
	Concealed Information  Mean (SD)	Control Information  Mean (SD)	Area under the ROC curve (with 95 % confidence interval)	Concealed Information  Mean (SD)	Control Information  Mean (SD)	Area under the ROC curve (with 95 % confidence interval)
<i>SCR (<math>\mu S</math>)</i>						
Students	.44 (.38)	.19 (.21)	.72 (.65 - .79)	.22 (.24)	.11 (.22)	.66 (.59 - .73)
Prisoners	.24 (.31)	.10 (.15)	.68 (.62 - .74)	.16 (.28)	.08 (.15)	.60 (.54 - .66)
<i>HR (bpm)</i>						
Students	-2.09 (2.31)	.24 (2.14)	.64 (.57 - .72)	-1.04 (2.01)	-.05 (2.02)	.55 (.47 - .63)
Prisoners	-1.15 (2.13)	.10 (1.96)	.60 (.54 - .66)	-.66 (1.51)	-.91 (2.22)	.50 (.44 - .57)
<i>RLL (ms)</i>						
Students	8358 (116)	8379 (123)	.63 (.55 - .70)	8355 (94)	8367 (105)	.62 (.54 - .70)
Prisoners	8405 (134)	8414 (137)	.59 (.53 - .66)	8400 (137)	8416 (151)	.60 (.53 - .66)

In order to compare autonomic reactivity in the prisoners sample with the data obtained in the student sample, we pooled the data of both samples together and ran a 2 x 2 x 2 MANOVA on the electrodermal responses with stimulus and block as the within-subjects, and group (students vs. prisoners) as the between-subjects factor. This MANOVA revealed a significant main effect of stimulus,  $F(1,65) = 58.84, p < .001, PV = .47$ , block,  $F(1,65) = 27.40, p < .001, PV = .30$ , and Stimulus x Block,  $F(1,65) = 6.79, p < .05, PV = .09$ . Furthermore, the block by group interaction effect was marginally significant,  $F(1,65) = 3.42, p < .07, PV = .05$ , indicating that electrodermal responding habituated faster in the student sample. No other effect with group as a factor reached significance,  $F$ 's < 1.

#### Heart rate

A 2 (stimulus: concealed vs. control information) x 2 (block: block1 vs. block2) MANOVA was used to analyze the heart rate data. The main effect of stimulus was significant,  $F(1,39) = 4.34, p < .05, PV = .10$ , as was the Stimulus x Block interaction,  $F(1, 39) = 7.77, p < .01, PV = .17$ . This latter finding indicated that the larger heart rate deceleration to concealed information as compared to control information in the first block, disappeared in the second block (see Table 1).

A 2 x 2 x 2 MANOVA with stimulus and block as the within-subjects, and group as the between-subjects factor was run in order to compare cardiac reactivity in the prisoners sample with the data obtained in the student sample. This 2 x 2 x 2 MANOVA revealed a significant main effect of stimulus,  $F(1,65) = 13.64, p < .001, PV = .17$ , and of Stimulus x Block,  $F(1,65) = 7.37, p < .01, PV = .10$ . No effect with group as a factor reached significance, all  $F$ 's < 1.30.

#### Respiration

Results of the 2 (stimulus: concealed vs. control information) x 2 (block: block1 vs. block2) repeated measures MANOVA on respiration line length showed a significant effect of stimulus,  $F(1, 39) = 18.11, p < .001, PV = .32$ . As predicted, the length of the respiration line was shorter after concealed information, as compared to control information (see Table 1). Furthermore, the main effect of block was significant,  $F(1, 39) = 8.65, p < .01, PV = .18$ . The Stimulus x Block effect did not reach significance,  $F < 1$ .

A 2 x 2 x 2 MANOVA with stimulus and block as the within-subjects and group as the between-subjects factor was used to compare respiratory reactivity in the prisoners and the students. This analysis revealed a significant of stimulus,  $F(1,65) = 28.86, p < .001, PV = .31$ , and of block,  $F(1,65) = 8.95, p < .01, PV = .12$ . No effect with group as a factor reached significance, all  $F$ 's  $< 1$ .

#### *Detection efficiency*

The area under the curve ( $a$ ), along with 95% confidence intervals, for each measure in each condition can be found in Table 1. As can be see in Table 1, detection efficiency ( $a$ ) was about .59 to .68 in the first block, and declined to .50 to .60 in the second block. A comparison of the detection efficiency in students and prisoners shows that detection efficiency is slightly smaller in the prisoners sample, but not significantly so.

#### *Psychopathic traits and the concealed information test*

First, we examined whether psychopathic traits were related to overall stimulus reactivity. We therefore calculated Pearson's  $r$  between the Psychopathic Personality Inventory factor scores and the mean (raw) response of each participant on each dependent measure. In order to reduce the number of analyses and because correlations per block were near identical to the overall correlations, we calculated the correlations across blocks. Inspection of Table 2 reveals that the Impulsive Antisociality factor of the Psychopathic Personality Inventory correlated significantly negatively with skin conductance reactivity,  $r = -.37, p < .05$ . Antisocial prisoners thus showed reduced overall electrodermal reactivity, indicative of autonomic underarousal. No other significant correlations were found.

*Table 2. Correlations between Psychopathic Personality Inventory (PPI) factor scores and overall stimulus reactivity (left panel) and the effect of concealed information (right panel).*

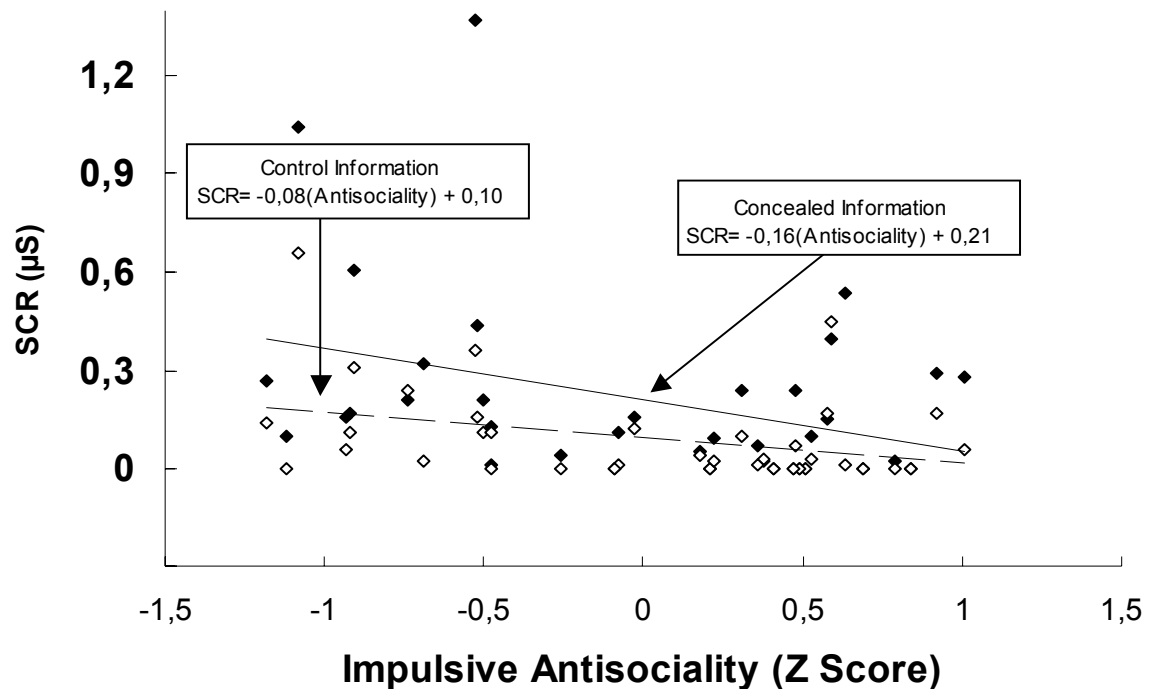
	Overall stimulus reactivity		Concealed information effect	
	PPI-I	PPI-II	PPI-I	PPI-II
<i>Skin conductance</i>	.15	-.37*	.04	-.34*
<i>Cardiac change</i>	.20	.14	.01	-.21
<i>Respiration line length</i>	-.07	-.11	.18	-.19

Note. Signs have been reversed for cardiac and respiratory reactivity, so that a negative correlation indicates reduced reactivity for all measures. \* denotes  $p < .05$ ; \*\* denotes  $p < .01$ ; PPI-I = the Fearless Dominance factor of the Psychopathic Personality Inventory; PPI-II = the Impulsive Antisociality factor of the Psychopathic Personality Inventory.

Second, we examined whether psychopathic traits were related to differential reactivity in the concealed information test. We therefore calculated Pearson's  $r$  between the Psychopathic Personality Inventory factor scores and the concealed information effect measure (the mean standardized response to the concealed information minus the mean standardized response to the control information). Inspection of Table 2 reveals that the Impulsive Antisociality factor correlated negatively with all three response measures, all  $r < -.18$ , and that the relationship with skin conductance reached statistical significance,  $r = -.34$ ,  $p < .05$  (see Figure 1). All correlations with the fearless Dominance factor of the Psychopathic Personality Inventory were close to zero.



Figure 1. Scatterplot, prediction lines, and prediction equations for the relationship between Impulsive Antisociality skin conductance responses (in  $\mu S$ ) separately for concealed information (closed diamonds) and control information (open diamonds).



## GENERAL DISCUSSION

### Autonomic responding to concealed information in a prison sample

A concealed information polygraph test was performed in a sample of male inmates of a high security prison. As expected, concealed information elicited enhanced orienting responses compared to control information. This finding replicates and extends previous research (Lieblich, Ben-Shakhar, & Kugelmass, 1976), which demonstrated that responding to concealed information in male prisoners is comparable to responding in undergraduates. Our study differs in two important aspects from this earlier research. First, examining basic autonomic responding, we used an equal proportion of concealed and control information in

order to prevent a confound between novelty and significance (see Dawson et al., 2000). Second, while Liebllich et al. (1976) only used skin conductance, we also measured respiratory and cardiac responding. As a global measure of arousal, skin conductance does not give insight in the underlying mechanism of the concealed information test. Cardiac and respiratory responding on the other hand allow a test of whether orienting responses account for the enhanced responding. Specifically, orienting is accompanied by a decline in heart rate and respiratory suppression (Lynn, 1966). As predicted from the orienting hypothesis, concealed information elicited greater cardiac decline and greater respiratory suppression compared to control information. The present data showed that enhanced orienting underlies the concealed information test in both the undergraduate and the prison sample. By demonstrating that the pattern of physiological responding in the prison sample was similar to responding in the undergraduate sample, our study provides good evidence for the external validity of the concealed information test.

#### *Psychopathy and physiological detection of deception*

Our results further demonstrate that antisocial inmates display reduced electrodermal responding to concealed information. This finding is consistent with the results of two experiments by Waid and colleagues (1979a, b), who also observed reduced skin conductance responding to concealed information in low socialized undergraduates (but see Balloun & Holmes, 1979; Gudjonsson, 1982). Raskin and Hare (1987) noted that lack of responding to concealed information results in a truthful outcome (e.g., a false negative outcome). The electrodermal hyporesponsiveness in antisocial individuals might therefore threaten the validity of the concealed information test, particularly because the electrodermal measure is the most sensitive index of concealed information (Ben-Shakhar & Elaad, 1990). The reduced responding could imply that profoundly antisocial individuals have a greater chance of escaping detection. Notably, field research with the concealed information (Elaad, 1990, 1992), has found a higher percentage of false negatives compared to laboratory research. This has been attributed to the fact that these field studies were not optimally designed in that they used a lower number of concealed information questions. The present data, however, lead us to speculate that the increased percentage of false negatives could partly be due to a number of antisocial offenders that passed the polygraph test. Future field

research could include a measure of psychopathy in order to examine this possibility.

Given that physiological responses to concealed information are related to the orienting reflex, reduced orienting seems to account for the present findings. Reduced skin conductance orienting in antisocial/psychopathic individuals is a well-known finding in psychophysiology (for a recent review see Lorber, 2004). For example, compared to nonpsychopaths, psychopaths show reduced skin conductance responding to punishment cues (e.g., Arnett, Smith, & Newman, 1997), and to emotional pictures (e.g., Herpertz et al., 2001). This fits well with the theory by Eysenck (1964), who reasoned that the psychopath is in a chronic state of underarousal, and therefore in need for stimulation in order to optimize the arousal level. This may explain why psychopaths are quickly bored, impulsive, and thrill-seeking. Antisocial acts, then, are regarded as a deviant form of stimulation seeking. Raine (1997) has demonstrated that this underarousal is mainly related to the impulsive antisociality facet of psychopathy. Likewise, we found that the reduced skin conductance reactivity in the concealed information test was related to the Impulsive Antisociality factor of the Psychopathic Personality Inventory.

### **Limitations and conclusions**

The present study is not without its limitations. First, psychopathic personality traits were assessed using a self-report measure, which may be biased by response tendencies. Akin to this concern is the fact that the mean total scores in the present prison sample ( $M = 350$ ,  $SD = 40$ ) were not particularly higher than those observed in undergraduates (e.g.,  $M = 344$ ,  $SD = 39$ ; Jellicic et al., in press). Chapman, Gremore, and Farmer (2003) have reported a similar finding, in that they observed similar mean total scores in a normal female sample and a sample of female prisoners. This issue definitely needs further examination. Second, at least two alternative explanations could account for the reduced responding in antisocial prisoners. One possibility is that personal names may be less significant for antisocial individuals. Another possibility is that the antisocial prisoners answered deceptively on the questionnaire about their personal names. Future research could resolve these issues by (a) assessing the significance of the personal names prior to the concealed information test or by using other variants

of the concealed information paradigm (e.g., mock crime), and (b) by checking the self-reported information through objective resources, such as file information.

Despite these limitations, two main conclusions emerge from the present data. First, orienting accounts for the concealed information effect in both undergraduates and prisoners. The present data therefore support the test theory (construct validity) of the concealed information test and provide evidence for its external validity. Second, our study also highlights the importance of assessing personality variables, such as psychopathic traits, which may moderate responding to concealed information.

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## GENERAL DISCUSSION

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The present dissertation empirically tested predictions resulting from the orienting theory on the Concealed Information Test. I will first summarize the results of the present research. Then, I will discuss the theoretical and applied implications of my research. Finally, I will mention the limitations of my dissertation and suggest directions for further research.

### Summary of results

Orienting theory has been proposed as the explanatory mechanism for responding to concealed information. Three main research questions were examined in this dissertation: (1) whether concealed information demands attention, (2) whether findings in the CIT can alternatively be explained by defensive responding, and (3) whether orienting to concealed information is moderated by psychopathy.

Chapter I describes three studies that examined whether concealed information demands attention. In line with predictions, more attention was allocated to concealed information, compared to unfamiliar non-relevant information and familiar non-relevant information. However, differences were small and not always significant. In Chapter II, it was examined whether the results could be strengthened, but this was not successful. Still, error-analysis replicated the basic finding of greater allocation of attention to concealed information compared to both unfamiliar non-relevant information and familiar non-relevant information. These results are in line with previous studies that found reaction-time slowing to concealed information (e.g., Gronau, Ben-Shakhar, & Cohen, in press). The most often used paradigm is the oddball task, in which participants are asked to make a speeded decision on whether stimuli are task-relevant (target) or not (irrelevant). Concealed information stimuli are also included, and participants are forced to classify them as irrelevant. Results consistently showed longer reaction-times to concealed information items compared to the irrelevant items (e.g., Seymour, Seifert, Shafto, & Mosmann, 2000). The results of Chapters I and II extend these findings. Reaction-time slowing in the oddball task could be explained by relevance-orienting, but also by stimulus-response conflict, relative novelty, and familiarity. The data described in Chapters I and II provide a more stringent test of the relevance-orienting hypothesis, and demonstrate that concealed information demands attention, due to its relevance.

No evidence for shifts in visual attention was found (Chapters I and II). Two more (unpublished) studies, in which I used a modified version of the Posner paradigm (cf. Koster, Crombez, Van Damme, De Houwer, & Verschuere, 2004), also failed to show effects of concealed information on visual attention. At first, this seems at odds with the orienting theory. However, the orienting reflex may



not be strictly related to visual attention (Harris, Pashler, & Coburn, 2004). Indeed, several studies have found a dissociation between reaction-time measures and physiological indicators of the orienting reflex. Niepel (2001), for example, presented participants with 30 auditory tones in a classic orienting paradigm. Novelty and surprise were independently manipulated. For half of the participants, the same tone was presented 30 times. For the other half of the participants, the pitch of the tone changed from trial 29 to trial 30. Surprise was manipulated by informing half of the participants of each condition that there would be a change from trial 29 to trial 30, whereas the remaining participants did not obtain this information. It appeared that skin conductance and heart rate were affected only by novelty. Reaction-time interference, on the other hand, was influenced by both novelty and surprise. Niepel conceived the physiological changes as components of the orienting reflex, and the reaction-time interference as an index of the emotion surprise. Using a Stroop-like task, Gronau et al. (2004) measured skin conductance orienting and slowing of reaction-times to personally significant words. When presented centrally, personally significant words elicited enhanced skin conductance responses and slowing of reaction-times. However, when words were presented peripherally, personally significant words still elicited longer reaction-times, but did no longer elicit an increase in skin conductance. Gronau et al. (2004) reasoned that the orienting response is related to higher-order executive functioning, rather than to visual attention per se. The data described in Chapters I and II are in line with this idea.

In Chapter III, I investigated whether the behavioural and physiological responses to concealed information could be explained in terms of defensive responding. It could be argued that polygraph questions are experienced as threatening and that a suspect will respond defensively to them. Both the behavioral (e.g., task interference) and the physiological responses (e.g., enhanced skin conductance responses) could, therefore, be considered correlates of the defensive reflex instead of the orienting reflex. Using a mock crime procedure, I investigated whether concealed information was accompanied by a decrease in heart rate, indicative of orienting, or by an increase in heart rate, indicative of defensive responding (Graham & Clifton, 1966). Additionally, skin conductance and reaction-times were measured. Concealed information elicited enhanced skin conductance responding, greater reaction-time slowing (not significantly), and a greater decline in heart rate compared to control information. These data are not

easily explained in terms of defensive responding, and indicate that orienting is responsible for responding to concealed information.

In Chapter IV, I examined whether autonomic responding to concealed information was moderated by psychopathy. Previous research has typically found reduced physiological responding in psychopathy. However, enhanced responding has also been observed sometimes (Raine, 1997). Arnett (1997) argued that psychopathy may be associated with reduced responding to threat, but increased responding to reward. Physiological responses during the CIT were measured in high and low psychopathic undergraduates under rewarding and threatening conditions. Replicating results of Chapter III, concealed information elicited enhanced skin conductance responding and a greater cardiac decline compared to concealed information. However, the relevant interaction effect between motivation and psychopathy was not significant. Methodological shortcomings might account for this null-finding. Sample size, for example, was restricted, and the motivation manipulation might have been unsuccessful (as indicated by the absence of a main motivation effect). Perhaps more importantly, group allocation might have been problematic for several reasons: test-retest reliability of the BIS Scale was moderate, the unidimensionality of the BAS Scales has been challenged (Ross, Millis, Bonebright, & Bailley, 2002), and the validity of the BIS/BAS Scales as a measure of psychopathy needs further evidence. Given these methodological shortcomings, no firm conclusions can be drawn from the research described in Chapter IV.

In Chapter V, I investigated the external validity of the findings reported in the previous chapters. I examined whether the orienting reflex drives responding to concealed information in a prison sample. Results showed that concealed information elicited enhanced orienting compared to control information, as indexed by measures of skin conductance, heart rate and respiration. Thus, orienting theory stands the test of falsification in both undergraduates and male offenders. Additionally, the moderating role of psychopathy was investigated. It was found that high antisocial prisoners exhibited reduced skin conductance responding. This finding is consistent with the results of two previous reports (Waid & Orne, 1979a, b), but not with others (Balloun & Holmes, 1979; Gudjonsson, 1982; Chapter IV). The present study, however, was the first to

investigate the role of psychopathy on physiological responding in the CIT using (1) a valid measure of psychopathy, (2) prison inmates, and (3) multiple response measures. These methodological adjustments strengthen the validity of the present findings. Further research is needed to clarify the nature and generalizability of these findings.

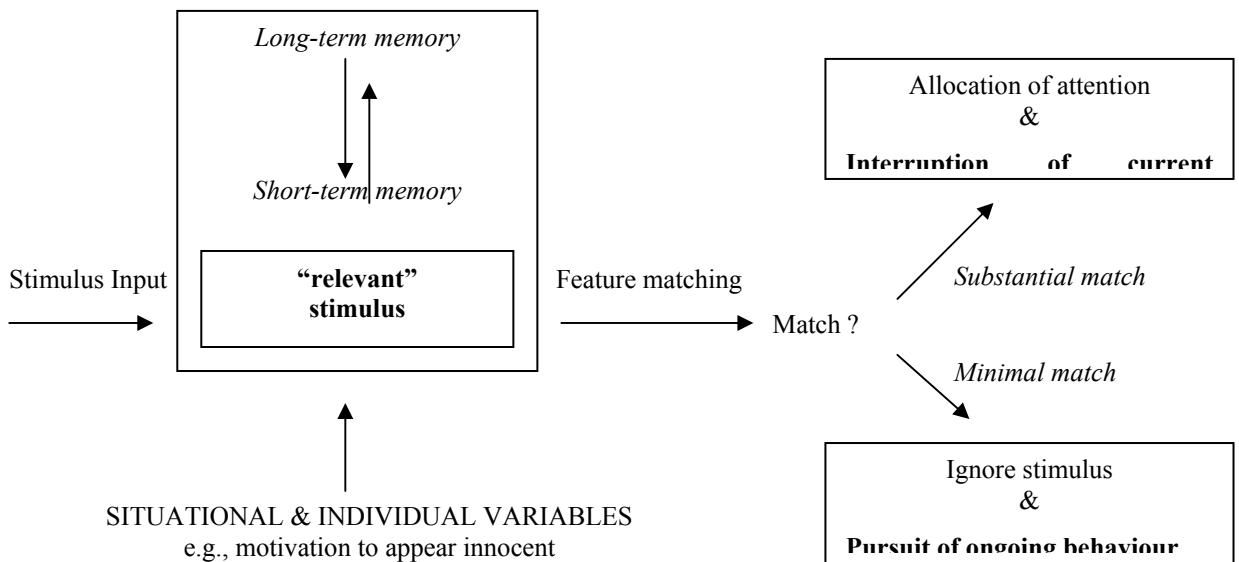
### **Theoretical Implications**

Ever since its introduction, the validity of the polygraph has been debated. Recently, the National Research Council (2003) examined the accuracy of polygraph tests in a review of 52 studies, encompassing more than 3000 polygraph tests. It was found that polygraph tests perform well above chance with a median accuracy index  $a$  of .86. This is considered good in psychology, medicine, and other sciences. Regarding the theoretical underpinning of polygraph tests, the National Research Council concluded that “polygraph research has failed to build and refine its theoretical base (...). As a consequence, the field has not accumulated knowledge over time or strengthened its scientific underpinnings in any significant manner (p 102)”. One could argue that this argument makes sense for the Control Question Technique, but I argue that this statement does not hold for the CIT. In contrast, half a century of empirical research, has provided accumulating and strengthening evidence for the theoretical underpinning of the CIT in the orienting theory.

The idea behind the CIT is simple and elegant. The perpetrator of a crime knows things about the crime, of which an innocent is unaware. When confronted with this crime information, only the guilty will recognize it and is likely to show a bodily response towards it. The advantage of the CIT on the CQT may not be a better ability to detect deception, but a strong theoretical underpinning. Emotional factors, such as feelings of guilt or fear, are often thought to explain polygraph efficacy. However, neither anxiety, guilt or fear are necessary factors to explain enhanced responding to concealed information (Ben-Shakhar & Furedy, 1990; see also Chapters II and IV). A cognitive account is, therefore, more likely to explain responsivity in the Concealed Information Test. An influential cognitive account was proposed by Lykken (1974), who argued that concealed information is more relevant than control information, and will, therefore, elicit a larger

orienting reflex. Building upon this account, I conceive relevance-orienting as the mediating mechanism in the CIT (see Figure 1). This simplified model is based upon the information processing view on orienting (Öhman, 1992) and the feature-matching approach formulated by Gati and Ben-Shakhar (1990).

Figure 1. *A simplified model on relevance-orienting to concealed information.*



Each answer in the CIT will be compared through feature-matching with the stimulus that has been primed in the short-term memory as relevant. If there is only a minimal match between the answer and the primed relevant stimulus, only a small reaction will be elicited that will undergo fast habituation. If, on the other hand, the match is substantial, ongoing behavior will be interrupted and attention allocated towards the orienting-eliciting answer. The CIT measures the behavioral and physiological components of the process of stimulus detection, feature-matching, interruption of behavior and attention allocation.

Based upon a review of the literature and the research presented in this dissertation, I will now discuss the evidence for this account. First, concealed information is accompanied by the same physiological and behavioral changes as the orienting reflex. Thus, the orienting account can explain why, compared to control information, concealed information elicits greater skin conductance responses (Lykken, 1959), greater cardiac deceleration (see Chapters III, IV, and V), greater pupil dilation (Lubow & Fein, 1996), a larger p300 (Rosenfeld, Cantwell, Nasman, Wojdacz, Ivanov, & Mazzeri, 1988), greater reaction-time interference (see Chapters I and II), greater respiratory suppression (see Chapter V), and greater peripheral vasoconstriction (Elaad & Ben-Shakhar, 2004). I have argued that these measures can be usefully integrated within an orienting framework (Chapter I). At present, it remains unclear which part of the orienting process is exactly measured by the different indicators. For example, reaction-time interference could be due to the interruption of behavior or to the allocation of attention (Meyer, Niepel, Rudolph, & Schützwohl, 1991). The p300 occurs at an earlier stage, perhaps at the outcome of the feature-matching process (Dien, Spencer, & Donchin, 2004), but again this remains speculative. Distinguishing these components has mainly theoretical implications, and does not have any direct impact on the CIT. Second, the orienting reflex to a stimulus is known to generalize to similar stimuli (generalization), and to diminish with repeated presentation (habituation). Both defining characteristics have been demonstrated in research on the CIT (Ben-Shakhar, Frost, Gati, & Kresh, 1996). Third, concealed information draws attention, as indexed by enhanced memory (e.g., Iacono, Boisvenu, & Fleming, 1984), and by reaction-time slowing on a secondary task (see Chapters I and II). Moreover, these findings are due to the relevance of concealed information, not mere familiarity (see Chapters I and II). Taken together, empirical evidence provides firm support for the orienting account of the CIT.

The review by Ben-Shakhar and Elaad (2003) has shown that factors, other than orienting, can also contribute to responding. Specifically, the motivation to beat the test, and overtly denying knowledge influence physiological responding. One possibility, then, is that these factors uniquely and independently produce enhanced physiological reactions. Thus, the “motivation impairment effect” states that the harder people try to deceive, the easier they are caught (Burgoon, 2000). The effect of deception could be explained by emotional factors (Davis, 1961), or

by inhibitory processes (Pennebaker & Chew, 1985). These findings can, however, also be integrated within the orienting theory. Indeed, any manipulation that increases the relevance of the concealed information items, increases the magnitude of the orienting reflex (Ben-Shakhar & Elaad, 2003). Clearly, the relevance of concealed information increases by raising the stakes, and by instructing the participant to overtly answer deceptively. Thus, deception and motivation can be conceived as moderating variables, operating through the orienting reflex. The finding that the mock crime and the autobiographical information procedure produce stronger effects than the code word paradigm and the card test, can also be interpreted in this way (Ben-Shakhar & Elaad, 2003). Empirical research could determine whether these factors operate through the orienting mechanism.

Empirical evidence converges upon the idea that physiological and behavioral response to concealed information are components of the orienting response, and not the defensive reflex. The differentiation between orienting and defense may, however, not be as sharp as one would think. Orienting and defense have been argued to differ in their behavioral and physiological correlates, and in the kind of stimuli that elicits them. Both criteria need some qualification. First, orienting and defense share several response components (e.g., skin conductance, EEG desynchronisation, peripheral vasoconstriction; Graham, 1979), and other components have been much debated (e.g., cephalic vasomotor responding; Sokolov, Spinks, Näätänen, & Lyytinen, 2002; Turpin, 1986). The cardiac measure used in Chapters III through V, has, however, been generally accepted as a valid criterion to distinguish orienting from defensive activation (Graham, 1979; Graham & Clifton, 1966; Turpin, 1986; but see Barry & Maltzman, 1985). Second, much research on the eliciting factors of orienting and defense has been done by varying the intensity of otherwise meaningless tones. In line with the orienting theory, it was found that mild tones (<90dB) elicit orienting, and intense tones (>90dB) eliciting defensive activation (Turpin, 1986). These findings should be corroborated by research using meaningful stimuli, before results can be safely generalized to physiological responding during polygraph examinations. Picture viewing has been proposed as a research paradigm to measure physiological and behavioural reactions to meaningful stimuli (Lang, Greenwald, Bradley, & Hamm, 1993). It has been shown that, in normal individuals, highly

aversive pictures (e.g., a mutilated body) elicit a decline in heart rate (Lang et al., 1993). Thus, the orienting reflex is not confined to neutral and pleasant stimuli. In order to explain these findings, Lang, Bradley and Cuthbert (1997) have proposed that defensive activation involves stages of responding, with a transition from attentive orienting to action with increasing aversive motivation. When threat level is low, unpleasant stimuli elicit orienting (i.e., cardiac deceleration). The magnitude of this orienting reflex increases with augmented threat (i.e., pronounced cardiac deceleration), but will transit into defensive activation at very high threat levels (i.e., cardiac acceleration). Because pictures do not pose real threat, they elicit orienting rather than defense in normal individuals. High fearful individuals, experiencing real fear when looking at threatening pictures, respond with cardiac acceleration to pictures of their phobic object (Frederikson, 1981). In sum, cardiac changes to affective pictures are consistent with the earlier work that used neutral tones. differentiation between orienting

From the defense cascade model, it could be predicted that concealed information elicits defensive action in some (e.g., high anxious) individuals or (e.g., high threatening) situations. Although the topic needs further examination, the available evidence suggests that anxiety does not have a large impact on the CIT (Ben-Shakhar & Furedy, 1990). Comparing physiological responding to concealed information obtained in laboratory and field settings could determine whether attentive orienting shifts to defensive action with increasing threat. Recently, Pollina, Dollins, Senter, Krapohl, and Tyan (2004) have compared physiological responding during the Control Question Technique in laboratory and field setting. The increase in blood pressure observed in the field, was not found in the laboratory data. The authors interpreted this finding as evidencing that different physiological mechanisms drive responding in the laboratory (orienting) and the field (defensive reflex). However, this difference was not statistically significant, and it remains to be demonstrated whether such differences occur with the CIT. Field observations of cardiac deceleration to concealed information (Nakayama, personal communication, July 2004; Elaad, personal communication, October 2004), suggest that orienting drives the CIT, also in highly threatening field settings. Alternatively, additional mechanisms could be involved in field examinations. Suzuki, Nakayama, and Furedy (2004), for example, noted that respiratory apnea to concealed information is often observed in field examinations, but not in the laboratory. This respiratory apnea is

assumed to reflect an additional “emotional factor”. It remains to be demonstrated empirically that such a factor exists, and occurs only during field examinations. Furthermore, several studies suggest that the respiratory apnea may be integrated within the orienting framework. Barry (1977), for example, suggested that the respiratory pause is a component of the orienting reflex, and Stekelenburg and Van Boxtel (2001) have identified respiratory suppression as an index of orienting.

### **Applied Implications**

Based upon the orienting explanation of the concealed information effect, several implications for practical use can be formulated. First, I will discuss the impact of orienting theory for setting up a good CIT. I will discuss how items should be selected, and point to the implications of generalization and habituation. Second, I will discuss the implications for using the CIT as a forensic tool.

Regarding the selection of appropriate concealed information items, it is important to assure that the concealed information is likely to be noted, encoded, stored and remembered by the culprit. Minor or irrelevant details (e.g., the name of the shop where the cash register was stolen) are not good test items, because chances are that the perpetrator did not notice or may have forgotten. Information related to planned action for the crime, on the other hand, are good test items (Nakayama, 2002). Bradley, MacLaren, and Carle (1996) have demonstrated that the use of such “action items” can enhance the sensitivity of the CIT. Thus, concealed information should be maximally relevant. At the same time, this information should not have greater relevance for the innocent. This could be accomplished by preventing leakage of concealed information to the innocent by the media or by prior interrogations. Furthermore, using a Doob and Kirshenbaum (1973) procedure, it could be checked whether all alternatives are truly homogeneous for the innocent. Prior to the actual polygraph examinations, a pilot study can be run in which the alternatives are presented to a group of innocent subjects and asking them to guess the correct alternative. Items that are guessed above chance level should not be included in the actual test. In order to further protect the innocent, the actual test items can be discussed with the



suspect (Hira & Furumitsu, 2002). Items that are in some way relevant to the suspect should be excluded.

Polygraph examiners need to pay attention to the mechanism of generalization in two ways. As noted by Nakayama (2002), concealed information should be clearly distinguishable from the control information in order to avoid generalization of responding. So, it is unwise to ask the suspect whether the stolen painting was a Monet, a Picasso, a Dali, a Miro or a Kaminsky. A better alternative would be to ask whether the stolen good was a painting, a golden ring, a laptop, a sum of money or a credit card. An advantage of generalization, is that the critical item does not need to be exactly the same as the crime information that is stored in the brain of the culprit. If the test item shares sufficient features with the crime information, it will elicit relevance-orienting. For example, the description of the murder weapon using the label “handgun” is likely to elicit orienting, even though the actual weapon was a “revolver”. Through the process of generalization, verbal descriptions as well as photographic representation can be used.

The strength of the orienting response is known to diminish through repeated presentations. Several implications follow from the principle of habituation. First, repeated testing should be avoided, because habituation increases the chances of a false negative outcome. In criminal investigations, repeated testing occurs (e.g., because of disputed test results). Second, multiple questions are preferred above repeating a single question. Ben-Shakhar and Elaad (2002) demonstrated that the accuracy index  $a$  was .79 when 1 question was repeated 12 times, compared to .99 when 12 different questions were presented each once. However, this is no argument to include as much items as possible, because this will inflate the chance that some items will not be recognized by the perpetrator. An optimal test would therefore probably include around 5 questions, each containing 5 alternatives (Iacono et al., 1984). Third, the interval between the crime and the actual polygraph tests should be minimized. Field examinations typically have relative long crime-test intervals. For example, the mean interval in 271 Japanese field cases was 148 days ( $SD = 374$  days), ranging from 0 to 3101 days (Hirota, personal communication, July 2004). Habituation (and forgetting) is likely to occur during the crime-test interval. It could be argued that habituation is reduced by priming the relevance of the information in the context of the criminal

investigation, but this should be examined empirically. Fourth, it has been argued that discussing the polygraph questions with the examinee prior to the examination is problematic as it is likely to lead to habituation (National Research Council, 2003). Hira and Furumitsu (2002) on the other hand, argued that previewing the questions might diminish novelty orienting, but is likely to maximize discrimination between crime and control information, thus enhancing relevance-orienting to concealed information. No critical test has been performed to test these opposing predictions.

It is well known that physiological responding, including orienting, can vary strongly between individuals. Research has shown that the same stimuli can elicit (1) no, or (2) moderated responding in different individuals. First, whereas most individuals display skin conductance orienting to mild stimuli, this response is typically absent in around 5-15% of non-clinical participants (e.g., O’Gorman, 1990). In clinical samples this proportion of non-responders may be seriously elevated. Schnur, Bernstein, Yeager, Schmitt, and Bernstein (1995), for example, reported percentages of non-responders as high as 39-78% in specific samples of depressed or schizophrenic patients. One possible solution for concealed information polygraph testing might be to use several response measures. This solution may not be entirely satisfying, because the study of Schnur et al. (1995) also demonstrated high correlation of non-responding in different response measures of orienting. It is, therefore, advisable to assess responding in several response measures prior to the examination with the CIT. This diagnostic phase should include relevant, rather than neutral stimuli. For example, emotional pictures, which are known to elicit relevance-orienting (Lang et al., 1997), could be used. Second, it is well known that the magnitude of orienting can vary strongly between individuals. It is, therefore, advisable to work with range-corrected (Ben-Shakhar, 1985) rather than raw scores in polygraph tests. This has already been implemented in computerized scoring systems. However, the suggested solutions (i.e., pre-polygraph assessment of physiological reactivity and range-correction) may not be entirely satisfying, and it is therefore advisable to give more weight to a positive outcome than to a negative outcome. Although this topic needs further examination, the available evidence suggests that anxiety does not have a large impact on the CIT (Ben-Shakhar & Furedy, 1990).

I recommend computerized presentation of the CIT. This would further enhance standardization of the test, and reduces the - potentially biased - impact of the polygraph examiner (Elaad, 1997). When verbally presenting questions, examiners might (un-)intentionally put more emphasis on certain items thereby manipulating their relevance. Another possibility would be to question the examinee by an examiner who is naïve with respect to the correct items. Manipulating the knowledge of the examiner, Elaad (1997) found that naïve examiners obtained higher detection efficiency compared to informed examiners. Still, this “blind” presentation may be influenced by the examiners conviction of the correctness of the answers. Indeed, experimenters might influence test results without the intention do so (Harris & Rosenthal, 1985). Furthermore, computerized scoring is advisable to enhance standardization and reliability. Research that compared human with computerized scoring has shown that “the formula is better than the head” (p. 495; Szucko & Kleinmuntz, 1981).

Practical and theoretical reasons argue against screening large populations with polygraph tests. However, as an indirect memory test, the CIT seems a valuable tool with regard to specific-incident testing. Most importantly, crime suspects can be assessed about recognition of crime knowledge (for other applications see Allen & Movius, 2000; Bauer, 1984; MacLaren, 2001; Verfaellie, Bauer, & Bowers, 1991). Taking into account the considerations above, a well-designed test can provide an accurate judgment on whether a suspect has secret knowledge about a crime. Japanese police polygraphers perform about 5000 CITs per annum in a wide range of cases, such as murder, arson, burglary, kidnapping, and hold-ups (Nakayama, 2002).

Some important restrictions of the CIT should be mentioned. First, the test can only determine whether someone possesses crime knowledge, not how the knowledge was acquired. Whether this was through actual committing the crime or through witnessing the crime, is a matter for further police investigation. Second, the CIT is not always applicable in criminal investigations. In particular, several critics of the CIT – usually proponents of the Control Question Technique – have argued that it is very difficult to develop sufficient concealed information items in the field. Certain details may have been unnoticed or forgotten by the guilty suspect. More problematic, the innocent suspect might have been informed on some crime details through prior police investigators, attorneys, or the media.

The mean number of concealed information items in published field research was indeed low (2 and 1.8 in Elaad, 1990, and Elaad, Ginton, & Jungman 1992, respectively). Podlesny (2003) estimated the number of useful concealed information items in a sample of 758 FBI polygraph examinations. Useful items were found in 10.8% of the cases, and only in 3.3% of the cases 5 or more useful items were found. The most important reason for the failure to find useful items was that the examinee had legitimate reasons to have crime knowledge (37.1%). In 20.1% of the cases, the crime details needed to be verified by the crime suspect. In 11.9%, suspicion was based only upon allegations and no factual crime details were present. Sometimes (3.8%), the examinee admitted involvement but denied intention to commit a crime. This estimate may well be an underestimation due to selective case sampling, i.e., FBI investigations in which a Control Question Technique was used. In sum, the applicability of the CIT because it requires that several conditions are fulfilled. Still, Japanese praxis (5000 tests/year) illustrates that the test can be of use in many cases.

In sum, the CIT is a standardized and uncontested polygraph test with an accuracy well above chance. Although its applicability may be restricted, it is an interesting forensic tool. The polygraph test is an interrogation method that may guide police officers in their investigation. Reports of polygraph tests should acknowledge that the accuracy is far from perfect, and that no polygraph test is immune to countermeasures.

### **General Limitations**

There is a number of limitations to the current dissertation. First, research in Chapters I through IV was conducted in undergraduates. This population is expected to differ from the target population in several important ways, amongst which age, sex, socioeconomic status and personality. It remains to be tested whether the findings generalize to the target population. The research described in Chapter V provided evidence for the external validity of the findings, but should be corroborated by data from properly matched control groups.

Second, alternative explanations should be formulated and tested. Most importantly, the defensive reflex needs further investigation. The cardiac data obtained in Chapters III through V seem to refute the defensive reflex hypothesis. Perez, Fernandez, Vila, and Turpin (1997), however, have argued that the cardiac component of the defensive reflex to high intense physical stimuli consists of alternating decelerating and accelerating components, and that the accelerating component might have a long latency (>30s). This research used intense physical stimuli (e.g., a 109dB tone), and the results may not generalize to affect-laden stimuli. Thus, follow-up research should (1) measure cardiac change for a longer time period, and (2) include additional parameters (e.g., vasomotor responses) that might help to differentiate between the orienting reflex and the defensive reflex.

Third, psychopathic traits was assessed using self-report measures (see Chapters IV and V), which may be distorted by response tendencies such as social desirability. The validity of the BIS/BAS Scales (Carver & White, 1994), which were used in Chapter IV, as a measure of psychopathy needs further investigation. Cumulating evidence subscribes the validity of the Psychopathic Personality Inventory (Lilienfeld & Andrews, 1996). The best-validated instrument of psychopathy to date, however, is the Psychopathy Checklist - Revised (PCL-R; Hare, 2004). The PCL-R consists of 20 items, encompassing affective, interpersonal, and behavioral aspects of psychopathy. Items are scored on their presence, based upon a lengthy interview and inspection of objective file information. Empirical research has confirmed the reliability, validity and predictive power of the PCL-R. The main shortcoming of the PCL-R is its restricted applicability: it is very time consuming, and the necessary collateral information is not always available. Despite good reasons to use the Psychopathic Personality Inventory, it seems worthwhile to use the Psychopathy Checklist when examining the effect of psychopathy on the CIT.

### **Directions for future research**

Many important research topics in the field of psychophysiological detection of deception can be formulated. I refer the interested reader to the report of the National Research Council (2003) for detailed suggestions on validity research.

Here, I restrict my discussion to new research avenues that directly follow from orienting theory on concealed information.

Several studies have investigated behavioral responding to concealed information using a wide variety of reaction-time tasks, among which the modified Stroop task, the dot probe task, the oddball task, the lexical decision task, and the secondary reaction-time task (see Chapters I and II). Overall, it was found that concealed information elicited slower reaction-times and/or more errors compared to control information. However, several questions both at the theoretical as well as at the applied level remain unanswered. At an applied level, it is important to note that several studies indicate that reaction-times are less sensitive than physiological measures (e.g., Chapter III; Gronau et al., 2004). However, it seems premature to discard reaction-times as an index of concealed information, because the results with the oddball task form an exception to these findings. In this research, reaction times have been shown to perform at or even above the level of evoked potentials (e.g., Allen, Iacono, & Danielson, 1992). The incremental validity of reaction-times on physiological measures of concealed information is an important research avenue. Furthermore, at a theoretical level the association between visual attention and the orienting reflex merits further investigation. The combined measurement of reaction-times and physiological components of the orienting reflex seems a promising project. The study by Harrison and Turpin (2003) demonstrates how this can be accomplished in cognitive paradigms such as the dot probe task or the exogene cueing task.

The amplitude and occurrence of orienting reflexes vary in different individuals. Electrodermal labile individuals, for example, are characterized by large and spontaneous changes in electrodermal activity. Furthermore, a number of individuals do not show orienting responses (O’Gorman, 1990). Only few studies have examined the impact of such factors on the accuracy of the CIT. It seems worthwhile to examine their effect more closely. Other personality factors, that are known or theorized to correlate with the magnitude of the orienting reflex, should also be examined. Novelty seeking, sensation seeking, and behavioral activation, for example, are argued to be associated with enhanced orienting (e.g., Neary & Zuckerman, 1976). Evidently, research on individual differences has great implications for applied purposes. Personality factors that have great

influence on physiological responding should be assessed in the pre-polygraph psychological and psychophysiological assessment.

If orienting drives physiological responding to concealed information, response measures that are connected with orienting might be useful as indices of concealed information. A number of these measures have already been used, but many others remain unexplored. For example, Sokolov (1963) has argued that the main function of the orienting reflex is to enhance stimulus intake. At a cognitive level, this is accomplished by allocating attention to the orienting-eliciting stimulus. At the physiological level, orienting is, among others, associated with cardiac, respiratory and pericranial inhibition (Stekelenburg & Van Boxtel, 2001), postural adjustments and eye movements towards the orienting-eliciting stimuli, and possibly lowering of the sensory threshold. Cardiac and respiratory suppression have already been demonstrated to co-occur with concealed information (see Chapter V), but pericranial inhibition is yet uninvestigated. Stekelenburg and Van Boxtel (2001) presented participants with unannounced environmental sounds (e.g., human talk) while measuring cardiac change, respiration, and electromyographic (EMG) activity of specified facial muscles. As expected, the sounds elicited orienting, indicated by cardiac deceleration and respiratory suppression. Moreover, inhibition of EMG activity was found in the masticatory and lower facial muscles. Thus, it could be investigated whether concealed information also leads to enhanced facial EMG inhibition. With decreasing technological complexity, eye movements, might also provide an interesting new index for the detection of concealed information. No research to date has found a clear effect of concealed information on visual attention. These studies, however, have all used reaction-time tasks. Registration of eye movements could provide a more direct, naturalistic and detailed indication of visual attention (Mogg, Miller, & Bradley, 2000). Changes in postural adjustment could be measured by videotaping the participant during the examination, or by a pressure plate. The study by Hillman, Rosengren, and Smith (2004) illustrates how this measure could be implemented in the CIT. While standing on a pressure plate, participants were presented with affective slides. It was found that, relative to men, women displayed greater movement away from negative pictures, which was taken as evidence for a greater defensive responding tendency in females. This study illustrates that postural adjustment, as measured by the pressure plate, is sensitive to the affective dimension of stimuli. Using this device in a CIT could

reveal whether concealed and control information elicit approach (as predicted by orienting theory) or withdrawal (as predicted by defensive responding) tendencies.

Substantial evidence legitimates the use of the CIT for specific-incident testing. As mentioned above, more field research is needed to assess the criterion validity in applied settings and to compare the data obtained in the laboratory and the field. Another important issue concerns the efficacy of countermeasures. Countermeasures are everything the examinee does in trying to alter the polygraph test outcome (Honts, 2002). Usually, a distinction is made between global and specific countermeasures, which can be further classified into physical and mental countermeasures. Global or general state countermeasures have an effect on the general condition of the examinee. Taking drugs is an example of a physical global countermeasure, and yoga is an example of mental global countermeasures. When using specific countermeasures, the examinee tries to affect physiological responding to certain questions. The examinee might, for example, bite his/her tongue (physical specific countermeasure) in order to enhance responding on the control questions. Trying to inhibit responding to concealed information, for example by trying to think of something else (mental specific countermeasure), is another manipulation technique. With few exceptions (e.g., Waid, Orne, Cook, & Orne, 1981), research has shown that global countermeasures do not reduce the accuracy of the CIT (for a review see Honts, 2002). Several studies have, however, demonstrated that specific countermeasures reduce the accuracy of the CIT (e.g., Honts, Raskin, & Kircher, 1994). Several solutions have been proposed: using counter-countermeasures (see Honts, 2002), introducing an additional task during the polygraph test (e.g., Ben-Shakhar, Gronau, & Elaad, 1999), using new or a combination of response measures (e.g., Rosenfeld, Soskins, Bosh, & Ryan, 2004; Seymour et al., 2000), and specialized statistical analyses (Honts et al., 1994). At present, their effectiveness in reducing or eliminating the effect of countermeasures is uncertain. Thus, this is an important topic for further investigation.

To summarize, orienting theory provides a theoretical framework for the CIT. This theory is well developed and stands the test of falsification. Together with previous reports on the accuracy of the test, these findings suggest that the CIT



can be a useful forensic tool for criminal investigations. Furthermore, orienting theory provides several new and exciting questions that may progress our understanding of the orienting reflex and the processes involved in physiological detection of deception.

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