BABEȘ-BOLYAI UNIVERSITY CLUJ-NAPOCA, ROMANIA
Faculty of Psychology and Educational Sciences
Department of Psychology

Ph.D. Thesis

Memory detection: Examining deceptive behavior and the role of individual differences in executive functioning

-ABSTRACT-

Ph.D. student: Mihai Varga

Scientific supervisor: Prof. Univ. Dr. Mircea Miclea

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Abstract

Chapter 1

GENERAL INTRODUCTION AND THESIS OVERVIEW

1.1. Introduction

Across most cultures, truth is regarded as highly valuable. However, because telling the whole truth does not always offer advantages in everyday life, deception is much more frequent in our lives than most people generally believe. Lying is a prevalent feature of human behavior, which may be expressed in a variety of forms and situations. The research on deception is exciting and emotionally engaging, “because human relationships and the human condition can rise or fall depending upon whether key actors adopt truthful or deceptive strategies when they navigate life situations” (Bond, 2012, p. 1).

After many previous attempts to develop an operational definition of deception (for a review, see Vrij, 2008), researchers argued that it is*“a successful or unsuccessful deliberate attempt, without forewarning, to create in another a belief which the communicator considers to be untrue”* (Vrij, 2008, p. 15). This definition may seem broad, but it successfully integrates most types of deception, such as exaggeration (Tyler, Feldman & Reichert, 2006), presenting truthful information in a misleading manner (Vrij, 2008), concealing information (Metts, 1989) and outright falsifications (DePaulo, Kashy, Kirkendol, Wyer & Epstein, 1996; Ekman, 1997). The process of concealing information is the focus of the investigation in the present thesis.The frequent use of deception in social contexts is associated with a growing desire to detect it. Perhaps the main difficulty is that there are no verbal, nonverbal or physiological cues uniquely associated with deception. For example, a comprehensive meta-analysis conducted by DePaulo et al. (2003) examined 158 behavioral cues from the deception literature and failed to support the existence of the majority of these as cues to deceit. In other words, the equivalent of Pinocchio’s growing nose does not exist.

It is of particular interest to forensic science to advance in the understanding of memory processes that underlie suspects’ knowledge with regards to crime-related information. Guilty suspects are unique in comparison to innocent suspects, because they possess such critical knowledge about the crime. Only they can recognize the crime-scene items when they are confronted with them and respond accordingly. Instead of relying on suspects feeling aroused or anxious when deceptively answering to crime-related questions, examiners might assess the recognition of crime-relevant information. When the test is properly designed, the knowledgeable (guilty) suspect is the only one who can differentiate the probe from the incorrect items.The method designed to detect concealed knowledge was traditionally named the Guilty Knowledge Test (GKT, Lykken, 1959), but more recently it has been referred to as the Concealed Information Test (CIT; see Verschuere et al., 2011).

Recently, Verschuere and Ben-Shakhar (2011) reviewed the main theoretical approaches proposed to account for the underlying mechanisms of concealed information detection.As previously explained, the critical information regarding the crime details can elicit behavioral and physiological responses in guilty suspects. It has been argued that these responses are most likely to be explained by cognitive, rather than emotional factors (Ben-Shakhar & Furedy, 1990). The main theoretical account for the enhanced reactions to the critical information is structured around the construct known as the orienting response (OR, Sokolov, 1963). During a CIT, 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 response is elicited. This will interrupt the ongoing behavior and attention will be allocated to the relevant information, resulting in impaired performance on a secondary task (Verschuere, 2005).

The validity of additional measures that can be incorporated into the CIT may also be important.Several behavioral measures can be used for detecting concealed information with the CIT. Seymour et al. (2000) were the first to examine whether concealed information can be detected using only RTs, without concurrent ERP recordings. It has been found that RT measures can be reliable indicators of guilty knowledge (RTs were slowest for guilty-probe responses). This version of the test is now known as the RT-based CIT (Verschuere et al., 2010). In this procedure, the subject is required to give speeded responses to three types of items: probes, targets, and irrelevants. Probe items are selected from the crime itself and are supposed to represent relevant details of the crime; the irrelevant items share a variable degree of categorical similarity with the relevant items, and are usually several times more numerous. The deceptive participant denies recognition of both irrelevant and probe items. Target items (explicitly learned and recognized as such) are used in order to prevent the subject from entering an automatic mode of responding; they also share categorical similarity with the other two types of items. Several studies have suggested that this procedure can successfully differentiate between truthful and deceptive responses, supporting the validity of the RT-based CIT (see Verschuere and De Houwer, 2011).

Although behavioral cues to deception are important, past research on concealed information detection has largely overlooked the cognitive processes involved in producing deceptive behavior. Recently it has been argued that focusing on basic cognitive mechanisms and strategies would be an essential step in the development of deception research (Bond, 2012) and in improving the existing deception detection techniques. Most of the scientific literature implies that deception is associated with greater cognitive effort than truthful responses. When deceiving, one has to coordinate several cognitive demanding tasks: to select a response that is incompatible (i.e., conflicts) with the truth, to suppress a recurring awareness of the truthful information, to compile alternatives, while maintaining the consistency of the lie, to monitor personal behavior and the reaction of the audience to the deception (Vrij, 2000; Gombos, 2006). These actions rely on many cognitive mechanisms, such as: inhibition, working memory, and cognitive flexibility. In the literature, these mechanisms have been generally covered under the umbrella term of *executive processes* or *executive functions* (EFs).

The Activation-Decision-Construction Model (ADCM, Walczyk et al, 2003) claims that following a question, relevant information (in particular, the truth) is automatically activated in long-term memory. This information is then made consciously available in working memory. In order to respond to a question deceptively, cognitive resources are required to monitor and organize the deceptive response. Similarly, the Working Model of Deception (WMD, Vendemia et al, 2009) highlights the role of executive processes in responding to a question deceptively.

1.2. Thesis overview

Considering the possible scientific gains of an individual differences approach in executive functions and their relation to concealing information, the present thesis will follow this line of research. Given that deception is a complex cognitive act, such different mechanisms are likely to interact with each other. The theoretical positions which convincingly argue for the involvement of executive functions in deceptive behavior need to be empirically tested. Thus the first major aim of the current thesis is to investigate the relation between individual differences in executive functioning and deceptive behavior. Second, we wanted to provide further validation of the RT-based CIT by sequencing and examining its outcomes, both in terms of dynamics deceptive responses and the residual costs incurred by stimuli on the immediately following responses. Third, we engaged in the pursuit to enhance the detection efficiency of the CIT by increasing executive load. Finally, we explored whether the introduction of emotional stimuli in the CIT would have a differential impact on responses to crime-relevant versus irrelevant items.

Chapter 2

SEQUENCING THE RT-BASED CIT: CONTRIBUTIONS FROM INDIVIDUAL DIFFERENCES IN WORKING MEMORY AND PROCESSING SPEED

2.1. Introduction

Despite the extensive body of research intended to elicit reliable cues of deception (DePaulo et al., 2003; Vrij, 2008), only a few studies have so far investigated the temporal dynamics of deceptive communication (Burgoon & Qin, 2006). By adding a temporal dimension to the designs commonly used in deception research, a deeper understanding of the cognitive dynamics of deceptive behavior can be reached. For example, past research targeting verbal deception indicators found inconsistent patterns, possibly due to failure to consider the dynamic nature of interpersonal deception (Burgoon & Qin, 2006). In a study focusing on verbal and nonverbal indicators of deception, Granhag and Stromwall (2002) measured the parameters displayed by deceivers and truth tellers across three repeated interrogations and found temporal changes in nonverbal behaviors.Across repeated interrogations, the liars' behavior also became increasingly over controlled. Considering this dynamic nature of real-life deceptive communication, it has been argued that "if deceptive behavior fluctuates rather than remaining stable over the course of an interaction, then much of what has been written about verbal or nonverbal indicators of deception may be inaccurate" (Burgoon & Qin, 2006, p. 77). A first step, before analyzing the dynamics of the multiple parameters involved in realistic deception settings, would be to verify whether such indicators (accuracy, speed) also change across time in simpler, more controlled experimental settings. This would require a specific focus on the temporal unfolding of successive deceptive versus truthful responses, without taking into account the complexities inherent in dyadic interactions, which involve a constant modulation of the deceivers' responses according to the feedback received from the audience (Burgoon, Buller, Floyd, 1996).

Bond(2012) suggested that at least two of the basic mechanisms directly and specifically relate to the experience of 'cognitive load' in deception, a term which became popular in this field of research. Specifically, Bond (2012) suggested that working memory (WM) and speed of processing are two key mechanisms that would be used when producing deceptive communication, and should therefore be examined separately and in interaction. Processing speed and working memory have received considerable interest and support as underpinnings of cognitively demanding performance outcomes. Furthermore, Kyllonen and Christal (1990) argued that individual differences effects on cognitive tasks arise from (a) the type and extent of knowledge (declarative and procedural – e.g. crime-relevant information acquired during the mock crime), (b) working memory capacity and (c) the speed with which one can execute the processing cycles. Given that deception is a complex cognitive task, such mechanisms are most likely to be integrated.

Basic individual differences in the speed of processing were so far omitted as a possible variable related to successful deception in the CIT, although it is well documented that the rate at which people process information appears to influence many aspects of cognition (Cepeda, Blackwell, and Munakata, 2013).

2.2. The current study

As noted, little empirical research has examined how initial responses on a task requiring subjects to conceal information differ (in terms of speed and accuracy) from later responses provided by the same subject. Thus, we wanted to *explore the temporal fluctuations of responses to crime-relevant versus irrelevant items, in a sequenced RT-CIT*.

Second, we analyzed the possibility of *residual costs* for the following response incurred by responses to probes, compared to truthful responses.

A final aim of the present study was to *investigate the relation between individual differences in speed of processing, working memory and deceptive behavior.* More specifically, we wanted to explore whether individual advantages in these cognitive processes would be translated in a lower detection efficiency.

2.3. Method

2.3.1. Participants and Procedure

Participants (N = 96, 80 females; mean age 21.2 ± 3.6 years) were recruited from psychology undergraduate courses. Due to a technical failure, data from four participants were discarded from the analysis. Participants received the mock crime instructions, memorized the critical items (i.e. probes) and executed the assignment. After performing the mock crime, they completed a filler task for approximately 15 minutes, and then they were asked to learn the target items. Afterwards they were assessed with the RT-based CIT, followed by the speed of processing and working memory tasks.

2.3.2. Mock Crime

The procedure and all the relevant details of the mock crime were specified in the written instructions. Each participant had to access the personal office of a research assistant responsible for an upcoming exam. Upon entering the office using a *key*, he/she had to search for a *memory stick* on which to copy the exam questions. In order to log into the computer, a password had to be used and the participants looked it up in an agendafound on the professor's desk. After they copied the exam questions onto the memory stick, they put it into a *laptop bag*. Participants were instructed to steal another three objects from the desk: a *mobile phone*, *a wireless mouse* and the *agenda*. Subjects read the written instructions twice and were instructed to memorize the six critical items (i.e. the probes). To increase the realism and the pressure of the scenario, they were also instructed to be fast and avoid being caught. Moreover, the testing scenario took place in a formal office in the Faculty's main building, during office hours. After completing the mock crime, participants returned to the first room and were asked to describe the physical characteristics of each stolen item in order to ensure a better encoding. Following the mock crime, a *Stop-Signal* inhibition *Task* (Logan, 1994) was used as a filler task, lasting for about 15 minutes. This data was not further analyzed.

2.3.3. Reaction Time-based Concealed Information Test

Following the filler task, each participant received written instructions to learn six items (i.e. *targets items*) that were from the same category with the probes. Each of the six targets was presented on a computer screen for 10 seconds and the sequence was repeated three times. Participants had to memorize the physical characteristics of each item in order to reproduce them later. To ensure a good retention of the target items, a verbal recall was performed. Subsequently, each participant received written instructions explaining that they were suspects of a theft and that they will undergo a behavioral test designed to assess their involvement in the crime. The items used in the CIT procedures were pictures belonging to three categories of items: *probes* (the six critical items stolen in the mock crime - the key, the laptop bag, the mobile phone, the wireless mouse, the agenda, and the memory stick), *targets* (six previously learnt items from the same category as the probes) and *irrelevants* (four items from the same category as each probe, resulting in a total of 24 items not previously encountered during the experiment).Subjects were instructed to respond "Yes" to targets and "No" to any other item (including probe items) by pressing the corresponding keys with their index fingers (two keyboard buttons were indicated for positive and negative answers). Answers had to be given as quickly as possible. There were three blocks, consisting of 72 trials per block (12 probes, 12 targets, 48 irrelevants). Items were presented in a randomized order.

In addition, the processing speed was assessed with the*Simple Reaction Time (SRT) task*, following the procedure used by Albinet et al. (2012). Working memory measures included an adapted *Item recognition task*(Steinberg, 1966) and *Letter-number sequencing (LNS) task*(Gold et al., 1997).

2.4. Results

We first analyzed the **RT data**, as this is considered the main output from the RT-based CIT (Verschuere & de Houwer, 2011). A two-way repeated-measures ANOVA with Condition (Block 1 vs. Block 2, and Block 3) and Stimulus type (*probes* vs. *irrelevants*) as within-subject factors was conducted for the mean RT data. The results showed that there was a significant effect of Condition, F(2, 182) = 60.01, p < .01, MSE = 2870.85, η_p^2 = .39. *Posthoc* pairwise comparisons (with Fisher's least significant difference - LSD) indicated that subjects were significantly slower on the first block than on both of the following blocks, p < .001. Also, reaction times were slower on the third block compared to the second one, p < .001. There was a significant main effect of Stimulus type, F(1, 91) = 384.36, p < .001, MSE = 2487.68, η_p^2 = .80. Across conditions, subjects were faster in responding to irrelevants than to probes, p < .001.

To investigate the magnitude of the difference between RTs for irrelevants and probes across conditions, a *detection efficiencyscore* (difference between mean RTs for probes minus mean RTs for irrelevants) was computed for each block. A higher value of this difference indicates higher detection efficiency. A one-way repeated-measures ANOVA with Condition (Block 1 vs. Block 2, and Block 3) was conducted for the mean RT. There were no significant differences between blocks regarding the detection efficiency score, F(2,182) = 1.42; p = .24, indicating that the differences between probes and irrelevants remain relatively stable over the three blocks. Additional analyses regarding performance accuracy according to stimulus type were also conducted.A two-way repeated-measures ANOVA with Condition (Block 1 vs. Block 2, and Block 3) and Stimulus type (*probes* vs. *irrelevants*) as within-subject factors was conducted for the mean accuracy data. The results indicated that there was a significant effect of Condition, F(2, 182) = 10.85, p < .01, MSE = .02, η_p^2 = .10. *Posthoc* pairwise comparisons (LSD) indicated that subjects were more accurate on the third block than on both of the first blocks, p < 0.01. However, there were no significant differences between the first and the second block (p = .21). There was a significant main effect of Stimulus type, F(1, 91) = 68.14, p < .001, MSE = .03, partial η_p^2 = .42. Across conditions, subjects were more accurate in responding to irrelevants than to probes, p < .001.

To assess the priming effect of the CIT stimuli, we removed the first response for every participant, since it was not preceded by any other response. Then, a univariate two-way

ANOVA with Condition (Preceded by Probe vs. Preceded by Irrelevant and Preceded by Target) and Stimulus type (probes vs. irrelevants) was conducted for the mean RT across all trials. The results showed that there was a significant effect of Condition, F(2, 16102) = 79.99, $p < .001$, MSE = 17656.71, $\eta_p^2 = .01$. *Posthoc* comparisons (LSD) indicated that participants were faster to the CIT stimuli which were preceded by an irrelevant item vs. the conditions in which the stimuli were preceded by probes or by targets ($p < .001$). As expected, there was a significant effect of Stimulus type, F(1, 16102) = 627.77, $p < .001$, MSE = 17656.71, partial $\eta_p^2 = .03$. Subjects were faster in responding to irrelevants than to probes, $p < .001$.

Following the procedure proposed by Carmel et al. (2003), we computed our signal detection parameters comparing the guilty group with a simulated innocent group consisting of 92 participants. We found a *d* of 2.18 andan *area under the curve(a)* of *0.93.*

Bootstrapping of the CIT reaction times resulted in a hit rate of 91%, i.e., for 84 out of 92 participants concealed information was detectable through their slower responses on probe stimuli.

To test the relation between speed of processing and CIT's outcomes, as well as the relation between verbal working memory and the CIT's outcomes, Pearson correlations were computed. Our previous results showed that RTs are more accurate in detecting concealed information than accuracy. Thus, for the Pearson correlations, we used two RT outcomes of CIT: a *detection efficiency* (difference between mean RTs for probes minus mean RTs for irrelevants) and the mean RT for deceptive responses to probes. To explore the predictive power of the speed of processing and WM variables, a two stage hierarchical multiple regression was conducted with *detection efficiency* as the dependent variable. Prior to conducting a hierarchical multiple regression, data were screened and all the relevant assumptions of this statistical analysis were tested and met. Mean reaction time from the SRT task was introduced at Step one of the regression to assess the predictive value of the speed of processing. The WM variables (*Item recognition task RT* and *Letter-number sequencing (LNS) task score*) were entered at Step two. The hierarchical multiple regression revealed that at Step one, the processing speed measured by the SRT task contributed significantly to the regression model, F (1,90) = 6.06, $p< .05$, and accounted for approximately 6% (adjusted R^2 =.05) of the variation in *detection efficiency*. Introducing the WM variables explained an additional 8% of variation in *detection efficiency* and this change in R^2 was significant, F (2,88) = 4.5, $p < .01$. All the independent variables included in stage two of the regression model were significant predictors of *detection efficiency, $p < .05$*. Together the three independent variables accounted for approximately 15% (adjusted $R^2 = .12$) of the variance in *detection efficiency*, $F(3,88) = 5.20$, $p < .01$.

2.5. Discussion

Firstly, detection efficiency was assessed for the RT-based CIT. Consistent with previous studies, we demonstrated that reaction times in the CIT alone could most effectively detect concealed information. Bootstrapping of the CIT reaction times indicated that 84 out of 92 guilty participants were correctly detected through their slower responses on probe stimuli. Signal detection parameters also showed adequate overall CIT accuracy. These results support the validity of the RT-based test for concealed information detection.

The key finding of this study is that we were able to establish whether the RT-based CIT could offer stable detection over time. Intra-group comparisons between blocks of the CIT revealed practice effects, translated in an increase in the speed and accuracy of responses over time. Furthermore, our analysis revealed that responses preceded by irrelevants were faster than those preceded by probes or targets. It is most likely that some memory processes common to the recognition of both probes and targets, but not to irrelevants (e.g. familiarity and recollection, Seymour et al., 2000) are likely to explain the residual costs for the immediately following responses.

As expected, fast processing speed was associated with a smaller difference between responses to probes and to irrelevants. High performance in the speed of working memory was also associated with lower detection efficiency.Slower processing limits the amount of information that will simultaneously be available for processing, limiting the number of associations that can be created or accessed during retrieval. Therefore, it is conceivable that high processing speed and fast performance in working memory may actually allow more information to be processed in the CIT, which can lead to a decreased conflict between critical and irrelevant information. Stimulus-response conflict is likely to contribute to the differential responding to concealed information (Verschuere et al., 2005).Moreover, our findings show subjects with better WM capacity are actually harder to detect. The present study provides a valuable contribution to the ongoing pursuit of identifying tools sensitive enough to reliably detect concealed information.

Chapter 3

INCREASING EXECUTIVE LOAD TO FACILITATE DECEPTION DETECTION IN THE CONCEALED INFORMATION TEST

3.1. Introduction

There is a growing body of behavioral, psychophysiological and neuroimaging evidence revealing that lying is a complex, cognitively demanding behavior. Most of this evidence reflects an overall increase in executive control demands imposed by lying, as compared to truth-telling. Truth-telling is considered a baseline, almost automatic cognitive state (Spence, 2004). To support this claim, lying has been proven to take longer than truth-telling (Spence et al., 2001), necessitating greater cognitive effort (see Vrij et al., 2011, for a recent review).Inducing an overall increase in cognitive/executive load, such as by asking participants to narrate their deceptive stories backwards has been shown to interfere with lying, facilitating the process of lie detection by enhancing verbal and non-verbal cues to deception (Vrij et al., 2008). However, the backwards recall technique has been questioned with regard to the accuracy and completeness of the retrieved information (Dando et al., 2011), suggesting that a global interference with deceptive and memory processes might induce some unwanted collateral effects.

Vrij et al., (2006) suggested that requiring interviewees to perform a *concurrent* secondary task while being interviewed might provide a useful tool to enhance lie detection. There have been some preliminary experimental attempts to add a parallel task aimed at disrupting the executive functions involved in the deceptive act, yielding mixed evidence in terms of effects on deception. In a recent investigation, Ambach et al., (2011) introduced a working memory (WM) task in parallel with a Concealed InformationTest. This manipulation affected RTs to critical items to a larger extent when compared to irrelevants. Considering the limitations induced by the very long RTs specific to the psychophysiological measurement design, the authors suggested that a faster pace of the task (asking the subjects to respond within a second) would enhance this preliminary documented effect. This idea was recently tested by introducing an interfering inhibition (dot-probe) task within each trial of the Reaction Time-based (RT-based) CIT, which led to an increase in its detection efficiency (Hu, Evans, Wu, Lee, & Fu, 2013). The present study aimed at further testing this prediction, using the RT-based CIT at a faster pace, and interfering with two different executive functions shown to be involved in the deceptive act (WM updating and shifting).

The main aim of the present study was to systematically investigate whether introducing a concurrent executive load targeting the very CIT items, rather than a parallel interfering task, would better differentiate between truthful and deceptive responses in the RT-based CIT. The current investigation used an interference design, introducing tasks involving two executive functions evidenced to be relevant for the deceptive act: memory updating and flexible set-shifting (Morgan et al., 2009; Visu-Petra et al. 2012). In order to efficiently plan and execute a deceptive act, a person needs to continuously monitor and update memory contents in order to distinguish truthful from deceptive responses, and to flexibly alternate between these mental sets in producing the deceptive response (Walczyk et al., 2003).

3.2. Materials and Methods

3.2.1. Participants

Participants (N = 75, 62 females) were recruited from general psychology classes by using an online recruitment system and received credit for their participation. A remaining total of 73 participants (62 females) were included in the data analyses. All participants completed a series of tasks as follows: they read the instructions for the mock crime, they executed the mock crime, then completed a filler task; afterwards, they studied and learned the target items and finally resolved the three CIT conditions (the order of presentation was counterbalanced across subjects).

3.2.2. Materials

CIT items were two-word phrases: five probes, five targets and twenty irrelevants (four corresponding to each probe), similar to items used in previous studies (e.g Farwell & Donchin, 1991; Seymour et al., 2000)

3.2.3 Mock crime

The participants were initially required to read and sign the informed consent form. Afterwards, the mock crime scenario was presented. Written instructions were used at this time, according to which they had to pretend to be a student of Psychology who was about to take a previously failed exam at an important course in the following day. Because of some personal issues, he/she had been unable to study. However, in the previous day, the student had presumably visited the professor's office for a meeting. There he/she noticed a paper on the desk and saw the login Id (Psiho MCC) and password (*patru verde / four green*) for the discipline’s e-mail account which is hosted on the faculty’s official web site. With this information, he/she was instructed to access the course e-mail account from a *café (Café Amber)* placed in certain *street* (*Bicaz Street*; all locations were chosen from another city in order to avoid previous exposure). After accessing the account (which was created to be identical to a real course application on the actual faculty website), the participant had to search the Inbox for the e-mail with the exam subjects that the professor had sent to the course *tutor* (*Amalia Ciuca*; the name of the actual tutor was used, with her and the professor's consent) for multiplying exam papers. The participant had to forward this message with the attachment to their personal e-mail account. Subjects read these written instructions twice and memorized (emphasized) the five critical items (i.e. the probes). Afterwards, they were asked to go into a distant room of the same building (designated as Café Amber) and perform the actions from the scenario (access the e-mail account with the username and password, forward the e-mail). Following the mock crime, a non-verbal reasoning test taken was used as a filler task. In the target learning phase, the participants learned a sequence of five items similar to the probes.

3.2.4. RT-based CIT

After the mock crime and the target learning phase, the participants undertook the three CIT procedures designed for this study: a classical RT-based CIT, a CIT with a concurrent memory task (CITMem), and a CIT with a concurrent shifting task (CITShift).

The items utilized in this study were two-word phrases belonging to three categories of items: *probes* (the five critical items from the mock crime), *targets* (five to be recognized items, also from the same category as the probes) and *irrelevants* (items from the same category as the probes, not previously encountered). The participants were instructed to press Yes when presented with the targets, indicating recognition, and No to any other item encountered.For the CITMem, a randomized list was generated and kept constant across subjects, to allow for verbal recall accuracy to be checked by the experimenter with a response key. In the CITShift condition, the primary task remained the same, but the stimuli themselves appeared written in bold or in italics. Subjects had to press the answers to the CIT *once* if the item was written with *bold* and *twice* if the item was written with *italics*. Stimuli were presented equally often in bold or italics. The assignment of number of presses to the respective fonts was also counterbalanced across subjects. In the CITMem condition, the task was spaced in sequences consisting in groups of three items, with items randomly divided over sequences. The subject again had to press Yes or No to each item according to CIT instructions, but additionally he/she had to memorize the last word of each two-word item. After each three items sequence, a blank screen appeared. The subject had to verbally reproduce the three words he/she had memorized. After this, the participant pressed the space bar in order to initiate the next three items sequence. The experimenter verified the accuracy of verbal answers with an answer-key. A total of 40 memory checks were performed.

For each condition, accuracy and RT (for accurate responses) on the CIT according to stimulus type represented the main collected measures. On the CITMem, an additional index of memory for each stimulus type across trials, and also for mixed groups of three was added. For each group of three items, we checked whether they recalled the last word for irrelevants, probes or target items, and whether the group of three items was also correctly recalled. For the CITShift, accuracy in pressing once/twice the answer according to stimulus font was calculated; however, an inaccurate shift was not considered to be an error on the CIT (e.g. if the subject pressed once the answer No when presented with a probe it was scored as a shifting error, if the task was to press twice, but it was not scored as a CIT error). However, in the analysis of RTs, only time until first press was recorded and analyzed (for correct CIT responses).

3.3. Results

A two-way repeated-measures ANOVA with Condition (CIT vs. CITMem, and CITShift) and Stimulus type (probe vs. irrelevant) as within-subject factors was conducted for the mean RT data. The results showed that there was a significant effect of Condition, F(2, 144) = 341.91, p < .001, MSE = 9600.04, partial η^2 = .83. Post-hoc pairwise comparisons (with a Bonferroni correction) indicated that subjects were significantly faster on the traditional CIT than on both the CITMem, and the CITShift, p < .001. They were also significantly faster on the CITMem than on the CITShift.There was a significant main effect of Stimulus type, F(1, 72) = 288.63, p < .001, MSE = 1958.06, partial η^2 = .80. Across conditions, subjects were faster in responding to irrelevants than to probes, p < .001.Finally, there was a significant Condition X Stimulus type interaction, F(2, 144) = 12.5, p < .001, MSE = 678.88, partial η^2 = .15. There was a significant increase across tasks in RTs to both irrelevants, and probes, respectively, with the fastest responses on the CIT, followed by responses on the CITMem, and by longest responses on the CITShift, p < .001 in each case. To investigate the magnitude of the difference between RTs for irrelevants and probes across conditions, *detection efficiencyscores* (difference between mean RTs for probes minus mean RTs for irrelevants) were calculated for each condition. Post-hoc paired t-tests revealed that RT differences were smaller in the CIT than in the CITMem, t(72) = 2.12 , p = .04, and in the

CITShift, $t(72) = 5.23$, $p < .001$. Additionally, difference scores were significantly larger in the CITShift compared to the CITMem, $t(72) = 2.80$, $p < .007$.

Although we included only guilty participants in our study, the distribution of the detection score for innocent individuals can be estimated. Our signal detection parameters were based on a comparison with a simulated innocent group consisting of 73 participants. After we computed the distance (in standard deviation units) between the centers of the two distributions (d'), we derived the *area under the receiver operating characteristic* – ROC.We found thatd' values for the CIT, CITMem and CITShift were 1.54, 1.39 and 1.71, respectively. The d' value for the combination of CIT and CITShift was 1.75. The areas under the ROC curve (*AUC*) were .86 for the CIT, .84 for the CITMem, .88 for the CITShift and .89 for the combination between CIT & CITShift.

Bootstrapping of the CIT reaction times resulted in a hit rate of 67%. For the CITMem, a hit rate of 64% was computed, while for CIT-Shift, 68% of the participants were detected.

Additional analyses regarding performance accuracy according to stimulus type were conducted. First, a two-way repeated-measures ANOVA with Condition (CIT vs. CITMem vs. CITShift) and Stimulus type (probe vs. irrelevant) as within-subject factors was conducted. The results showed that there was a significant effect of Condition, $F(2, 144) = 31.30$, $p < .001$, $MSE = .03$, partial $\eta^2 = .30$. Post-hoc pairwise comparisons (with a Bonferroni correction) indicated that subjects were significantly less accurate on both the CIT and the CITShift than on the CITMem (although accuracy on the CIT and on the CITShift did not differ). There was also a significant main effect of Stimulus type, $F(1, 72) = 80.86$, $p < .001$, $MSE = .01$, partial $\eta^2 = .53$. Across conditions, accuracy in responses to irrelevants was higher than accuracy in responses to probes, $p < .001$. Finally, there was a significant Condition X Stimulus type interaction, $F(2, 144) = 23.59$, $p < .001$, $MSE = .01$, partial $\eta^2 = .25$. Accuracy in response to irrelevants differed across tasks, $F(2, 144) = 10.65$, $p < .001$, $MSE = .01$, partial $\eta^2 = .13$, with responses on the CITMem being more accurate than on both CIT and CITShift, $p < .05$. Accuracy in response to probes also significantly differed across tasks, $F(2, 144) = 33.67$, $p < .001$, $MSE = .03$, partial $\eta^2 = .32$. Again, post-hoc contrasts revealed that accuracy to probes on the CIT and CITShift was significantly lower than accuracy to probes on the CITMem, $p < .05$. To investigate the magnitude of the difference between accuracy for irrelevants and probes across conditions, difference scores (accuracy for irrelevant minus accuracy for probes) were calculated for each condition. Post-hoc paired t-tests revealed that the difference between irrelevants and probes was larger on the CITShift, compared to both CIT, t(72) = 2.37, p < .02, and to CITMem, t(72) = 6.58 , p < .001, respectively. This difference was also larger in the CIT, compared to the CITMem, t(72) = 4.93, p < .001.). Results showed that accuracy for recalling groups of three on the concurrent memory task was high, mean percent correct = 93.37, SD = 5.62. Comparing memory for probes versus irrelevants, we found that subjects were significantly more accurate in recalling the last word of the probes, than of the irrelevants, t(72) = 7.85, p < .001. Overall accuracy in shifting between responses to stimuli written in bold or italics was also high, mean percent correct = 87.24, SD = 11.06. This time, accuracy in shifting responses to probes was lower than accuracy in shifting responses to irrelevants, t(72) = 6.88, p < .001.

3. 4. Discussion

By contrasting general detection efficiency between the three conditions, we found the following. According to the group analyses, both dual-task conditions were superior in discriminating between truthful and deceptive responses. Signal detection parameters based on a comparison with the simulated innocent group showed accurate discrimination for all conditions, but did not reveal the same advantage of the dual-task conditions over the traditional RT-based CIT. This apparent inconsistency is not simply a byproduct of the overall slower responses found in the dual tasks, as revealed by our analyses on standardized data. The most plausible explanation is that some participants in the CITShift condition might have presented extremely large probe-irrelevant differences, which were responsible for the group effect. The computed hit rates for all conditions were slightly higher than those previously found in other RT-based CIT studies (e.g., hit rate of 56%, Verschuere et al., 2009). However, the hit rates computed in our study were still modest (as compared to 95% discrimination accuracy found by Seymour et al., 2000, although different estimating methods were used in that study). Looking at combinations between CIT versions, a combined measure including both CIT and CIT-Shift showed the highest discrimination efficiency. In terms of accuracy, the demand to flexibly shift between types of responses generated the largest discrepancy between probes and irrelevants, while the additional memory load led to ceiling levels of performance accuracy on the CIT (98% for both probes and irrelevants). Performance accuracy on the concurrent tasks was affected by the type of trial (truthful or deceptive), revealing that these tasks could themselves provide valuable clues for deception detection.

Chapter 4

THE "GOOD COP, BAD COP" EFFECT IN DECEPTION DETECTION. INTRODUCING FACIAL EMOTIONAL STIMULI IN THE RT-BASED CIT

4.1.Introduction

The quest for identifying objective indicators of deceptive behavior represents a flourishing field of scientific inquiry. Although behavioral cues to deception represent an obvious candidate for deception detection, the traditional approach has largely overlooked the cognitive processes involved in producing and executing deceptive behaviors.

A growing body of literature investigating the cognitive underpinnings of deceptive behavior suggests that it requires greater cognitive effort compared to truthful responses (Zuckerman et al., 1981; Vrij et al., 2006), with the truth being considered an automatic, default-like state of the cognitive system (Spence, 2004). When deceiving, one has to coordinate several cognitive demanding tasks: to select a response that is incompatible with the truth, to suppress a recurring awareness of the truthful information, to compile alternatives, while maintaining the consistency of the lie, to monitor personal behavior and the reaction of the audience to the deception (Vrij, 2000; cf. Gombos, 2006).Based on the findings of previous studies, we decided to further explore the relationship between deception and *working memory updating,* since all the approaches mentioned above pointed to its specific involvement in deceptive behavior.

Most of the CIT research usually relies on testing subjects in an environment lacking of social stimuli, despite the fact that concealing information is mostly a social action that amplifies the emotional involvement and consequences for the deceptive agent. Ambach et al. (2012) addressed this gap and provided arguments for introducing social stimuli into the CIT. In real life, most interrogations take place in an environment that is saturated with social stimuli. The mere presence of an investigator triggers various physiological and behavioral responses, not to mention the role played by the ongoing feedback provided by such an individual in response to deceptive responses. It has been suggested that introducing the presence of the investigator in the CIT would lead to an increased involvement and enhanced arousal (Ambach et al., 2012). Results of the study confirmed that social stimuli seem to play an important role in the CIT, beyond the mere presentation of items about which knowledge has to be concealed. A uniform male face presentation with every question and item in a CIT enhanced differential physiological and behavioral responding to critical items compared to responses to irrelevants. While the CIT has been considered relatively invulnerable to the effects of the stress experienced by the examinee (see the recent review by Ben-Shakhar, 2012), other variables such as motivation to avoid detection have been shown to influence responses, leading to an increased CIT effect (Ben-Shakhar & Elaad, 2003).

While there is some speculation in the literature that a friendly attitude of the investigator makes the subject more willing to divulge important or sensitive information (Inbau, Reid, Buckley, & Jane, 2013), to our knowledge, there is no research to test this prediction directly, either in a realistic interview, or in the controlled CIT context. On the contrary, displaying a negative emotional expression such as anger has been deemed to suggest either indiscriminate hostility or even to convey a presumption of guilt, associated with the so-called "investigator bias" which usually accompanies the "heavy-handed" tactics used by law enforcement professionals (Meissner & Kassin, 2002).

4.2.The current study

Several research questions were addressed through this design. First, we were interested whether *the simple introduction of a social stimulus simulating a virtual investigator would facilitate the process of deception detection*.

Next, we wanted to explore whether *the introduction of facial emotional displays of the virtual investigator* (happy, angry or neutral) *would have a differential impact on the responses to crime-relevant versus irrelevant items*.

Finally, we were interested in the *modulating effect played by individual differences* in executive functions and trait-like predispositions to experience symptoms of depression, anxiety, stress, as well as in the effects of state anxiety during the CIT.

4.3. Method

4.3.1. Participants

Participants (N = 47, 11 males and 36 females; mean age 22.8 ± 5.1 years) were recruited from psychology undergraduate courses and received credit for their participation. All participants executed the mock crime procedure, followed by the RT-based CIT (four conditions) and the *n*-back (four conditions). Throughout the procedure, participants had to fill out four questionnaires, which are described below. Due to a technical failure, data from one participant were discarded from the analysis. Participants were debriefed at the end of the study and were informed about the nature of the experiment. This study was approved by the ethics committee of the Faculty of Psychology and Educational Sciences, Babes-Bolyai University, according to the University's board regulations, the national College of

Psychologists and international guidelines from the Declaration of Helsinki (1964) for research involving human subjects.

4.3.2.Procedure

Upon arrival, all participants signed a consent form indicating the participation was voluntary and that they could withdraw at any time. Then they received and read the mock crime instructions, memorized the critical items (i.e. probes) and executed the assignment. After executing the mock crime, they completed a filler task consisting in two questionnaires (measuring state anxiety and executive functions) and lasting for approximately 15 minutes. Subsequently, participants learned the target items. Afterwards they were assessed with the four conditions of the RT-based CIT (one classical and three EM-RT-based CIT). Participants then completed the composite measure of depression, anxiety and stress. Finally, participants were tested with the Emotional *n*-back task (EM *n*-back, one without a facial background and three with facial backgrounds) and they filled out the trait anxiety questionnaire (see description below).

4.3.2.1. Mock Crime

Participants received written instructions about the mock crime procedure, so that all the relevant details were specified in advance. Each participant had to access the personal office of a university research assistant responsible for an upcoming exam. Upon entering the office, he/she had to search for a *memory stick* on which to copy the exam questions. In order to log into the computer, a password had to be used and the participants looked it up in an agendafound on the professor's desk. After they copied the exam questions on the memory stick, they put it into a *laptop bag.* Participants were instructed to steal another three objects from the desk: a *mobile phone*, *a wireless mouse* and the *agenda*. Subjects read the written instructions twice and were instructed to memorize the five critical items (i.e. the probes). To increase the realism and the pressure of the scenario, they were also instructed to be fast and avoid being caught. Moreover, the testing scenario took place in a formal office, during program hours. After completing the mock crime, participants returned to the original room and were asked to verbally describe the physical characteristics of each stolen item in order to ensure a better encoding.

Two questionnaires had to be filled out: STAI-Y1 (State Anxiety Inventory, developed by Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) to assess the state anxiety levels related to the mock crime scenario and the BRIEF (Behavior Rating Inventory of Executive Function, developed by Gioia, Isquith, Guy and Kenworthy, 2000, see description below).

4.3.2.2. Reaction Time-based Concealed Information Test

Following this filler task, each participant received written instructions to learn five items (i.e. *targets items*) that were from the same category as the probes. Each of the five targets was presented on a computer screen for 10 seconds and the sequence was repeated three times. The instructions specified that participants had to memorize the physical characteristics of each item in order to reproduce them all later. To ensure a good retention of the target items, a verbal recall was performed.Subsequently, each participant received another set of written instructions explaining that they were suspects of a theft and that they will undergo a behavioral test designed to assess their involvement in the crime. Also, they were informed that they will be assessed by a virtual investigator (similar to Ambach et al., 2012). After completing the mock crime and the target learning phase, the participants undertook four CIT conditions designed for this study: a classical RT-CIT condition consisting in one block, and three Emotional RT-CIT conditions Em-RT-CIT, negative, positive and neutral). The order of presentation of these procedures was drawn randomly for each participant. The items used in all of the CIT procedures were pictures belonging to three categories of items: *probes* (the five critical items stolen in the mock crime), *targets* (five previously learnt items from the same category as the probes) and *irrelevants* (four items from the same category as each probe, resulting in a total of 20 items not previously encountered during the experiment). Subjects were instructed to respond “Yes” to targets and “No” to any other item (including probe items) by pressing the corresponding keys with their index fingers (two keyboard buttons were indicated for positive and negative answers). Answers had to be given as quickly as possible. The item remained on the screen until a response was made; if an answer was not offered within a 1200-millisecond interval, a ‘too slow’ message appeared on the screen. After a short training phase, the test began. A condensed version of the instructions was displayed on the computer screen at the beginning of the testing session. Each of the four blocks included two presentations of each item, generating a total of 60 trials per block. Items were presented in a randomized order.

The RT-CIT condition contained one block similar to previous versions of the test using visual stimuli (e.g. Hu, Evans, Lee, & Fu, 2013; Visu-Petra, Miclea, & Visu-Petra, 2011). In thethreeEm-RT-CIT conditions, a photo of a “virtual investigator” appeared on the screen before the presentation of each item. On the same slide the question was shown: “Do you recognize this item?”. The slide’s duration was either 500 ms or 2000 ms (randomly) and no action was required to be performed by the participant. For this condition, an image of a middle-aged man was used from the FACES 3.3.1. database (Ebner, Riediger & Lindenberger, 2010). Within each block (positive, negative, or neutral), the facial expression of the investigator was happy, angry, and neutral, respectively. After completing the four CIT conditions (presented in a randomized order), participants took a short break. Then, the DASS Questionaire (Lovibond, S.H. & Lovibond, P.F., 1995) was administered.

4.2.2.3. Emotional n-back

The EM-*n*-back task consisted of superimposing the original *n*-back task onto one of four backgrounds: no background (blank screen), negative background, neutral background or, positive background (Casey et al., 2000; Ladouceur et al, 2005). However, following the suggestion of Casey et al., 2000, who specified that in order to control for the different complexity of the pictures used as backgrounds, it would be preferable to include faces rather than natural scenes as backgrounds, we reverted to the use of facial expressions onto which the *n*-back items were superimposed. This also allowed us to better compare performance (accuracy, RT) on the EM-*n*-back blocks to the emotionally valenced blocks used in the Em-RT-CIT conditions which also involved facial expressions.

Participants received verbal and on-screen instructions which described that they were going to see a series of letters presented one at a time, over a background consisting of facial pictures or over a blank screen (depending on the condition). The photos depicting facial expressions were selected from the same FACES 3.3.1. database (Ebner, Riediger & Lindenberger, 2010), but excluded the identity of the "virtual investigator" presented in the Em-RT-CIT. The same emotional valence was maintained during each condition (i.e., angry, happy or neutral), except for the no-background condition. There were eight blocked conditions comprising two memory-load conditions (i.e., 0-back and 2-back) by four background conditions (none, negative, neutral, positive). The blocked conditions included 20 trials each, for a total of 160 trials. For the 0-back condition, participants were asked to press a button when presented with a specific letter (e.g., X). In the 2-back condition, the target was any letter that was identical to the one presented two trials back. An example for the instructions (e.g., A-F-A) was provided on the computer screen. After a short training phase, the test began. Each trial consisted of the simultaneous presentation of a letter and a blank screen or facial stimulus. Letters and corresponding backgrounds appeared for 500 ms and then disappeared, leaving only the picture or blank screen visible for another 2500 ms. Trials were randomized within each block; faces stimuli were randomized within each background condition and letters were randomized across trials.

In the current study we used the *Behavior Rating Inventory of Executive Function—Adult version* (BRIEF-A, Roth, Isquith, & Gioia, 2005), the *Depression Anxiety Stress Scales*

(DASS, Lovibond & Lovibond, 1995) andthe *State-Trait Anxiety Inventory* (STAI, Spielberger et al., 1983).

4.4. Results

We first analyzed the ***RT data***, as this is considered the main output from the RT-based CIT (Verschuere & de Houwer, 2011). A preliminary analysis with presentation duration of the "virtual investigator" face (500 vs. 2000 ms) revealed non-significant differences between subsequent responses to CIT items across the four conditions, so this variable was omitted from the final analysis.A two-way repeated-measures ANOVA with Condition (RT-CIT vs. Neg RT-CIT, Neu RT-CIT, and Pos RT-CIT) and Stimulus type (*probes* vs. *irrelevants*) as within-subject factors was conducted for the mean RT data. The results showed that there was a significant effect of Condition, $F(3, 135) = 4.49$, $p < 0.01$, $MSE = 5836.5$, $\eta_p^2 = .091$. *Posthoc* pairwise comparisons (LSD) indicated that subjects were significantly faster on the traditional RT-CIT than on both Neu RT-CIT andPos RT-CIT, $p < 0.01$. Also, reaction times were lower on Neg RT-CIT than on Pos RT-CIT, $p < .05$. No significant differences were found between Neg RT-CIT and RT-CIT ($p = .26$) or Neu RT-CIT ($p = .09$).There was a significant main effect of Stimulus type, $F(1, 45) = 171.03$, $p < .001$, $MSE = 3885.5$, $\eta_p^2 = .079$. Across conditions, subjects were faster in responding to irrelevants than to probes, $p < .001$.

A one-way repeated-measures ANOVA with Condition (RT-CIT vs. Neg RT-CIT, Neu RT-CIT, and Pos RT-CIT) was computed for the *detection efficiency score*. There was a significant effect of Condition, $F(3, 135) = 2.88$, $p < .05$, $MSE = 2367.59$, $\eta_p^2 = .06$. *Posthoc* pairwise comparisons (with Fisher's least significant difference - LSD) indicated that detection efficiency was higher in the Pos RT-CIT condition than in the Neg RT-CIT one, $p < .01$. Detection efficiency was also higher in the Pos RT-CIT compared to the RT-CIT, $p < .03$, and in the Neu RT-CIT compared to the Neg RT-CIT, $p < .04$. No significant differences were found between RT-CITand Neu RT-CIT ($p = .43$), nor between RT-CIT and Neg RT-CIT ($p = .38$).

A two-way repeated-measures ANOVA with Condition (RT-CIT vs. Neg RT-CIT, Neu RT-CIT, and Pos RT-CIT) and Stimulus type (*probes* vs. *irrelevants*) as within-subject factors was conducted for accuracy data. The results showed that there was a significant effect of Stimulus type, $F(1, 45) = 29.84$, $p < .001$, $MSE = .08$, $\eta_p^2 = .39$, with more errors in response to probes compared to irrelevants. There were no significant effects regarding the

Condition ($F(3, 135) = .61$, $p = .60$) or the interaction between Condition and Stimulus type ($F(3,135) = 1.11$, $p = .34$).

Regarding the signal detection parameters, we found that *d'* values for the RT-CIT, Neg RT-CIT, Neu RT-CIT and Pos RT-CIT were 1.66, 1.59, 2.02 and 2.29, respectively. The *areas under the ROC curve* (*a*) were 0.87 for the RT-CIT, 0.86 for the Neg RT-CIT, 0.91 for the Neu RT-CIT and 0.94 for Pos RT-CIT.

Bootstrapping of the RT-CIT reaction times resulted in a hit rate of 71%. For the Neg RT-CIT, a hit rate of 69% was computed, while for Neu RT-CIT, 73% of the participants displayed a reaction time for probes that sufficiently deviated from that for irrelevant stimuli to be of diagnostic value. The highest hit rate resulted for Pos RT-CIT, 78% of participants were detected in this condition.

A two-way repeated-measures ANOVA with Task (0-back and 2-back) and Condition (no background, negative background, neutral background and positive background) as within-subject factors was conducted for the mean RT data. The results showed that there was a significant effect of Task, $F(1, 45) = 163.44$, $p < .001$, $MSE = 7889.9$, $\eta_p^2 =.78$. Subjects were faster in responding to the 0-back task, compared to the 2-back task. There was also a significant effect of Condition, $F(3, 135) = 68.4$, $p < .001$, $MSE = 1547.8$, $\eta_p^2 = .60$. *Posthoc* pairwise comparisons (LSD) indicated that subjects were faster on both tasks on the no background condition, than on those with emotional backgrounds ($p < .001$). No significant difference was found between the background conditions. A two-way repeated-measures ANOVA with Task (0-back and 2-back) and Condition (no background, negative background, neutral background and positive background) for accuracy data indicated a significant effect of Task, $F(1, 45) = 139.55$, $p < .001$, $MSE = .009$, $\eta_p^2 = .75$. Subjects had better performances on 0-back than on 2-back. No significant differences were found between the background conditions. For the Task x Condition interaction, there was a significant effect, $F(3, 135) = 3.47$, $p < .02$, $MSE = .002$, $\eta_p^2 = .07$. *Posthoc* pairwise comparisons indicated that subjects had better performances in 0-back on the background conditions than on the blank condition, $p < .001$. However, no significant differences were found between conditions in the 2-back task.

Pearson correlations were computed between performance on the *n*-back task (mean RTs and accuracy scores for 0-back, 2-back) and on the RT-based CIT (mean RTs for deceptive responses to probes in CIT, and detection efficiency scores), separately for each of their conditions (no emotion, positive, negative and neutral). Regarding the mean RTs, we found a significant relation, $r (46) = .30$, $p < .05$, between speed of responses to RT-CIT probes and speed of responses on the 0-back, no background condition. Also, mean RTs for responses on the standard 2-back (no background condition) were positively related with those on RT-CIT probes, r (46) = .30, $p < .05$. No other significant correlations were found between the conditions of WM tasks and those of the CIT. In terms of accuracy, no significant relations were found between similar WM and CIT conditions.

Regarding the self-report assessment of individual differences in executive functioning measured with the BRIEF-A, there were some marginal relations which failed to reach significance after the Bonferroni correction for multiple correlations.

Regarding anxiety measures, the detection efficiency score computed for Neg RT-CIT was negatively related with state anxiety (StaiState), r (46) = -.44, $p < .01$, and also with trait anxiety (StaiTrait), r (46) = -.42, $p < .01$. Post-hoc correlations examining the meaning of this association showed that mean RT for deceptive responses to probes (but not to irrelevants) from the Neg RT-CIT was related significantly with state anxiety (StaiState), r (46) = -.46, $p < .01$, and with the trait anxiety (StaiTrait), r (46) = -.45, $p < .01$. Therefore, the association between anxiety and speed of deceptive responses seems to be circumscribed to the Neg RT-CIT and does not affect truthful responses.However, the negative relationship with detection efficiency in the Neg RT-CIT did not reach significance in the case of the DASS Anxiety subscale r (46) = -.24, $p < .10$, yet it was present in the case of the DASS Tension/Stress subscale r (46) = -.43, $p < .01$. In addition, mean RT to probes was negatively related with two of the DASS' subscales: DASS Anxiety, r (46) = -.36, $p < .05$, and DASS Tension/Stress subscale, r (46) = -.42, $p < .01$. No significant relations were found between the other conditions of RT-CIT and anxiety or stress measures.

We conducted a repeated measures ANCOVA with Condition (RT-CIT vs. Neg RT-CIT, Neu RT-CIT, and Pos RT-CIT) and Stimulus type (*probes* vs. *irrelevants*), introducing the state anxiety score as a covariate. The results showed that there was a significant effect of Condition, $F(3, 129) = 2.75$, $p < 0.05$, MSE = 5633.52, $\eta_p^2 = .06$. Also, there was a significant effect of Stimulus type, $F(1,43) = 34.24$, $p < 0.01$, MSE = 3765.63, $\eta_p^2 = .44$. There was no significant effect for the interaction between Stimulus type and the state anxiety score, F (1,43) = 3.21, p = 0.08, nor between Condition and the state anxiety score, F (3, 129) = 2.38, p = 0.07. We also checked whether the same relationship between anxiety/depression/stress scores would hold true in the case of the *n*-back task. We only found some positive relations between the state anxiety score and latency of responses in the positive (r = .27), negative (r = .26) and neutral (r = .33) conditions of the EM-*n*-back, which did not remain significant after the Bonferroni correction.

4.5. Discussion

The present study attempted to simulate interference from social and emotional stimuli and to assess its impact in a controlled, laboratory-based deceptive scenario. Despite the artificial elements induced by explicitly instructing participants to commit a mock crime and to lie about it, the RT-based CIT has proven its efficiency in identifying the “memory traces” of concealed information and has the potential to represent a cost-effective method for real-life deception detection settings (see Verschuere & de Houwer, 2011, for a review). It is important, therefore, to introduce social and emotional information in this task and to assess to what degree this manipulation impairs/facilitates the process of deception detection.

First, deceptive performance (accuracy) was similar across all conditions, and only the RT measure was sensitive to the effects of emotional valence. Second, in the presence of a social stimulus with a neutral emotional valence, although participants took longer to respond, this did not differentially affect responses to probes and to irrelevants, and thus it did not improve detection efficiency. This essential measure was improved only in the condition containing a happy/friendly examiner, in which subjects provided significantly longer responses to probes, compared to irrelevant items. In contrast with this tendency, in the condition containing an angry/hostile examiner, subjects were actually faster in responding to probes compared to all conditions containing facial stimuli, this leading to a decreased detection efficiency. Interestingly, this contrasting effect of positive versus negative distracting information was not noted when measuring cognitive performance on a task requiring memory updating, a process proven to be relevant for the production of deceptive behavior. A simple elongation of response times (and the same absence of effects on response accuracy) was visible across the conditions of the EM-*n*-back task, compared to the standard version. This could imply that specific motivational factors assigning relevance to the emotional distractor could have differentiated between the impact of positive versus negative emotional information in the Em-RT-CIT.

Emotional valence has been shown to differentially affect speed of responses to critical items in a mock-crime derived RT-based CIT, with positive facial expressions from a virtual examiner enhancing detection efficiency, compared to a version containing negative facial expressions. The study also raises the possibility that individual differences in state anxiety and in the amount of stress experienced by deceptive participants could also play a motivational role, further interfering with the process of deception detection.

Chapter 5

CONCLUSIONS

5.1. Overview of our findings

The research on deception is exciting and emotionally engaging. Several detection methods have been developed since the beginning of the twentieth century and the study of deception has attracted a great deal of interest from both researchers and practitioners and has is has become an important area of applied psychology.It is of particular interest to forensic science to advance in the understanding of memory assessment of suspects with regards to crime-related information. There has been a significant preoccupation with developing adequate techniques that allow for such assessment.Recently it has been argued that focusing on basic cognitive mechanisms and strategies would be an essential step in the development of deception research (Bond, 2012) and in improving the existing deception detection techniques(Vrij, Fisher, Mann, & Leal, 2006; Meijer et al., 2009).

We provided scientific evidence and arguments for the use of a standardized and well-supported research paradigm that would substantially benefit the integration of various investigations targeting the cognitive dynamics that underlie deceptive communication. This research context is provided by the Concealed Information Test, which is one of the most widely adopted techniques by today's researcherswho work in the field of detecting information that the subject does not want to disclose (Verschuere et al., 2011; Ben-Shakhar, 2012). In the present thesis, initially we reviewed the main theoretical assumptions behind this novel method and we presented an overview of the current research in the field.A well-supported CIT test based on measuring reaction times was proposed by Seymour et al., (2000), and is now known as the RT-based CIT. Several studies have suggested that this procedure can successfully differentiate between truthful and deceptive responses, or between guilty and innocent participants on the basis of RTs, supporting the validity of the RT-based CIT (see Verschuere & de Houwer, 2011 for a recent review). Adding a cognitive view on the concealed information paradigm provided a theoretical framework that allows a more complete understanding of the cognitive mechanisms involved in deception. Given the robust theoretical background and its simplicity, the RT-based CIT has great advantages for related cognitive research of deception.

Thus, **the first major aim of the current thesis was to investigate the relation between individual differences in executive functioning and deceptive behavior**. This relation is of special interest, given that the ability to deceive may depend upon optimal cognitive control mechanisms.This challenging aim was grounded theoretically in the introductory section, and later empirically tested in the experiments described in detail in **Chapter 2**, **3** and **4**.

Our first experiment indicated that high performance in the speed of working memory was associated with lower detection efficiency. Slower processing limits the amount of information that will simultaneously be available for processing, limiting the number of associations that can be created or accessed during retrieval. Therefore, it is conceivable that high processing speed and fast performance in working memory may actually allow more information to be processed in the CIT, which can lead to a decreased conflict between critical and irrelevant information. Stimulus-response conflict is likely to contribute to the differential responding to concealed information.Furthermore, supporting the theoretical hypothesis suggested by Bond (2012), our regression model involving processing speed and working memory as predictors revealed that they accounted together for approximately 15% of the variance in detection efficiency. Our findings suggest that higher WM capacity of the verbal memory was associated with lower detection efficiency. Better WM capacity was in our case associated with faster responses to both probes and irrelevants (although significant only in the case of probes), which resulted in a negative association between WM capacity and detection efficiency. This means that subjects with better WM capacity are in fact harder to detect.

In the second experiment, by introducing different concurrent tasks, we explored which particular executive skill is essential to concealing information when disrupted. Studies have shown that there is a general mechanism subserving both executive functioning and deceptive responses (Johnson et al., 2004), so that disrupting the efficiency of executive functions would directly impact the way a person conceals information. Our findings suggested that the elevation of cognitive workload on memory updating and flexible set-shifting can increase the detection efficiency of concealed memory based on behavioral measures.

Finally, in our third study, we additionally explored the relationshipbetween individual difference*s* in executive functions and deceptive responses. No significant relations were found between self-reported executive dysfunctions and deceptive responses. It is possible that the use of a non-clinical sample might not have allowed for substantial variation within scores measuring executive deficits (Roth et al., 2013). Alternatively, it is possible that the subtle variations in executive functioning consequential for deceptive behavior are not readily captured by a self-report measure, which in other studies was at best moderately related to performance-based measures of attentional/cognitive control performance (McAuley et al., 2010; Toplack et al., 2009).

Regarding the main aim of the current thesis, we successfully provided evidence for the involvement of executive functions in deceptive behavior. In order to efficiently plan and execute a deceptive act, a person needs to continuously monitor and update memory contents to distinguish truthful from deceptive responses, and to flexibly alternate between these mental sets in producing the deceptive response. This finding is consistent with the model proposed by Walczyk et al.(2003). It is conceivable that working memory may facilitate keeping the truth active while the lie is being constructed.Cognitive inhibition could be a key factor in inhibiting the truth response from leakage, while cognitive flexibility could allow the shifting between being honest and deceiving.

Second, **we wanted to provide further validation of the RT-based CIT by sequencing and examining its outcomes**, both in terms of dynamics between deceptive responses and the residual costs incurred by stimuli on the immediately following responses. By adding a temporal dimension to the designs commonly used in deception research, a deeper understanding of the cognitive dynamics of deceptive behavior was developed.In the first study, we examined the dynamics of both truthful and deceptive responses in a RT-based CIT administered to 92 subjects across three separate blocks of trials. Consistent with previous studies, we demonstrated that reaction times in the CIT alone could effectively detect concealed information. Bootstrapping of the CIT reaction times indicated that 84 out of 92 guilty participants (a hit rate of 91%) were correctly detected through their slower responses on probe stimuli. Signal detection parameters also showed adequate overall CIT accuracy. The key finding of this study is that we were able to establish whether the RT-based CIT could offer stable detection over time. Intra-group comparisons between blocks of the CIT revealed an increase in the speed and accuracy of responses over time. After 216 trials, there was a significant increase in speed of approximately 45 ms. Still, the detection efficiency (the difference between probes and irrelevants) remained quite stable over time.Across the three blocks, although subjects significantly speeded up their overall RTs, detection efficiency remained relatively stable over time. Furthermore, we analyzed the possibility of *residual costs* for the following response incurred by responses to probes, compared to truthful responses. Deceptive responses to probes have been claimed to elicit a higher degree of conflict compared to truthful denials in the case of irrelevants (Hu, Evans, Wu, Lee, & Fu, 2013; Verschuere et al., 2005). Besides the inhibition required to suppress the truthful answer, responses to probes might also require a higher degree of set-shifting between the truthful and the deceptive response, thus generating an increased residual switch cost for the following response (DeJong, 2000; Rogers & Monsell, 1995). We provided evidence supporting the fact that irrespective of stimulus type (probe or irrelevant), responses preceded by irrelevants were faster than those preceded by probes or targets. This finding is relevant for the future re-designs of the CIT task, which will have to take into account the order in which stimuli are presented. Overall, these results support the validity of the RT-based test for concealed information detection, and its potential use for understanding the cognition of deception.

A third aim of our scientific endeavor was**to enhance the detection efficiency of the CIT by increasing executive load**. In the second study, the possibility to enhance the detection efficiency of the CIT by increasing executive load was investigated, using an interference design. After learning and executing a mock crime scenario, subjects underwent three deception detection tests: an RT-based CIT, an RT-based CIT plus a concurrent memory task, and an RT-based CIT plus a concurrent set-shifting task. The concealed information effect, consisting in increased RT and lower response accuracy for probe items compared to irrelevant items, was evidenced across all three conditions. The group analyses indicated a larger difference between RTs to probes and irrelevant items in the dual-task conditions, but this difference was not translated in significantly increased detection efficiency at an individual level. Signal detection parameters based on the comparison with a simulated innocent group showed accurate discrimination for all conditions. Among the two interfering tasks, the demand to flexibly shift responses on a trial-to-trial basis created the largest discrepancy between responses to probes and to irrelevants, and was also associated with the highest hit rate among the three conditions, even though the differences among them were not significant.Our results also indicated that it is worthwhile to combine several different types of measures in order to increase detection efficiency. Our study extended the existing literature dealing with the impact of interfering tasks on the CIT (Ambach et al., 2008; Ambach et al., 2011; Hu et al., 2013).

Finally, **we wanted to explore whether the introduction of emotional stimuli in the CIT would have a differential impact on responses to crime-relevant versus irrelevant items**. Our third study, envisioned deception as an integrated process, placing it at the interplay between contextual demands and individual differences in cognitive and socio-emotional functioning. The RT-based CIT was used to assess subjects' ability to hide the possession of relevant knowledge related to a mock crime. Several research questions were addressed in this experimental scenario. First, we were interested whether the simple introduction of a social stimulus simulating a virtual investigator would facilitate the process of deception detection. Next, we wanted to explore whether the introduction of facial emotional displays of the virtual investigator (happy, angry or neutral) would have a differential impact on responses to crime-relevant versus irrelevant items. Finally, we explored the modulating effect played by individual differences in executive functions and trait-like predispositions to experience symptoms of depression, anxiety, stress, as well as in the effects of state anxiety experienced during the mock crime. Results indicated that the mere presence of a virtual investigator slowed down participants' responses, but did not enhance detection efficiency. Emotional valence was shown to differentially affect speed of responses to critical items, with positive facial expressions from a virtual examiner enhancing detection efficiency, compared to the version containing negative facial expressions, which had the opposite effect. Higher levels of state anxiety experienced during the mock crime actually speeded up subjects' responses to the critical items in the negative condition of the RT-CIT. While the flows of social, emotional and cognitive information are naturally intertwined in deceptive scenarios, most of the literature on deception detection has selectively focused on the impact of enhancing cognitive load on deception. The present study attempted to simulate interference from social and emotional stimuli and to assess its impact in a controlled, laboratory-based deceptive scenario. Despite the artificial elements induced by explicitly instructing participants to commit a mock crime and to lie about it, the RT-based CIT has proven its efficiency in identifying the "memory traces" of concealed information and has the potential to represent a cost-effective method for real-life deception detection settings. These findings further emphasize the need to take into account motivational and emotional factors when considering the transfer of deception detection techniques from the laboratory to real-life settings.

5.2. Limits and future directions

Although our findings have significant theoretical and applied relevance, several limitations warrant discussion.Firstly, we have to take into account some limitations of the use of the RT-based CIT, which indirectly constitutes limitations to the present thesis. In spite of the extensive research conducted on the CIT and its impressive validity estimates, the method has not been applied extensively in the forensic field (Nahari & Ben-Shakar, 2011). The small number of studies regarding the external validity of the RT-based CIT is one of the notable limitation of the CIT research conducted so far. The more realistic mock crime studies involving incidental encoding of crime-related information emphasized the importance of the rigorous study of information encoding of stimuli in the CIT (Gamer et al., 2010; Nahari &

Ben-Shakhar, 2011). However, the most valuable use of the RT-based CIT is to explore the underlying cognitive processes involved in deceptive behavior. Future field studies should be conducted in order to assess the practical applicability of this method for detecting deception in real life situations.

Although the RT-based CIT is promising for lie detection, it is especially useful for understanding the cognition of deception. However, to improve its probative force, a good approach would be to use proper statistical methods to interpret the results. Z-score transformations are recommended to augment traditional analyses of raw response latencies and to remove the influence of individual differences in overall mean response latency within a single group. Also, to properly determine the hit-rate, the bootstrapping method (Wasserman & Bockenholt, 1989) would be the optimal solution.

Considering the current status of the field, using reaction time might raise certain issues. Firstly, reaction time can be the subject of intentional control. Countermeasures affecting reaction time might be easier to use than those affecting autonomic responses. Secondly, one cannot rely on the examinees following the critical instructions, such as "respond as quickly and accurately as possible". In contrast to the autonomic-based CIT, in a reaction-time test examinees must respond actively (Matsuda et al., 2012). Despite these limitations, research might profit from further examination of reaction time in the CIT. It is an easily obtained measure, and individual differences in response times might not be of concern if quantified using within-subject metrics (z-scores).

Given the robust theoretical background of the RT-based CIT, and the promise of improvements using more sophisticated statistics, we hope that the use of the RT-based CIT will grow in the current research of concealed information detection.

5.3. Contributions of the present thesis

The studies described in the current thesis provide a valuable contribution to the ongoing pursuit of identifying tools sensitive enough to reliably detect concealed information. Moreover, these findings extend the emerging literature on the role of cognitive processing in deception. Specific contributions are as follows.

- We provided a comprehensive review of the scientific literature regarding the deception detection methodology.
- We presented evidence regarding the validity of specific behavioral measures that can detect concealed information.
- We described the main theoretical assumptions behind the RT-based CIT and we presented an overview of the current research in the field.

- We provided an extensive overview of the current research in concealed information detection.
- We presented an extensive review of the literature regarding cognitive processes involved in deceptive behavior.
- We conducted the first study to explore the RT-based CIT's detection efficiency over time, the temporal dynamics of responses to crime-relevant versus irrelevant items, and the residual cognitive costs of stimuli in the RT-based CIT.
- We conducted the first study to explore whether the introduction of facial emotional displays of a virtual investigator (happy, angry or neutral) would have a differential impact on responses to crime-relevant versus irrelevant items. Emotional valence was shown to differentially affect speed of responses to critical items, with positive facial expressions enhancing detection efficiency. These findings have significant practical and theoretical implications.
- Basic individual differences in the speed of processing were so far omitted as a possible variable related to successful deception in the CIT, although it is well documented that the rate at which people process information appears to influence many aspects of cognition. We conducted the first study to address this gap in the scientific literature.
- We have assed individual differences in executive functioning in relation to deceptive behavior by using several experimental tasks and designs.
- We conducted a rigorous analysis and computed signal detection parameters in order to assess the detection efficiency of our instruments. As discussed extensively in the report of the National Research Council (2003), this approach is particularly relevant for describing the diagnostic value of detection tests.
- Moreover, we performed a state of the art data analysis to allow for a more in-depth testing of probe versus irrelevant differences within an individual. Data from each condition were bootstrapped using a rigorous method proposed by Wasserman and Bockenholt (1989) and hit rates were subsequently calculated.
- We have integrated our research findings in the greater body of literature on the role of cognitive processing in deception, thus extending its reach.

Our findings extend the emerging literature on the role of cognitive processing in deception and provide a valuable contribution to the field of concealed information detection. The research on deception is exciting and emotionally engaging and has attracted significant interest from diverse fields, such as social psychology (e.g., Cole, 2001; DePaulo & Kashy, 1998) or philosophy (e.g., Meibauer, 2005), not just from forensic science and its practical need to detect deception. Despite the huge interest for deception research, very little work has been conducted on the cognitive mechanisms involved in concealing information.Thus we engaged in an ambitious endeavor to examine deceptive behavior and the role of individual differences in executive functioning. The present thesis followed a theory-driven approach which provided proper direction to our experiments.

The most important strength of the present thesis is also its limitation. We conducted all of our experiments in the controlled environment of the laboratory. Most of the CIT research usually relies on testing subjects in an environment lacking of social stimuli, despite the fact that concealing information is mostly a social action that amplifies the emotional involvement and consequences for the deceptive agent. By controlling specific variables involved in producing deceptive behavior, we artificially reduced the dynamic components and the variability of deceptive communication. However, this ambitious attempt to isolate specific variables might be the only way in which we could generate accurate knowledge which can be properly grounded in scientific research and theory. Future studies should test our findings in a more realistic environment.

We envision deception as anembodied and embedded process, placing it at the interplay between individual differences in cognitive and socio-emotional factors and contextual dimensions.

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