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DETECTING DECEPTIVE BEHAVIOR:
AN INDIVIDUAL DIFFERENCES APPROACH

PhD Thesis Abstract

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Chapter 1

INTRODUCTION

In recent years, the cognition of deception has become a recurrent research topic, in an effort to elucidate its underlying mechanisms and to improve deception detection techniques. The relation between deception and *executive functioning* (EF) is especially of interest, since the ability to deceive may depend upon optimal cognitive control mechanisms (see Gombos, 2007, for a review). Recently, a growing number of behavioral and neuroimaging investigations have linked deception skills to executive functions (see Christ, Van Essen, Watson, Brubaker, & McDermott, 2009, for a metanalysis). These efforts were two-folded: initially, researchers subscribed to a global approach to executive functioning (Hughes, Farrow, Hopwood, Pratt, Hunter, & Spence, 2005; Spence, 2004), revealing that lying takes longer (Spence, Farrow, Herford, Wilkinson, Zheng, & Woodruff, 2001), is more cognitively demanding (Vrij, Fisher, Mann, & Leal, 2006), and activates more prefrontal brain areas than truth-telling (Mohamed, Faro, Gordon, Platek, Ahmad & Williams, 2006; Christ et al., 2009).

Another approach was to assess individual differences in specific EFs in relation to deception (Morgan, Le Sage, & Kosslyn, 2009; Visu-Petra, Miclea, & Visu-Petra, in press). It is essential to take into account the simultaneous "unity and diversity" of EFs, suggesting the differential involvement of distinct EF dimensions in the act of deception. Using a latent variable approach, Miyake and collaborators (2000) found support for the independence and interdependence of three executive components: updating (updating and monitoring working memory - WM representations), set-shifting (shifting back and forth between multiple tasks, operations, or mental sets), and inhibition (ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary). This tripartite model received extensive empirical support and is now the prevalent conceptualization for the structure of EFs across the lifespan (Best, Miller, & Jones, 2009). However, in the deception literature, only a recent study explicitly incorporated this model to guide the (meta)analysis (Christ et al., 2009) of neuroimaging data.

From an individual differences point of view, this *fractionation* of the central executive leads to a different prediction than the global view, arguing for a differential involvement of distinct EFs in deception. One of the few studies relating individual differences in cognitive abilities to deception supported this fractionated view, suggesting that "different kinds of lies arise from the operation of different cognitive processes" (Morgan, LeSage, & Kosslyn, 2009, p. 554).

Aside from these cognitive variables, individual differences in *personality* have been shown to influence deception (Farrow et al., 2003). In the thesis, we were interested whether stable, trait-like tendencies to present higher levels of anxiety in social contexts, or to present oneself in a favorable manner (social desirability) are related to the efficiency of deception.

Two more issues of interest were investigated in the thesis. We wanted to investigate the added value of introducing an additional cognitive load to differentiating between truthful and deceptive responses in the RT-based CIT. More specific, the current investigation used an *interference design*, introducing concurrent tasks involving two EFs evidenced to be relevant for the deceptive act: memory updating and flexible set-shifting (Visu-Petra, Miclea, & Visu-Petra 2011). Finally, we were interested in the malleability of the (supposedly) prepotent truthful response, by investigating how initially lying would differentially affect subsequent truthful responses (and vice-versa) to crime-related items.

A few considerations are appropriate regarding the methodological tools used to elicit and assess deception. Lykken (1959, 1974) introduced a testing format named the Guilty Knowledge Test (later known as the Concealed Information Test – CIT, or the Concealed Knowledge Test - CKT). It is essentially a recognition test in which the subject is presented with several items, among which a critical or relevant item is embedded. The rationale is that the critical item will be recognized only by the "guilty" subjects, but not by the "innocent" subjects. The CIT is aimed at disclosing the possession of information and is not meant to directly reflect deception. A repeated pattern of reacting differentially to the relevant items would suggest that the examinee has knowledge regarding the crime committed. It is also worth mentioning that in Japan, the CIT is used exclusively in forensic practice (Nakayama, 2002).

Recently, a number of authors (Seymour, Seifert, Shafto, & Mosman, 2000; Seymour & Kerlin, 2008) have suggested that reaction times (RTs) may be useful for detecting liars, because it has been consistently documented that it takes longer to produce a lie that to tell the truth (Spence, 2004). However, it was important to identify a test format in which both psychophysiological measures and RT indexes could be extracted, in order to assess their cumulative contributions to the detection of concealed information. The combination of the traditional Concealed Knowledge Test with an RT test resulted in what is known as the RT-based CIT (Seymour & Kerlin, 2008; Verschuere, Crombez, Degrootte & Rosseel, 2009). Throughout the thesis, we aimed to validate the potential of this technique in detecting deceptive behavior, as well as in revealing the neurocognitive mechanisms involved in deception production.

Chapter 2

DETECTING CONCEALED INFORMATION FROM A MOCK CRIME SCENARIO BY USING PSYCHOPHYSIOLOGICAL AND RT-BASED MEASURES

Introducing the RT-based Concealed Information Test

The combination of the traditional Concealed Knowledge Test with an RT test resulted in what is known as the RT-based CIT (Seymour & Kerlin, 2008; Verschuere, Crombez, Degrootte & Rosseel, 2009). In this paradigm, the subject is asked to give speeded responses to three types of items: relevant, targets, and irrelevant. The relevant items (usually presented as written/auditory stimuli) are derived from the crime itself and are supposed to represent aspects of the crime that the suspect could not miss to identify or notice; the irrelevant items share a variable degree of categorical similarity with the relevant items, and are usually several times more numerous; the target items are used in order to prevent the subject to enter an automatic mode of responding (e.g. simply inversing the rules specified in the instructions) and also share categorical similarity with the other two types of items. Although a number of studies have suggested that this procedure can successfully differentiate between guilty and innocent participants on the basis of RTs (e.g., Gamer, Bauerman, Stoeter, & Vossel, 2007; Seymour et al., 2000; Seymour & Kerlin, 2008; Verschuere et al., 2009), less conclusive results exist regarding the utility of *images* as stimuli in RT-based CIT, an issue worth investigating, especially considering that in forensic practice the use of pictorial items is the rule, rather than the exception (Nakayama, 2002).

Verschuere et al. (2009) designed the first study that comparatively assessed the detection efficiency of the physiological-based CIT with the detection efficiency of the RT-based CIT. The authors used a variant of the CIT relying on autobiographical information, asking subjects about personal information such as personal name, parent's names or birthdays. Results showed that participants made more errors on the probes than on the irrelevant items and that RTs were longer in response to probes. For the polygraph test, all three indices successfully differentiated between probes and irrelevants: the SCR magnitude was higher for probes than for irrelevants, the heart rate deceleration was greater for probes, and the RLL indicated greater respiratory suppression. The effect sizes indicated that the SCR and RTs were the measures that achieved the best discriminative power, but interestingly, they were not significantly correlated. This may suggest that they have independent contributions to the prediction of deceptive behavior.

STUDY 1: Comparing the detection efficiency of the RT-based Concealed Information Test with the polygraph

In the present study, we were interested in assessing the detection efficiency of the two methods: psychophysiological and behavioral. More specific, we comparatively assess the sensitivity of two deception detection paradigms: the traditional CIT which includes psychophysiological measures taken while the participant answers questions related to a mock crime, and the newer oddball paradigm, comparing RTs to images of items involved in the mock crime versus irrelevant items. For the polygraph test, we designed a questionnaire following the suggestions of Nakayama (2002), in order to parallel common practice in the field. Regarding the RT measure however, for the critical item (e.g. a camera) we used items from the same category (different cameras from different manufacturers), in order to keep in line with the literature in the field, which commonly uses items from the same category in RT-based CIT studies. Moreover, keeping in mind the lack of sufficient knowledge regarding the utility of using images in RT-based CIT, we decided to use for this part of the experiment images extracted from the mock crime scenario. Several studies have shown that an RT-based CIT having images as stimuli can be useful in detecting concealed information, but the available data is insufficient and does not permit a straightforward conclusion (Verschuere et al., 2004). Consequently, in order to further address this issue, in the present study we used images as stimuli.

Given these constraints, the application order of the two techniques couldn't be counterbalanced across subjects because the innocent subjects would have been able to identify the critical item; if the RT-based test was to be used first (e.g., if they were presented with different types of cameras), then at the corresponding polygraph question they could have inferred the camera is the critical item (because the camera is presented among other types of items, such a wrist watch, file etc.). Consequently, the polygraph test was always used first (see also the justification regarding the habituation effect above).

METHOD

Participants

Participants were 41 undergraduate psychology students (32 females, mean age = 21.76 years, SD = 2.31); they were randomly split in two groups (Guilty or Innocent). However, the physiological data from one Innocent participant were unusable, so the final samples included 21 Guilty and 19 Innocent participants. All participants had normal or corrected-to-normal vision and wore glasses or contact lenses if necessary.

Mock crime

The guilty participants received written instructions asking them to go into professor *Anton Ionescu's* office on the same floor of the building, locate a black *laptop bag* in that room, find inside the bag a *Traxdata CD* case, open the CD case to verify if the CD is in it's place and noticing in this way that inside the CD case was also a *100 RON bank note* (approximately 25 Euros). They were also instructed to take from the professor's desk *a mobile phone* and *a picture camera*, put all these items in the black bag and bring the bag in the examination room. They were also told that the people working at that level of the building were not informed that an experiment is taking place and should be cautious not to be seen behaving suspiciously. When the participant returned, he/she was asked to verbally describe the physical characteristics of each item in order to ensure a better encoding. Next, the items were taken out of sight and the participants received written instructions specifying that they were suspects in a theft and they will undergo a polygraph and a behavioral test designated to assess their involvement in the crime. The instructions also specified that they should try their best to appear innocent at the test; motivational instructions were also used (only smart people with excellent emotional control can sting the polygraph). They were asked to wash their hands and take a seat in the examination chair. Then, the sensors were attached and testing started.

Polygraph-based CIT

For the polygraph test, the Lafayette polygraph system, model LX-4000, was utilized. The CIT contained six questions with five alternatives each. Each question consisted in one buffer item presented after the presentation of the question, one relevant item and three irrelevants. The order of the relevant and irrelevant items within each question was randomly determined but remained constant across subjects. The questions were verbally presented by the examiner with an inter-stimulus interval of approximately 25s.

SCR was defined as the maximum amplitude observed in the 10s interval following question onset; the amplitude was calculated by the QuESt software (Quantitative Evaluation System). The respiration was analyzed using the respiration line length procedure (RLL, Timm, 1982). RLL is a composite measure of respiratory amplitude (depth of breathing) and respiratory cycle (rate of breathing). The RLL was calculated by the LX software for a 15s interval starting at question onset both for thoracic and abdominal channel. For further analyses the mean thoracic and abdominal RLL was computed. The data from the cardio channel were not analyzed in this study.

RT-based CIT

After completion of the polygraph test, participants were asked to undertake the second procedure. The items utilized in this study were pictures belonging to there categories of items: probes (the six critical items from the mock crime items), targets (to be detected items, also from the same category as the probes) and irrelevants (items from the same category as the probes, never seen before). First, a target study phase was administered; the subjects viewed a presentation with the six target items, each item being presented on the screen for 10 seconds. The instructions specified that the task was to memorize the physical characteristics of each item in order to reproduce them later. After three successive runs of the presentation, the subject was requested to describe each item. A minimal standard was applied in order to ensure good memory, consisting in a minimum of five relevant features of each item (e.g. color, shape etc.); when the standard was not met, the subject viewed the specific item for an extra 10s. Finally, after the verbal description of the target items, the subjects viewed the presentation once more. This part was identical for both groups. Then, the guilty participants were told that they were going to see pictures from three categories: the probes (the six critical items), the targets (the six targets studied earlier) and irrelevants (other pictures never seen before), and were instructed to respond YES to targets and NO to any other item (including probe items). These instructions were repeated in a shortened version by presenting them on the computer screen at the beginning of the testing session. The need to answer as quickly as possible to all items (including the targets) was emphasized. After a short training phase the test began. The innocent subjects were told to answer as quickly as possible both to targets and to irrelevant items (since they could not differentiate probes from irrelevants).

For the items presentation the Superlab 2.0 software was used. Each picture was about 15 x 15 cm, except the items referring to names, which were about 20 x 10 cm. The item remained on the screen until a response was made; if an answer was not performed within a 1000 milliseconds interval, a “too slow” message appeared on the screen. The inter-trial interval varied between 500, 800 and 1000 milliseconds in order to prevent automatic responding or preparation. Two blocks of trials were used in the Lie condition. There was a total of 108 trials / block: each probe, target and irrelevant was presented three times in a randomized order. After the completion of the trials, a memory test was used for the in order to ensure that the subjects remembered target items. After this test, the experiment ended for both guilty and innocents subjects.

RESULTS

RT-based test

Accuracy

First we computed the percentage of correct responses for guilty and innocent respondents for both types of stimuli (probe or irrelevant). In order to compare these percent correct data, an arcsine transformation was applied, which is used to stabilize the variance of percentage data (Cohen, 1988, cf. Gamer, Rill, Vossel & Gödert, 2006).

A repeated-measures analysis of variance (ANOVA) with Guilt (innocent vs. guilty) as a between-subjects and Stimulus type (probe vs. irrelevant) as a within-subjects measure was conducted. The results revealed a main effect of Guilt, $F(1, 38) = 7.68$, $p < .01$, partial $\eta^2 = .17$, and a Guilt X Stimulus type interaction, $F(1, 38) = 8.66$, $p < .01$, partial $\eta^2 = .19$. These results indicate that guilty subjects had poorer accuracy on the probes, whereas accuracy for irrelevant items did not differ as a function of guilt.

RTs

The 2 X 2 ANOVA with the mean RTs as dependent variables revealed a main effect of Guilt, $F(1, 38) = 4.35$, $p < .05$, partial $\eta^2 = .10$, a mean effect of Stimulus type, $F(1, 38) = 13.43$, $p < .001$, partial $\eta^2 = .26$, and a Guilt X Stimulus type interaction, $F(1, 38) = 35.00$, $p < .0001$, partial $\eta^2 = .48$. This pattern of results indicated that while RTs for probes were slower in the guilty, compared to the innocent condition, no reliable difference was noted on the irrelevant items. This interaction pattern, visible on both accuracy and RT measures, characterizes the concealed knowledge effect (Seymour et al., 2000), translated (in this case) in a temporal penalty of about 100 ms in the responses to probe, compared to irrelevant items.

Polygraph test

A first step which needed to be taken in order to eliminate individual differences in responsivity and to generate a comparable index of the response differences between relevant and irrelevant items for the whole test, was to standardize physiological responses within each question for each subject (Ben-Shakar, 1985). Therefore, standard difference scores for each subject and each measure (SCR amplitude and RLL) were calculated according to the following procedure, indicated by Gamer et al. (2006), and Meijer, Smulders, Johnston, and Merckelbach (2007). First of all, the responses to each item were z-standardized based on the mean and the standard deviation of the responses to the irrelevant items. In a second step, difference scores between the response to the relevant item and the mean of the three irrelevant items (the first irrelevant was a buffer and thus not included in the analysis) within each of the six multiple-choice questions were calculated. Afterwards the mean of these measures was computed as an overall index of the differential responsivity in each physiological measure. This difference should be around zero for innocent subjects, as they are supposed to show similar response patterns to relevant and irrelevant items, whereas a negative value (for a lower RLL on relevant items) or a positive value (for higher responses on relevant items in terms of SCR) should indicate knowledge of crime-related details. These standardized response differences were then used in all subsequent statistical analyses.

Mean *z*-standardized differences between relevant and irrelevant responses were compared between Innocent and Guilty subjects. T-tests showed significant differences between these two groups for the mean of both respiratory channels (thoracic and abdominal); $t(38) = 6.14$, $p < 0.0001$, $d = 2.00$. Additionally, the SCR data differed significantly between the two experimental groups; $t(38) = 6.16$, $p < 0.0001$, $d = 2.01$.

In addition to this differential analysis, a classical method to contrast responses in Guilty and Innocent participants was used. Lykken (1959) proposed a scoring procedure for CIT that allows individual classification for each examinee. According to this procedure, the first item in each question is never scored; then, if the strongest physiological reaction appears at the relevant item, a score of two is assigned. If the physiological reaction at the relevant item is second highest, a score of one is assigned; if third or lower, no score is assigned. If a test has six questions, the highest score possible is 12 and the lower is 0. Decision rules may vary (Elaad & Ben-Shakhar, 1997), but usually the cutoff point is equal with the number of questions. In our study, we had 6 questions, so the cutoff point was 6; the data offered by the QuEst software were used for order ranking the physiological amplitudes for the SCR amplitude. If a sum higher than 6 was obtained, the participant was classified as guilty; if a number under 6 was obtained, the participant was classified innocent. Compared to ground truth, the results showed that 86% of guilty participants and 95% of innocents were correctly classified.

Detection efficiency

Two statistical methods were used to compare the detection efficiency of the two tests. Before proceeding, we calculated difference scores for the RT-based CKT by subtracting the RTs and the percent correct scores for irrelevants from probes (to allow for comparisons with the polygraph difference scores). We correlated the differences between physiological responses to relevant items and neutral ones in the polygraph test with differences between probes and irrelevants in the RT-based CIT. In the case of Innocent subjects, there was no significant correlation, revealing that there was no systematic variation in subject's reactions to critical items as compared to neutral items in the two tests. In the case of Guilty subjects, there were some significant relationships between the indexes. More specific, differences in the RT measure were positively related to differences in mean RLL, $r(19) = 46$, $p < .05$. Differences in terms of accuracy from the RT-based CIT were positively related to differences in the SCR, $r(19) = .45$, $p < .05$. However, these correlations are only moderate and suggest that the two measures can bring independent contributions to the detection of deceptive behavior.

Next, a comparison of the magnitude of effects for *t*-tests comparing difference scores between Guilty and Innocent participants was conducted. A second index for comparisons was extracted by calculating the areas under ROC (Receiver Operating Characteristic) curves (using the command included in SPSS 13.00). This is a measure designed to assess the diagnostic utility of tests used to classify subjects in different categories (here in Guilty vs. Innocents). The areas can vary between 0 and 1, with an area of 0.5 being regarded as a random variation. If a value of 1 is obtained, then one could conclude that the areas for the Guilty and the areas for the Innocent participants are not overlapping at all, and that a correct decision was made for each participant (cf. Gamer et al., 2006, and the National Research Council, 2003).

Looking at our results, and comparing them to similar outputs from other studies (e.g. Verschuere et al., 2009; Gamer et al., 2006), several conclusions can be derived. Confidence intervals indicate that the area under the ROC curves of all physiological and behavioral variables differed significantly from a chance area of 0.5. Values above 0.80 for all indexes indicate that they were all successful in differentiating between Guilty and Innocent subjects. The best classification was made according to SCR, followed by the respiratory measures which yielded similar results to the RT-based test. The least discriminative measure was the accuracy of responses in the RT-based test.

Discussion

This study used a mock crime scenario and two methods for the detection of concealed information: a polygraph test and the analysis of RTs, both involving a contrast between reactions to critical items from the mock crime scenario and responses to irrelevant items. We hypothesized that both measures, using both types of stimulus presentations (verbal or visual) could be used as stand-alone tests for the detection of deception, successfully differentiating between guilty and Innocent participants. Our results largely supported our hypotheses.

Regarding the polygraph data, our results generally confirmed previous findings regarding accuracy rates observed in studies using CIT in order to detect knowledge from mock crime scenarios. Ben-Shakhar & Elaad (2003) showed in their meta-analysis that usually, in studies that used a mock crime, an average effect size of 2.09 has been achieved for SCR data. Similarly, in our study we have found an effect size of 2.01, which is in line with current research in the field. Regarding RLL, an effect size of 2.00 was obtained, which is slightly larger than other studies (e.g. 1.50 in Gamer, Bauermann, Stoeter, & Vossel, 2007, or 1.76 in Ambach, Stark, Peper, & Vaitl, 2008b). It should be mentioned that our study was conducted in optimal condititions as the ones specified by Carmel, Dayan, Naveh, Raveh, & Ben-Shakar, (2003): for instance, an adequate number of CIT questions, testing phase imediatly after mock crime, good memory for critical item and motivational instructions; these chracteristics may account for the good discriminatory power of the RLL recordings.

Elaad (1998) presented data from 15 mock crime CIT studies and showed that 81% of guilty and 96% of innocent examinees were correctly classified. In 11 of these studies no false positive errors occurred. This is also in line with the results presented in a quantitative review of the Concealed Information Test, where MacLaren (2001) has shown that using electrodermal measures alone, a correct classification of about 76% of guilty and 83% of innocent examinees can be achieved. Using the Lykken Scoring procedure, our investigation correctly classified 86% correct of guilty and 95% of innocent participants.

Regarding the RT-based test, the results we obtained also mimicked the main findings in literature, suggesting that the RT-based CIT can reliably differentiate between probes and irrelevants (Seymour et al., 2000; Verschuere et al., 2009). The effect size we obtained was rather high (d = 1.97), confirming that the concealed knowledge effect can be reliably evidenced also in a mock crime paradigm and using pictures of actual objects handled by subjects.

In the present study, guilty participants needed an approximately 100 milliseconds more to respond to guilty items. In the literature, depending on the methodology, various time penalties associated with lies have been found: Verschuere et al. (2009) reported a difference between probes and irrelevants for about 60 ms in an autobiographical CIT; Seymour & Kerlin (2008) found a mean difference between probes and irrelevant for about 185 ms, but no mock crime was used for the picture condition in their study; Seymour et al. (2000), using a mock crime scenario reported a mean difference of about 300 ms between probes and irrelevants. However, numerous studies support the idea that lying can be reliably distinguished from true responses in terms of average RT, generating a "lying constant" to the truthful RTs (Sheridan & Flowers, 2010). However, the cognitive processes underlying this additional time needed to produce a lie warrant further investigation.

In the present study, pictures of the actual objects were used for the RT-based CIT. Several studies support the fact that the concealed information effect is independent of the mode of presentation: auditory or visual (Ambach et al., 2010; Farrow, Reilly, Rahman, Herford, Woodruff, & Spence, 2003), or is enhanced in the case of pictures (Cutmore, Djakovic, Kebbell, & Shum, 2009). Although the effect sizes were similar to the ones previously found using words (e.g. Seymour et al., 2000), they were also smaller.

This leads us to the final purpose of the study, which was to comparatively investigate the detection efficiency of the two methods. Contrasting reactions to probes and to irrelevant items in the two conditions, and based on standard criteria for assessing the magnitude of effect sizes (Cohen, 1988), we can say that we obtained large (> .80) effects for all types of outputs being analyzed. Indicators for physiological reactions to verbal presentations of stimuli were only slightly more efficient than the RT-based measure (Cohen's d = 2 and 1.92, respectively). However, the fact that the correlation between the two measures, although significant (only in the case of RLL and RT, and not for SCR and RT), was not very high could indicate that each measure brings independent contributions to the identification of concealed knowledge (Verschuere et al., 2009). The analysis of accuracy in responses to probes or irrelevants, although significant, was less efficient than the other measures in differentiating between guilty and innocent subjects.

However, from a theoretical perspective, the RT-based CIT offers a unique framework for the analysis of the neurocognitive mechanisms involved in producing and executing deceptive responses. In other words, if one is interested to investigate the cognitive mechanisms involved in concealing information as a method of lying, the RT-based measurements could be one of the most relevant indexes of supplementary (executive) processing.

Chapter 3

RELATING DECEPTION ON THE RT-BASED CONCEALED INFORMATION TEST TO INDIVIDUAL DIFFERENCES IN EXECUTIVE FUNCTIONING AND ANXIETY

The multidimensional model of executive functions (EFs, see Introduction) can generate more specific predictions regarding their interplay with deceptive behavior. For instance, while proficiency in some executive skills (e.g. inhibition) might be related to an ability to produce better, harder-to-detect lies, enhanced functioning of other EFs (e.g. WM for the truthful response) might interfere with and undermine the lying process. This view has been theoretically supported by the Activation-Decision-Construction-Model (Walczyck, Roper, Seemann & Humphrey, 2003), which proposes that a stronger activation of the truthful, prepotent response, might undermine its subsequent inhibition during lying. The same authors (Walczyck, Schwartz, Clifton, Adams, Wei, & Zha, 2005) found that the enhanced accessibility (distance in time) of true memories interferes with the speed of deceptive responses.

Most importantly for the context of deception, anxiety might be best represented not simply as a bidimensional construct (state-trait), but rather as a multidimensional construct at the intersection of individual and contextual factors (Endler, Edwards, Vitelli, & Parker, 1989). According to the Multidimensional Interaction Model of anxiety (Endler, 1983), distinct facets of anxiety correspond to situational-based vulnerabilities; changes in state anxiety are expected only if there is congruency between the trait anxiety dimension and the type of situational stress. In the current study we assessed distinct dimensions of trait anxiety in relation to parameters of state anxiety in a simple evaluative situation (cognitive testing) and subsequently, in the context of deception detection. To our knowledge, this is the first study investigating the relationship between multidimensional anxiety measures and deceptive outcomes (RTs and errors) in a Concealed Information Test (CIT) context.

Comparing physiological and RT-bases measures of deception, Verschuere et al. (2009) found support for the validity of the RT-based test and indicated a similar discriminative power to the polygraph (the skin conductance measure; see also Visu-Petra, Bus, & Miclea, 2011). This evidence motivated our decision to detect the behavioral aspects of deception in an RT-based CIT format.

STUDY 2*:* Relating deception to individual differences in executive functioning and anxiety

The present study aimed to investigate behavioral correlates of deception, and to relate them to cognitive and personality individual differences. A mock crime scenario was used, followed by a pictorial RT-based oddball paradigm to detect concealed knowledge in guilty, compared to innocent participants. There were two main issues of interest, which significantly extend the existing literature in the field. First, we wanted to know if the pictorial version of the RT-based CKT with items derived from a mock crime would discriminate (in terms of accuracy and RT costs) between guilty and innocent subjects. Second, we were interested in the relationship between lying and individual differences in executive functioning and anxiety. More specific, we assessed individual strengths and weaknesses in the three dimensions from the factorial EF model and related them to deceptive responses (RTs and error rates).

Further investigating individual differences, we were also interested in the relationship between measures of deception and several dimensions of state and trait anxiety We hypothesized that parameters of state (autonomic and cognitive) and trait anxiety (related to social evaluation, ambiguous events) will act as personal characteristics which interfere with the distinction between responses of guilty and innocent participants.

METHOD

Participants

Participants (N = 44, 34 females) were recruited from general psychology classes (42% freshmen, 58% sophomores) by using an online recruitment system or in-class announcements, and received credit for their participation. The age of participants ranged from 19 to 33 years, and mean age was 21.76 years (SD = 2.31). They all completed the cognitive and personality measures in an initial session. From this initial sample, 40 subjects also completed a second session, which involved a mock crime scenario (for the 21 randomly selected guilty participants), and a physiological and behavioral and measure of deception (for all 40 participants). Participants had normal or corrected-to-normal vision and wore glasses or contact lenses if necessary.

Materials, scoring and procedure

Session 1

Executive functions measures

The cognitive tasks were administered first, followed by the anxiety questionnaire. Both anxiety and cognitive measures are included in the Cognitrom Assessment System (CAS++, Miclea, Porumb, Cotârlea & Albu, 2009), a computerized cognitive and personality assessment battery. The EF tests included in the CAS++ battery were explicitly designed to measure the three EF dimensions specified in the model of Miyake and collaborators and relied on well-established paradigms in the field (see task description below). An additional test of spatial WM was included from the Automated Working Memory Assessment battery (AWMA, Alloway, 2007, see Visu-Petra, 2008 for the adapted version), also applied in a computerized version. The test-retest reliabilities of the selected measures ranged from moderate to high (.71 for the Inhibition test, .34 for accuracy and .63 for efficiency on the Shifting test, .74 for the verbal WM test, Miclea et al., 2009; and .77 for the spatial WM test, Alloway, 2007), a finding which is common in the literature investigating EFs (Miyake et al., 2000). Participants were individually tested in a single computerized session lasting for approximately 50 minutes.

Inhibition was evaluated using a CAS++ task measuring both “active” inhibition (suppression of a prepotent response, as specified by the Miyake et al. model) and “reactive” inhibition (negative priming).

Shifting was assessed using a task-switching measure included in the CAS++, which presented stimuli in a random task sequence (see Monsell, 2003). Following the guidelines provided by the Miyake et al model, this task required the subject to flexibly alternate between two distinct mental sets, according to a switching rule.

Updating of working memory representations was evaluated using the WM test from the CAS++ to assess verbal updating, and the Mr. X task from the AWMA to assess spatial updating. As specified by the Miyake et al. paper for the updating dimension, both tasks required ongoing monitoring and updating of WM representations. The verbal WM test involved a classic Letter-Number Sequencing procedure (Gold et al., 1997). The spatial WM task involves the memory of an increasing number of locations, by pointing to a picture with six compass points. None of the WM measures offered any efficiency indexes. Total accuracy for each test was considered as the measure of individual proficiency.

As this study investigated individual strengths and weaknesses in executive functions in relation to deceptive behavior, we used the norms provided by the CAS++ and AWMA in order to obtain an individual level of proficiency on each task, as compared to the general population. Individual scores on each task were thus translated in a 5-levels proficiency scale, with 1 signifying very poor, and 5 an excellent performance on the task. All reported correlations will be based on these levels of proficiency in distinct EFs.

Anxiety measures

State and Trait anxiety were assessed using the Endler Multidimensional Anxiety Scales (Endler et al., 1989), which have been adapted and standardized on the Romanian population (Miclea, Ciucă, Albu, 2009).

Session 2

Mock crime

A mock crime scenario was used and participants were randomly distributed to one of the two conditions: (a) a guilty group (21 subjects), who committed the mock crime and interacted with the six critical details and (b) an innocent group (20 subjects) who did not commit the crime and were unaware of the six critical details. Upon arrival, each subject received written instructions according to the experimental condition they were randomly assigned to. The guilty participants received a scenario requiring them to steal the subjects for an upcoming exam. They had to go into Professor *Anton Ionescu's* office on the same floor of the building, locate a *black laptop bag* in that room, find inside the bag a *Traxdata CD case,* open the CD case to verify if the CD with the exam subjects was inside and notice that inside the CD case there was also a *100 RON banknote* (approximately 25 Euros). Aside from the CD and the money, they were also instructed to take a *mobile phone* and a *picture camera* from the professor's desk, put all these items in the black bag and bring the bag in the examination room. To increase the realism and the pressure of the situation, they were also told that the people working in the building had not been informed that an experiment is taking place, and should be cautious not to be seen behaving suspiciously. When the participant returned, he/she was asked to verbally describe the physical characteristics of each item in order to ensure a better encoding. Next, the items were taken out of sight and the participants received written instructions specifying that they were suspects of a theft and they will undergo a polygraph and a behavioral test, designated to assess their involvement in the crime. These final instructions were received by innocent participants upon arrival; therefore they were notified that they are suspects of a theft will undergo the two examination procedures mentioned above.

RT-based CIT

After being presented with the polygraph setting, both guilty and innocent participants were re-administered the EMAS-State measure, in order to assess potential increases in anxiety due to the deception detection context. Before undergoing the two deception detection tests, all participants were warned about the lie-detection intention of the experimenter, about the fact that they will encounter crime-related items, and were asked to make their best to appear innocent across both study procedures. As suggested by Nakayama (2002), and by Ben-Shakhar, Gati and Salamon (1995), the words used in the polygraph CIT test belonged to distinct categories (as compared to the RT-based CIT items, which belonged to the same category). Considering the difference between the two stimuli sets, the results of the polygraph test are not presented here (but see, for details, Visu-Petra, Buş & Miclea, 2011). Subsequently, the participants were asked to undertake a second procedure. They were invited in another room where another experimenter, blind to the guilt status of the participant, conducted the RT- based CIT. The items utilized in this study were pictures belonging to there categories of items: probes (the six critical items from the mock crime items), targets (to be detected items, also from the same category as the probes) and irrelevants (four for each probe; items from the same category as the probes, not previously encountered during the experiment).

The six targets were presented and learned at the beginning of the recognition test; the subjects viewed a presentation with the six target items, each item being presented on the screen for 10 sec. The instructions specified that the task was to memorize the physical characteristics of each item in order to reproduce them later. After three successive runs of the presentation, the subject was requested to verbally describe each item. A minimal standard was applied in order to ensure good memory, consisting in a minimum of four relevant features of each item (e.g. color, shape etc.); when the standard was not met, the subject viewed the specific item for an extra 10 sec. After the verbal description of the target items, the subjects viewed the presentation once more. This part was identical for both groups.

Then, in order to question the ability of guilty subjects to strategically alter their responses to probes (similar to Seymour et al., 2000, Experiment 2), subjects were told to expect pictures from three categories: crime-related items, targets (studied earlier) and irrelevants (other pictures never seen before). They 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; their assignment being counterbalanced). The need to answer as quickly as possible to all items (including the targets) was emphasized. After a short training phase the test began. A condensed version of the instructions, identical for guilty and innocent participants was displayed on the computer screen at the beginning of the testing session.

For the item presentation and response time recording, the Superlab v. 2.0 software was used. Each picture was about 15 x 15 cm, except the items referring to names, which were about 20 x 10 cm. The item remained on the screen until a response was made; if an answer was not offered within a 1000 ms interval, a "too slow" message appeared on the screen. A pilot study showed that we needed to increase the time frame (as compared to the usual 800 ms used in oddball paradigms for the recognition of verbal information) because of floor levels of performance induced by shorter stimulus durations. It is possible that the greater quantity of visual details needed to differentiate between pictures of complex visual stimuli required this extra-time to be taken. The inter-trial interval varied randomly between 500, 800 and 1000 ms in order to prevent automatic responding or preparation effects. Two blocks of trials were used in the Lie condition. We included a total of 108 trials / block: each probe, target and irrelevant was presented three times in a randomized order. After task completion, a memory test was used for both innocent and guilty subjects in order to ensure that the subjects had remembered the target items. At the end of the experiment, participants were debriefed; later on, they also received the results for the cognitive and anxiety tests via e-mail.

RESULTS

Behavioral measures of deception

Accuracy

We first calculated the percentage of correct responses for guilty and innocent respondents according to type of stimulus: probe or irrelevant. For the statistical comparison of percentages, an arcsine transformation was applied to the percent correct data (Cohen, 1988, cf. Gamer et al., 2007).

A repeated-measures analysis of variance (ANOVA) with Guilt (innocent vs. guilty) as a between-subjects and Stimulus type (probe vs. irrelevant) as a within-subjects measure was conducted. The results revealed a main effect of Guilt, $F(1, 38) = 7.68$, $p < .01$, $\eta^2 = .17$, and a Guilt X Stimulus type interaction, $F(1, 38) = 8.66$, $p < .01$, $\eta^2 = .19$. These results indicate that guilty subjects had poorer accuracy on the probes, whereas accuracy for irrelevant items did not differ as a function of guilt.

RTs

Using a similar 2 X 2 ANOVA with the mean RTs as dependent variables (for correctly rejected probes and irrelevant items), we obtained a main effect of Guilt, $F(1, 38) = 4.35$, $p < .05$, $\eta^2 = .10$, a mean effect of Stimulus type, $F(1, 38) = 13.43$, $p < .001$, $\eta^2 = .26$, and a Guilt X Stimulus type interaction, $F(1, 38) = 35.00$, $p < .0001$, $\eta^2 = .48$. This pattern of results indicated that while RTs for probes were slower in the guilty, compared to the innocent condition, no reliable difference was noted on the irrelevant items. This interaction pattern, visible on both accuracy and RT measures, characterizes the concealed (guilty) knowledge effect (Seymour et al., 2000).

In order to assess the *detection efficiency* of the RT-based CIT, we first calculated for each subject the difference between responses (accuracy and RT, respectively) to probes and irrelevants. The resulting difference scores were used to generate receiver operating characteristic (ROC) curves and the area under each curve was computed. This area can vary between 0 and 1, with an area of 0.5 can be regarded as a random classification. In addition to this descriptive value, confidence intervals (90% - 95%) were calculated (see Gamer et al., 2006). Areas under the curve were 0.92 (0.81 - 1.02) for the RT measure, and 0.80 (0.66 - 0.95), for the accuracy measure.

Relation to individual differences

In order to determine the interrelationships between executive, anxiety and deceptive behavior measures (accuracy and RT for each stimulus type, plus difference scores between accuracy and RT for probes and irrelevants), Pearson correlations were separately computed for the guilty ($N = 21$), and the innocent subjects ($N = 19$), respectively.

In the Innocent group, we found no significant interrelations between EF measures and outcomes from the recognition memory test (RTs / errors). The overall picture of intercorrelations between EFs and deception measures was different in the case of the guilty group, with several significant correlations being noticeable. Spatial WM was positively related to RTs for all item categories: $r(21) = .66$, $p < .01$ for Irrelevants, $r(21) = .56$, $p < .01$, for Probes, and $r(21) = .54$, $p < .05$, for Targets. Subjects with better spatial WM took longer to correctly classify all types of items, but especially Irrelevants. In terms of accuracy, subjects with higher levels of spatial WM were better at recognizing targets, $r(21) = .53$, $p < .05$. Verbal WM was only related to longer times in classifying an item as Irrelevant, $r(21) = .59$, $p < .01$. Another significant relationship was noted between Shifting performance and accuracy in lying about probes probe, $r(21) = .57$, $p < .01$, or recognizing the irrelevants, $r(21) = .68$, $p < .01$. There was a marginally significant negative correlation between time taken to lie to probes and inhibition skills, $r(21) = -.42$, $p < .06$, suggesting that subjects with better inhibitory skills were faster in their deceptive responses. Finally, there were no significant correlations between EFs and difference scores (probes minus irrelevants).

Looking at the relationship between anxiety and deception in the case of innocent participants, neither state, nor trait anxiety, were significantly correlated with deception outcomes. Since state anxiety was assessed twice, first in a neutral and second in a deception detection context, we wanted to investigate whether guilty subjects would experience an enhanced level of state anxiety during the second session, compared to innocent participants. Therefore, a repeated-measures ANOVA was conducted with Time of assessment (Session 1 vs. Session 2) as a within-subjects variable, and Guilt condition (Innocent vs. Guilty) as a between-subjects variable for each of the two state anxiety subscales (Autonomic-Emotional and Cognitive-Worry). For the Autonomic-Emotional scale, results indicated a main effect of time of assessment, with overall anxiety scores being higher in the second, deception detection session, $F(1, 38) = 24.55$, $p < .01$, $\eta^2 = .39$. However, the interaction between time of assessment and guilt condition was non-significant, $F(1, 38) = .03$, *n.s.*, revealing that this effect was present in all participants, and was not differentially enhanced for guilty subjects. The increased (autonomic-emotional) state anxiety was not translated in any significant association with the deceptive outcomes. For the Cognitive-Worry scale, no significant main effects or interaction between variables were identified, and no relationships between this scale and deceptive responses.

Looking at the relationship between trait anxiety and deception, we first have to note that all subjects had relatively low scores (only 5 out of 40 subjects had slightly above-mean T-scores on several trait anxiety dimensions, and 18 had below-mean T-scores, the rest presenting mean levels of trait anxiety). Two significant (negative) relationships between trait anxiety and accuracy in responses to probes were identified in the guilty group. More specific, subjects with higher anxiety regarding social evaluation, and with higher apprehensions related to ambiguous situations, made more errors in lying about the probes, $r(21) = -.47$, $p < .05$, and $r(21) = -.53$, $p < .05$, respectively.

DISCUSSION

First, the RT-based CIT with pictorial items from the mock crime successfully discriminated between guilty and innocent participants, the type of significant effects being similar with the ones obtained in other RT-based studies using verbal stimuli (e.g. Seymour et al., 2000).

Similar to one of the studies in the Seymour et al. (2000) paper, subjects were explicitly told to expect crime-related probe items, and were asked to respond to them in a manner as similar as possible to the irrelevant items, in order to mask their guilty (concealed) knowledge. However, this warning did not eliminate the concealed knowledge effect, suggesting that the pictorial RT-based deception detection test is also not easily altered by strategic manipulation and that surprise is not the mechanism underlying the concealed information effect (Seymour et al., 2000).

After establishing the pictorial RT-based test as a reliable indicator of deception, our next research interest was to analyze the relationship between individual differences in executive functioning and deception outcomes. We subscribed to a fractionated model of EFs (Miyake et al., 2000), which supports the independence and interdependence of three components: updating, inhibition and set-shifting. Intersecting this model with cognitive models of deception (i.e. Walczyk et al., 2005), we hypothesized that while inhibition and set-shifting would directly relate to deception skills, WM would be a negative correlate of lying proficiency. The results were mostly congruent with our initial expectations and to recent findings by Farrow et al. (2010), revealing that enhanced verbal and spatial memory skills are related to longer response time required to tell a lie.

A final area of interest was the relationship between anxiety seen as a multidimensional construct and deception. For innocent participants, neither state, nor trait anxiety were related to performance on the memory recognition test. It is possible that the use of a facile test (see the ceiling levels of performance accuracy) did not generate a stressful situation for the participants, even if the presence of an experimenter represented a social evaluation context. For all participants, there was a significant increase in the Automatic-Emotional component of state anxiety during the memory recognition context, compared to the anxiety experienced during the first psychological testing. However, this increase in state anxiety was not related to their actual performance according to the type of item being recognized (target, probe or irrelevant). This suggests that in this context, state anxiety did not differentially affect deceptive or truthful responses. A more specific relationship appeared in the case of trait anxiety, which was negatively related to the accuracy of deceptive responses. More specific, those with higher levels of trait anxiety in relation to social evaluation and to ambiguous situations had a poorer accuracy in their deceptive responses related to probes. Thus, similar to their distinct psychophysiological outputs in response to relevant and non-relevant items (Giesen & Rollinson, 1980), guilty individuals also show differential accuracy in their deceptive responses to probes.

Our results provide support to the idea that executive control processes play an essential role in a person's ability to accurately execute deceptive responses. While there is a direct relationship between an individual's capacity to switch between distinct mental sets or to inhibit prepotent responses and deception skills, there is a negative relationship between WM skills and deception speed. Thus, as specified by previous models of deception (e.g. Walczyk et al., 2003), enhanced memory of the truth undermines deception accuracy, a finding confirmed by recent findings (Farrow et al., 2010).

The capacity to flexibly switch between mental sets (such as for truthful and deceptive responses) appears to be essential in order to construct a plausible and effective lie. It is important to note that our interpretation relies on an underlying assumption that there is a general mechanism for both EF and deceptive responses, so that "the executive processes required to carry out a successful deception are likely to be the same as those used generally when pre-potent responses must be inhibited and incompatible responses executed." (Johnson et al., 2004, p. 879).

Chapter 4

RELATING DECEPTION ON THE RT-BASED CONCEALED INFORMATION TEST TO INDIVIDUAL DIFFERENCES IN EXECUTIVE FUNCTIONING, PERSONALITY AND SOCIAL DESIRABILITY

Considering that lying manifests at the interplay between dispositional and contextual characteristics, several authors tried to link personality characteristics with the propensity to lie. Kashy & DePaulo (1996) were interested in the relationship between lying frequency and personality characteristics. The authors investigated in a diary study if two types of lies (self-centered and other-oriented) were related to several personality characteristics. Results suggested that people who told more lies were also more manipulative, more concerned with self-presentation and more sociable. Farrow, Reilly, Rahman, Herford, Woodruff, & Spence (2003) also investigated individual differences in personality in relation to deception skills. The authors anticipated a positive relation between responses on the Lie scale and speed of deceptive responses, compared to truthful ones, due to habitual patterns of (deceptive) response generation. However, this prediction was not confirmed by their investigation (see Farrow et al., 2003, for a discussion of negative findings). Other studies using self-report measures of deception, however, revealed a connection between neuroticism and deception scores (Sigurdsson & Gudjonsson, 1996; Weaver, 2005). A classic study relating individual differences in personality and social skills (Riggio & Friedman, 1983) showed no significant correlations between personality measures from the Eysenck Personality Inventory and deceptive behaviors (although there was an association with extraversion measured by another self-report measure). Summarizing, investigations which tried to relate general personality characteristics with the propensity to lie have yielded mixed results (McLeod & Genereux, 2008).

Second, and anticipated by the previously mentioned studies, a key dimension which interferes with the investigation of the relationship between personality and deception is social desirability. However, some researchers consider that social desirability might be “reflecting a basic attribute of personality in its own right beyond that of a pervasive confound to personality assessment” (Helmes & Holden, p. 1016). Paulhus (1984) distinguished two forms of socially desirable responding: self deception and impression management. The Balanced Inventory of Desirable Responding (BIDR; Paulhus, 1991) was constructed to assess these two facets. It was consistently reported that IM is more situation-, or context-constrained than SDE (Gudjonsson and Moore, 2001; Paulhus, 2006; Snell et al., 1999). Results on IM scales were found to correlate strongly with the EPQ Lie scale in both typical, and offender populations (Davies, French, & Keogh, 1998; Paulhus, 1991; Gudjonsson & Sigurdsson, 2004), suggesting considerable overlap between these two measures. Moreover, the Lie scale from the EPQ has been seen as a measure of attempted social desirability (Forrest, Lewis & Shevlin, 2000) or as a measure of social conformity (Birembaum & Montag, 1989).

STUDY 3: Predicting deception efficiency from individual differences in executive functioning, personality and social desirability

To summarize, the general aim of the study was to assess the relationship between deception speed (in an RT-based CIT) and individual differences in executive functioning and personality, with a focus on social desirability. We hypothesized that better executive skills would enhance deception speed, although it is possible that WM proficiency would play an opposite role, by reinforcing the memory contents which need to be actively suppressed during deception. Due to the lack of previous studies using the RT-based CIT, no strong hypotheses could be advanced regarding this relation between personality dimensions and deceptive outcomes. We hypothesized that participants with higher levels of social desirability (high scores on the Lie scale of the EPQ-R, and on the BIDR-IM) would exhibit a reduced difference between time taken to lie and to tell the truth, due to habitual patterns of deceptive responding.

METHOD

Participants

Participants (N = 47, 37 females) were undergraduates from psychology classes. Mean age was 23.45 years (SD = 5.90). All participants signed informed consent forms and received course credit for the participation to both testing sessions**.**

Procedure and tasks

Session 1 – Personality and Executive functions

There were two testing sessions; in the first one, the participants initially completed the *Eysenck Personality Inventory* – EPQ-R, (Eysenck & Eysenck, 1991; Pitariu, Iliescu, & Băban, 2008, the Romanian version). The EPQ-R (106 items) measures three personality factors: Extraversion (E), Neuroticism (N), and Psychoticism (P). Two further scales, Addiction (A) and Criminality (C), can be extracted from the questionnaire. In addition to this, a Lie (L) scale is introduced to test for dissimulation and social desirability effects. It aims to detect subjects who report socially desirable, but infrequently practiced behaviors, or who deny socially undesirable, but frequently practiced behaviors (e.g. minor dishonesties, bad thoughts, weaknesses of character, etc.). The Romanian EPQ-R subscales have good internal consistency (Cronbach's α) and test-retest reliability for this age group: E (α = .83, r = .82); N (α = .89, r = .90); P (α = .75, r = .74); L (α = .77, r = .87); A (α = .80, r = .88); C (α = .83, r = .87) (Pitariu, Iliescu, & Băban, 2008).

Next, participants completed the *Balanced Inventory of Desirable Responding* – BIDR (Paulhus, 1991; see Visu-Petra, Borlean, Chendran, & Buş, 2008; Steenkamp, de Jong, & Baumgartner, 2010, for the Romanian version). BIDR is a 40-item self-report questionnaire consisting in two 20-item subscales, measuring self-deception (SDE), and impression management (IM). Test-retest reliability for the Romanian version was moderate, r (SDE) = .49, r(IM) = .67 (Steenkamp et al., 2010).

In the second part of this individual session, four EF tasks were completed: verbal WM, inhibition and set shifting (extracted from the Cognitrom Assessment System - CAS^{++} assessment battery, Miclea et al., 2009). A spatial WM test from the Automated Working Memory Assessment battery (AWMA, Alloway, 2007) was added to the CAS++ tests, because this dimension was documented to be related to deception speed (Morgan et al., 2009; Visu-Petra et al., in press). The cognitive tasks were applied in a computerized version, and the EPQ-R and BIDR were paper and pencil.

Session 2 – Deception detection

A second testing session targeted deception detection and used a mock crime scenario. Participants first read the instructions for the mock crime, they implemented it, then completed a filler task for about 15 min; afterwards, they studied and learned the target items and finally attended the CIT test with verbal items.

Mock crime

First, the participants read and sign the informed consent. 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 at 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 participated in a meeting which took place in the professor's office and noticed on his desk on a piece of paper the *Id* (*Psiho MCC,* where the

MCC abbreviation stands for – in Romanian - cognitive behavioural modifications, the actual name of the course) and *password (patru verde / four green)* for the discipline's e-mail account 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 location were chosen from another city in order to avoid previous exposure). After accessing the account (which was created identical to a real course application on the actual faculty website), they 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 professor's consent) for multiplying exam papers. The participant had to forward this message with attachment to their personal e-mail account. After reading these instructions twice and memorizing (emphasized) the five critical items (i.e. the probes), they were asked to go into a distant room (designated as Café Amber) and perform the actions specified in the instructions. The interface was a mock program designed especially for this study and was deactivated after the completion of the study.

After the mock crime, a non-verbal reasoning test taken from a standardized battery was used as a filler task, lasting for about 12 to 15 minutes. This data were not further analyzed.

In the target learning phase, the participants learned a sequence of five items similar with the probes. They were instructed to memorize the items in order to reproduce and recognize them. In order to obtain a good memory for the target items, after the memorizing phase, the participant was asked to complete two pencil and paper cued recall tests: in the first run, they were presented with the first word of the two-word phrase, and in the second run they were presented with the second word, in each run the participant completing the missing item. If a wrong answer was given, they were again shown the instructions and asked to memorize the items. If a correct answer was given, they were asked to verbally reproduce from memory the targets. If a wrong answer was given this time, they were shown the instructions asked to memorize the items again; a final verbal recall was asked to ensure good memory of the item.

RT-based CIT

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 detected items, also from the same category as the probes) and *irrelevants* (items from the same category as the probes, not previously encountered). For each probe, another four similar irrelevants were selected. The items were matched on number of syllables across the three categories (see Apendix 1). The subjects were instructed to press YES when presented with the targets, indicating recognition, and NO to any other item. The two response keys were counterbalanced across subjects. The E-Prime software was utilized for item presentation on a 17'' monitor; the subject was seated approximately 60 cm from the screen. Item presentation was randomly established by the E-Prime software.

Written instructions were presented to participants and these instructions were also verbally clarified by the experimenter. First, a short training phase was presented. A shortened version of the instructions also appeared on the computer screen before the practice trials. The need to answer as quickly as possible was emphasized.

Accuracy and RT on the CIT, according to stimulus type, were measured. The inter-stimulus interval randomly varied between 500, 800 and 1100 ms in order to discourage automatic responses or preparation effects. The items remained on the screen until a response was made. The items were presented on a white screen, written in black capital letters. The subject was seated approximately at 60 cm from the computer screen.

RESULTS

The concealed knowledge effect, reflecting decreased accuracy and increased RT in response to probes, compared to irrelevants, was evidenced in the present study. More specific, subjects had lower accuracy, $t(46) = 9.84$, $p < .001$, (Cohen's) $d = 1.38$, and longer response times, $t(46) = 15.37$, $p < .001$, $d = 2.24$ when responding to probes, compared to irrelevants.

Subsequently, relations between the main variables of the study were investigated, using Pearson's correlations. First, we have to note that there was no significant correlation between Neuroticism and Lie subscales, $r(45) = .26$, n.s., revealing that the group, as a whole, was not "faking good" (Jackson & Francis, 1999). Exploratory analyses revealed no significant relations between the EPQ-R scales and response speed in the deception test (except for a weak negative relation between Extraversion and RT to irrelevants, $r(45) = .30$, $p < .05$). Therefore, we only introduced the EPQ-Lie scale in the correlation analyses.

A strong relationship (which remained significant even after the Bonferroni correction for multiple comparisons) was noted between the EPQ-Lie scale and the BIDR-IM scale, $r(45) = .53$, $p < .01$.

Our main aim was to study the interrelations between deceptive responses and EF or social desirability measures. Analyzing the relations between EFs and speed of deceptive responses, some interesting relations were noted. First, proficiency in all EFs was positively (and moderately) related to speed of responses to irrelevants, with correlations ranging from $r(45) = .30$, $p < .05$, for the relationship with negative priming, to $r(45) = .46$, $p < .01$, for the relationship with verbal WM. In other words, those with better EFs (especially better WM and resistance to interference) were also the fastest to correctly reject not previously encountered word pairs. Response latency to probes was not significantly related to EF proficiency, except for a weak negative relation to verbal WM accuracy, $r(45) = -.34$, $p < .05$.

We found several significant relationships between EF proficiency and the difference between RTs to probes and irrelevants (the elongation of times specific to deception). Surprisingly, subjects with better EF performance (spatial WM, negative priming, resistance to interference, and shifting), actually had a larger difference between responses to probes and to irrelevants. Looking at each EF dimension which shares this relationship, we noted that the strongest relationships (which remained significant even after the Bonferroni correction) were with shifting, $r(45) = .61$, $p < .01$, and with spatial WM, $r(44) = .56$, $p < .01$, followed by the relationships with the two inhibition measures: $r(45) = .48$, $p < .01$, for resistance to interference, and $r(45) = .37$, $p < .01$, for negative priming. It is most likely that the explanation for this negative association between EF proficiency and extra time taken to deceive resides in the abovementioned positive relation between EF proficiency and speed of responses to irrelevants. In other words, rather than enhancing speed of deceptive responses to probes, better EFs seemed to accelerate correct rejection of irrelevants, accounting for a negative relation with the difference scores between RTs to probes and irrelevants.

Finally, we were interested in the relationship between speed of deceptive responses and social desirability measures. Self-deception was not significantly related to any deception outcome. Speed of responses to irrelevants was also unrelated to any social desirability measure. An interesting relationship was noted between scores on the EPQ-R Lie scale and speed of responses to probes, $r(45) = .47$, $p < .01$. The difference between response speed to probes and to irrelevants was negatively related to responses on both the EPQ-R Lie scale, $r(45) = .39$, $p < .01$, and on the BIDR-IM, $r(45) = .49$, $p < .01$. This suggests that a higher level of social desirability is associated with a reduced difference between deceptive and truthful answers, thereby with an increased deception efficiency. Looking again at relationships with responses to the two types of items, we note that social desirability, unlike EFs, is not associated with faster truthful responses (to irrelevants), but with a specific tendency to lie faster (in responses to probes).

DISCUSSION

The main aim of the present study was to investigate the relationships between deceptive behavior and individual differences in executive functioning and personality (focusing on the dimension of social desirability). We hypothesized that better executive functioning abilities will enhance deceptive efficiency (speed), except for the WM ability, which could be negatively related to the speed of deceptive behavior. We also predicted that individuals with higher levels of social desirability (high scores on the Lie scale of the EPQ-R, and BIDR-IM) would lie more efficiently (faster RTs when lying in comparison to truth-telling). The results we obtained partially supported these hypotheses.

First, it was shown that the concealed information effect was present, given the fact that the subjects needed more time to lie than to tell the truth, and made more errors when lying. This confirms that the RT-based CIT as utilized in the present study represented an adequate paradigm for the study of deception. Second, the executive functioning measures (verbal and spatial working memory, inhibition and shifting) were associated with lying proficiency (difference between RTs to probes and to irrelevants), although in an unexpected direction. Third, while no personality characteristics were specifically related to deceptive responses, both social desirability measures (the Lie scale of the EPQ-R, and BIDR-IM) were negatively correlated with the time needed to lie. We will discuss each of these results separately, integrating them in the (limited) existing literature.

First, regarding the *executive functioning* measures, the results showed that the difference scores (RT's to probes minus RT's to irrelevants) were strongly related to all EF measures (except verbal WM). The strongest relationships observed were with shifting and spatial WM. However, the direction of this relation was unexpected: EF proficiency (better spatial WM accuracy, shorter times for inhibition and shifting) was related to *larger* differences between RTs to probes and to irrelevants. This result can be seen as puzzling, since the difference between responses to probes and irrelevants has been considered an index of deception efficiency. Our pattern of results might suggest that people with better executive skills are actually poorer liars, which is counterintuitive (and divergent from previous findings, Visu-Petra et al., in press). However, looking at the pattern of correlations between EFs and irrelevants or probes, it became obvious that better EFs were actually related to faster responses to irrelevants, rather than to slower responses to probes. Therefore, in this task using verbal stimuli, people with better EFs might be more easily detected when lying, not because they take longer in their responses to probes, but because they are faster in responding to irrelevants, which creates a larger discrepancy between responses to these two stimulus types.

Latency of deceptive responses to probes and irrelevants was negatively correlated with verbal WM, which means that the subjects with better verbal WM skills needed shorter intervals to clasify these two item categories. This result may seem intuitive, since the deception task mainly relied on verbal responses and on verbal WM. Previous behavioral and neuroimaging studies have confirmed the important role of verbal WM in deception planning and execution (Abe, Suzuki, Mori, Itoh, & Fujii, 2007; Johnson, Barnhardt, & Zhu, 2004; Ambach, Stark, & Vaitl, 2011).

Regarding the *personality* measures, it was shown that the Lie scale from the EPQ was strongly correlated with the IM scale of the BIDR. This result is in accordance with several previous studies that also suggested this relation (Davies, French, & Keogh, 1998; Paulhus, 1991; Gudjonsson & Sigurdsson, 2004). Moreover, a strong negative correlation was also observed between the IM scale and the difference scores (probes minus irrelevants), meaning that the higher the IM scores, the more efficient the lying behavior (the smaller the difference between time needed to lie and to tell the truth). This confirms the hypothesis according to which the habitual tendency to present oneself in a favorable way (also involving a greater tendency to lie, Kashy & DePaulo, 1996) is associated with faster deceptive responses in the RT-based CIT. A recent study (Verschuere, Spruyt, Meijer, & Otgaar, 2011) has also shown that habitual lying becomes easier with time, a result supporting the assumption that a habitual pattern of deception in everyday situations generates a more efficient deceptive response in this test.

Regarding the EPQ questionnaire, there were no significant relations between its scales and deception measures, except for the Lie scale, which negatively correlated both with RT's to probes and with the difference score (probes minus irrelevants).

To conclude, an individual differences approach to deception can be used to uncover the cognitive and personality mechanisms involved in lying, and to assist deception detection by pinpointing potentially better liars, who may require complex interrogational techniques in order to be identified (Vrij, Granhag, & Porter, 2010). At the opposite side of the spectrum, it could support the identification of cognitive and personality vulnerabilities of witnesses (see Gudjonsson, 2010, for a comprehensive discussion), which could lead to unreliable outcomes of police interrogations.

Chapter 5

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

STUDY 4: Interfering with executive functioning to facilitate the detection of concealed information

The main aim of the present study was to investigate the added value of introducing an additional cognitive load to differentiating between truthful and deceptive responses in the RT-based CIT. More specific, the current investigation targeted two EF dimensions proven to be relevant for the deceptive act: updating and flexible set-shifting (Visu-Petra et al., in press). In order to efficiently plan and execute a deceptive act, a person needs to continuously monitor the contents of the memory in order to distinguish truthful from deceptive responses, and to flexibly alternate between these mental sets. The impact of introducing concurrent tasks engaging either memory updating or flexible set-shifting was evaluated, in comparison with the traditional CIT.

Consistent with previous findings by Ambach and collaborators (2011), we hypothesized an increase in CIT detection accuracy due to the introduction of the concurrent memory load condition. More specific, we anticipated that the introduction of a requirement to hold on to a memory load while performing recognition judgments would interfere with WM updating processes, and disrupt their efficiency, by slowing them down (Logan, 1979). The manipulation was supposed to affect deceptive responses to a greater degree than truthful responses, since they require a larger amount of executive resources (as compared to simple visual recognition demands necessary for responses to irrelevants and targets), depleted by the concurrent task. This would be evidenced by an increase in difference scores (RTs) between probes and irrelevants. A second research interest was to investigate whether this effect could be replicated when targeting another EF, namely set-shifting. We hypothesized that performance slowing would be further increased in this context, since flexibly shifting between responses in a trial-to-trial manner could place greater executive demands than a simple memory load, well below medium span length. Finally, we wanted to see whether performance on the concurrent tasks itself would be more impaired on the trials containing probes, than on the trials with irrelevants, reflecting the reciprocal interference generated by deception-related increased executive demands.

METHOD

Participants

Participants (N = 42, 33 females) were recruited from general psychology classes by using an online recruitment system and received credit for their participation. The age of participants ranged from 20 to 43 years, and mean age was 23.31 years (SD = 5.62). All participants underwent the mock crime procedure described below, followed by the three CIT conditions. Data from the CIT plus memory test of one participant were lost due to a technical failure and data from one participant were discarded altogether from the analysis because he remembered less than 4 of the 5 probes used in this experiment. Participants had normal or corrected-to-normal vision and wore glasses or contact lenses if necessary.

Materials

CIT items were two-word phrases: five probes, five targets and twenty irrelevants (four corresponding to each probe), generated for this study and very similar with the items used in previous studies (e.g Seymour et al., 2000). They were displayed using the E-Prime software on a 17’’ monitor, while subjects viewed them from a distance of approximately 60 cm.

Procedure and tasks

The participants completed a series of task as it 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).

Mock crime

The mock crime was identical to the one presented in Chapter 4. This manipulation was surprisingly efficient, since three participants initially refused to access the professor’s account (and agreed only after they were assured that they will not be penalized); moreover, one participant freely decided to delete the forwarded message from the Sent folder in order to avoid detection. One participant had minor difficulties in using the Internet website and received succinct verbal clarification for the procedural steps he had to undertake.

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 parallel memory task (CITMem), and a CIT with a parallel shifting task (CITShift).

In the CIT procedure we followed the paradigm developed first in an ERP study of deception (Farwell & Donchin, 1991). 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 detected items, also from the same category as the probes) and *irrelevants* (items from the same category as the probes, not previously encountered). For each probe, another four similar irrelevants were selected. The items were matched on number of syllables across the three categories. In each of the three conditions, each item was repeated four times, generating a total of 120 trials/ condition. The subjects were instructed to press YES when presented with the targets, indicating recognition, and NO to any other item encountered. The two response keys were counterbalanced across subjects. Item presentation was randomly established by the E-Prime software.

In the CITShift, the primary task remained the same, but the stimuli themselves appeared written in bold or in italics. Subjects had to press YES or NO *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.

Each task began with a training phase identical in length. For each task, written instructions were presented and verbally clarified by the experimenter. The instructions for the CIT were identical for all the three tasks. For the CITMem and CITShift, general CIT instructions were followed by specific instructions referring to the additional task. A shortened version of the instructions also appeared on the computer screen before the practice trials.

The inter-stimulus interval randomly varied between 500, 800 and 1100 ms in order to discourage automatic responses or preparation effects. If a response was not made within 1200 ms, a “Too slow” message appeared. The 1200 ms interval was established after a pilot study in which shorter stimulus presentation RTs were associated with floor levels of performance on the CITMem and CITShift. No feedback was given (except the practice trials, where the participant received feedback after every response). Each item remained on the screen until a response was made.

Scoring

For each condition, accuracy and RT on the CIT, according to stimulus type, represented the main collected measures. On the CITMem, an additional index of memory for each stimulus type, and also for groups of three was added. More specific, 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 an error on the CIT (e.g. if the subject pressed once 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).

RESULTS

Response accuracy

Looking at accuracy on the CIT, mean percent correct for responses to irrelevants and for deceptive responses to probes were first calculated. In order to directly compare these percentages, an arcsine transformation was then applied to this percent correct data (Cohen, 1988, cf. Gamer et al., 2006).

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, $F(2, 78) = 24.07$, $p < .001$, $MSE = 0.03$, partial $\eta^2 = 38$. Post-hoc pairwise comparisons (with a Bonferroni correction) indicated that subjects were significantly less accurate on the CIT than both on the CITMem, $p < .001$, and on the CITShift. There was no significant difference between accuracy on the CITMem and on the CITShift, $p > .05$.

There was also a significant main effect of Stimulus type, $F(1, 39) = 58.95$, $p < .001$, $MSE = .04$, partial $\eta^2 = .60$. Across conditions, mean accuracy in responses to irrelevants was higher than mean accuracy in responses to probes, $p < .001$.

Finally, there was a significant Condition X Stimulus type interaction, $F(2, 78) = 13.09$, $p < .001$, $MSE = .02$, partial $\eta^2 = .25$. Accuracy in response to irrelevants did not differ across tasks, $F(2, 78) = 3.06$, n.s. Accuracy in response to probes significantly differed across tasks, $F(2,78) = 29.71$, $p < .001$, $MSE = .03$, partial $\eta^2 = .43$. Post-hoc contrasts revealed that accuracy to probes in the CIT was significantly lower than accuracy to probes in the CITMem and in the CITShift, respectively, $p < .001$. 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 in the CIT, compared to both CITMem, $t(39) = 5.85$, $p < .001$, and CITShift, $t(40) = 4.27$, $p < .001$, respectively. This difference was not significant when comparing CITMem with CITShift, $t(39) = .03$, *n.s*.

Response time

In order to analyse the RT data, an elimination of outliers was first conducted. Since there was an established upper limit for RTs, we only eliminated responses faster than 200 ms as outliers (1.85 % of the data). We also removed additional outliers by excluding from analysis reaction times 3 standard deviations below the mean per condition for each participant (a further 0.64 % of the data).

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 RT data. The results showed that there was a significant effect of Condition, $F(2, 78) = 222.47$, $p < .001$, $MSE = .7126.26$, partial $\eta^2 = .85$. 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 slower on the CITShift than on the CITMem, $p < .001$.

There was also a significant main effect of Stimulus type, $F(1, 39) = 172.96$, $p < .001$, $MSE = 3019.67$, partial $\eta^2 = .82$. Across conditions, subjects were faster in responding to irrelevants than to probes, $p < .001$.

Finally, there was a significant Condition X Stimulus type interaction, $F(2, 78) = 10.16$, $p < .001$, $MSE = 845.09$, partial $\eta^2 = .21$. 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, difference scores (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, $t(39) = 3.42$, $p = .001$, or in the CITShift, $t(40) = 4.77$, $p < .001$. However, when comparing RT differences in the CITMem to CITShift, no significant difference was noted, $t(39) = 1.1.4$, *n.s.*

Accuracy on the concurrent tasks

A final step was to check for accuracy on the secondary tasks (Mem and Shift). Results showed that accuracy for recalling groups of three on the concurrent memory task was high, mean percent correct = 92.25, SD = 5.5. Subjects were significantly more accurate in recalling the last word of the probes, than of the irrelevants, $t(40) = 7.16$, $p < .001$.

Overall accuracy in shifting between responses to stimuli written in bold or italics was also high, mean percent correct = 89.65, SD = 10.86. There was no significant difference between mean percent correct on the concurrent Mem or Shift tasks, $F(1, 39) = 2.91$, n.s. This time, the number of shifting errors made on the probes did not differ significantly from the number of errors made on the irrelevants (after the arcsine transformation of percent correct data), $t(41) = 1.66$, n.s.

DISCUSSION

The present study analyzed the impact of introducing an additional cognitive load on the accuracy and efficiency of deceptive responses in the RT-based CIT. We hypothesized that the introduction of a concurrent memory load or of set-shifting demands along with the primary recognition task would selectively interfere with the executive processes required by deception. Therefore, we expected increased detection accuracy of the CIT in the two conditions with concurrent executive demands, compared to the traditional CIT. We anticipated that the introduction of additional set-shifting demands would affect performance to a larger degree than the additional memory demands. Finally, we also checked whether performance on the concurrent task was itself affected by stimulus type (probe vs. irrelevant).

Looking at differences between conditions in terms of *RT*, we found that subjects were faster on the CIT than on the versions containing additional updating or set-shifting demands. This is a consequence of extra time required to deal with the increased cognitive load, affecting preparatory, procesing or execution stages of responses (Pashler, 1994). This confirms previous findings with an interfering WM task, which increased RTs to both irrelevants and probes (Ambach et al., 2011). Similar to this study, increase in RTs to probes was larger than increase in RTs to irrelevants, leading to increased detection efficiency in the two conditions containing interfering tasks, compared to the traditional CIT.

However, the picture was different when looking at performance *accuracy*. Subjects were more accurate on the conditions with interfering tasks (CITMem and CITShift), compared to the traditional CIT. Importantly, this effect was only present for the probes, and not for the irrelevants. Previous studies support the idea that increasing demands for attentional control induced by concurrent tasks do not affect simple recognition accuracy (Baddeley, Lewis, Eldridge, & Thomson, 1984; Craik, Govoni, Naveh-Benjamin, & Anderson, 1996), unless there is a deep encoding of the to-be-recognized items (Hicks & Marsh, 2000), which was not the case for irrelevant items in the current study.

Contrasting detection efficiency between the two conditions with additional cognitive load, we found that subjects took longer to resolve the recognition accompanied by set-shifting task, than the recognition plus memory task, confirming superior executive demands induced by switching between task sets, compared to simple memory storage (Oberauer, Süß, Wilhelm, Wittman, 2003). Another possibility suggested in the literature (Pashler & Christian, 1994) is that the two manual responses (elicited by the CITShift) interfered to a greater degree than the manual with the vocal interference, present in the CITMem). However, accuracy between CIT performance in these two contexts (or between performance on the concurrent Mem and Shift tasks themselves) did not differ, suggesting that the additional time required by the CITShift task sufficed to ensure comparable performance accuracy.

The results of the present investigation confirm the assumption that the introduction of an increase in cognitive load interferes with the deceptive act and can facilitate the RT-based deception detection. However, when these additional processing demands target the very contents of deception, an increased accuracy of deceptive responses can be noted. The latter effect is probably due to increased/prolonged processing of these contents, which leads to better performance in deceptively denying their recognition. An underlying assumption which guides the interpretation of our results is that there is a general mechanism subserving both executive functioning and deceptive responses (Johnson, Barnhardt, & Zhu, 2004), so that disrupting the efficiency of EFs would directly impact the way a person constructs and executes the deceptive response.

Chapter 6

LYING AND TRUTH-TELLING: EFFECTS OF SEQUENCING AND HABITUATION

STUDY 5: Investigating how constant lying/truth telling interferes with subsequent truth telling/lying

Truth has been considered a baseline, almost automatic quality of the cognitive system (Spence, 2004). However, telling the truth in conjunction to / after lying might induce a temporal penalty, so that constant lying interferes with our subsequent ability to tell the truth. Some researchers (Osman, Channon, & Fitzpatrick, 2009) have investigated the detrimental effect of truth telling upon subsequent lying (and vice-versa) in a forced-choice paradigm. Similar to their line of reasoning regarding truth telling, we hypothesized that constant lying demands also lead to the development of a task set (Mayr & Kliegel, 2000), and to switching costs when another task set (i.e. truth telling) is demanded. Vendemia, Buzan, & Green (2005) designed a task-switching study which required participants to alternate between true telling and lying about self on a trial-to-trial basis. They obtained longer RTs and more errors for deceptive responses; however, this type of design did not permit participants to build a task set for lying or truth telling. Very recent results (Verschuere et al., 2011) reveal that when practiced repeatedly, lying "moves toward becoming the dominant response", interfering with subsequent acknowledgment of the truth.

Truth telling could be an automatic state of the cognitive system, unaffected by previous lies. However, telling the truth after having previously denied it might be resource consuming; this would be visible in enhanced RTs/error rates. We were interested in how initially lying would differentially affect subsequent truthful responses (and vice-versa) to crime-related items (probes), and to irrelevant items in an RT-based CIT.

METHOD

Participants

Participants (N = 43, 35 females) were recruited from general psychology classes (32% freshmen, 68% sophomores) by using an online recruitment system or in-class announcements, and received credit for their participation. The age of participants ranged from 19 to 39 years, and mean age was 21.83 years (SD = 3.9). Participants had normal or corrected-to-normal vision and wore glasses or contact lenses if necessary.

Materials

In an initial session, participants completed executive functions measures (3 tests from the CAS++ battery), and anxiety measures (state and trait).

In a second session, a mock crime scenario was used, followed by an RT-based CIT in which participants were divided in two groups: a True first group (n = 23), or a Lie first group (n = 20).

Mock crime

In the second testing session, that took place in different location (an official building of academic staff), the participants underwent the deception detection phase. A mock crime scenario was used (identical to the one in Chapter 1 and 2) and participants were randomly distributed to one of the two conditions: (a) a guilty group (21 subjects), who committed the mock crime and interacted with the six critical details and (b) an innocent group (20 subjects) that didn't commit the crime and were unaware of the six critical details.

RT-based CIT

After completion of the state anxiety measure and the polygraph test, the participants were asked to undertake a second procedure. They were invited in another room where another experimenter conducted the session. In this procedure, an RT- based CIT test was administered. The items utilized in this study were pictures belonging to there categories of items: probes (the six critical items from the mock crime items), targets (to be detected items, also from the same category as the probes) and irrelevant (four for each probe; items from the same category as the probes, not previously encountered during the experiment). The six targets were presented at the beginning of the recognition test; the subjects viewed a presentation with the six target items, each item being presented on the screen for 10 sec. The instructions specified that the task was to memorize the physical characteristics of each item in order to reproduce them later. After three successive runs of the presentation, the subject was requested to describe each item. A minimal standard was applied in order to ensure good memory, consisting in a minimum of four relevant features of each item (e.g. color, shape etc.); when the standard was not met, the subject viewed the specific item for an extra 10 sec. Finally, after the verbal description of the target items, the subjects viewed the presentation once more.

For the item presentation and response time recording, the Superlab v. 2.0 software was used. Each picture was about 15 x 15 cm, except the items referring to names, which were about 20 x 10 cm. The item remained on the screen until a response was made; if an answer was not performed within an 1000 ms interval, a “too slow” message appeared on the screen. A pilot study showed that we needed to increase the time frame (as compared to the usual 800 ms used in oddball paradigms for the recognition of verbal information) because of floor levels of performance induced by shorter stimulus durations. It is possible that the greater quantity of visual details needed to differentiate between pictures of complex visual stimuli required this extra-time to be taken. The inter-trial interval varied randomly between 500, 800 and 1000 ms in order to prevent automatic responding or preparation.

For the *Lie* condition, all participants were instructed to respond *yes* to targets and *no* to any other item (including probe items), in order to camouflage the theft which they had committed. Two blocks of trials were used in the Lie condition. There was a total of 108 trials / block: each probe, target and irrelevant was presented three times in a randomized order. These instructions were repeated in shortened version by presenting them on the computer screen at the beginning of the testing session. The need to answer as quickly as possible to all items (including the targets) was emphasized. For the *True* condition, participants were requested to answer truthfully to both targets and probes, i.e. to admit that they have recognized the critical items from the mock crime. This phase was shorter (only one block, 108 trials) and identical in every other respect to the Lie condition, except the requirement to press *Yes* in response to recognition of an item from the mock crime procedure.

After task completion, a memory test was used in order to ensure that the subjects had remembered the target items. At the end of the experiment, participants were debriefed; later on, they also received the results for the cognitive and anxiety tests via e-mail.

RESULTS

1) RT-based CIT

In order to analyze the RT data, an elimination of outliers was first conducted. Since there was an established upper limit for RTs, we only eliminated responses faster than 200 ms as outliers (1.25 % of the data). We also removed additional outliers by excluding from analysis reaction times 3 standard deviations below the mean per condition for each participant (a further 0.44 % of the data). Looking at *accuracy* on the CIT, mean percent correct for responses to irrelevants and for deceptive responses to probes were first calculated. In order to directly compare these percentages, an arcsine transformation was then applied to this percent correct data (Cohen, 1988, cf. Gamer et al., 2007).

In order to reveal concealed knowledge effects (enhanced RT and reduced accuracy) we analyzed the significance of the difference between probes and irrelevants for each Group, across conditions.

a. Reaction time

For the *Truth first* group, a repeated measures ANOVA with Condition (Lie vs. True), and Stimulus type (probe vs. irrelevant) revealed a significant effect of Condition, $F(1, 22) = 12.46$, $p < .01$, partial $\eta^2 = .36$, suggesting that overall RT was longer in the Lie than in the True condition. There was also a significant main effect of Stimulus type, $F(1, 22) = 127.07$, $p < .01$, partial $\eta^2 = .85$, revealing that, across conditions, responses to probes were significantly longer than responses to irrelevants. Finally, there was a significant interaction between Condition and Stimulus type, $F(1, 22) = 79.97$, $p < .01$, partial $\eta^2 = .78$. This interaction suggested that while RTs in response to irrelevants did not differ across conditions, $t(22) = 1.61$, n.s., RTs in responses to probes were significantly longer when subjects needed to lie (after having repetedly told the truth during the previous block), $t(22) = 8.38$, $p < .01$. Comparing responses to irrelevants and to probes in each condition, we obtained significant differences only in the Lie condition, $t(22) = 12.24$, $p < .01$, while in the True condition, responses to irrelevants and to probes did not significantly differ, $t(22) = 0.06$, n.s, suggesting that concealed knowledge effects were only present in the Lie condition.

For the *Lie first* group, a repeated measures ANOVA with Condition (Lie vs. True), and Stimulus type (probe vs. irrelevant) revealed a non-significant effect of Condition, $F(1, 20) = 0.92$, $p > .05$, n.s., suggesting that overall RT was not significantly faster in the True or in the Lie condition. However, there was a significant main effect of Stimulus type, $F(1, 20) = 85.56$, $p < .01$, partial $\eta^2 = .81$, revealing that, across conditions, responses to probes were significantly longer than responses to irrelevants. Finally, there was a significant interaction between Condition and Stimulus type, $F(1, 20) = 8.09$, $p < .01$, partial $\eta^2 = .29$. This interaction suggested that while RTs in response to irrelevants did not differ across conditions, $t(20) = 0.06$, n.s., RTs in responses to probes were (marginally significant) longer when subjects needed to tell the truth (after having repetedly lied during the previous block), $t(20) = 1.76$, $p < .07$. Comparing responses to irrelevants and to probes in each condition, we obtained significant differences in both the Lie condition, $t(20) = 6.48$, $p < .01$, and in the True condition, $t(20) = 8.55$, $p < .01$, suggesting that concealed knowledge effects were visible in both cases.

b. Accuracy

The same analyses were repeated with accuracy as a dependent variable.

For the *Truth first* group, a repeated measures ANOVA with Condition (Lie vs. True), and Stimulus type (probe vs. irrelevant) revealed a revealed a non-significant effect of Condition, $F(1, 22) = 1.24$, $p > .05$, n.s., suggesting that overall accuracy did not significantly differ in the True or in the Lie condition. There was a significant main effect of Stimulus type, $F(1, 22) = 84.72$, $p < .01$, partial $\eta^2 = .79$, revealing that, across conditions, responses to probes were significantly less accurate than responses to irrelevants. Finally, there was a significant interaction between Condition and Stimulus type, $F(1, 22) = 24.72$, $p < .01$, partial $\eta^2 = .53$. This interaction suggested that while accuracy in response to irrelevants did not differ across conditions, $t(22) = 1.36$, n.s., accuracy in responses to probes was significantly lower when subjects needed to lie (after having repetedly told the truth during the previous block), $t(22) = 3.52$, $p < .01$. Comparing responses to irrelevants and to probes in each condition, we obtained significant differences in both the True condition, $t(22) = 3.63$, $p < .01$, and in the Lie condition, $t(20) = 10.12$, $p < .01$, suggesting that concealed knowledge effects were visible in both cases.

For the *Lie first* group, a repeated measures ANOVA with Condition (Lie vs. True), and Stimulus type (probe vs. irrelevant) revealed a a significant effect of Condition, $F(1, 20) = 6.12$, $p < .05$, partial $\eta^2 = .23$, suggesting that overall accuracy was lower in the True than in the Lie condition. There was also a significant main effect of Stimulus type, $F(1, 20) = 54.60$, $p < .01$, partial $\eta^2 = .73$, revealing that, across conditions, responses to probes were less accurate than responses to irrelevants. Finally, there was a significant interaction between Condition and Stimulus type, $F(1, 20) = 6.60$, $p < .01$, partial $\eta^2 = .25$. This interaction suggested that while accuracy in response to irrelevants did not differ across conditions, $t(20) = 0.20$, n.s., accuracy in response to probes was lower when subjects needed to tell the truth (after having repetedly lied during the previous block), $t(20) = 2.79$, $p < .01$. Comparing responses to irrelevants and to probes in each condition, we obtained significant differences in both the Lie condition, $t(20) = 3.08$, $p < .01$, and in the following True condition, $t(20) = 6.37$, $p < .01$, suggesting that concealed knowledge effects were visible in both cases.

c. Comparison between groups

Next, in order to compare the results between the two groups, we calculated *difference scores* between speed of responses to probes minus irrelevants (RTdiff) and between accuracy to irrelevants minus probes (ACCdiff). A repeated-measures ANOVA with with Condition (Lie vs. True) as a within-sujects variable, and Group (Truth first vs. Lie first) as a between-subjects variable was conducted with RT and accuracy scores as dependent variables.

First, in terms of **RTdiff**, there was a significant effect of Condition, $F(1, 42) = 24.91$, $p < .01$, partial $\eta^2 = .37$, revealing that across groups, there were larger differences between probes and irrelevants when subjects needed, to lie, compared to when they were telling the truth. There was a non-significant effect of group, $F(1, 42) = 1.75$, $p > .05$, n.s., suggesting that overall RTdiff did not differ between the two groups (lying or telling the truth first). However, there was a significant Group X Condition interaction, $F(1, 42) = 77.47$, $p < .01$, partial $\eta^2 = .65$. This interaction can be interpreted in the following direction: while the RTdiff in the *time taken to tell the truth* was significantly smaller in the Truth first group, compared to the Lie first group, $t(42) = 7.20$, $p < .01$, the RTdiff in the *time taken to lie* was significantly larger in the Truth first group, compared to the Lie first group, $t(42) = 4.59$, $p < .01$.

To summarize, a repeated response (truth telling or lying) elongated the RTs for the subsequent opposite response, compared to when the opposite response was first produced.

A similar analysis was repeated for **ACCdiff**. This time, there was no significant main effect of Condition, $F(1, 42) = 0.03$, $p > .05$, n.s., suggesting that subjects were not different in terms of ACCdiff when lying compared to when they were telling the truth. There was also no significant effect of Group, $F(1, 42) = 1.67$, $p > .05$, n.s, revealing that subjects who told the truth first or who lied first did not significantly differ in ACCdiff scores. Again, there was a significant Group X Condition interaction, $F(1, 42) = 21.66$, $p < .01$, partial $\eta^2 = .34$. This interaction shows that while the ACCdiff for *truth telling* were significantly smaller in the Truth first group, compared to the Lie first group, $t(42) = 4.09$, $p < .01$, ACCdiff for *lying* were significantly larger in the Truth first group, compared to the Lie first group, $t(42) = 2.66$, $p < .05$.

DISCUSSION

After establishing the pictorial RT-based test as a reliable indicator of deception, our next research interest was to analyze the potential interference between lying and subsequent truth telling in the case of guilty participants. Our results reveal substantial differences between distinct item categories in these two test conditions. More specific, RTs and errors for irrelevant items did not significantly differ between the two conditions (lying vs. truth telling). An explanation would be that subjects reached ceiling levels of performance (around 98% correct and about 600 ms) in the first condition, making it harder to obtain an additional progress in the second condition. For target items, we found practice effects similar to the Osman et al. (2009) study, with accuracy and efficiency improving in the second condition. For the critical items, subjects were asked to tell the truth and acknowledge their recognition. However, only for these critical items there was a (marginally significant) tendency to respond slower and less accurate than during the previous Lie condition (while accuracy and speed for recognizing the targets increased). As recently suggested by Verschuere et al. (in press), when practiced repeatedly, lying "moves toward becoming the dominant response", interfering with subsequent acknowledgment of the truth. Two types of explanations might relate to this effect. First, a task switching hypothesis would suggest that after developing a task set for certain stimuli (i.e. lying for probes), switching to another response (telling the truth) would incur additional costs for the cognitive system (Rogers & Monsell, 1995). For the other stimulus types (targets and irrelevants), the True condition did not imply any switching costs, the response being identical to the previous task set. Vendemia, Buzan, & Green (2005) designed a task-switching study which required participants to alternate between true telling and lying about self on a trial-to-trial basis. They obtained longer RTs and more errors for deceptive responses; however, this type of design did not permit participants to build a task set for lying or truth telling. Since our design was based on switching from a "lie mode" to a "truth mode", it is possible that the results in the second condition - revealing a tendency for the truthful responses related to probes to take even longer than the time taken to lie about them in the first condition - are a simple reflection of task-switching costs.

Another hypothesis would be more specific with regard to deceptive processes, and rely on the fact that the truth is actively suppressed during deception (Spence et al., 2001), which makes it more difficult to be retrieved afterwards. In other words, the initial lie would not (only) affect the execution of the opposed response (the switching costs), but it would also limit the accessibility of the truthful response (the response suppression costs). Johnson, Barnhardt, & Zhu (2004) differentiate between cognitive processes involved in the intention (strategy) and the execution of a deceptive response. While the cognitive suppression hypothesis suggests specific costs in retrieving the truth after previously inhibiting it (intent stage), the switching hypothesis suggests specific costs associated with performing a distinct response in response to an identical task set (execution stage). One way to distinguish between these two hypotheses would be to equate switching demands by asking the subjects to change their responses with regard to all three types of items. More specific, after performing the classic oddball paradigm, subjects would be asked to change their initial response (press *Yes* to irrelevants, *No* to targets, and *Yes* to probes). If switching costs are the only ones responsible for the increased RTs in the True condition, we would expect similar increases in RT, irrespective of stimulus type. If in this context we noticed that it is easier (faster) to switch from the false to the truthful response (in the case of probes), than from the truthful to the false response (for targets and irrelevants), this would provide additional support for regarding the truth as a baseline of the cognitive system (Spence, 2004), being easier to return to this state than to depart from it. Conversely, if we found that the temporal costs for acknowledging the truth after previously denying it (probes) are higher than for lying after telling the truth (targets and irrelevants), it could suggest that during lying, the true content is actively suppressed, being harder to access later on. Such a design would help elucidate the cognitive mechanisms involved in lying, truth telling, and most importantly, in the interference between (constant) lying and truth telling.

Finally, an important insight comes from our findings regarding truth telling after repeated lying. The impact of repeated interrogations upon verbal and non-verbal cues to deception has been previously investigated (Granhag & Stromvall, 2002), but not when lying and truth telling demands alternated. From the perspective of a general-purpose cognitive control mechanism subserving deceptive responses, switching to another response mode (telling the truth) after establishing a mental set (deception) should incur additional processing costs. An alternative view would be that there are deception-specific and truth-specific mechanisms, with truth being a baseline, automatic feature of the cognitive system; therefore, telling the truth should always be faster and easier than deceiving. Our results bring support to the first hypothesis (and to recent findings by Verschuere et al., in press), revealing that habitual lying negatively has costs in terms of both accuracy and the efficiency of subsequent truthful responses.

Chapter 7
CONCLUSIONS AND IMPLICATIONS

The investigations included in the present thesis aimed at exploring different facets of deceptive behavior, elicited and assessed with the deception detection technique known as the Concealed Information Test (CIT). We have followed this general aim across five experimental studies, connected by the method being used for deception detection and by the theoretical focus on an individual differences approach to the mechanisms involved in the production of deceptive behavior.

In the first chapter of the thesis, we presented detailed information regarding the Concealed Information test in general, but also regarding the RT-based CIT (a CIT with reaction time measurements). Additionally, we believed that it was important to clarify the main theories regarding the dynamic nature of deception. We favored one of them, the *Activation-Decision-Construction Model – ADCM* (Walcyzk, Roper, Seemann, & Humphrey, 2003), and intersected it with a cognitive perspective over cognitive functioning proposed by Miyake and collaborators (2000). The tripartite model of executive control proposed by these authors revealed three dimensions as being independent and interdependent in executive behavior.

First, we assessed the degree to which CIT can discriminate between honest and deceptive subjects. We compared the efficiency of the polygraph-based CIT with the efficiency of the behavioral CIT based on reaction time outcomes. The results included in Chapter 2 indicated that the two tests have similar efficiency in detecting deception, but that their contribution to deception detection is dissociable. From that point on, having established the RT-based CIT as a valid indicator of deception, we relied exclusively on its use in the subsequent studies.

Next, we followed the individual differences perspective on the analysis and detection of deceptive behavior. We believe that in order to obtain a mechanistic account of the processes involved in deception, multiple interactions between individual differences in personality, anxiety, executive control proficiency need to be considered, measured and explicitly related to the (in)efficiency of deceptive behavior.

More precisely, in the present thesis we were interested in the relationship between the efficiency of deceptive behavior and individual differences at the level of *executive functions* (Chapters 3, 4 and 5). We approached the investigation of the relationship between executive abilities and deceptive behavior in two ways: first, we used the *latent* approach, in which executive abilities and deception were assessed separately, and subsequently correlated (Chapters 3 and 4). Second, in order to theoretically and empirically validate the involvement of executive control in deception, we used the *on-line* approach, that is, an interference design. In this design, participants had to solve cognitive tasks that involve different executive functions, such as working memory or shifting (Chapter 5), concurrently with the simulation task. Both approaches have revealed, at times with unexpected results, the essential role of executive abilities in the planning and implementing of deceptive behavior.

Next, we focused on investigating the relationship between individual differences at the level of *personality* and efficiency of deceptive behavior (Chapter 4). We started with a series of data from other areas of forensic and social psychology which suggest that certain people have a tendency to use lying more often; as a consequence, it is possible that they are more efficient in implementing deceptive behavior, due to habitual response patterns. In a close relationship with personality characteristics, we also investigated the relationship between lying and individual differences at the level of *social desirability*.

Finally, we studied *the dynamics of the relationship between truth and lie*, as well as their reciprocal influences, an innovative aspect, still insufficiently investigated in the literature. We accomplished this by including truth-lie and lie-truth sequences as two distinct conditions of the RT-based CIT. Surprisingly, and confirmed by very recent intuitions from the literature (Versuchere et al., 2011), we demonstrated that participants who constantly lied in the beginning had longer reaction times and more errors in subsequent truth telling than those who started by telling the truth. This approach contradicts the idea of absolute dominance of truth as a baseline state of the cognitive system, supporting the hypothesis according to which habitual lying can become a prepotent response.

Throughout the thesis, we have supported the idea of *theory-guided research*, an assumption that has been at the basis of conceiving experimental designs used in this work. Because in data-guided research (favored by the majority of studies conducted in the field) a plateau effect has been noticed regarding the improvement of deception detection techniques, we consider that theory-guided research can offer essential information both for the theoretical conceptiualisation of cognitive mechanisms involved in deception, as well as for the improvement of deception detection techniques.

In the standardized context provided by the Concealed Information Test, behavioral measures based on reaction time can offer new and valuable information for the deeper understanding of mechanisms that support deception, offering knowledge different from (but complementary with) that offered by physiological measures. Moreover, behavioral measures allow insights regarding the direct involvement of different executive functions in the act of deception. As a consequence, we consider that this type of measurement can be valuable both for a better theoretical understanding of executive involvement in deception, as well as for the completion of deception detection instruments with a new technique that is just as valid, but simpler and more cost-effective. However, as long as cognitive mechanisms that underlie the additional time necessary to generate and produce deception are not clarified, a series of unpredictable effects can occur (for example, the concomitant improvement of the “accuracy” of deception, as we have found in one of the studies of the thesis). We consider that there is already a sufficiently solid body of evidence so as to justify the continuation of research using RT-based CIT, from the perspective of a theory-guided approach. As a priority, a better *contextualization* of the method through ecological simulation tasks is necessary, which would subsequently allow its inclusion in forensic practice.

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