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Introduction

Over the past year we have made progress towards our major aims. In addition, we have completed some studies to speak to concerns of external reviewers, and we have made some changes in how we handle and process data to adapt to major advances in the technology that supports our research. Over the following pages the project Aims are presented in order along with a discussion of the major findings from this year's work. Some of our findings are ongoing – the analyses represent partially completed projects. Following the aims we present Appendicles for Laboratory Posters, Papers, and curriculum vita.

Aim 1. Complete Design of Major Software Components

1a. Complete ERP-Suite design allowing integration of new database structures (completion of this task is required before simultaneous analysis of the datasets can be addressed). The ERP-Suite has been completed. However, after our initial work on our laboratory package, SAS, the premiere statistical analysis package, made an ODBC that end-users could use with our type of database. This let us focus on developing a better database structure for the analyses. This process is still underway, and will continue for several years.

1b. Complete cross-platform adaptation of CATDD Questionnaire Software. This aim has been addressed in the discussion of Aim 4.

1c. Modify experimental programs developed with E-Prime for ERP (event-related brain wave) environment parameters to deliver identical stimuli within fMRI paradigm parameters. This process is ongoing as experimental designs are completed.

Aim 2. Create a comprehensive database for the analysis and storage of ERP and fMRI data.

2a. Modify in house data analysis programming (the "ERP-Suite" of software) to accommodate additional data from fMRI measures of brain activation.

We are working with Dr. John Richards to develop a storage facility for the data. We are converting to the data storage recommendations of FSL. Although we will be storing the data in its original format, we will be only be rendering the 4-d data and structural data in .nii.gz format. We have made a decision to publish the individual result data online following publication of manuscripts. This is a step forward from our previous decision only to provide pre-analysis data.

2b. Modify the in house adjunct programming to isolate brain function using dipole source models seeded with fMRI data.

This year we have stopped using linear registration to registration our participant brain volumes to the standard brain volumes. This decision was a difficult decision to make, but research from experts in brain registration conclusively shows that non-linear brain registration provides significant gain of linear brain registration. These gains are critical in a field where individual cortical differences can produce marked changes in results. Because of this change no dipole source localization data were completed during this year. Every individual MRI that has been collected since the beginning of this proposal will need to be normalized using non-linear techniques.

Aim 3. Determine the specific impact of exogenous attention on attention-networks during deceptive processing

It is critical to determine how strongly exogenous attention affects ERP and fMRI activations of attention networks, because exogenous attention is the most common confound reported in studies of deception. A series of studies utilized a multi-method approach to examine the question of exogenous studies. We manipulated a key variable related to the number of deceptions an individual makes during an individual interview.

Behavioral Study

This study demonstrated that interactions between stimulus salience, attention-switching and workload affect reaction time (RT) and accuracy of truthful and deceptive responses by manipulating the frequency of deceptive responding. Participants completed a two-stimulus sentence verification task with trials that cued them to respond truthfully or deceptively. Participants were randomly assigned to one of 11 groups, which varied in the ratio of truthful to deceptive response cued trials. Replicating findings from other deception studies, deceptive responses showed significantly longer RT and lower accuracy than truthful responses (Goldstein, 1923; Seymour et al., 2000; Vendemia, Buzan & Green, 2005a; Vendemia, Buzan & Simon-Dack, 2005b). The RT and accuracy data were analyzed with two 11 (10%, 15%, 20%, 25%, 40% 45%, 50%, 55%, 60%, 80%, or 90%) x 2 (truthful and deceptive) factorial ANOVAs. As expected, individuals had longer RT for deceptive responses than truthful responses, $F(1, 268) = 83.082$, $p < .001$, $\eta^2 = .24$. This was a moderate effect with individuals having a mean RT of 1036.74ms (SE = 19.50) for deceptive responses and 966.14ms (SE = 14.87) for truthful responses. Additionally, individuals displayed less accuracy for deceptive responses than truthful responses, $F(1, 268) = 85.99$, $p < .001$, $\eta^2 = .24$. This was a moderate effect with individuals having a mean accuracy of 88.30% (SE = 0.008) for deceptive responses and 93.90% (SE = 0.004) for truthful responses. In order to determine whether the RT differences in deceptive and truthful responding were the result of presentation frequency, we matched truthful and deceptive RT by ratio. That is, we compared those that told the truth on 10% of trials (and lied on 90%) to those that lied on 10% of trials. The RT data were analyzed using a 7 (10%, 20%, 40%, 50%, 60%, 80%, or 90%) x 2 (truthful or deceptive) between-subjects ANOVA. RT were significantly different at 10% and 50%, $t(52) = 2.24$, $p < .05$; $t(23) = 2.66$, $p < .05$. These results show that the effect of stimulus salience significantly impacted RT at 10% presentation frequency, with individuals having a mean RT of 1103.09ms (SE = 49.86) for deceptive responses and 966.50ms (SE = 37.70) for truthful responses. Additionally, the effect of attention-switching impacted RT at 50% presentation frequency, with individuals having a mean RT of 1083.70ms (SE = 53.86) for deceptive responses and 1006.29ms (SE = 40.72) for truthful responses. Attention-switching impacted both truthful and deceptive RT, but deceptive RT increased significantly more than truthful RT. These findings indicate that stimulus salience and attention-switching impact deceptive responses more than truthful responses.

ERP Study

The results from the ERP study are preliminary. The goal of this study was to examine the effects of stimulus salience, attention-switching and workload on brain event-related potentials (ERP), specifically the P300, in a two-stimulus sentence verification task by varying the frequency of deceptive responding. 55 undergraduate and graduate students from the University of South Carolina participated in this study (31 females, 24 males). Ages ranged from 18 – 39 (M = 19.40). In this sample, 77% of participants were Caucasian, 10% were African American, 6% were Asian, 4% were Hispanic and 3% identified as Other. A total of 200 two-stimulus trials were presented. Participants were cued by stimulus color to respond deceptively and truthfully and were randomly assigned to respond deceptively to either 20%, 50% or 80% of trials. Additionally, participants were required to make a congruent response (“agree”) on 50% of the trials and an incongruent (“disagree”) response on the other 50% of the trials. ERP data were acquired with a 128-channel Hydrocel sensor net at 250 Hz and 3-10 kΩ, filtered offline (1-33 Hz), segmented -100 to 1000 ms after stimulus onset, baseline corrected with bad channels and artifact removed. Data were submitted to sPCA followed by tPCA of first ten sPCs. Final tsPCs related to P3a and P3b were submitted to 3 x 2 mixed factorial ANOVA.

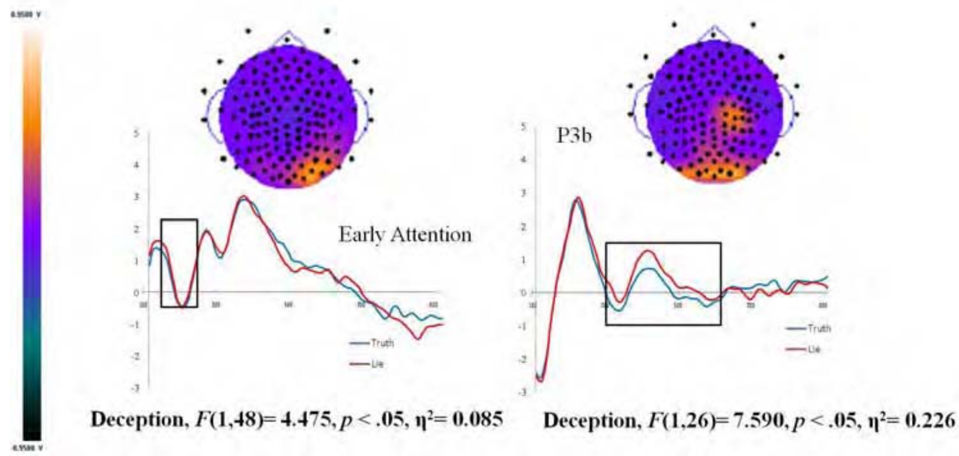


Figure 1. Event-Related Potential Waveforms Related to Overall Deception.

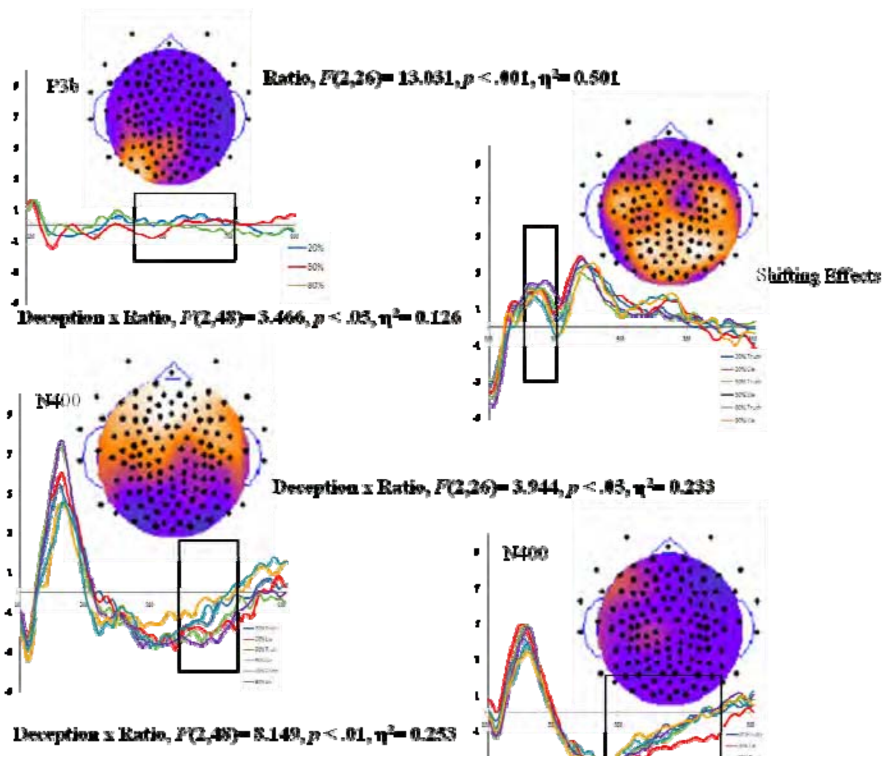


Figure 2. Changes in Event-Related Potential Waveforms Related to Number of Deceptions in an Interview.

Deception influences cognitive processing as early as 200ms post-stimulus when early attention is recruited to alert that deception is required. This data supports the behavioral finding that deception requires more workload than telling the truth, mainly due to effect of low-frequency deceptive responding.

Switching between two tasks presented at equal frequency requires more workload than when one task is presented at high-frequency. The effects of early attention shifting is evident at approximately 220ms post-stimulus. This effect is larger when responding deceptively at a higher frequency. High-frequency deceptive responding also elicits a larger late evaluation response at approximately 675ms post-stimulus.   Workload is highest when making infrequent deceptive responses.

fMRI Study.

In order to avoid repetition the effects of Ratio are discussed in Neuropsychological Study 2: Risk Taking.

Aim 4. Map neocortical functional activation during deceptive behavior.

4a. Conduct deception research with parallel measures of ERP, fMRI.

We are working from the following model of cognition associated with deceptive behavior.   During the current sequence of studies we have focused a great deal on the impact of manipulating the variable of frequency. This variable has the greatest implications for detection of deception in real world scenarios. Polygraphers (and other credibility assessment experts), particularly in screening environments, may not know how many times an individual is lying during an exam. If the measures associated with lying on 10% of an exam are different than the measures associated with lying on 90% of an exam, examiners must be made aware of that fact. Research in our lab has demonstrated conclusively that frequency does change central nervous system measures of deception, but that those changes can be assessed and controlled.

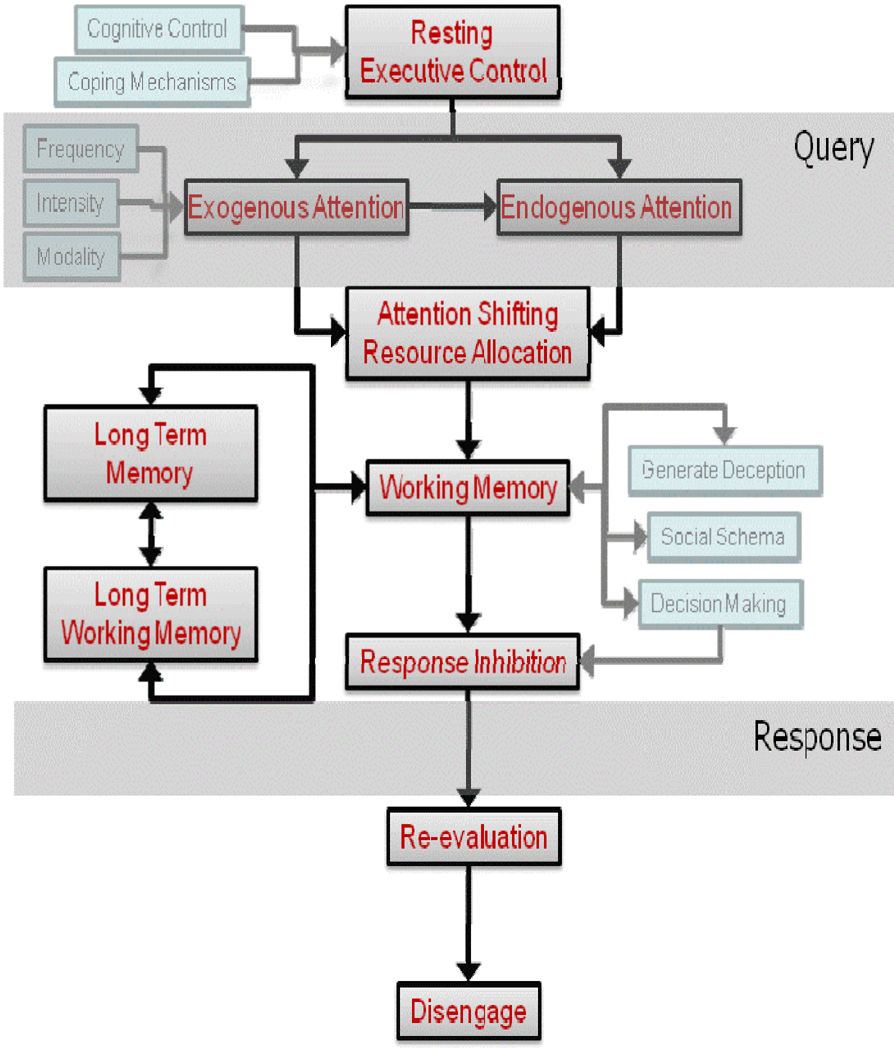


Figure 3. A Cognitive Model of Deception

The main experimental design that this laboratory employs is a variation of the directed lie procedure. The original proposal for this grant addressed why the directed lie procedure is comparable to other types of credibility assessment protocols such as the probable lie procedure. However, we were asked by experts in the field to demonstrate that the two-stimulus part of the directed lie paradigm that we chose was comparable to a standard yes/no response in other exams. The two stimulus exam is a procedure that we use to control for eye movement when recording event-related brain waves.

Participants view statements that are true or false (randomly presented) followed by a second stimulus to which they respond with a key press indicating agreement or disagreement. They were prompted to either tell the truth (blue) or lie (red). Intra-trial switching between truth and deception occur in four different ways as depicted below.

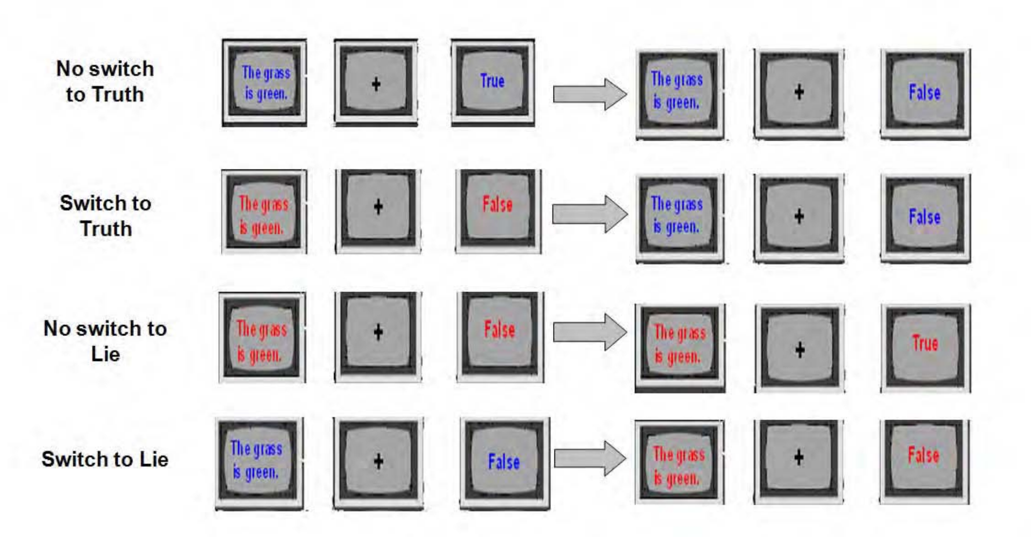


Figure 4. The Directed-Lie Paradigm. Each Line Represents two, three-screen trials in which a participant sees a sentence and then responds to a prompt.

In order to answer this reasonable concern, we converted the two-stimulus paradigm to a forced choice paradigm. The forced-choice paradigm has been in use in the cognitive community since Donders first presented it in 1878, and the properties of the task are well established. The differences between the two tasks are that instead of presenting the word "True" or "False" on the second screen, to which participants agreed or disagreed we presented the word "Yes" and the word "No" on the second screen. Participants chose the best fitting option.

Participants were 99 undergraduates from the University of South Carolina who received extra credit. In the study, participants were presented with a set of twenty-five questions, with each question repeated in random order four times. Questions (3000ms) were followed by a central fixation point (1000ms) and response screen with two potential alternatives (2500ms); one obviously truthful, and one obviously deceptive. A sample question would read as follows: who pilots jet planes? The possible answers in this case would be "zebras", or "humans". Participants were directed, by question sentence color, to respond truthfully on 50% of the trials or deceptively on the remaining trials. The answer selection corresponded to either the 1 or 3 key on the numeric keypad, and was consistent with the on-screen answer spacing.

Forty-forty of the trials involved a preceding trial in which a participant was directed to respond in differently. In 22 of the trials participants were directed to respond deceptively following a trial in which they had been directed to respond truthfully and in 23 of the trials the opposite pattern occurred. The remaining 55 trials involved no switching (27 truthful trials and 28 deceptive trials). Students will be allowed to practice the procedure before the actual trials begin. Repeated measures ANOVAs compared deception X switch (2X2) for reaction time and repeated measures data. Overall deceptive responses had significantly longer latencies (M = 934.55, SD = 200.37) than truthful responses [M = 834.46, SD

=186.92), $F(1, 98) = 136.81$, $p = 0.0001$, $\eta^2=0.58$. There was no main effect for switch type; however, there was a significant interaction between deception and switch type $F(1, 98) = 226.12$, $p = 0.0001$, $\eta^2=0.70$. In trials in which participants switched from one response to another, deceptive responding took longer than truthful responding (M=889.98 (202.05) vs. 875.69 (201.57)), but the effect was not significant $t(98)=1.32$, $p =0.19$, ns.

However in the no-switch condition the impact of deception resulted in significantly longer deceptive responses (M=979.12, SD = 198.68) than truthful responding (M=793.23, SD=172.25; $t(98)=19.07$, $p =0.0001$). The analysis of the error data revealed that participants were much more likely to make errors while responding deceptively (M=1.66, SD=0.12) than when responding truthfully (M=1.14, SD =0.08), $F(1, 98)=17.12$,$p=0.0001$, $\eta^2=0.15$. There were no main effects of switching; however, there was a significant interaction between switching and deception. Errors were the most frequent on trials in which an individual did not switch and responded deceptively (M=1.78, SD = 1.47) and nearly as frequent on trials in which an individual switched from truthful to deceptive (M=1.55, SD=1.43), $t(98)=10.82$, $p = 0.0001$. Within the truthful responses, errors to switch trials were more frequent (M=1.46, SD = 1.25) than errors to no switch trials (M=0.82, SD=0.97), $t(98)=8.94$, $p =0.0001$.

This study answered concerns about the two-stimulus design showing that 100 ms difference between truthtelling and deception is consistent across two-stimulus and forced choice paradigms.

4b. Test measurement batteries of neuropsychological function and personality variables with the newly developed self-report scale of deception behavior patterns.

We have collected neuropsychological data and personality variables along with fMRI and ERP studies of deception. We have two preliminary reports based on this work.

Neuropsychological Study 1: Working Memory

Reaction time (RT) studies have shown that working memory capacity has a significant effect on deceptive response times (Vendemia, Buzan, & Simon-Dack, 2005). Studies have also shown working memory is associated with prefrontal cortical activation (Rypma, Berger, & D'Esposito, 2002). Baddeley's model of working memory includes a central executive, phonological loop, and a visual spatial sketchpad (Baddeley & Hitch, 1974). Previous work in our lab examined the theoretical mechanisms underlying reaction times in deceptive responding. In this study we further examine these mechanisms using individual difference measures of working memory.

Previous research with event related potentials (ERP) and RT suggest workload, oddball, and attention switching as possible theoretical mechanisms underlying increased RTs during deception. The effect of workload should occur maximally when deceptively-cued trials are presented very frequently (80%). The oddball effect occurs in response to the presentation of a low-frequency stimulus. This effect is maximal at parietal electrodes. Additionally our lab is investigating attention switching as a third possible mechanism underlying deceptive RTs. Research has indicated that switching attention from an easier task to a more difficult task produces a decrease in P3a amplitude and an increase in RT. We used the Spatial Span Task and the Verbal Recognition Memory Task from the CANTAB, a large neuropsychological battery. The Spatial Span Task is an assessment of working memory capacity which requires participants to track boxes that change color in a particular sequence. The number of boxes increases in complexity from 2 to 9 boxes. The Verbal Recognition Memory Task assesses immediate memory of verbal information. Participants are shown lists of 12 words after which they must produce as many of the words as possible.

Table 1. Means and Standard Deviations for the Spatial Span Task and Verbal Recognition Task (N=55)

Condition	N	Mean SSP	SD SSP	Mean VRM	SD VRM
20	15	7.13	1.25	8.80	1.93
50	21	7.10	1.41	9.05	1.47
80	19	7.05	1.27	8.63	1.64

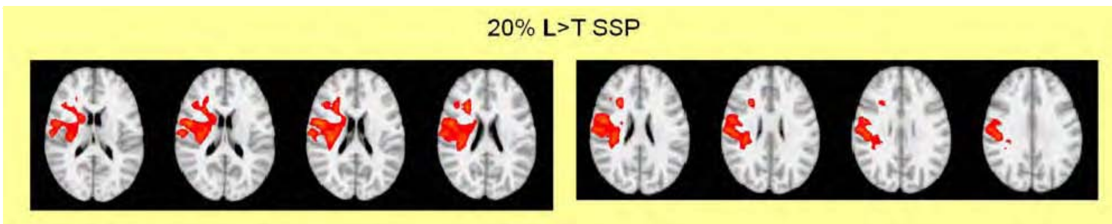
Participants were 89 undergraduate college students (61 females, Mean age = 20.9 yrs, SD = 3.45). Ethnicity breakdown : 78% Caucasian, 8% African-American, 3% Asian, 2% Hispanic, 3% identified as Other, 5% did not report. An event-related paradigm was implemented with 200 trials of the two-stimulus type being presented. Participants were randomly assigned to one of three conditions, 20% Lie (N = 15) or 50% Lie (N = 21), or 80% Lie (N=19). These N's represent the final numbers, as participants were thrown out for too much motion or accuracies below 85% before analyses. All scans collected at 3T with Siemens Magnetom Trio System using T2* weighted echoplanar images sensitive to blood oxygen levels were acquired during the functional scans (gradient echo; *TR* = 2490 ms; *TE* = 30 ms; image matrix = 64 X 64; in-plane resolution = 208 X 208 mm; slice thickness = 3.2 mm). Voxel-wise analysis was carried out using flexible hemodynamic response function (HRF) modeling, allowing HRF to vary spatially and between subjects. (Woolrich 2004). Analysis was carried out using FEAT (FMRI Expert Analysis Tool) Version 5.63, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl). Time-series statistical analysis was carried out using FILM with local autocorrelation correction (Woolrich 2001). Z (Gaussianised T/F) statistic images were thresholded using clusters determined by Z>2.3 and a (corrected) cluster significance threshold of P=0.05 (Worsley 1992). Registration to high resolution and/or standard images was carried out using FLIRT (Jenkinson 2001, 2002).

Only correct trials were included in the analysis. The 20% and 80% conditions were balanced by randomly selecting correct responses from the truthful switch/no switch condition to match the number of correct deceptive switch/no switch responses.

Responses for the Spatial Span and Verbal Recognition tasks were mean centered and entered into the analysis as explanatory variables in a general linear model. Results are shown in the images below. The tables indicate the Talairach coordinates for the activation clusters shown. Region and BA information was obtained through the Talairach Daemon.

Lie > True Spatial Span

Region (L)	BA	Z	Tal (x)	(y)	(z)
Right Inferior Frontal Gyrus	44	3.27	49	-2	20



Lie > True Verbal Recognition

Region (L)	BA	Z	Tal (x)	(y)	(z)
L Middle Frontal Gyrus	10	3.39	36	41	21
L Middle Frontal Gyrus	46	3.42	-44	30	25

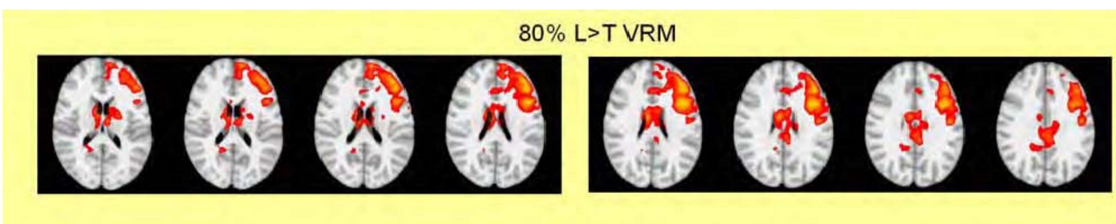


Figure 5. fMRI Activations for Lie Greater than Truth using Working Memory as an Explanatory Variable in the Model.

The results show in the expected direction for the spatial span task in the 20% condition. Similar results were not found for individual differences in the 50% condition. The expected results were also found for the verbal recognition task in the 80% condition, but not in the 20% or 50% conditions. The fMRI results indicate a similar direction to previous RT results shown here. One possible explanation for the robust group effects in the 50% condition may be attention switching. Similarly the switching mechanism may be so dominant in working memory that executive and phonological loop resources can not be found when it occurs.

Neuropsychological Study 2: Risk Taking

Self-report studies of deceptive behavior suggest a link between deception and risk-taking behavior. Individual differences in decision-making and risk-taking were associated with cortical activation during deceptive responding. In order to assess risk taking behavior we used the Cambridge Gambling Task. This task was designed to assess decision-making and risk-taking outside a learning context. The subject must guess whether a yellow token is hidden in a red box or a blue box. In the gambling stages, subjects start with a number points and can select a proportion of these points, displayed in either rising or falling order, to gamble on their confidence in this judgment.

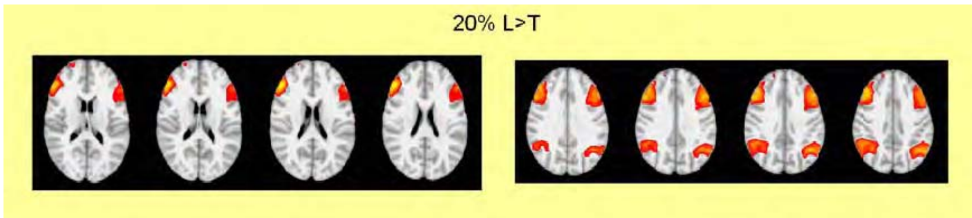
Participants (N=89) were Undergraduate college students (F=61), Age (*M*=20.9 yrs, *SD*=3.45). Ethnicity: 78% Caucasian, 8% African-American, 3% Asian, 2% Hispanic, 3% identified as Other, 5% did not report. The design was event-related with 200 trials of the two-stimulus type being presented. Participants were randomly assigned to one of three conditions, 20% Lie (N = 15) or 50% Lie (N = 21), or 80% Lie (N=19). These N's represent the final numbers, as participants were excluded due to motion artifact or low response accuracy (below 85%). All scans collected at 3T with Siemens Magnetom Trio System using T2* weighted echoplanar images sensitive to blood oxygen levels were acquired during the functional scans (gradient echo; *TR* = 2490 ms; *TE* = 30 ms; image matrix = 64 X 64; in-plane resolution = 208 X 208 mm; slice thickness = 3.2 mm). Voxel-wise analysis was carried out using flexible hemodynamic response function (HRF) modeling, allowing HRF to vary spatially and between subjects. (Woolrich 2004). Analysis was carried out using FEAT (FMRI Expert Analysis Tool) Version 5.63, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl). Time-series statistical analysis was carried out using FILM with local autocorrelation correction (Woolrich 2001). Z (Gaussianised T/F) statistic images were thresholded using clusters determined by Z>2.3 and a (corrected) cluster significance threshold of P=0.05 (Worsley 1992). Registration to high resolution and/or standard images was carried out using FLIRT (Jenkinson 2001, 2002).

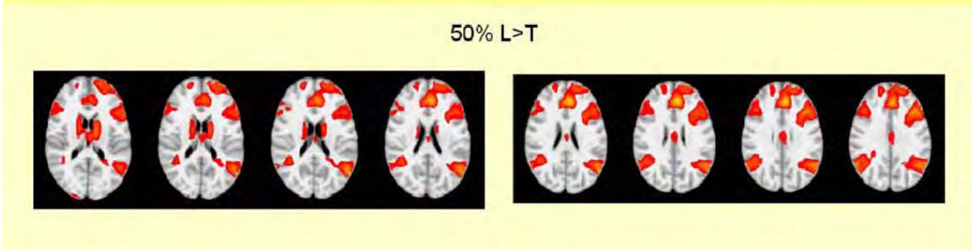
Two variables were taken from the CGT, a measure of quality of decision-making and a measure of amount of risk-taking. Both scores were proportions that varied between 0 and 1.

Table 2. Means and Standard Deviations for Quality of Decision Making and Risk Taking in the Cambridge Gambling Task.

Condition	N =81	Mean DEM	SD DEM	Mean RSK	SD RSK
20	15	0.95	0.09	0.58	0.12
50	21	0.93	0.07	0.60	0.09
80	19	0.93	0.11	0.53	0.15

Region	BA	20% Lie > True Z	Tal (x	y	z)	50% Lie > True Z	Tal (x	y	z)
R Middle frontal gyrus	10	4.41	35	63	1				
L Middle frontal gyrus	10	4.72	-38	60	-6	5.87	-46	50	-8
R Inferior parietal lobule	40	4.13	45	-56	56	5.31	-47	-54	55
L Superior parietal lobule	7	4.14	-40	-67	51	40 (L) 4.90	-49	-57	49





50% > 20% Activity related to deception

Region	BA	Z	Tal (x	y	z)
Anterior Cingulate	24	3.46	1	2	44
R Inferior parietal lobule	40	3.67	60	-25	29

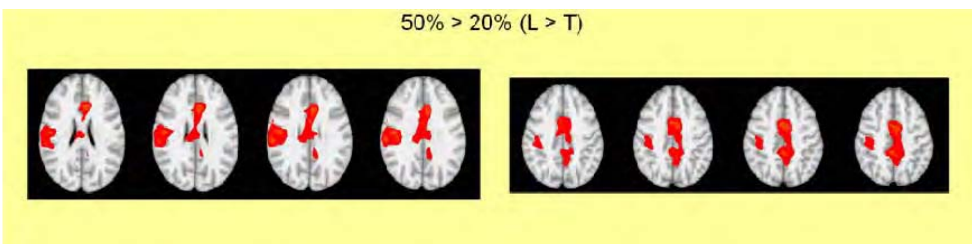


Figure 6. fMRI Activations for Lie Greater than Truth using Quality of Decision Making and Risk Taking as Explanatory Variables in the Model (note: the effects of both were not significant).

Effects of workload were supported in the 50% condition. Bilateral workload effects were also present in the 20% condition. Analyses revealed activation in posterior parietal areas during deceptive trials in the 50% and the 20% conditions, suggesting that this attention network is active regardless of deceptive trial frequency and may be more related to endogenous attention rather than attention switching. Effects of attention switching were present in 50% versus the 20% condition when comparing deceptive to truthful responses. This also supports previous fMRI work in our lab demonstrating the anterior cingulate's involvement in attention switching. Analyses revealed significantly greater activation in the right inferior parietal lobe specifically related to deception in the 50% condition. In addition, the 20% condition showed unique activation in the left superior parietal lobe. It seems that while the posterior attention network is active in both conditions, it may be behaving differently. Analyses revealed no significant results at 80%.* While this is contrary to out hypotheses regarding workload effects, it does mimic results from a behavioral study in our lab. We will do further analyses to determine the nature of this non-difference.

The Directed Lie Procedure does not seem to be associated with individual differences in a risk and reward-related decision task. Non-directed lie paradigms, especially those in which a “reward” is offered for successful deception, may have more in common with this type of task. Evaluation of risk is not a necessary component of deceptive behavior.

4c. Utilize structural equation models of deceptive behavior to mathematically assess the impact of neuropsychological function and personality measures on constructs within our working model of deception.

- The first step in 4c will be to develop models of preparatory attention based on anxiety coping strategies (discussed in background). These two constructs have been loosely associated in the EEG literature, and form a strong conceptual intersection from which to proceed with strategies associating personality and ERP/fMRI measures.

Aim 5. Determine the impact of retrieval failures on subsequent deceptions.

In the real world environment a substantial proportion of deceptions occur when the deceiver only has partial recall of past events.

We began the process of examining the impact of memory retrieval on deceptive responses by studying reaction time data. The purpose of this study was to examine the effects of conflicting information on a person’s ability to respond deceptively to questions about an event. We also tested a classical debate in the misinformation field. The additional workload of deception should create a more robust misinformation effect in the data, which in turn should make differences between factual responding and misinformed responding more statistically distinct as measured by reaction time. Additionally, in our design we used measures of individual differences that are correlated with central executive functioning. If the process of deception is centered in the central executive, then individual differences in central executive performance should become apparent in a regression analysis of the reaction time data for deceptive responders. Participants consisted of 78 (51 females, 27 males) University of South Carolina undergraduate volunteers of a mean age of 21 years with a standard deviation of 5.16 years. Ages ranged from 18 to 54 years old. Participants viewed a sequence of slides that visually depicted a crime and were followed with a narrative description of the same events that contained conflicting information for several items. In between they took the State Trait Anxiety Inventory and the Cognitive Failures Questionnaire as filler tasks. Following the slide sequence they were instructed to either lie or tell the truth to a series of questions concerning the slide sequence they previously viewed. The results indicate that deceptive responses took significantly longer than truthful responses ($F(1, 68) = 4.64$, $p = .035$), and misinformation responses showed longer reaction times than factual responses ($F(1, 68) = 8.74$, $p = .004$). A significant interaction was also found between deceptive responding and narrative content ($F(1, 68) = 6.56$, $p = .013$). The results of this study indicate that the data we are finding matches our current set of hypotheses that conflicting knowledge regarding a scenario can impact deceptive response time.

As the ERPs dependent on long-term memory processes are the most predictive of deception, the effects of retrieval failure must be determined. We have moved forward into an ERP study of the same data.

Aim 6. Identify cultural norms.

6a. Expand the research program to special populations and examine cultural norms.

A first step in this research was to create a questionnaire that could be used to quantify deception across populations. It is very important to begin to understand how patterns of lying vary across cultures and based on individual experiences. The following describes the result of the second major analysis of the questionnaire data after category development. The goal of this project was to investigate individual differences in the use of deceptive categories developed by our lab in a previous experiment. Specifically, our goal was to explore the interactions between personality characteristics and types of lies in order to determine if a unique set of personality variables can predict each of our categories. In the first experiment, along with questions to assess use of each deceptive category, we administered a broad range of self-report personality measures.

In the present study, after evaluation of the results from study 1, we re-administered a revised instrument and looked specifically at interactions between the relevant personality characteristics and the lie categories. We administered questions from eight deceptive categories and re-administered the personality scales, including a new Machiavellianism scale to a sample of college students. Participants were 286 (206 females) undergraduates at the University of South Carolina. Ages ranged from 18 – 51 with a mean age of 19.86 years ($SD = 2.78$). They were recruited through the Psychology Department's online participant pool. They received course credit in exchange for their participation. In this study, we utilized frequency type questions with a four-point Likert-type scale, which ranged from Never to Frequently, to measure frequency of use in each of our deceptive categories. The questionnaire was posted online with the open-source Lime Survey program. Results showed that Gainful Misleading was the least frequently used lie and Social Enhancement was the most frequently used lie. Results of eight linear regressions supported our hypothesis that a unique combination of personality characteristics is associated with each type of lie.

This stage of the process has been completed and is currently under review. Although, the next stage of this work is slated to begin in January 2010, we are waiting for feedback from experts in the field of the deception. Two manuscripts are included in the appendices of this document. The first is an unpublished detailed description of the process of questionnaire development in the first stage of the survey. The second manuscript is a description of both experiments. This manuscript is currently under review.

6b. This process will begin as soon as the CATDD Questionnaire Administration software can be distributed to interested national and international researchers.

The administration software has been completed and the questionnaires are now available online. We sought to work with two vendors during the development of these questionnaires. Neither vendor provided the utility we needed to administer many different question types and both had problematic question coding procedures. Although it slowed our questionnaire development process, we decided to use an open-source code that could be combined directly to our existing database platform. That strategy has been successful. As noted in the previous section we are waiting on feedback from experts in the field of deception. We will begin translating these questionnaires into Chinese in January 2010.

Conclusion

We have completed the development of an fMRI laboratory to function with existing ERP Laboratory. The Steering Committee of the fMRI Center has been interviewing candidates for the endowed chair in Cognitive Neuroscience with extensive experience in Magnetic Resonance Imaging to assist in future research and training efforts. We have changed our data analysis strategy in two major methodological directions. First we have made the decision to work with realistic head models instead of the standard 4-shell spherical model. This will add substantial accuracy to the cortical localization of brain wave activation which is a critical step in combining fMRI and ERP data. Second, we have decided to pursue non-linear registration procedures for fMRI anatomical and functional data. The experts in the field of MR localization are unanimous in their support of non-linear approaches. This analysis strategy does not require additional data acquisition, but will improve overall accuracy of our models. We will continue data acquisition on paradigms designed to establish the impact of cognitive and neuropsychological variables on HD-ERP and fMRI. Our major findings over the past year suggest that the ratio of deceptive to truthful responses in a single interview profoundly impact prefrontal measures of deceptive responding in both ERP and fMRI data, and have implications for the way polygraph paradigms are designed. Finally, we continue with the development of questionnaire research related socio-cognitive variables related to deceptive behavior. Taxonomic research into deceptive behavior has suggested that dimensions such as harm and benefit can be used to separate types of deception. However, research in our lab has suggested that situational variables (such as deception duration and modality) may play much larger roles than previously thought. We have finished the design of this questionnaire and its design is being reviewed by experts in the field. We are preparing to translate this questionnaire into Chinese.

Appendix 1: Presentations

Anterior Cingulate and Prefrontal Activity as Correlates of Attention Switching and Consideration of Multiple Relations during Truthful and Deceptive Responses: A BOLD Imaging Study

McCausland Center for Brain Imaging

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Project Overview

Deception is one of the most complicated and dynamic socio-cognitive tasks performed by the brain. The process of deception includes endogenous and exogenous attention, executive control and working memory, such that when a question is asked, attention is switched, workload demands are evaluated, memory for the truthful information is accessed, motivation to deceive is considered, and then a decision to deceive is made. Two areas purported to mediate deception are the anterior cingulate and prefrontal cortex. Activation of the anterior cingulate has been consistently reported in acts of deception and it is thought to be involved in conflict resolution, attention shifting and resource allocation processes. The anterior prefrontal cortex is thought to be activated when an individual must make simultaneous considerations of multiple relations. The present study investigated the degree to which the act of switching between lying and deceiving differentially affects activation of the anterior cingulate and prefrontal cortex.

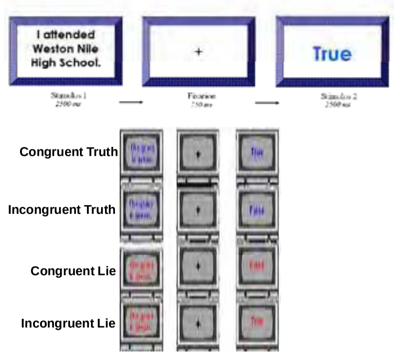
Abstract

In a study with college-aged students (N=16) using directed deceptions during a sentence verification task with two stimuli, BOLD activations in the anterior cingulate and prefrontal cortex were measured. Although general comparisons were made between truthful and deceptive responses as well as switch vs. no-switch trials two further comparisons were made to address specific hypotheses. It has been debated whether or not the anterior cingulate activity observed during fMRI studies of deception is related to attention-switching alone or to both attention-switching and conflict resolution. In the current study, deceptive switch trials were compared to no-switch trials to answer this question. Some fMRI researchers argue that the anterior prefrontal cortex, specifically Brodmann's Area 10, is involved in the act of deception. ECD models of HD-ERP data have supported this supposition (Vendemia, 2003). Ramnani and Owen (2004) argue that this area is activated when an individual must make simultaneous considerations of multiple relations. When an individual deceives, these multiple relations may occur between situational context, goal-driven behavior, divergence of the deceptive information from truthful information, and a variety of internal states. Given the generalist nature of these "simultaneous considerations", it is no surprise that several researchers have identified activation in this region during the act of deception. Prefrontal activity during deceptive responding was contrasted with prefrontal activity during truthful responses in switch and no-switch conditions. The findings are discussed as they relate to early attentional mechanisms and decision making during deceptive responses.

The Two-Stimulus Paradigm

Directed Lie Procedure

Participants view autobiographical statements that are true or false (randomly presented) followed by a second stimulus to which they responded with a key press indicating agreement or disagreement. During the experiments, a total of 40 of each response type were presented.



Methods

An event-related paradigm was implemented with 200 trials of the two-stimulus type being presented to participants (N=16). Trials were evenly balanced for 1) instructions to lie (LIE) or to tell the truth (TRUE) and 2) switching between instructions (SWITCH), or continuing with the same instructions (NO SWITCH). Participants were cued by stimulus color to respond deceptively on 50% of the trials and truthfully on the other 50%. Additionally, participants were required to make a congruent response ("agree") on 50% of the trials and an incongruent ("disagree") response on the other 50% of the trials. The stimuli were presented in red and blue and the color of Stimulus 1 always predicted Stimulus 2. Participants responded to the second stimulus by pressing a key to indicate whether it agreed or disagreed with their answer to the first stimulus.

Image Acquisition

All scans collected at 3T with Siemens Magnetom Trio System. T_2* weighted echoplanar images sensitive to blood oxygen levels were acquired during the funtional scans (gradient echo; T_R = 3000 ms; T_E = 40 ms; image matrix = 64 X 128; in-plane resolution = 1.49 X 1.49 mm; slice thickness = 6 mm).

Image Analysis

Voxel-wise analysis was carried out using flexible hemodynamic response function (HRF) modeling, allowing HRF to vary spatially and between subjects. The HRF modeling used a parameterized HRF consisting of basis functions that includes only physiologically plausible HRF shapes. The choice of basis set was driven by a standard parametric HRF. The restriction of the subspace spanned by the basis set allows for superior separation of activating voxels from the nonactivating voxels in the fMRI data (Woolrich 2004).

We analyzed the fMRI time series data with a fully Bayesian hierarchical statistical model, in which spatial dependencies were represented by conditioned autoregressive priors, and the linear model was used for temporal dependencies. The posterior distributions were estimated using the Variational Bayes framework. Analysis was carried out using FEAT (FMRI Expert Analysis Tool) Version 5.63, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl). The following pre-statistics processing was applied; motion correction using MCFLIRT [Jenkinson 2002]; slice-timing correction using Fourier-space time-series phase-shifting; non-brain removal using BET [Smith 2002]; spatial smoothing using a Gaussian kernel of FWHM 8mm; mean-based intensity normalisation of all volumes by the same factor; highpass temporal filtering (Gaussian-weighted least-squares straight line fitting, with sigma=50.0s). Time-series statistical analysis was carried out using FILM with local autocorrelation correction [Woolrich 2001]. Z (Gaussianised T/F) statistic images were thresholded using clusters determined by Z>2.3 and a (corrected) cluster significance threshold of P=0.05 [Worsley 1992]. Registration to high resolution and/or standard images was carried out using FLIRT [Jenkinson 2001, 2002].

ERP Energy and Cognitive Activity

Energy from Power

We integrate the instantaneous channel-power over successive time intervals to obtain a measure of the energy *emitted* during individual response trials:

$$E_n^C(t) = \frac{1}{z}\int_0^t V_n^C(t')V_n^C(t')dt',$$

where z is the impedance value. The differences in response energy are set by population dynamics.

$$E_n^{C_1} = E_n^{C_2} + k_B T \ln\left(\frac{N_n^{C_2}}{N_n^{C_1}}\right)$$

Cognitive Activity

We define the *cognitive activity* for ROIS with a weighted sum of the ratio of the channel-energy for one state to the total energy from both states:

$$\eta_{ROI}^{C_1}(t) = \sum_{n \in ROI} \frac{E_n^{C_1}}{E_n^{C_1} + E_n^{C_2}},$$

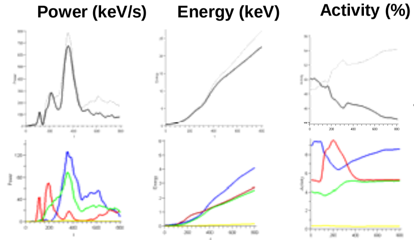
By construction, the sum over all channels and responses is unity. i.e.,

$$\sum_{n=1}^{128} \eta_n^{C_1}(t) + \eta_n^{C_2}(t) = 1.$$

Power (keV/s) | Energy (keV) | Activity (%)

EXP 1 Cortex Average

EXP 1 Posner ROIs



Neocortical Interactions

Attention Based Activity

We observe that cognitive activity levels over the AAN tend toward a minimum value at nearly the same time that activity levels over the PAN reach their maximal values. It is plausible to assert that attention switching between executive control functions in the frontal areas and access to language processing skills in posterior regions may account for this.

Load-Switching Time

We assess *neocortical interaction times* by determining the latency for extrema of the regional activity values. Hence we define the load-switching time as the difference in the maximal PAN and minimal AAN latency values:

$$t_{ls} = t_{PAN_{max}} - t_{AAN_{min}}$$

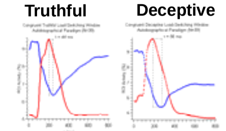
"Neocortical Circuits"

A straight forward model of cognition wherein access to memory (TPJ) precedes stimulus processing (PAN) and task execution (AAN) illustrates that truth and deception utilize similar neocortical circuits with different timing.

EXP	TASK	PAN MAX (ms)	TPJ MIN (ms)	AAN MIN (ms)
1	CT	200	124	244
1	CL	188	136	276
2	CT	220	132	248
2	CL	208	136	276

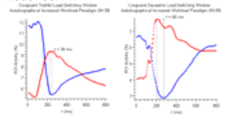
Truthful | Deceptive

EXP 1



Deceptive response load-switching times are twice as great: Ratio=88/44.

EXP 2

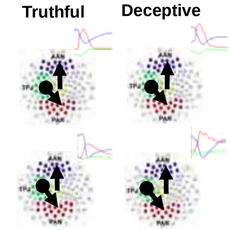


Increased workload decreases interaction time but confirms memory access priority: Ratio= 68/28.

Truthful | Deceptive

EXP 1

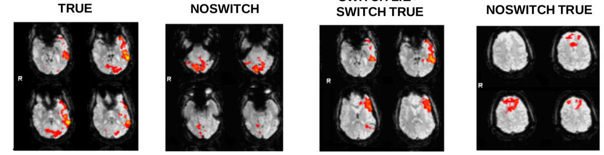
EXP 2



fMRI Activations

200 trials of the two-stimulus type were presented to a participant (**N=1**). On 100 trials he was directed to lie (**LIE**) and on 100 trials he was directed to tell the truth (**TRUE**); balanced across these trials were 100 trials in which he told a lie after telling the truth or told the truth after telling a lie (**SWITCH**), and 100 trials in which lies followed lies or truths followed truths (**NO SWITCH**). Z (Gaussian T/F) statistic images were threshold weighted using clusters determined by **z >2.3** and a (corrected) cluster significance threshold of **p=0.05.** All scans collected at 3T with Siemens Magnetom Trio System.

LIE > TRUE | SWITCH > NOSWITCH | SWITCH LIE > SWITCH TRUE | NOSWITCH LIE > NOSWITCH TRUE



Greater activation in right frontal and regions of the precuneous during deceptive trials than truthful trials.

Greater activations in PAN suggest there will be differences when one switches between lying and truth telling.

Greater activations related specifically to switching to lie, suggests areas that may allocate resources during deception.

Greater activation during deceptive no-switch trials occurs in Brodmann's Area 10, and suggests that multiple internal comparisons during deception.

Slide 1

M1 Reduce methods to bullet points

Change congruency to switching
Meeks, 4/30/2007

Event-Related Potential Correlates of Switching Between Truthful and Deceptive Responding

CATDD — Center for Advanced Technologies for Deception Detection

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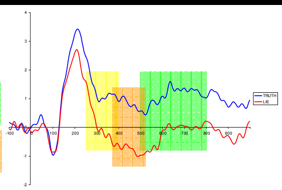
Abstract

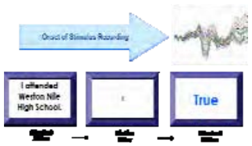
Deception

P3a - an early waveform with positive anterior distribution and latency between 250-350 ms

P3b - a positive waveform with parietal distribution and latency between 500-800 ms

N4 – an anterior waveform with negative deflection with latency of about 400 ms



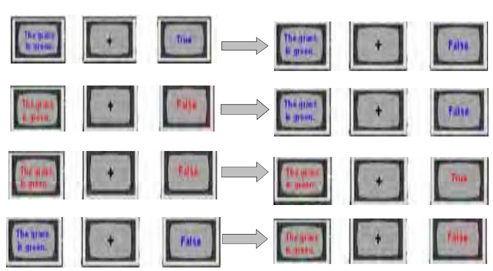


The goal of this study was to examine the influence of deception and response switching on brain event-related potentials (ERP) in a two-stimulus sentence verification task as well as comparing two approaches to HD-ERP analysis.

The Two – Stimulus Paradigm

Directed Lie Procedure

Participants viewed autobiographical statements that were true or false (randomly presented) followed by a second stimulus to which they responded with a key press indicating agreement or disagreement. Participants were prompted to either tell the truth (blue) or lie (red). Intra-trial switching between truth and deception occurred in four different ways as depicted below.



Methods

Participants

19 undergraduate and graduate students from the University of South Carolina participated in this study (12 females, 7 males). Ages ranged from 20 – 38 (M = 26.95). In this sample, 74% of participants were Caucasian, 16% were Asian, 5% were African American, and 5% identified as Other.

Methods

Design and Procedure

200 of the two-stimulus trials were presented to participants. Trials were evenly balanced for 1) instructions to lie (LIE) or to tell the truth (TRUE) and 2) switching between instructions (SWITCH), or continuing with the same instructions (NO SWITCH). Participants were cued by stimulus color to respond deceptively on 50% of the trials and truthfully on the other 50%. Additionally, participants were required to make a congruent response ("agree") on 50% of the trials and an incongruent ("disagree") response on the other 50% of the trials.

Waveform Recording and Analysis

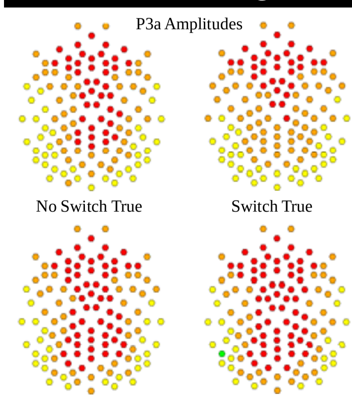
ERP data were acquired with a 128-channel Geodesic sensor net at 250 Hz and 3-10 kΩ, filtered offline (1-33 Hz), segmented -100 to 1000 ms after stimulus onset, baseline corrected with bad channels and artifact removed.

Average HD-ERP analysis of Raw Data:
Using ERPeak data analysis software, participant grand average data were scaled and then regional waveform data was plotted for waveforms of interest, including P3a, N4, and P3b. The channels containing maximum amplitude and latency were averaged and submitted to a 2 X 2 repeated measures ANOVAs. Pictured below are four plots of P3b amplitude data, one for each condition.

Principal Component (PC) Analysis of Data:
Data were submitted to tPCA followed by sPCA of first ten tPCs. Final tsPCs related to P3a, N4, P3b were submitted to 2 x 2 repeated measures ANOVAs.

Raw Data Findings

P3a Amplitudes



Trend effects were found for deception (F (1,16) = 4.450, p = .051) and switching (F (1,16) = 3.975, p = .064) for P3a latency

No effects were found for deception (F (1,16) = .002, ns) or switching (F (1,16) = 1.624, ns) for P3a amplitude

No effects were found for deception (F (1,16) = 1.151, ns) or switching (F (1,16) = .282, ns) for P3b latency

No effects were found for deception (F (1,16) = .998, ns) or switching (F (1,16) = .649, ns) for P3b amplitude

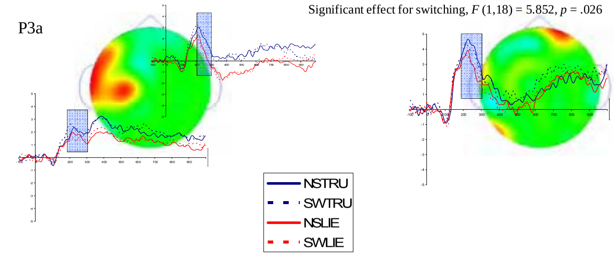
*Post-hoc analyses were conducted using more refined spatial parameters and still no significant effects found

Waveform Findings

Significant effect for switching, F (1,18) = 4.778, p = .042

Significant effect for switching, F (1,18) = 5.852, p = .026

P3a

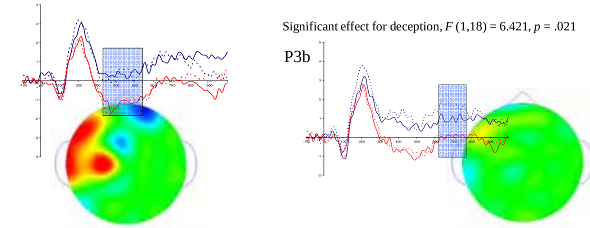


N400

Significant effect for deception, F (1,18) = 11.002, p = .004

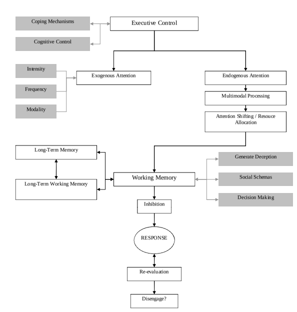
Significant effect for deception, F (1,18) = 6.421, p = .021

P3b



Discussion

A Working Model of Deceptive Behavior:



- Differential P3a activation supports its involvement in attention switching
- Differential N4 activation may support a role for the N4 in deceptive responding
- P3b suppression for deceptive responses supports the idea of greater workload during deceptive responding
- PCA analysis yielded better results than Raw Data analysis for the current data
    - Why? PCA analysis helps to account for individual variation in underlying cortical substrates (e.g. variation in brain anatomy); Raw data analysis does not

McCausland Center for Brain Imaging

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Parsing the Effects of Working Memory Load and Attention Allocation During Deceptive Responding: An fMRI Study

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Project Goal

Numerous reaction time (RT) studies report greater RT during deceptive responding than truthful responding. Two theoretical explanations have been posed in the literature: 1) Increased working memory load during deceptive responding results in increased RT at deceptive responses, 2) Allocation of attention resources to the highly salient deceptive-cue conditions results in a greater latency. The working memory load theory has been primarily utilized in studies where deceptive and truthful responses occur equally, while the allocation of attention resources explanation predominates when infrequent deceptive trials are placed among frequent truthful trials. Comparisons of event-related experiments within our laboratory suggest a potential third mechanism sub-serving reported RT differences, attention switching. In two experiments using behavioral and fMRI measures, we test several hypothetical interactions of these theoretical mechanisms by manipulating the ratio of truthful to deceptive responses in a two-stimulus sentence verification task.

Workload Deceptive responding requires more cognitive effort than truthful responding. It has been reported that the P3b waveform amplitude decreases and waveform latency increases with increased working memory load, and results in increased RT's. The effect of workload should occur maximally when deceptively-cued trials are presented very frequently (greater than 60%), but will be measureable at all ratios. Working memory load related to evaluating multiple streams of information is related to activity in BA 10. We expect to see activation in BA 10 in the 50% condition during deceptive no-switch trials vs. truthful no switch trials, and during deceptive no-switch trials vs. deceptive switch trials.

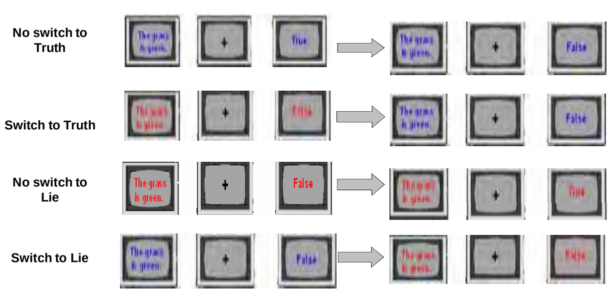
Stimulus Salience In studies of event-related activity (ERPs) low-frequency stimuli, or oddballs, produce an increase in P3b waveform amplitude and elicit longer RT's than equal- or high-frequency stimuli. This effect is maximal at parietal electrodes, and has been demonstrated with several types of deceptive responses. As deception is more salient than truth telling we would expect to see an increase in deceptive, but not truthful RTs when response ratio is low (10% and 20% trials).
Attention allocation related to salience: Previous ERP evidence from our lab has linked the posterior parietal activation (N2b waveform) to preparedness to deceive. We should see this attention effect in posterior parietal areas, specifically BAs 40 and 7 when comparing 20% condition and 50% condition on deceptive trials.

Attention Switching Switching attention from an easier task to a more difficult task produces a decrease in P3a amplitude and an increase in RT. The effect of attention-switching should occur maximally when deceptively-cued trials are presented equally with truthfully-cued trials. Therefore we should see an increase in RT for BOTH deceptive and truthful trials when presentation is at 50%.

The Two-Stimulus Paradigm

Directed Lie Procedure

Participants viewed autobiographical statements that were true or false (randomly presented) followed by a second stimulus to which they responded with a key press indicating agreement or disagreement. Participants were prompted to either tell the truth (blue) or lie (red). Intra-trial switching between truth and deception occurred in four different ways as depicted below.



Behavioral Experiment

Participants

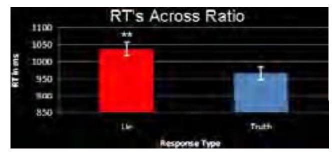
- 179 undergraduates (54 males, 125 females)
- Ages ranged from 17 to 37 years (*M* = 19.47, *SD* = 2.33).
- Two participants were excluded from analysis due to 0% accuracy on all trials.

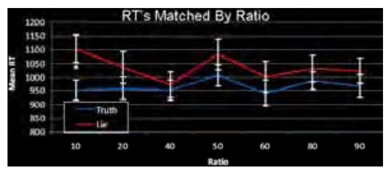
Design and Procedure

- Participants responded deceptively on a percentage of the trials and truthfully on the remaining trials.
- Participants were randomly assigned to on of 7 conditions **10%, 20%, 40%, 50%, 60%, 80% or 90%.**
- Switching and congruity (agree vs. disagree) were balanced across conditions.

Behavioral Results

- Participants responded more quickly in truthful trials than deceptive trials in all response ratio groups, F (1, 172) = 47.81, $p < .001$.
- However, the cumulative difficulty of deception was not measureable at higher ratios of deceptive responding.





- Stimulus salience impacted RT when the overall ratio of truthful to deceptive response was greatest (10% trial frequency), t (52) = 2.24, $p < .05$.
- Matched ratios of truthful and deceptive responses did not differ significantly when overall ratio was higher.

fMRI Experiment

Design

- An event-related paradigm was implemented with 200 trials of the two-stimulus type being presented.
- Participants were randomly assigned to one of two conditions, 50% Lie (N = 19) or 20% Lie (N = 12).

Image Acquisition

- All scans collected at 3T with Siemens Magnetom Trio System.
- T2* weighted echoplanar images sensitive to blood oxygen levels were acquired during the functional scans (gradient echo; *TR* = 2490 ms; *TE* = 30 ms; image matrix = 64 X 64; in-plane resolution = 208 X 208 mm; slice thickness = 3.2 mm).

Image Analysis

- Voxel-wise analysis was carried out using flexible hemodynamic response function (HRF) modeling, allowing HRF to vary spatially and between subjects. The HRF modeling used a parameterized HRF consisting of basis functions that includes only physiologically plausible HRF shapes. The choice of basis set was driven by a standard parametric HRF. The restriction of the subspace spanned by the basis set allows for superior separation of activating voxels from the nonactivating voxels in the fMRI data (Woolrich 2004).
- fMRI time series data was analyzed with a fully Bayesian hierarchical statistical model, in which spatial dependencies were represented by conditioned autoregressive priors, and the linear model was used for temporal dependencies. The posterior distributions were estimated using the Variational Bayes framework.
- Analysis was carried out using FEAT (FMRI Expert Analysis Tool) Version 5.63, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl).
- Time-series statistical analysis was carried out using FILM with local autocorrelation correction (Woolrich 2001). Z (Gaussianised T/F) statistic images were thresholded using clusters determined by Z>2.3 and a (corrected) cluster significance threshold of P=0.05 (Worsley 1992). Registration to high resolution and/or standard images was carried out using FLIRT (Jenkinson 2001, 2002).

fMRI Activations

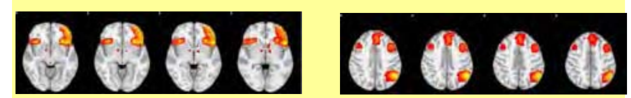
Group Analysis

	Truth	Lie
Switch	Match LSW	Match TSW
No Switch	Match LNSW	Match TNSW

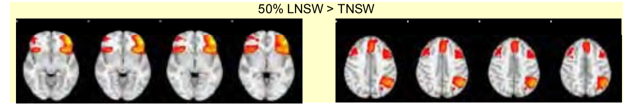
- Only correct trials were included in analysis.
- The 20% condition was balanced by randomly selecting correct responses from the truthful switch/no switch condition to match the number of correct deceptive switch/no switch responses.

		Lie > True				Lie NSW > True NSW			
Region (L)	BA	Z	Tal (x y z)			Z	Tal (x y z)		
Inferior frontal gyrus	47	5.52	-50	18	3	4.33	-46	44	-7
Middle frontal gyrus	10	5.02	-37	58	4	4.58	-38	55	-4
Inferior parietal lobule	40	5.44	-51	53	42	4.53	-45	58	44
Superior parietal lobule	7	4.35	-38	-60	50				

50% L>T



50% LNSW > TNSW



Discussion

Behavioral

Previous investigations in our lab replicated the finding that overall deceptive RT's are significantly longer than truthful RT's regardless of the frequency of presentation. Stimulus salience, rather than attention-switching or workload, significantly impacts the behavioral response, producing significantly longer RT's for deceptive responses when frequency of presentation is low. We aim to replicate these findings using non-deceptive stimuli in attempts to discover whether these results are specific to deception or related to general processes. Additionally, we plan to carry out several split half comparisons of this data in order to determine if working memory load at higher rates of responding result in degradation of performance related to tiredness.

Imaging

Effects of workload were supported in the 50% condition. Analyses revealed greater activation in left frontal areas during deceptive trials in the 50% condition. Analyses also revealed greater activation in left frontal areas when comparing deceptive no switch trials to truthful no switch trials.

In contrast to what was expected, we did not find any differences between the 50% and 20% conditions regarding workload or attention. However, we expect to see this effect with a larger sample size.

We found activation in posterior parietal areas during deceptive trials in the 50% condition, suggesting that this network is active regardless of deceptive trial frequency and may be more related to salience rather than attention switching. However, we were not able to carry out several comparisons within the switch trials as we could not sample enough data with this paradigm.

McCausland Center for Brain Imaging

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Relationship between individual differences in spatial and working memory and cortical activation during a deceptive task: An fMRI study

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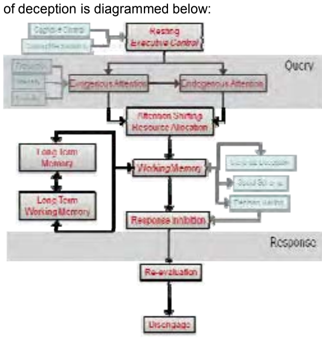
Project Goal

Reaction time (RT) studies have shown that working memory capacity has a significant effect on deceptive response times (Vendemia, Buzan, & Simon-Dack, 2005). Studies have also shown working memory is associated with prefrontal cortical activation (Rypma, Berger, & D'Esposito, 2002). Baddeley's model of working memory includes a central executive, phonological loop, and a visual spatial sketchpad (Baddeley & Hitch, 1974). Previous work in our lab examined the theoretical mechanisms underlying reaction times in deceptive responding. In this study we further examine these mechanisms using individual difference measures of working memory.

Deception Previous research with event related potentials (ERP) and RT suggest workload, oddball, and attention switching as possible theoretical mechanisms underlying increased RTs during deception. The effect of workload should occur maximally when deceptively-cued trials are presented very frequently (80%). The oddball effect occurs in response to the presentation of a low-frequency stimulus. This effect is maximal at parietal electrodes. Additionally our lab is investigating attention switching as a third possible mechanism underlying deceptive RTs. Research has indicated that switching attention from an easier task to a more difficult task produces a decrease in P3a amplitude and an increase in RT.
Our current model of deception is diagrammed below:

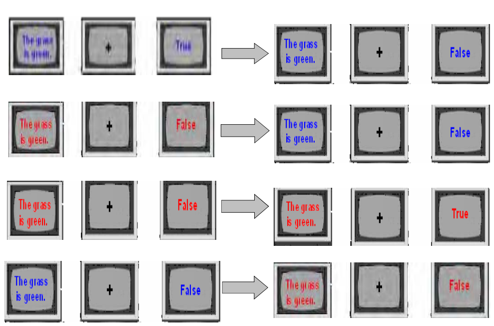


Individual Differences In this study we utilized the spatial span and verbal recognition memory tasks. We hypothesized that differences in spatial span scores would have a stronger impact in the 20% and 50% conditions due to the demand on working memory resources associated with executive function. We hypothesized that differences in verbal memory would affect the 50% and 80% conditions.

The Two-Stimulus Paradigm

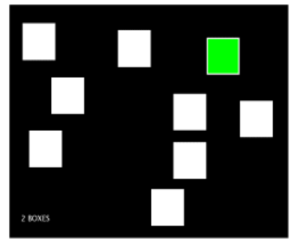
Directed Lie Procedure

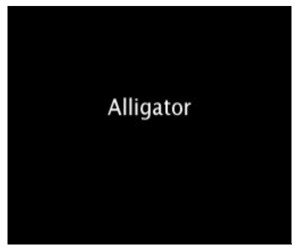
Participants viewed autobiographical statements that were true or false (randomly presented) followed by a second stimulus to which they responded with a key press indicating agreement or disagreement. Participants were prompted to either tell the truth (blue) or lie (red). Intra-trial switching between truth and deception occurred in four different ways as depicted below.



Working Memory Measures

- Spatial Span Task
- Assessment of working memory capacity
- Participants must track boxes that change color in a particular sequence
- Number of boxes increases from 2 at he start to 9 at the end
- Responses were measured for correctly identified sequences





- Verbal Recognition Memory Task
- Assesses immediate memory of verbal information
- Participant is shown a list of 12 words
- Following presentation the participant is then asked to produce as many of the words as possible
- Responses were recorded for correct identifications, redundancy, and novel answers

- Two one-way ANOVAs confirmed that the means did not differ significantly across groups
- Descriptive statistics for the SSP and VRM by condition are shown in the table below

Condition	N	Mean SSP	SD SSP	Mean VRM	SD VRM
20	15	7.13	1.25	8.80	1.93
50	21	7.10	1.41	9.05	1.47
80	19	7.05	1.27	8.63	1.64

fMRI Methods

Participants
- 89 undergraduate college students (61 females)
- Mean age = 20.9 yrs. (SD = 3.45)
- Ethnicity breakdown : 78% Caucasian, 8% African-American, 3% Asian, 2% Hispanic, 3% identified as Other, 5% did not report

Design
- An event-related paradigm was implemented with 200 trials of the two-stimulus type being presented.
- Participants were randomly assigned to one of three conditions, 20% Lie (N = 15) or 50% Lie (N = 21), or 80% Lie (N=19). These N's represent the final numbers, as participants were thrown out for too much motion or accuracies below 85% before analyses.

Image Acquisition
- All scans collected at 3T with Siemens Magnetom Trio System using T2* weighted echoplanar images sensitive to blood oxygen levels were acquired during the functional scans (gradient echo; *TR* = 2490 ms; *TE* = 30 ms; image matrix = 64 X 64; in-plane resolution = 208 X 208 mm; slice thickness = 3.2 mm).

Image Analysis
- Voxel-wise analysis was carried out using flexible hemodynamic response function (HRF) modeling, allowing HRF to vary spatially and between subjects. (Woolrich 2004).
- Analysis was carried out using FEAT (FMRI Expert Analysis Tool) Version 5.63, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl).
- Time-series statistical analysis was carried out using FILM with local autocorrelation correction (Woolrich 2001). Z (Gaussianised T/F) statistic images were thresholded using clusters determined by Z>2.3 and a (corrected) cluster significance threshold of P=0.05 (Worsley 1992). Registration to high resolution and/or standard images was carried out using FLIRT (Jenkinson 2001, 2002).

fMRI Activations

- Only correct trials were included in the analysis.
- The 20% and 80% conditions were balanced by randomly selecting correct responses from the truthful switch/no switch condition to match the number of correct deceptive switch/no switch responses.
- Responses for the Spatial Span and Verbal Recognition tasks were mean centered and entered into the analysis as explanatory variables in a general linear model.
- Results are shown in the images below. The tables indicate the Talairach coordinates for the activation clusters shown. Region and BA information was obtained through the Talairach Daemon.

Lie > True Spatial Span

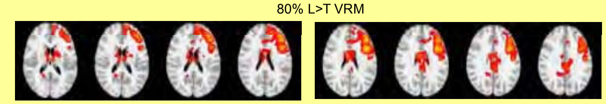
Region (L)	BA	Z	Tal (x)	(y)	(z)
Right Inferior Frontal Gyrus	44	3.27	49	-2	20

20% L>T SSP

Lie > True Verbal Recognition

Region (L)	BA	Z	Tal (x)	(y)	(z)
L Middle Frontal Gyrus	10	3.39	36	41	21
L Middle Frontal Gyrus	46	3.42	-44	30	25

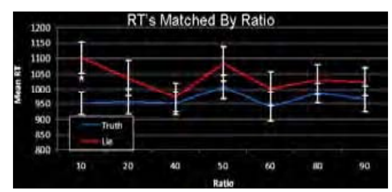
80% L>T VRM



- Significant activations were also found for the 20% and 50% group analysis for L>T.
- When compared, the 50% condition showed more significant L>T activation than the 20% condition

Discussion

The results show in the expected direction for the spatial span task in the 20% condition. Similar results were not found for individual differences in the 50% condition. The expected results were also found for the verbal recognition task in the 80% condition, but not in the 20% or 50% conditions.



The fMRI results indicate a similar direction to previous RT results shown here. One possible explanation for the robust group effects in the 50% condition may be attention switching. Similarly the switching mechanism may be so dominant in working memory that executive and phonological loop resources can not be found when it occurs.

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The Effects of Stimulus Salience, Attention-Switching and Working Memory Load on P3 Amplitude in a Deception Task: An ERP Study

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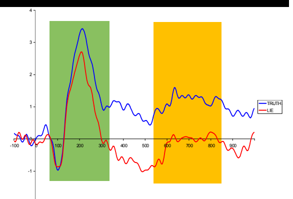
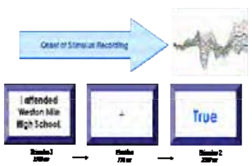
Abstract

Deception

P3a - an early waveform with positive anterior distribution and latency between 250-350 ms

P3b - a positive waveform with parietal distribution and latency between 500-800 ms





The goal of this study was to examine the effects of stimulus salience, attention-switching and workload on brain event-related potentials (ERP), specifically the P300, in a two-stimulus sentence verification task by varying the frequency of deceptive responding.

Hypotheses

Stimulus Salience: Low-frequency stimuli, or oddballs, produce an increase in P3b waveform amplitude. The effect of salience , as demonstrated by recruitment of exogenous attention, should occur maximally when deceptively-cued trials are presented infrequently.

Attention Switching: Switching attention from an easier task to a more difficult task produces a decrease in P3a amplitude. The effect of attention-switching should occur maximally when deceptively-cued trials are presented equally with truthfully-cued trials.

Workload: P3b waveform amplitude decreases and waveform latency increases with increased working memory load. The effect of workload should occur maximally when deceptively-cued trials are presented very frequently.

The Two – Stimulus Paradigm

Directed Lie Procedure

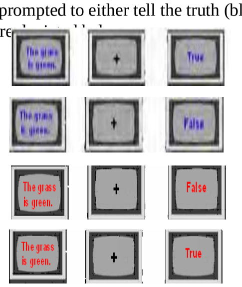
Participants viewed randomly presented statements designed to access semantic memory that were true or false. These statements were followed by a second stimulus to which participants responded with a key press indicating agreement or disagreement. Participants were prompted to either tell the truth (blue) or lie (red). Examples of truth and lie trials are…

Truth Congruent

Truth Incongruent

Lie Congruent

Lie Incongruent



Methods

Participants

55 undergraduate and graduate students from the University of South Carolina participated in this study (31 females, 24 males). Ages ranged from 18 – 39 (M = 19.40). In this sample, 77% of participants were Caucasian, 10% were African American, 6% were Asian, 4% were Hispanic and 3% identified as Other.

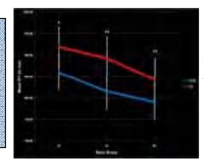
Design and Procedure

A total of 200 two-stimulus trials were presented. Participants were cued by stimulus color to respond deceptively and truthfully and were randomly assigned to respond deceptively to either 20%, 50% or 80% of trials. Additionally, participants were required to make a congruent response ("agree") on 50% of the trials and an incongruent ("disagree") response on the other 50% of the trials.

Behavioral Findings

Reaction Time (RT) for Truthful and Deceptive Responding by Ratio Group

Ratio	Truthful M	Truthful SE	Deceptive M	Deceptive SE
20	860.04	38.14	919.23	45.53
50	816.11	41.37	892.57	49.38
80	791.32	40.21	843.63	47.99



RT for deceptive responding is significantly longer than truthful responding for all ratio groups, $F(1,52) = 28.86$, $p < .001$, $\eta^2 = 0.357$

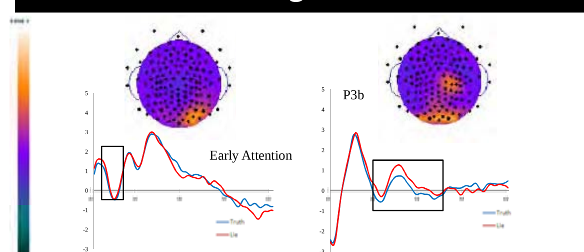
* $p < .05$; * $p < .01$

Waveform Recording and Analysis

ERP data were acquired with a 128-channel Hydrocel sensor net at 250 Hz and 3-10 kΩ, filtered offline (1-33 Hz), segmented -100 to 1000 ms after stimulus onset, baseline corrected with bad channels and artifact removed.

Principal Component (PC) Analysis of Data:
Data were submitted to sPCA followed by tPCA of first ten sPCs. Final tsPCs related to P3a and P3b were submitted to 3 x 2 mixed factorial ANOVA.

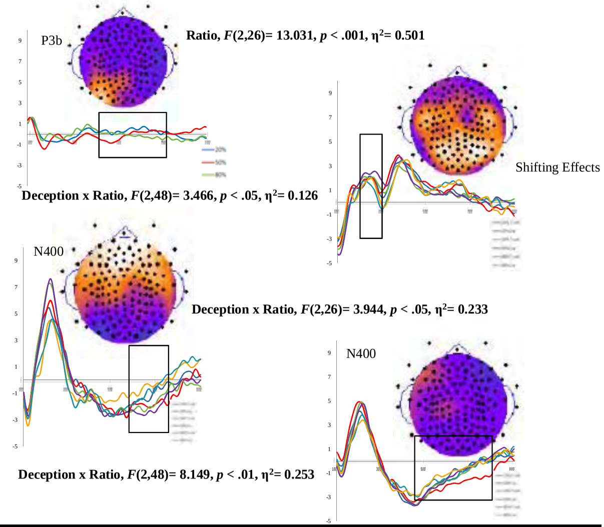
Waveform Findings



Deception, $F(1,48)= 4.475$, $p < .05$, $\eta^2= 0.085$

Deception, $F(1,26)= 7.590$, $p < .05$, $\eta^2= 0.226$

Waveform Findings



Ratio, $F(2,26)= 13.031$, $p < .001$, $\eta^2= 0.501$

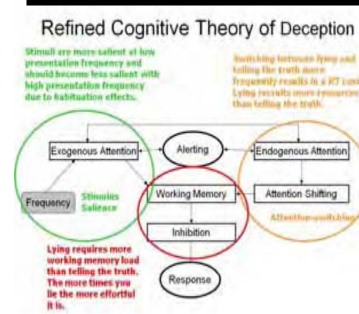
Deception x Ratio, $F(2,48)= 3.466$, $p < .05$, $\eta^2= 0.126$

Deception x Ratio, $F(2,26)= 3.944$, $p < .05$, $\eta^2= 0.233$

Deception x Ratio, $F(2,48)= 8.149$, $p < .01$, $\eta^2= 0.253$

Discussion

Refined Cognitive Theory of Deception



- The effects of early attention shifting is evident at approximately 220ms post-stimulus. This effect is larger when responding deceptively at a higher frequency.
- High-frequency deceptive responding also elicits a larger late evaluation response at approximately 675ms post-stimulus.
- Workload is highest when making infrequent deceptive responses.
- Deception influences cognitive processing as early as 200ms post-stimulus when early attention is recruited to alert that deception is required.
- Supports the behavioral finding that deception requires more workload than telling the truth, mainly due to effect of low-frequency deceptive responding.
- Switching between two tasks presented at equal frequency requires more workload than when one task is presented at high-frequency.

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Relationship between Individual Differences in Risk-Taking and Cortical Activation during a Deception Task: An fMRI Study

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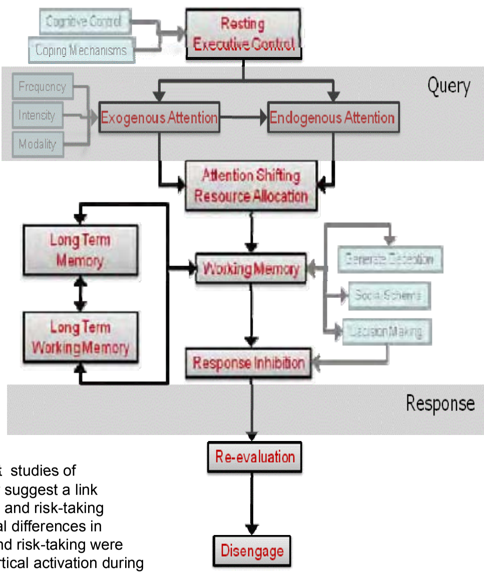
CATDD — Center for Advanced Technologies for Deception Detection

University of South Carolina

Project Goals

Goal 1 Numerous reaction time (RT) studies report greater RT during deceptive responding than truthful responding. In an experiment using fMRI BOLD signal measures, we test several hypothetical interactions of workload, endogenous attention allocation, and attention switching.

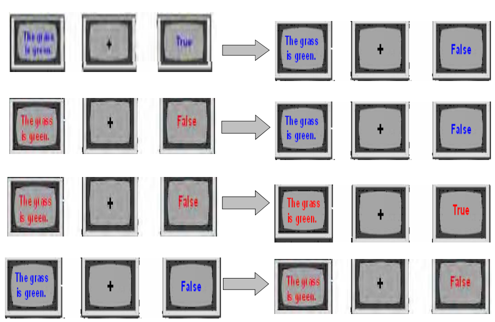


Goal 2 Self-report studies of deceptive behavior suggest a link between deception and risk-taking behavior. Individual differences in decision-making and risk-taking were associated with cortical activation during deceptive responding.

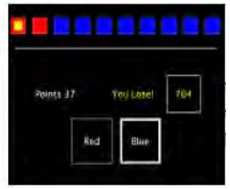
The Two-Stimulus Paradigm

Directed Lie Procedure

Participants viewed autobiographical statements that were true or false (randomly presented) followed by a second stimulus to which they responded with a key press indicating agreement or disagreement. They were prompted to either tell the truth (blue) or lie (red). Intra-trial switching between truth and deception occurred in four different ways as depicted below.



Cambridge Gambling Task



- This task was designed to assess decision-making and risk-taking outside a learning context.
- The subject must guess whether a yellow token is hidden in a red box or a blue box.
- In the gambling stages, subjects start with a number of points and can select a proportion of these points, displayed in either rising or falling order, to gamble on their confidence in this judgment.

fMRI Methods

Participants (N=89)

- Undergraduate college students (F=61), Age (*M*=20.9 yrs, *SD*=3.45)
- Ethnicity: 78% Caucasian, 8% African-American, 3% Asian, 2% Hispanic, 3% identified as Other, 5% did not report

Design

- ERD with 200 trials of the two-stimulus type being presented.
- Participants were randomly assigned to one of three conditions, 20% Lie (N = 15) or 50% Lie (N = 21), or 80% Lie (N=19). These N's represent the final numbers, as participants were excluded due to motion artifact or low response accuracy (below 85%)

Image Acquisition

- All scans collected at 3T with Siemens Magnetom Trio System using T2* weighted echoplanar images sensitive to blood oxygen levels were acquired during the functional scans (gradient echo; *TR* = 2490 ms; *TE* = 30 ms; image matrix = 64 X 64; in-plane resolution = 208 X 208 mm; slice thickness = 3.2 mm).

Image Analysis

- Voxel-wise analysis was carried out using flexible hemodynamic response function (HRF) modeling, allowing HRF to vary spatially and between subjects. (Woolrich 2004).
- Analysis was carried out using FEAT (FMRI Expert Analysis Tool) Version 5.63, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl).
- Time-series statistical analysis was carried out using FILM with local autocorrelation correction (Woolrich 2001). Z (Gaussianised T/F) statistic images were thresholded using clusters determined by Z>2.3 and a (corrected) cluster significance threshold of P=0.05 (Worsley 1992). Registration to high resolution and/or standard images was carried out using FLIRT (Jenkinson 2001, 2002).

Individual Differences

Analysis

- Two variables were taken from the CGT, a measure of quality of decision-making and a measure of amount of risk-taking. Both scores were proportions that varied between 0 and 1.

Condition	N =81	Mean DEM	SD DEM	Mean RSK	SD RSK
20	15	0.95	0.09	0.58	0.12
50	21	0.93	0.07	0.60	0.09
80	19	0.93	0.11	0.53	0.15

Two One-Way ANOVAs confirmed that the means were not different across groups.

- Scores on both variables were mean-centered for each group.
- These scores were then entered in as two additional explanatory variables in the general linear model for each of the three group-level FEAT analyses.

Results

- Results showed no association between these measures of Risk-Taking Behavior and cortical activation during deceptive responding.*

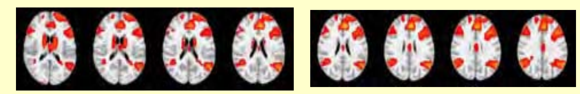
* Initial analyses identified significant findings related to RISK, however, further investigation suggested that the findings were the result of motion artifact.

fMRI Activations

Region	BA	20% Lie > True Z	20% Lie > True Tal (x y z)	50% Lie > True Z	50% Lie > True Tal (x y z)
R Middle frontal gyrus	10	4.41	35 63 1		
L Middle frontal gyrus	10	4.72	-38 60 -6	5.87	-46 50 -8
R Inferior parietal lobule	40	4.13	45 -56 56	5.31	-47 -54 55
L Superior parietal lobule	7	4.14	-40 -67 51	40 (L) 4.90	-49 -57 49

20% L>T

50% L>T



50% > 20% Activity related to deception

Region	BA	Z	Tal (x y z)
Anterior Cingulate	24	3.46	1 2 44
R Inferior parietal lobule	40	3.67	60 -25 29

50% > 20% (L > T)

Discussion

Imaging

Effects of workload were supported in the 50% condition. Bilateral workload effects were also present in the 20% condition.

Analyses revealed activation in posterior parietal areas during deceptive trials in the 50% and the 20% conditions, suggesting that this attention network is active regardless of deceptive trial frequency and may be more related to endogenous attention rather than attention switching.

Effects of attention switching were present in 50% versus the 20% condition when comparing deceptive to truthful responses. This also supports previous fMRI work in our lab demonstrating the anterior cingulate's involvement in attention switching.

Analyses revealed significantly greater activation in the right inferior parietal lobe specifically related to deception in the 50% condition. In addition, the 20% condition showed unique activation in the left superior parietal lobe. It seems that while the posterior attention network is active in both conditions, it may be behaving differently.

Analyses revealed no significant results at 80%.* While this is contrary to out hypotheses regarding workload effects, it does mimic results from a behavioral study in our lab. We will do further analyses to determine the nature of this non-difference.

Individual Differences

The Directed Lie Procedure does not seem to be associated with individual differences in a risk and reward-related decision task.

Non-directed lie paradigms, especially those in which a "reward" is offered for successful deception, may have more in common with this type of task.

Evaluation of risk is not a necessary component of deceptive behavior.

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Parsing the Effects of Working Memory Load and Attention Allocation During Deceptive Responding: An fMRI Study

CATDD — Center for Advanced Technologies for Deception Detection

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Project Goal

Numerous reaction time (RT) studies report greater RT during deceptive responding than truthful responding. Two theoretical explanations have been posed in the literature: 1) Increased working memory load during deceptive responding results in increased RT at deceptive responses, 2) Allocation of attention resources to the highly salient deceptive-cue conditions results in a greater latency. The working memory load theory has been primarily utilized in studies where deceptive and truthful responses occur equally, while the allocation of attention resources explanation predominates when infrequent deceptive trials are placed among frequent truthful trials. Comparisons of event-related experiments within our laboratory suggest a potential third mechanism sub-serving reported RT differences, attention switching. In two experiments using behavioral and fMRI measures, we test several hypothetical interactions of these theoretical mechanisms by manipulating the ratio of truthful to deceptive responses in a two-stimulus sentence verification task.

Workload Deceptive responding requires more cognitive effort than truthful responding. It has been reported that the P3b waveform amplitude decreases and waveform latency increases with increased working memory load, and results in increased RT's. The effect of workload should occur maximally when deceptively-cued trials are presented very frequently (greater than 60%), but will be measureable at all ratios. Working memory load related to evaluating multiple streams of information is related to activity in BA 10. We expect to see activation in BA 10 in the 50% condition during deceptive no-switch trials vs. truthful no switch trials, and during deceptive no-switch trials vs. deceptive switch trials.

Stimulus Salience In studies of event-related activity (ERPs) low-frequency stimuli, or oddballs, produce an increase in P3b waveform amplitude and elicit longer RT's than equal- or high-frequency stimuli. This effect is maximal at parietal electrodes, and has been demonstrated with several types of deceptive responses. As deception is more salient than truth telling we would expect to see an increase in deceptive, but not truthful RTs when response ratio is low (10% and 20% trials).
Attention allocation related to salience: Previous ERP evidence from our lab has linked the posterior parietal activation (N2b waveform) to preparedness to deceive. We should see this attention effect in posterior parietal areas, specifically BAs 40 and 7 when comparing 20% condition and 50% condition on deceptive trials.

Attention Switching Switching attention from an easier task to a more difficult task produces a decrease in P3a amplitude and an increase in RT. The effect of attention-switching should occur maximally when deceptively-cued trials are presented equally with truthfully-cued trials. Therefore we should see an increase in RT for BOTH deceptive and truthful trials when presentation is at 50%.

The Two-Stimulus Paradigm

Directed Lie Procedure

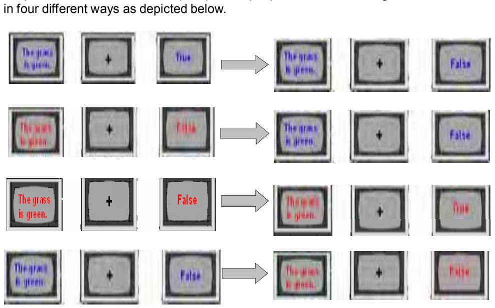
Participants viewed autobiographical statements that were true or false (randomly presented) followed by a second stimulus to which they responded with a key press indicating agreement or disagreement. Participants were prompted to either tell the truth (blue) or lie (red). Intra-trial switching between truth and deception occurred in four different ways as depicted below.

No switch to Truth

Switch to Truth

No switch to Lie

Switch to Lie



Behavioral Experiment

Participants

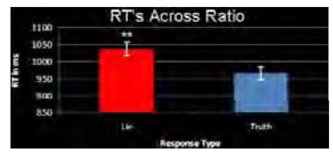
- 179 undergraduates (54 males, 125 females)
- Ages ranged from 17 to 37 years (M = 19.47, SD = 2.33).
- Two participants were excluded from analysis due to 0% accuracy on all trials.

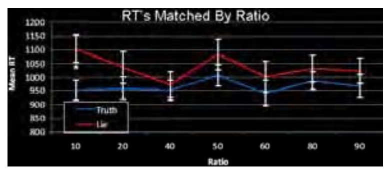
Design and Procedure

- Participants responded deceptively on a percentage of the trials and truthfully on the remaining trials.
- Participants were randomly assigned to on of 7 conditions
  10%, 20%, 40%, 50%, 60%, 80% or 90%.
- Switching and congruity (agree vs. disagree) were balanced across conditions.

Behavioral Results

- Participants responded more quickly in truthful trials than deceptive trials in all response ratio groups, F (1, 172) = 47.81, p < .001.
- However, the cumulative difficulty of deception was not measureable at higher ratios of deceptive responding.





- Stimulus salience impacted RT when the overall ratio of truthful to deceptive response was greatest (10% trial frequency), t (52) = 2.24, p < .05.
- Matched ratios of truthful and deceptive responses did not differ significantly when overall ratio was higher.

fMRI Experiment

Design

- An event-related paradigm was implemented with 200 trials of the two-stimulus type being presented.
- Participants were randomly assigned to one of two conditions, 50% Lie (N = 19) or 20% Lie (N = 12).

Image Acquisition

- All scans collected at 3T with Siemens Magnetom Trio System.
- T2* weighted echoplanar images sensitive to blood oxygen levels were acquired during the functional scans (gradient echo; TR = 2490 ms; TE = 30 ms; image matrix = 64 X 64; in-plane resolution = 208 X 208 mm; slice thickness = 3.2 mm).

Image Analysis

- Voxel-wise analysis was carried out using flexible hemodynamic response function (HRF) modeling, allowing HRF to vary spatially and between subjects. The HRF modeling used a parameterized HRF consisting of basis functions that includes only physiologically plausible HRF shapes. The choice of basis set was driven by a standard parametric HRF. The restriction of the subspace spanned by the basis set allows for superior separation of activating voxels from the nonactivating voxels in the fMRI data (Woolrich 2004).
- fMRI time series data was analyzed with a fully Bayesian hierarchical statistical model, in which spatial dependencies were represented by conditioned autoregressive priors, and the linear model was used for temporal dependencies. The posterior distributions were estimated using the Variational Bayes framework.
- Analysis was carried out using FEAT (FMRI Expert Analysis Tool) Version 5.63, part of FSL (FMRIB's Software Library, www.fmrib.ox.ac.uk/fsl).
- Time-series statistical analysis was carried out using FILM with local autocorrelation correction (Woolrich 2001). Z (Gaussianised T/F) statistic images were thresholded using clusters determined by Z>2.3 and a (corrected) cluster significance threshold of P=0.05 (Worsley 1992). Registration to high resolution and/or standard images was carried out using FLIRT (Jenkinson 2001, 2002).

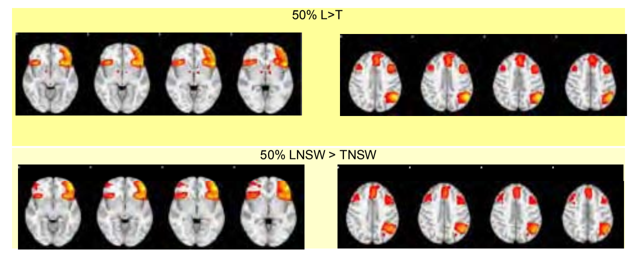
fMRI Activations

Group Analysis

	Truth	Lie
Switch	Match LSW	Match TSW
No Switch	Match LNSW	Match TNSW

- Only correct trials were included in analysis.
- The 20% condition was balanced by randomly selecting correct responses from the truthful switch/no switch condition to match the number of correct deceptive switch/no switch responses.

		Lie > True				Lie NSW > True NSW			
Region (L)	BA	Z	Tal (x y z)			Z	Tal (x y z)		
Inferior frontal gyrus	47	5.52	-50	18	3	4.33	-46	44	-7
Middle frontal gyrus	10	5.02	-37	58	4	4.58	-38	55	-4
Inferior parietal lobule	40	5.44	-51	53	42	4.53	-45	58	44
Superior parietal lobule	7	4.35	-38	-60	50				



Discussion

Behavioral

Previous investigations in our lab replicated the finding that overall deceptive RT's are significantly longer than truthful RT's regardless of the frequency of presentation. Stimulus salience, rather than attention-switching or workload, significantly impacts the behavioral response, producing significantly longer RT's for deceptive responses when frequency of presentation is low. We aim to replicate these findings using non-deceptive stimuli in attempts to discover whether these results are specific to deception or related to general processes. Additionally, we plan to carry out several split half comparisons of this data in order to determine if working memory load at higher rates of responding result in degradation of performance related to tiredness.

Imaging

Effects of workload were supported in the 50% condition. Analyses revealed greater activation in left frontal areas during deceptive trials in the 50% condition. Analyses also revealed greater activation in left frontal areas when comparing deceptive no switch trials to truthful no switch trials.

In contrast to what was expected, we did not find any differences between the 50% and 20% conditions regarding workload or attention. However, we expect to see this effect with a larger sample size.

We found activation in posterior parietal areas during deceptive trials in the 50% condition, suggesting that this network is active regardless of deceptive trial frequency and may be more related to salience rather than attention switching. However, we were not able to carry out several comparisons within the switch trials as we could not sample enough data with this paradigm.

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Appendix 2: Manuscripts

CHAPTER 13

Alternate Technologies for the Detection of Deception

JENNIFER M.C. VENDEMIA, MICHAEL J. SCHILLACI, ROBERT F. BUZAN, ERIC P. GREEN AND SCOTT W. MEEK

NEW DIRECTIONS IN THE DETECTION OF DECEPTION

Future technologies will integrate with existing polygraph techniques in one of three ways: (1) they will provide another source of information within the standard polygraph-testing scenario, (2) they will provide an alternate methodology to existing exams, or (3) they will identify new theoretical information about deception. If it is the case that future technologies reveal something new about deception, all 'technological boats' will rise. In other words, the more we know about the processes of human deception, the better all forms of measurement will be. However, there is not one path to new knowledge about deception. Some researchers who study new measurement technologies choose to use polygraph-like scenarios (e.g., Kozel, Padgett & George, 2004; Rosenfeld *et al.*, 1991). Others choose to use alternate strategies such as the oddball task or tests of semantic incongruity (e.g., Allen, Iacono & Danielson, 1992; Boaz *et al.*, 1991; Janisse & Bradley, 1980). Still others choose to use theoretical modeling approaches (e.g., Dionisio *et al.*,

The Use of the Polygraph in Assessing, Treating and Supervising Sex Offenders: A Practitioner's Guide
Edited by Daniel T. Wilcox.

2001; Vendemia, 2003b; Vendemia & Buzan, 2004b; Vendemia, Buzan & Green, 2005).

At the present time, developing technologies such as thermal imaging, voice recognition, and pupillometry operate within the existing polygraph methodology. These measures, like the polygraph, assess peripheral nervous system (PNS) activity, which is reliably manipulated by the standard detection of deception exam. They rely on emotion-related change to detect differences between an individual's deceptive and truthful responses. In contrast, many alternative psychophysiological detection of deception (PDD) techniques, such as event-related brain potential (ERP), functional magnetic resonance imaging (*f*MRI), and positron emission tomography (PET), assess aspects of deception that are not dependent on emotion-related change. For example, there is evidence to suggest that the cognitive processes involved in deception, such as attention, workload, memory and question salience, can be valid and reliable measures of deception. This is an important realization because, unlike PNS indicators of deception used in the standard polygraph approach, these cognitive processes are thought to be outside of one's control, thus not able to be manipulated by, or dependent on, emotion-related change.

NEW TECHNOLOGIES WITHIN THE EXISTING POLYGRAPH METHODOLOGY

Voice

Thus far, the most disappointing of the 'future' technologies has been voice stress analysis (VSA). The simple theory behind this measure states that anxiety related to deception can be detected by slight fluctuations in vocal recordings. This theory has received little scientific support. Nonetheless, voice stress technology built around this theory has been embraced by the public; 'lie-detectors' based on this methodology have even been advertised in popular catalogs such as *The Sharper Image*. One of the reasons for the continued public support of VSA in light of scientific criticism may be that the concept of VSA appears to have high face validity. In other words, the measurement of voice stress seems to correspond to 'common-sense' perceptions of deceptive behavior (Myers & Hansen, 1997, p. 160).

Efforts to detect deception by examining voice patterns date back to at least 1971 (National Academy of Sciences, 1979). But these efforts have largely been the efforts of marketers and salesman, not scientists. Unfortunately for the American taxpayer, many earnest law enforcement agencies and legitimate government funding organizations, under intense pressure to find alternate means of detecting deception, have fallen victim to incredible marketing claims of success. Who would not want a magic wand that could instantly detect deception while a suspect spoke? Imagine the possibilities of being able to detect a lie from a tape of a person's voice or while they spoke on television. Political debates would never be the same! Unfortunately none of the claims of voice stress marketers have ever been substantiated.

The voice stress devices that have been marketed include the Psychological Stress Evaluator (PSE), the Hagoth, the Mark II VSA and the Computerized Voice Stress Analyzer (CVSA). The CVSA is the most recent of these devices and has been heralded as a new dawn in voice stress detection. However, the only difference between CVSA and earlier devices is that it presents recorded vocal stimuli on a computer screen rather than on paper. Of the 15 university-grade publications on voice stress, only one found any evidence that voice stress may be effective; an attempt to replicate that study was unsuccessful. Table 13.1 presents a summary of studies presented in a comprehensive review of the scientific merits of voice stress analysis (Krapohl, 2001). The basic conclusions of these studies are that voice detection of deception is not valid, is not reliable and clearly does not work.

Thermal Imaging

Thermal imaging technology measures changes in regional facial blood flow, particularly around the eyes (see Figure 13.1). Changes in facial blood flow are often quite obvious, such as when a person blushes. However, the goal of thermal imaging is to capture changes in blood flow related to the fright/flight response mediated by the sympathetic nervous system (Pavlidis, Eberhardt & Levine, 2002a, 2002b). The clear advantage of this system is that individuals can be tested for deception without their awareness because measurement takes place through a camera that is sensitive to changes in temperature. The major drawback of current thermal imaging technology is the processing demand: results from a camera are recorded on a computer, and those files must undergo substantial computer processing before they can be interpreted.

Very few studies of thermal imaging as a deception detection methodology have been published, but early results have been promising. For instance, Pollina and Ryan (2002) had participants commit a simulated murder and theft similar to Pavlidis *et al.* (2002). Thermal images of the participants' faces were recorded as they answered questions during a standard polygraph examination. Pollina and Ryan (2002) found

Table 13.1 Studies that evaluated voice stress in the detection of deception

Authors	Year	Device	Participants	Location	Result
Brenner, Branscomb & Schwartz (1979)	1979	PSE	(a) 20; (b) 16	Lab	–/+
Brown, Senter & Ryan (2003)	2003	Vericator	170	Lab	
Cestaro (1995)	1995	CVSA	42	Lab	–
Cestaro (1996)	1996	CVSA	120	Lab	–
Cestaro & Dollins (1994)	1994	Verbal pitch & spectral energy	44	Lab	–
Hollien, Geison & Hicks (1987)	1987	PSE	–	Lab Lab	– –
Horvath (1978)	1978	PSE	60	Lab	–
Horvath (1979)	1979	PSE	64	Lab	–
Janniro & Cestaro (1996)	1996	CVSA	109	Lab	–
Kubis (1973)	1973	PSE, VSA	174	Lab	–
Nachshon & Feldman (1980)	1980	(a) PSE (b) PSE	20 56	Lab Field	– –
Nachshon, Elaad & Amsel (1985)	1985	PSE	40	Field	–/+
O'Hair & Cody (1987)	1987	Mark II VSA	49	Lab	–/+
Palmatier (1996)	1996	CVSA	50	Field	–
Suzuki *et al.* (1973)	1973	Voice pitch, intensity, duration	3	Case/ Field	–
Timm (1983)	1983	PSE	6	Field	–

Note: Partially adapted from Krapohl (2001), *Tech talk: Voice Stress Analysis Research*, American Polygraph Association

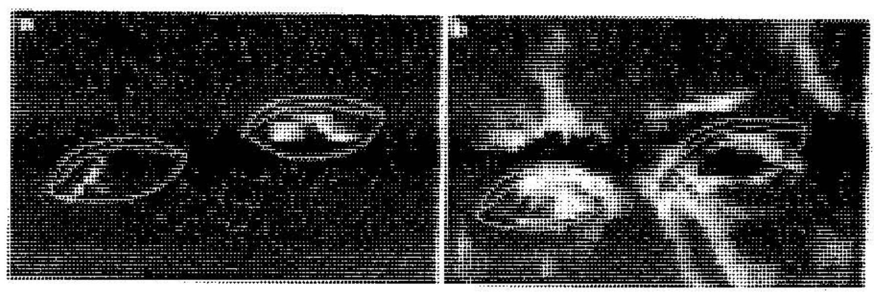

Figure 13.1 Periorbital thermal images of a participant before (a) and after (b) lying about a theft of which the participant was guilty. Reproduced from Pavlidis *et al.* (2002), with permission

that, although thermal imaging alone was unable to reliably detect deception, adding thermal imaging to the standard polygraph examination significantly increased their ability to differentiate deceivers from non-deceivers. Although this research is still in its infancy, preliminary findings suggest that thermal imaging remains a very promising deception detection technology.

Another scientific experiment, conducted at the Department of Defense Polygraph Institute (DoDPI), randomly assigned 20 volunteers to stab a mannequin and rob it. The participants were later instructed to assert their innocence during a thermal imaging exam. In the test, 83 % of the participants were correctly categorized as innocent or guilty (Pavlidis *et al.*, 2002b). However, the authors note that this technology is not quite ready for mass application; the high false-positive rate precludes the large-scale introduction of thermal imaging into security-screening applications (Pavlidis *et al.*, 2002a).

Pupillometry

Pupillometry, the study of changes in pupil size and movement, is not a modern technique. While pupillometry is best known for assessing attention and alertness, it was first studied in conjunction with deception in the 1940s (Berrien, 1942; Berrien & Huntington, 1943; Harney, 1943). These early studies suggested that deception was associated with a change in pupil size (see Figure 13.2). Study participants responded truthfully or deceptively to critical items presented among non-critical items. Berrien and Huntington (1943) measured pulse and pupil dilation and found a pupillary response related to the emotional effects of deception. Results showed that changes in pupil size occurred

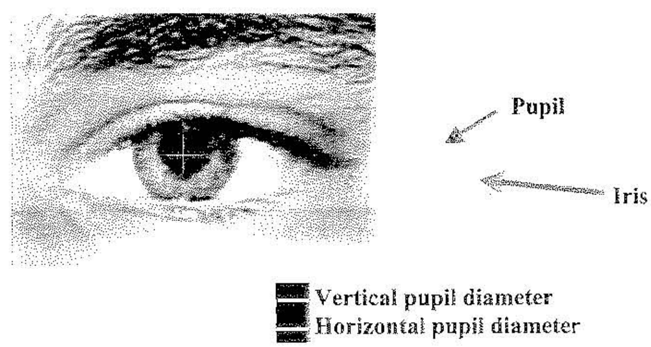

Figure 13.2 Illustration of vertical and horizontal pupil diameter utilized in pupillometry

whenever a crime-relevant question was asked, though the change was more pronounced when the participant intended to be deceptive. However, their data showed no improvement in deception detection for pupillary response over vascular changes.

Pupillometry is a robust measure of mental load that accurately reflects differences in processing demands between individuals, between tasks (such as lying and telling the truth) and within tasks (Bradley & Janisse, 1981a). When using this measure, variables such as environmental illumination level and psychosensory reflexes must be controlled (Tryon, 1975).

Pupillometry studies have identified a clear pattern of pupil dilation responses to mental workload (Simpson, 1969). Under increasing mental workload, pupil size increases until workload reaches asymptote (or overload) at which point dilations level off or decrease (Granholm, Asarnow & Sarkin, 1996; Peavler, 1974). Peavler (1974) argued that the cessation of pupil dilation following 'overload' results from the suspension of processing effort. This pair of responses, increase followed by asymptote, not only differentiates between levels of task difficulty, but also between individual differences in the ability to perform these tasks (Ahern & Beatty, 1979; Beatty, 1982; Peavler, 1974). Ahern and Beatty (1979) found that more intelligent participants (as measured by Scholastic Aptitude Tests) showed smaller evoked pupillary dilations than less intelligent students while performing tasks of the same difficulty; Peavler (1974) showed that differences in digit recall ability were associated with differences in pupil size.

The pattern of access into long-term memory has also been associated with differences in pupil dilation. (Headley, 1981; Krüger, Nuthmann & van der Meer, 2001). Headley (1981) was able to separate different patterns of memory retrieval from long-term semantic memory based on participants' unique patterns of pupil dilation. Krüger *et al.* (2001) used pupillometry to demonstrate that accessing items in memory by going sequentially backwards through time was more difficult than remembering past events forwards sequentially in time.

In studies of pupillometry and deception, such as concealed information (CI) paradigms, larger dilations were identified in 'guilt' than in 'innocent' participants (Bradley & Janisse, 1981b; Lubow & Fein, 1996). However, factors other than deception can influence pupil size. A participant's uncertainty about the test's outcome can cause greater relative changes in pupil size than certainty (Bradley & Janisse, 1979), and the more effective a participant believes the test to be (the bogus pipeline effect), the greater the change in pupillary response (Bradley & Janisse, 1981). The cognitive processes involved in deception can also influence pupillary dilation. Participants generate demonstrably greater pupil dilations when they respond deceptively to learned episodic or semantic information (Dionisio *et al.*, 2001), as well as to autobiographical information (Heilveil, 1976) than they do when responding truthfully.

Additionally, occulomotor measures can be used to assess and control for several variables known to affect ERPs, *f*MRI and polygraph measures of deception. In particular, saccade (a ballistic eye movement) velocity, pupil diameter, pupil constriction latency and pupil constriction amplitude have all successfully identified high and low arousal levels. These measures can be combined with behavioral measures to establish performance norms of the deceptive tests based on alertness, a variable that substantially influences the degree and latency to which respondents orient to salient stimuli.

New Technologies Outside of the Existing Polygraph Methodology

Brain wave. Event-related potentials (ERPs) have been used to detect deception for several decades (see Figure 13.3). In 1994, *Time* magazine named Larry Farwell *Inventor of the Year* for his work on the identification of brain waves associated with deception. However, intense debates on the theoretical and methodological approaches to using ERPs to identify deception continue. Like thermal imaging, ERPs measure

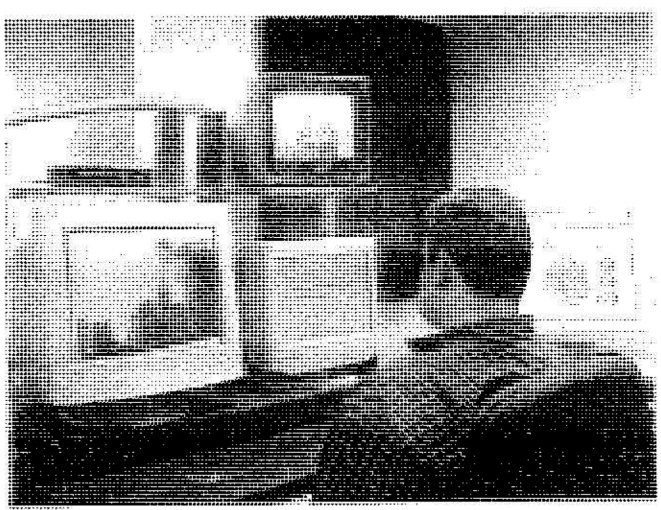

Figure 13.3 The control room during an ERP study showing clockwise from the top screen: the participant being recorded, a topographical map of the EEG, the question prompt in the study, and the initial crime scene footage (adapted from McCloskey and Zaragoza, 1985)

large quantities of data. Unlike thermal imaging, however, ERPs can be used to explore in depth the many underlying cognitive mechanisms associated with deception.

Conflicting theories of lying have been developed based on the brain processes known to elicit ERPs (Boaz *et al.*, 1991). Research suggests that the process of deception may involve attentional capture (Allen & Iacono, 1997), working memory load (Allen & Iacono, 1997; Dionisio *et al.*, 2001; Stelmack, Houlihan & Doucet, 1994a; Stelmack *et al.*, 1994b), or perceived conflict between question meaning and the examinee's memories (Boaz *et al.*, 1991).

Attentional capture refers to the directing of attention, generally toward a threat. For example, loud noises capture our attention because they could be threatening. For similar reasons, questions to which one is prepared to lie grab attention because of the threat of being caught. Working memory load refers to how many unique ideas an individual can attend to at one time. An individual telling the truth does not need to keep ideas in active awareness, but someone who is being deceptive must keep track of deceptive answers as well as truthful answers. Telling a lie is a far more cognitively complex activity than telling the truth.

Research has suggested that three waveforms are related to deception: the P3b, P3a and N4 (Allen & Iacono, 1997; Allen *et al.*, 1992; Bashore & Rapp, 1993; Boaz *et al.*, 1991; Pollina & Squires, 1998; Rosenfeld *et al.*, 1999; Vendemia & Buzan, 2005). These waves, illustrated in Figure 13.4, vary in the way they are generally produced and

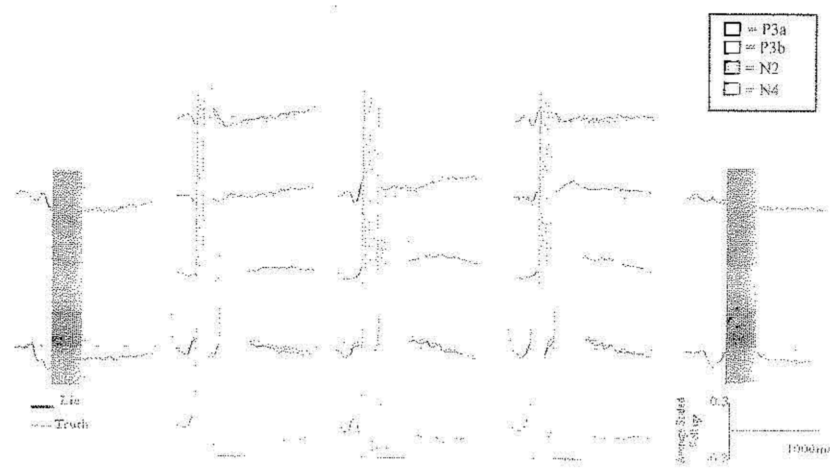

Figure 13.4 ERP waveforms of interest in the detection of deception

in the way they are studied in relation to deception. The P3b is by far the most frequently reported component of the three and is typically studied in the context of the CI (concealed information) oddball paradigm. An oddball paradigm presents an infrequently occurring stimulus within a sequence of frequently occurring stimuli. For example, a single high-pitched tone presented among a group of low-pitched tones would grab attention because it is different. This switch in attention is related to the P3b.

The 'oddball' stimulus produces a large positive ongoing peak with a latency of 350–600 ms and a distribution whose maximum amplitude occurs at parietal sites and whose minimum amplitude occurs at anterior sites (Verleger, 1997). Similar to the general oddball paradigm, the CI/oddball consists of low probability stimuli that involve guilty knowledge presented among a series of high probability stimuli that do not involve guilty knowledge. In this paradigm, the low probability guilty knowledge items elicit a larger P3b component than the non-targets (Allen *et al.*, 1992). Although researchers reporting ERPs from the CI/oddball in this area do not explicitly describe this waveform as a P3b, its spatio-temporal characteristics closely match those of the P3b (Rosenfeld *et al.*, 1999).

The CI/oddball effect has been demonstrated across multiple design permutations.

Across these studies, the P3 component of the ERP accurately and reliably indicated the presence of concealed knowledge (Allen & Iacono, 1997; Allen *et al.*, 1992; Bashore & Rapp, 1993; Ellwanger *et al.*, 1996; Farwell & Donchin, 1991; Rosenfeld, 1995, 2002; Rosenfeld *et al.*, 1996). However, the P3b is involved in many types of higher cortical functions, including stimulus evaluation (Gevins, Cutillo & Smith, 1995; Ruchkin *et al.*, 1990; Verleger, 1997), attention resource allocation (Comerchero & Polich, 1999), and updating of information held in working memory (Donchin & Coles, 1988; Ruchkin *et al.*, 1990). Thus, the precise cognitive sources for the effects of deception on the P3b remain unclear.

An often criticized confound of the CI/oddball task further obscures the findings (Allen & Iacono, 1997). Participation in an activity is not required to generate an ERP response to questions about that action; knowledge of the act is sufficient to bring about a measurable response. For example, a witness to a criminal episode will exhibit ERP responses to questions about the crime that are similar to ERP responses of the criminal. In the psychophysiological detection of deception field, therefore, the CI paradigm is now referred to as the concealed knowledge paradigm because central and peripheral nervous system responses are associated with the mere possession of knowledge, but not explicitly with guilt.

Two main theories of deception, the attention theory and the working memory load theory, suggest different patterns of response for the P3b based on the antagonistic effects of attention and workload (Kok, 2001). Attention theorists argue that attentional capture of the low frequency CI items increases the amplitude of the P3b, while working memory load theorists argue that the increased working memory demands required for deceptive processing suppress the P3b. Manipulating task demands can generate both of these effects. The P3b is larger in tasks with an attention grabbing concealed information item, while in tasks with no such oddball the P3b is suppressed. In order to examine the actual effects of deception, other waveforms must also be studied.

Like the P3b, the P3a is elicited by an oddball paradigm. In one variant of the oddball, the three-stimulus paradigm, the P3a occurs in response to novel-infrequent stimuli presented in addition to the 'typical' oddball stimuli. The P3a can be elicited by shifts in attention (Comerchero & Polich, 1999), switching from difficult to easy task demands (Comerchero & Polich, 1999; Harmony *et al.*, 2000), and alerting (Katayama & Polich, 1998). Across studies reporting the P3a in an oddball, it is alerting stimuli combined with initial attentional allocation that produce the phenomenon (Katayama & Polich, 1998). The term 'P3a' is applied to an assortment of early P3 components with anterior distributions, and the exact conditions necessary to evoke a P3a vary across paradigm and stimulus demands (Katayama & Polich, 1998). In general, the waveform is characterized as a positive going peak with an anterior distribution, and a post-stimulus latency of 250–350 ms (Comerchero & Polich, 1999; Harmony *et al.*, 2000; Spencer, Dien & Donchin, 1999).

Two ERP studies of deception reported an early positivity with spatiotemporal characteristics similar to the P3a (Matsuda *et al.*, 1990; Pollina & Squires, 1998). Neither of the reported studies involved the oddball paradigm: (a) Pollina and Squires (1998) employed graded judgments of true and false sentences and (b) Matsuda *et al.* (1990) used a two-stimulus target detection task in which the first stimulus involved participant-related information. Although the findings were mixed, Pollina and Squires (1998) suggested that the P3a occurred in probably true conditions.

Unlike P3b and P3a, the last component reported in studies of deception, the N4 component, is sensitive to semantic incongruity. Some researchers argue that deception represents an incongruity between internal truth and external response (Bashore & Rapp, 1993). The N4 is a large negative going peak occurring at around 400 ms post-stimulus with maximum amplitude in anterior and temporal regions (see Figure 13.5). It is produced by stimuli that are incongruent in relation

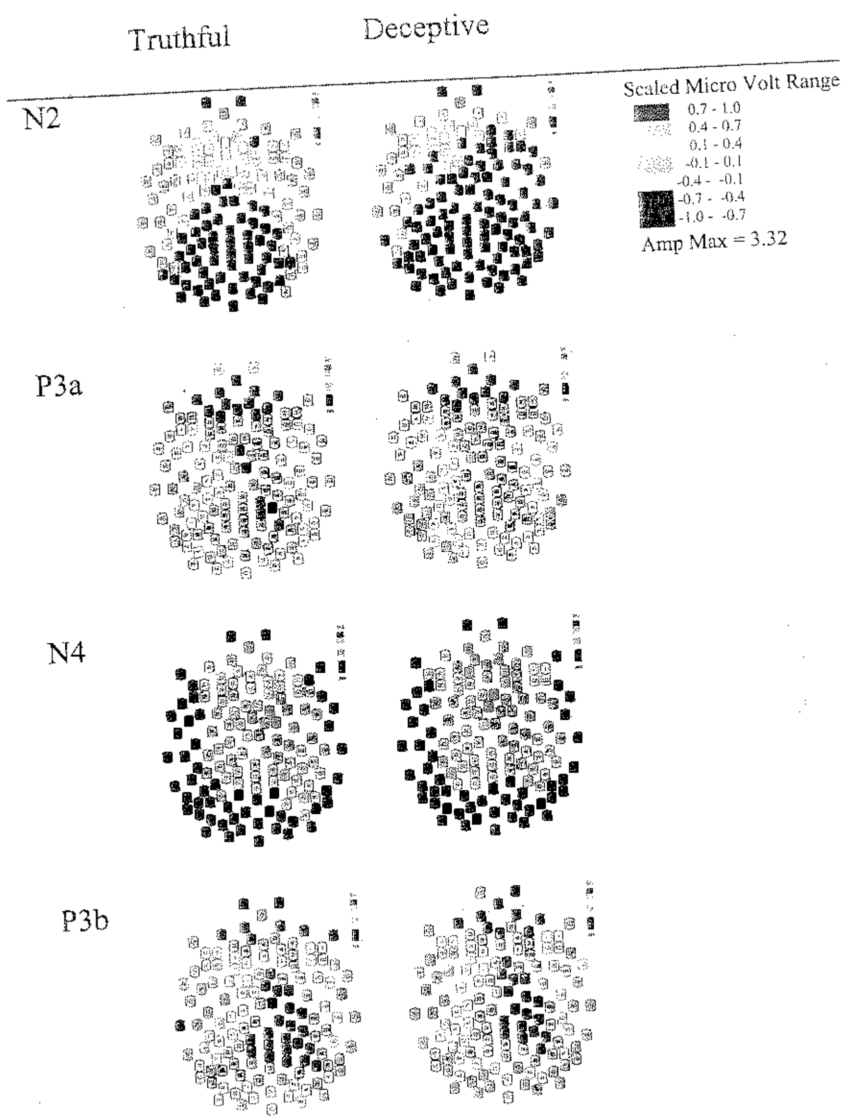

Figure 13.5 Topographical distributions of activity for ERP components of interest in the detection of deception

the preceding context, and is predominantly limited to linguistic ormation.

The N4 component has also been elicited by the possession of conlled knowledge in sentence completion tasks involving false sentence npletions (Boaz *et al.*, 1991) and in a two-stimulus target detection k (Stelmack *et al.*, 1994a, 1994b). Bashore and Rapp (1993) suggest it the N4 is reactive to anomalies in semantic and episodic memory well as to inconsistencies in language semantics. A study that did not ire language inconsistency, but did share anomalies in semantic and sodic memory, found no differences in N4 amplitude. In that study, ticipants made graded truth-value judgments that were sometimes onsistent with memory, and these failed to alter N4 amplitude or ency (Pollina & Squires, 1998). In a two-stimulus task, the N4 was ; found to be sensitive to deception, but was found to be sensitive to ponse congruity with the second stimulus (Stelmack *et al.*, 1994a, 94b).

Research by Vendemia and colleagues (Vendemia & Buzan, 2005), cussed in detail in the 'Fusing Alternative Technologies' section of s chapter, has revealed a combination of the P3a, P3b, N2, N4, and e positive potential during deception. Figure 13.4 shows the P3a, b, N2 and N4 depicted as ERP waveforms, while Figure 13.5 shows topographical distributions of these ERP components across the lp. The early positive component, the P3a, was localized to the anior cingulate gyrus, a region of the brain involved in attention. The b was associated with activity in many different brain regions, and med to be involved in decision-making. The late occurring negaity (N4) was predominantly localized to the inferior frontal gyrus, d seemed to be related to congruity of the response. Finally, the late sitive complex was associated with regions of the temporal gyrus d anterior cingulate, and may be related to a final reanalysis of the ponse.

Detecting deception using event-related potentials is a young, but omising technique. Research evaluating the relationships between otion, stress, individual personality variables, memory-modifying sinformation and psychopathology with deception are ongoing. While earch to date suggests that the psychophysiological detection of eption approach reliably differentiates truthful and deceptive remses, it remains to be seen what role ERP-based detection of detion methods will serve in the future. Additional research may lead ess cumbersome technologies and measurement strategies that will ke ERP the ideal choice for a variety of security settings. Altertively, the addition of event-related potential channels to other scifically tested methodologies, such as polygraph, thermal imaging, or functional magnetic resonance imaging, may further improve the ability of these methods to detect deception.

Functional Magnetic Resonance Imaging (*f*MRI)

When a human being engages in any cognitive activity, such as subtraction, reading, or lying, various parts of the brain become active. Increased activity in these areas increases the metabolism rate of the neurons, which therefore need more blood for nourishment. Brain mapping is achieved by setting up an MRI scanner in such a way that blood flow to the active areas of the human brain shows up superimposed on an MRI image.

In an *f*MRI experiment, a participant will lie in a magnet (see Figure 13.6) while performing an experimental task. In the earliest

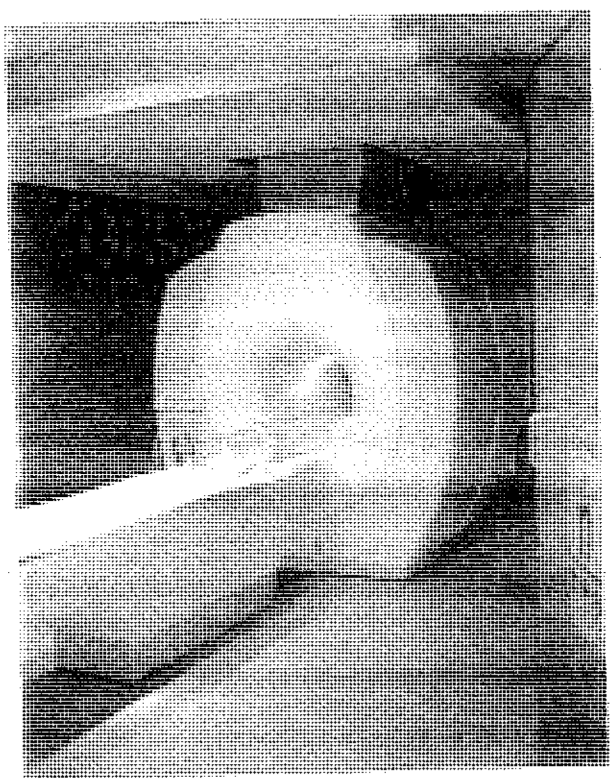

Figure 13.6 A typical *f*MRI machine. The participant lies prone on the table with his head facing the magnetic coil. The table is moved into the bore of the magnet during recording

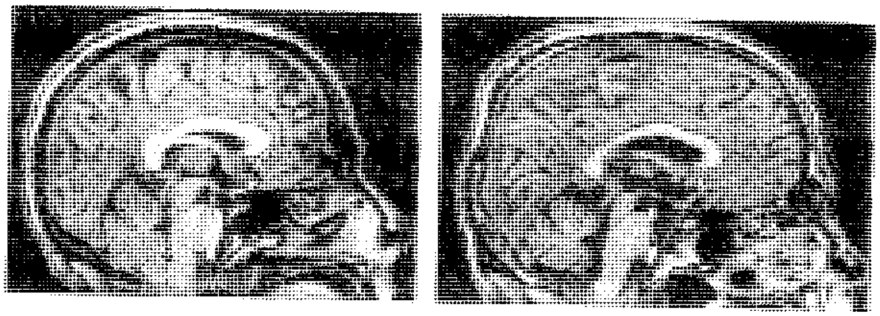

Figure 13.7 Midsagittal structural magnetic resonance images of left hemispheres from two people showing corpus callosum, cerebellum, brainstem and cortical regions

*f*MRI studies, participants watched patterns of grids, such as checkerboards, while scientists measured the output from the visual cortex. First, an MRI image is taken of the individual's brain, which, like a fingerprint, has its own unique shape and size (see Figure 13.7). Later, this image will serve as a template on which the images of brain activity will be overlaid.

Next, a series of low-resolution scans are taken over time, some during the task and some while the individual is not engaged in the task. For example, some scans might be taken while an individual is lying and others while an individual is telling the truth. The two sets of scans are later compared to see which is more active. Although it is possible to randomly present deceptive and truthful items with this technique, most *f*MRI research paradigms require that participants maintain the behavior of interest for an extended period of time. Thus, participants in *f*MRI-based deception research lie to a series of questions, then tell the truth to a series of questions, an experimental procedure known as a block design. Researchers using this technology employ a wide range of different paradigms, and for this reason and others the results across studies have not been consistent.

In block design *f*MRI studies, researchers have associated activations in the caudate (Lee *et al.*, 2002), cerebellum (Ganis *et al.*, 2003), cingulate (Faro *et al.*, 2004; Ganis *et al.*, 2003; Kozel *et al.*, 2004; Lee *et al.*, 2002), cuneus (Ganis *et al.*, 2003), fusiform/parahippocampal area (Ganis *et al.*, 2003; Kozel *et al.*, 2004), precental gyrus (Ganis *et al.*, 2003; Langleben *et al.*, 2002), ventrolateral prefrontal cortex (Faro *et al.*, 2004; Spence *et al.*, 2001), medial prefrontal cortex (Ganis *et al.*, 2003; Langleben *et al.*, 2002; Spence *et al.*, 2001), prefrontal cortex (Faro *et al.*, 2004; Ganis *et al.*, 2003; Kozel *et al.*, 2004; Lee *et al.*,

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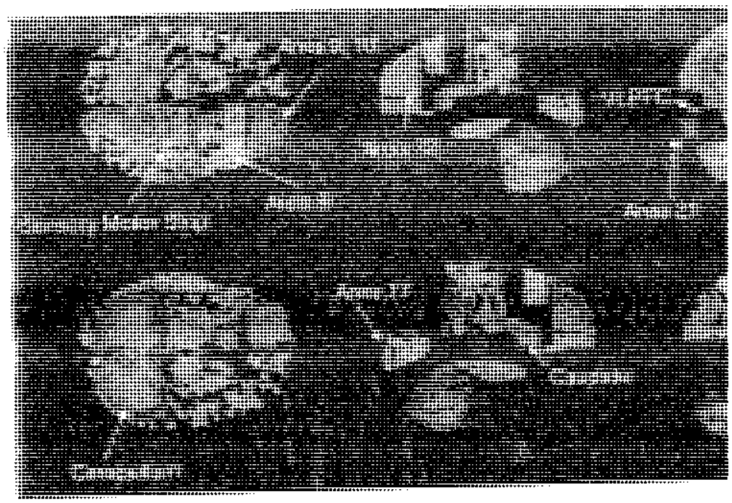

Figure 13.8 Cortical activation regions reported in Bhatt *et*
*f*MRI deception studies (Bhatt *et al.*, under review)

2002), left frontal (Ganis *et al.*, 2003; Langleben *et al.*, 2
et al., 2001), left inferior parietal (Langleben *et al.*, 200
2002; Spence *et al.*, 2001), and temporal (Faro *et al.*, 2004
2004; Lee *et al.*, 2002; Stelmack *et al.*, 1994b) regions
of deception. Bhatt, Fishbein and Zeffiro (under review)
meta-analysis of the brain regions activated in *f*MRI stu
tion. We have created a three-dimensional cortical map of
which are presented in Figure 13.8.

As is evident from Bhatt's review, the number of indiv
tions reported in these studies is quite varied, with act
single participants ranging throughout the cortex (Figu
tremendous variability in *f*MRI activations can be attr
large number of paradigmatic differences in these studi
lists *f*MRI studies in which participants engaged in decep
or observed deceptive behavior, and the specifics of each p
clear that these studies differ on how participants were
deceive, the types of lies they were asked to tell, the info
which they lied, and the type of polygraph scenario they
parallel.

Even given these differences, activations in certain re
anticipated based on the underlying processes engaged
For example, the studies by Kozel *et al.* (2004a, 2004b), a
et al. (2002), utilized a risk-taking scenario in which part

Table 13.2 Studies reporting *f*MRI differences in deception, compiled from Bhatt *et al.* (under review)

Author	Paradigm Description	Lie Type
Ganis *et al.* (2003)	Recorded work/vacation scenarios, after 1 week delay generated alternate scenarios and memorized them.	1. Memorized 2. Spontaneous
German *et al.* (2004)	Observers indicated whether real or acted clips revealed completed acts.	Observation only
Grezes *et al.* (2004)	Observers indicated whether actors actually lifted heavy boxes or pretended to lift heavy boxes.	Observation only
Kozel *et al.* (2004a)	For a reward, participants lied and told the truth regarding objects under which 50 $ was hidden.	Concealed information
Kozel *et al.* (2004b)	For a reward, participants, lied and told the truth regarding an object under which 50 $ was hidden.	Concealed information
Lee *et al.* (2002)	For a reward, participants lied in a card playing scenario.	Concealed information
Lee *et al.* (2002)	For an imaginary reward, participants faked amnesia to digits and autobiographical information.	Simulated amnesia 1. digits 2. autobiographic memory
Spence *et al.* (2005)	Participants were told to lie and tell the truth to events that happened earlier in the day.	Directed lie to episodic memory

receive a monetary reward if they 'fooled' the examiner, but no reward if they failed to 'fool' the examiner. Given this condition, activation in the orbitofrontal cortex, a region of the frontal cortex that has been implicated in the integration of motivational stimuli when guiding response selection, could be anticipated. Only Kozel *et al.* (2004a, 2004b) identified activation in this region.

John Gabrieli and other *f*MRI researchers argued that the anterior prefrontal cortex, or Brodmann's Area 10 (see Figure 13.8), is involved in the act of deception (personal communication, July 14, 2005). Ramnani and Owen (2004) argued that this area is activated when an individual must make simultaneous considerations of multiple relations. When an individual deceives, these multiple relations occur between situational context, goal-driven behavior, divergen the deceptive information from truthful information, and a varie internal states. Given the generalist nature of these 'simultaneous siderations', it is no surprise that several researchers have ident activation in this region during the act of deception (Faro *et al.*, 2 Ganis *et al.*, 2003; Kozel *et al.*, 2004; Lee *et al.*, 2002; Vendemia, 20(

However, the most widely reported region of activation is the ant cingulate (Faro *et al.*, 2004; Ganis *et al.*, 2003; Kozel *et al.*, 2004; *et al.*, 2002; Spence *et al.*, 2001; Vendemia & Buzan 2004a). This ac tion is broken down into two main areas, the ventral anterior cing and the dorsal anterior cingulate. Some researchers believe that area is involved in conflict resolution while others believe that it i volved in attention shifting and resource allocation processes. It be likely that the more ventral region is involved in conflict resol while the more dorsal area is involved in attention shifting; how as it is theoretically possible that the act of deception involves processes, it may be difficult to parcel out these anatomical correl

Fusing Alternative Technologies Together to Create a Model of Decep

The goal of testing deception using a modeling approach is to asses cognitive processes that subserve the larger process of deception to identify consistent patterns of activity in multiple measures c ception. The difference between utilizing testable models to deve theory versus utilizing a data-driven approach is purely methodolc and is not based on the type of dependent variable gathered. Acco to Keppel (1991), a testable model is, '. . . a fairly general state about the assumed nature of the world that we translate into an e iment. Typically . . . a research hypothesis asserts that the (varia will produce an effect' (p. 24).

Work in our lab began with a model (Figure 13.9) based on li ture from the fields of polygraphy and ERPs. Individual hypot derived from the model were then tested in a sequence of 13 indiv experiments over a period of 5 years. These studies involved se dependent variables including behavioral measures (reaction tim errors), ERPs (N2b, P3a, P3b, N4 and LPC), and ERP combined *f*MRI measures.

According to this model executive control monitors an ongoin logue with another person. The skill and degree to which this is ap depends on the type of coping mechanisms an individual uses an skilled an individual is at cognitive control. When a question to v the individual intends to deceive arises, certain characteristics o

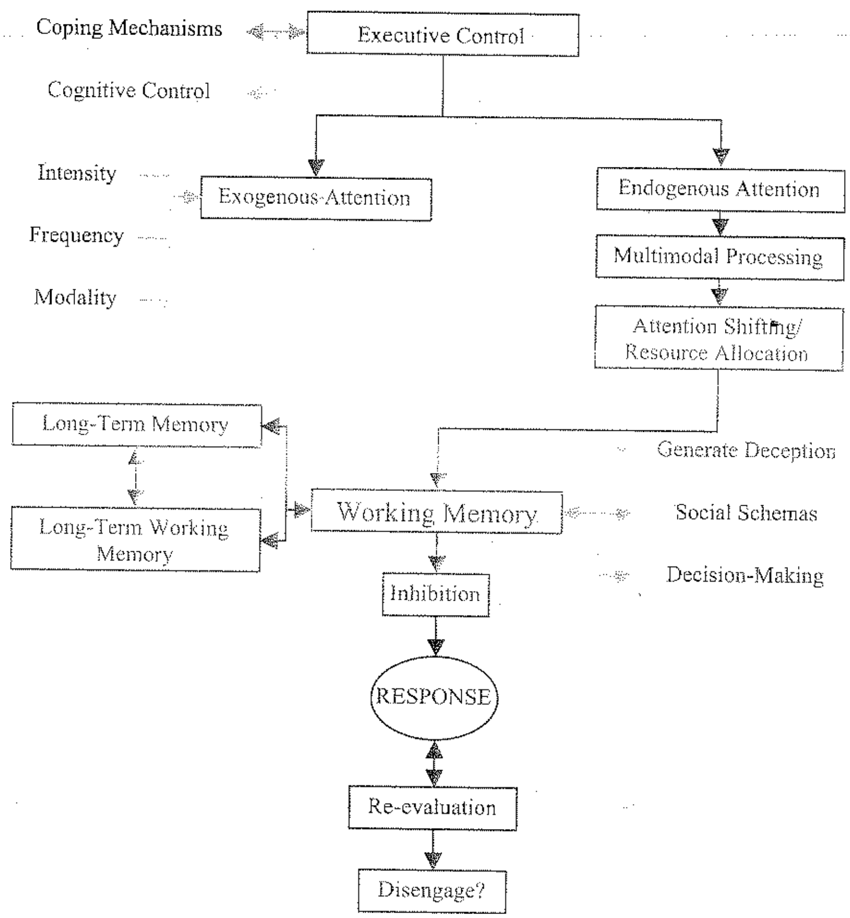

Figure 13.9 A working model of deceptive behavior

question, such as intensity (how strongly the question is asked), frequency (how often the question has been asked), and modality (is the question spoken or printed), attract their attention. The individual has no control over these demands on the exogenous attention system, but can control aspects of the endogenous attention system such as how the individual processes incoming stimuli and how they allocate resources to prepare the deception. These resources are then held in working memory, and the truthful information is pulled from long-term memory. In the case of individuals who have expert information or who have heavily practiced the deception, the information may be generated by a special type of memory called long-term working memory. Once the

truthful information is held in working memory, the indivi(
generate a deception and make a decision based on the socia
and the risk-benefit ratio to be deceptive or truthful. After th
is made the persou inhibits the inappropriate response an
the situationally appropriate response. In certain individu
followed by a re-evaluation of the response and a disengagen
deceptive working memory.

This model depicts the complexity of the cognitive pro
ception from which we can infer its measurable psychoph
activations. When individuals are in an environment in whic
they must be prepared to lie, they are likely to be in a state
ened alertness in which they must be vigilant about their ev
Not only must they lie convincingly when required, they m
truth when appropriate. They must further maintain a co
cohesive story; any lies they tell must fit together within thei
'storyline'. Such vigilance is controlled by what is commonly
as the 'central executive', which encompasses the 'executive

The executive functions include a vast array of cognitiv
associated with behavioral control and execution, many o
tapped into by the deceptive act. When one is uncertain w
must lie or tell the truth to the next question, the endoge
tional system is strongly activated; the respondent must qu
the situation to determine which response is correct. Our
gests that doing so will increase activation in the occipi
region of the brain, a higher-order multimodal associatio
controls awareness of one's surroundings and self. As atte
from one stimulus to another (i.e., from one question to t
would expect more medial-frontal *f*MRI activations relat
tional resource reallocation or a P3a ERP waveform. Next
the stimulus item with the internal representation of the ev
tion requires the interaction of working memory, long-te
and long-term working memory. Long-term memory acces
sociated with a negative waveform at about 400 ms that
in the temporal regions. We would anticipate psychophysi
ings associated with the executive control of this problem
respouse-selection process, such as in the dorsolateral pref
(Brodmann's areas 9 and 10) or a P3b ERP waveform occur
350 and 600 ms post-stimulus associated with working m

Finally, to generate a deceptive response, the respondent
a prepotent but situationally inappropriate response (e.g.
and answer the question. This activity will likely produc
tivations associated with the executive inhibition of beha
by precentral gyrus activity as the response is carried ou

activity will vary somewhat in location depending on response modality; verbal responses will activate a more ventral portion of the precentral gyrus than will manual responses. There is ERP evidence in the form of a late positive component (LPC) activation to support the notion of a re-evaluation after the response, which may serve to prepare respondents for upcoming questions.

In the initial studies testing this model, we had participants respond truthfully or deceptively to statements with a true or false base truth-value, such as the true statement 'Grass is green.' Similar to semantic verification tasks, participants evaluated these sentences and then made truthful or deceptive evaluations of the sentence's base truth-value. In order to examine the impact of long-term memory access, Study One ($N = 42$) used statements with semantic long-term information (general world knowledge), while Study Two ($N = 45$) used autobiographic long-term information statements (personal information such as, 'My name is [Name]' where [Name] is replaced by each participant's actual name) were used.

To begin formulating the specifics of the neuronal aspects of the theory, we undertook a post-hoc analysis of electrical current dipole sources (i.e., the sources of the electrical activity in the brain as measured from the scalp) on the data from Study One. Four ERP waveforms were affected by the experimental manipulations: an early positive component (P3a) in the cingulate gyrus, a subsequent centro-parietal positivity (P3b) with multiple cortical sources, a late occurring negativity (N4) in the inferior frontal gyrus, and a late positive complex in regions of the temporal gyrus and anterior cingulate (Vendemia, 2003b). The reaction time data showed that it took participants longer to deceive than to tell the truth, suggesting that deception is the more difficult task. With respect to long-term memory, participants took longer to respond to general world knowledge than to autobiographical knowledge. This phenomenon was additive with deception, suggesting that individuals retrieve information from long-term memory when deceiving (Vendemia, 2003b; Vendemia *et al.*, 2005a; Vendemia, Buzan & Simon-Dack, 2005b).

In the next sequence of studies, we (Vendemia *et al.*, 2005b) investigated the impact of preparedness to deceive on behavioral dependent variables (reaction time and errors). Three studies ($N = 45$, $N = 44$, $N = 38$, respectively) assessed reaction time in relation to deception, response congruity and preparedness to deceive. Each study provided less information preparing respondents to lie or tell the truth to each item than did the previous study. We found that deceptive responses generated longer reaction times than did truthful responses and that this relationship remained constant across response type (i.e.,

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responding with 'agree' versus responding with 'disagre
paredness to deceive. Overall, participants took longer to re
they were less prepared to deceive and when responding wi
However, there was no interactive effect between prepare
ceive and deception.

In the next sequence of studies (Vendemia *et al.*, 2006), v
to examine and unite the various methodological approa
ing upon the previous experiments, we derived hypothes
impact of preparedness to deceive on ERP waveforms ass
deception. Over three levels of preparedness ($N = 34, N =$
we manipulated working memory load by utilizing trut
ceptive response demands combined with congruent and
response demands. Random presentation of response der
trials in all three experiments required attention shiftin
between each trial, while preparedness to deceive was sy
decreased across the three studies. Four waveforms we
through principal components analysis: an N2b occurrin
ms with an anterior maximum; a P3a occurring at 250–45
anterior maximum, an N4 occurring at 300–500 ms with
temporal maxima, and a P3b occurring at 500–700 ms wi
maximum (see Figure 13.5).

The N2b, which had been identified in earlier studies,
viously varied with experimental manipulations related
memory or workload. In this study, however, we found it
tematically with preparedness; the more prepared an in
to deceive, the shorter the latency of this waveform and
amplitude. Classically, the N2b is elicited in 'attend' cond
associated with transient arousal and the orienting respo
1983; Loveless, 1986; Näätänen & Gaillard, 1983). Decre
tency is indicative of decreased orienting toward task-re
(Nordby *et al.*, 1999), while increased N2b latency is as
the decline in attentional skill with age (Amenedo & Día
N2b has also been associated with attention-switching ta
deception (Vendemia, 2003a; Vendemia & Buzan, 2005
tend to orient to stimuli to which they must respond de
the tasks became more difficult and the response prompt
relevant to the correct completion of the task, N2b lateuc

The next construct that we tested was practice. The
ception involves executive function with access into long-
memory processes, which can be improved through prac
session longitudinal study examined the effect of pract
relation to deception and response congruity (Session (
Session Two, $N = 36$; Session Three, $N = 25$). Participa

self-referent sentences and responded truthfully or deceptively. Findings indicated that RT decreased with increasing practice, but that deceptive responding consistently generated longer RTs than truthful responding regardless of practice.

In addition to examining the impact of preparedness, working memory load and practice, our laboratory began to investigate the effect of incomplete or inaccurate memories on the process of deception. In order to conduct these studies, we utilized a misinformation paradigm. Researchers in the field of misinformation have disagreed on whether the experiments in this area are truly showing misinformation effects, whether they are representative of patterns of recognition, or perhaps are the result of a source conflict effect (McCloskey & Zaragoza, 1985). In order to better investigate the cognitive processes involved in the misinformation effect, we added a memory workload task using deception. A pilot study with 96 participants (72 females, 24 males) showed main effects of narrative content and deception and a significant interaction between narrative content and deception on reaction times. Two current studies in our laboratory seek to parse out the possible explanations for this effect. In order to investigate recency effects, we are conducting a study using a modified forced-choice paradigm with novel response items replacing the misinformation items. In order to investigate source conflict, we are also conducting a study with novel response items and misinformation items.

Other research in our lab also merges developing detection of deception technologies. Using ERP and *f*MRI techniques, we studied neocortical correlates of deception. Participants ($N = 15$) were measured on two testing days while they performed the same deception-related semantic verification task with autobiographical information: (1) while their ERPs were recorded, and (2) while *f*MRI measures were recorded. Data from the *f*MRI were used to seed dipole models of the event-related data to garner specific cortical sources underlying the event-related signal, providing a specific localization of deception processes in time and cortical space. The preliminary results from this study suggest that general aspects of the visual attention system are involved in the deceptive process and that both the exogenous and endogenous components of attention are invoked.

Additionally, we studied a novel analysis approach for high-density event-related scalp potential data within a quantum mechanical formalism wherein each channel is treated as an independent two-state system. Empirical voltage values obtained with a 128-channel EEG/ERP array during truthful and deceptive responses to questions regarding autobiographical information were used to define energy values at discrete time points; exact solutions for the probability amplitudes are written in terms of the Rabi formulae at resonance assuming

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a 'pure truth' start. We assessed cognitive activity levels of the cortex by summing energy density contributions boring channels and demonstrated that, while channel ar states remain independent, transitions among response s through population inversions induced by cutoff and re time-dependent potential. A phase analysis of the transiti the truthful and deceptive channel states shows that after cease, the states evolve independently, allowing for effecti nation of the response state for 72 % of the participant po addition, a time course analysis for extrema of the cogni levels over posterior and anterior regions of the brain sug neocortical interactions may be responsible for differing w executive and semantic processes such that attention-sw demands take longer for the case of deception. These res that the quantum approach presented may provide a usefu analysis of higher cognitive functioning (Schillaci *et al.*, un

Through our work, we have determined that (a) both th and endogenous attentional systems play roles in the a tion and that (b) communication of information in the attentional system from posterior to anterior regions is sl deception. The exogenous system is impacted by a varie related to stimulus presentation such as frequency, m intensity. Furthermore, we have shown that the react deceptive behavior is intimately related to the type of m which one is being deceptive. The faster the access to the faster is the overall reaction time. For example, individu more quickly to semantic-autobiographical information th semantic information.

Additionally, we found strong support that both truthfu tive memories are held in working memory, and then one is inhibited preceding a response. We have successfully testable model of deception based on a review of existin the literature and refined it with data from our initial r tematically testing individual constructs from that model over several years. With each study, individual aspects o were refined and additional testable hypotheses created. T step in this process is to measure the impact of individua on the constructs within this model.

CONCLUSIONS

This chapter has reviewed a variety of technologies an for detecting deception. Some of these techniques, such a analysis and pupillometry, have been used for a long time, while others such as thermal imaging, ERP and *f*MRI are still fairly young. The analysis strategies that support these technologies are also burgeoning. We have reached a point in time where the specificity and complexity of our measurement tools approximate the complexity of the process we are attempting to model.

Thermal imaging shows potential, with preliminary research findings suggesting high rates of accuracy in detecting deception. Pupillometry, more often studied than thermal imaging, has demonstrated an ability to detect deception. However, factors other than deception have been shown to affect pupil diameter, a fact which may cloud findings of deception-related pupillometry examinations. ERP and *f*MRI research, though still in development, show promise as countermeasure-resistant forms of deception detection. Conversely, research on Computerized Voice Stress Analysis (CVSA) has been quite disappointing. Having failed to produce replicable results in rigorous scientific inquiry, CVSA has been found to be a deception detection technology that is neither reliable nor valid.

In the current sociopolitical climate with terrorism an ongoing global threat, the further development and study of reliable instruments to detect deception is of growing importance. Security screenings and interrogations could be greatly facilitated by using deception detection technology. However, each technology, whether established or developing, may have a particular niche in the deception detection field. One technology may be too cumbersome for use in airplane passenger screening, while the accuracy of another may be too low to provide adequate security. Additional research is therefore necessary to determine the reliability, validity and accuracy of each instrument as well as the specific arenas in which each deception detection technology is most appropriately used.

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Deception and the Misinformation Effect: Does Misinformation Influence Lying?

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Abstract

Research in the field of deception often tests participants' ability to lie about information with which they are familiar and have a strong recall of base truth. In our study we aimed to discover the affects that occur when participants attempt to lie about information that they do not have a great deal of familiarity or about which they are uncertain, as may happen in eye-witness scenarios. An excellent laboratory simulacrum, "the misinformation effect" can be used to decrease individuals' certainty regarding recently witnessed events. In order to investigate the cognitive processes involved in both deception and the misinformation effect we measured reaction time to a modified forced-choice paradigm originally presented by McCloskey and Zaragoza (1985). The results from this study demonstrated that misinformation and deception both exert main effects on reaction time, as well as sharing a cumulative effect. Individual difference measures of anxiety and cognitive-failures suggest that these effects may be related to frontal lobe function.

Deception and the Misinformation Effect: Does misinformation influence lying?

A steady growth of published studies documents increased scientific interest in deceptive behaviors. Nearly all research in the area concentrates on paradigms containing test items with which participants are familiar and have high recall confidence. Some paradigms, such as the concealed information test, are dependent on accuracy of a participant's memory (Krapohl & Sturm, 2002). However, in real-world scenarios individuals often lie when they do not know all of the details of an event, or when the details of an event have not been accurately encoded in memory. For example, witnesses of a street fight may choose to be deceptive to protect an active participant, but may also have memory interference due to other factors (i.e. leading questions, eyewitness recall issues). An ideal paradigm for studying this scenario in the laboratory is the misinformation effect, which occurs when an individual misreports events after exposure to misleading information (Loftus, Donders, Hoffman, & Schooler, 1989). Repeated studies have shown this effect across a variety of stimuli, from the misremembering of a hammer as a screwdriver (Belli, 1989; McCloskey & Zaragoza, 1985), to *Vogue* magazine being remembered as *Madamoiselle* (Tversky & Tuchin, 1989), to the word Yukon on a t-shirt being remembered as Nixon (Sheehan & Tilden, 1986).

A classic debate between the school of thought supported by Loftus' research and the theoretical counterclaims of McCloskey and Zaragoza divides the field. The debate concerns whether misinformation experiments are indicative of encoding/storage effects in memory, or whether they are simply representative of selection bias via source conflict errors (McCloskey & Zaragoza, 1985).

Loftus and colleagues defend the position that misleading post-event information impairs memory for the original event (Loftus, 1979; Loftus, Donders, Hoffman, & Schooler, 1989; Loftus & Hoffman, 1989; Loftus, 1991). They believe that events are stored in memory as representations, and upon the presence of new information in the environment, a person can choose to update this representation. If the representation is updated, the person is left only with the new representation in memory. Loftus has found that misled participants are less accurate than control participants on the critical details, an effect which she characterizes as the inability of participants to recall the critical items following presentation of misinformation.

Loftus's research has shown that accuracy performance varies when the appearance of a blatant misinformation item is delayed. In the original criminal event study, a purse was carried by the main character and was visible in all scenes. False information about the purse was readily identified by participants. Participants who received a blatant misinformation item before the presence of the new misinformation were more accurate than participants who received the blatant item after the presence of new misinformation. If participants choose one set of information over the other at the time of their responses, then the timing of the blatant misinformation item should not have an effect. However, Loftus's data indicates that participants chose to incorporate the new information into their memory representation based upon the already identified blatant misinformation item. This finding supports her claim that one can only have one representation present in memory, and that misinformation can impair this representation.

McCloskey and Zaragoza present a counter to Loftus' claim in their 1985 study. The modified paradigm study presented by McCloskey and Zaragoza (1985) examined the hypothesized effects on original information in the face of new misleading information. In their design, participants viewed images of an event, usually followed by written information that contained discrepancies from the original images. The response phase consisted of a forced choice paradigm that required participants to select between information presented in the images or information presented in the narrative. For questions that involved misinformation, participants were biased towards the most recently viewed information and therefore selected the answer choice presented in the narrative. For questions that did not involve misinformation, participants lacked this knowledge and selected the answer choice presented in the images. Data therefore showed a significant response bias by misled participants towards the incorrect answer choice.

In the modified paradigm participants were still presented the answer choice found in the images, but the second answer choice was novel to the study. In other words, if the original item was a hammer and the misled item was a wrench, the test items would be a hammer and a screwdriver. McCloskey and Zaragoza theorized that if misleading data actually eliminated memory for the original event, the results of the modified paradigm should match results found by Loftus and others. If the original information was still present in memory, then, when faced with the original answer choice and a novel choice that was clearly incorrect, mislead participants would respond with the original answer choice.

Data was collected from 120 participants and supported the theories of McCloskey and Zaragoza. In the original test paradigm participants achieved an accuracy of 37% for misleading information questions and 72% for control questions.

When the misleading information response choice was replaced by a novel response choice, accuracy for misleading information questions went up to 72% while accuracy for control questions went up slightly to 75%. The results indicated that both sources of information were still present in participants' memories during the response phase, contrary to theories presented by Loftus and others.

The purpose of this study is to examine the effects of conflicting information on a person's ability to respond deceptively to questions about an event. We also hope to be able to test the classical debate in the misinformation field. The additional workload of deception should create a more robust misinformation effect in the data, which in turn should make differences between factual responding and misinformed responding more statistically distinct as measured by reaction time. The earliest study reported in the deception literature on reaction times and deception was conducted by Marston (1920) who concluded that deception could either cause increases or decreases in reaction time. By adding a condition that causes a participant to lie, more demands are made on working memory, which can be measured behaviorally through reaction time performance (Vendemia, Buzan, & Simon-Dack, 2005). Studies conducted by Seymour, Seifert, Shaft, and Mosmann (1997) used reaction time data in mock-crime experiments to show that participants who possessed concealed information had longer reaction times when responding to crime-related probe items regardless of intent to deceive.

We believe the deception paradigm can be applied to misinformation, since it represents a basic reaction time measure related to knowledge of information. Cognitively, it has been argued that deception may capture constructs like attention (Allen & Iacono, 1997) as well as working memory load (Dionisio, et al., 2001). In addition work done by Amato and Honts (2002) shows that regardless of the success of a misinformation manipulation a majority of guilty subjects were incorrectly classified as truthful based on skin resistance amplitude data. Rosenfield (2002) has also conducted studies that suggest "P3 latency as the brain's unconscious recognition of false memory". This evidence suggests that deception does require more cognitive processing commitment, and can intensify participants' susceptibility to misinformation.

Neurological Evidence

A recent study conducted by Roediger and Geraci (2007) examined the effects of misinformation and aging. Their first experiment observed the differences between 24 young adults and 24 older adults across two misinformation tasks. Both groups were tested using yes-no and source recognition tests. The older adults performed significantly worse than the younger group in the recognition test, but not in the source-monitoring test. The results suggest that the misinformation effect occurs at the retrieval stage, an effect that could not be monitored in younger adults due to their more active source memory. When prompted for source-monitoring, older adults performed only slightly worse than their younger counterparts.

Frontal lobe function has been linked with susceptibility to misinformation in college students as measured by fMRI (Schacter *et al.*, 1997), and PET (Schacter *et al.*, 1996), as well as older adults in behavioral studies (Butler *et al.*, 2004; Roediger & Geraci, 2007). Additionally, a case study by Schacter et al. (1997) reports a pattern of false recognition in a patient with right frontal lobe damage. In a study of 60 older adults who were divided into low (n=34) and high (n=24) frontal lobe functioning groups based on neuropsychological test batteries, Roediger & Gararci (2007) identified effects on both recognition and source-monitoring.

Individual Difference Variables

The filler tasks in these studies are always presented between the different steps of misinformation to serve as filler information between presentation and responses. Normally these filler tasks are questions that are unrelated to the study itself, but do require participants to answer a series of problems or questions. In our design we used measures of individual differences that are correlated with central executive functioning. If the process of deception is centered in the central executive, then individual differences in central executive performance should become apparent in a regression analysis of the reaction time data for deceptive responders. Towards this end we used the state trait anxiety inventory (STAI) and the cognitive failures questionnaire (CFQ). The STAI was chosen because it serves as a measure of anxiety. Anxiety has been show to impact working memory, usually due to a decrease in task proficiency (Elliman, et al., 1997; Ashcraft and Kirk, 2001; Hadwin, Brogan, and Stevenson, 2005). Ashcraft & Kirk (2001) reported the impact of math anxiety, not only on math-related tasks, but also on more general working memory tasks. They suggest that the transitory experience of anxiety related to math performance in math anxious individuals causes a temporary disruption of working memory. Ikeda et al. (1996) hypothesize that worry (related external and internal evaluation) places demands on the articulatory loop of the working memory system which reduces overall working memory capacity and impairs task performance.

However, anxiety over task performance may also increase an individual's motivation to complete a task well. The motivation results in an allocation of processing resources to the task which could mitigate performance decrements related to articulatory demands. Therefore, high levels of anxiety could place increased demands on processing resulting in a reduction of Processing-Efficiency (Eysenck & Calvo, 1992), but may not affect task accuracy. In college students, sub-clinical anxiety did not impact simple RT or psychomotor performance and did not impair accuracy on a task involving high working memory resources, but the RTs of highly anxious participants did progressively increase throughout the testing session (Elliman et al., 1997). In this study, performance accuracy was similar between low- and high anxious participants, but processing efficiency was significantly poorer in high anxious participants. If the theory that the act of deception involves central executive functioning, then participants with higher levels of state anxiety should have longer reaction times when responding deceptively to misinformation.

The CFQ has been used in studies of false confession (Horselenberg, et al., 2003) and interrogative suggestibility (Wright and Osborne, 2005). Scores on the CFQ were not found to be related to the inducing of false confessions, but were related to interrogative suggestibility. The evidence on this measure is not conclusive, but results from these studies indicate that participants with high CFQ scores may have more difficulty with the process of deception, but not with acceptance of misinformation. The results would likely show that participants with high CFQ scores would only have longer reaction times when responding deceptively to misinformation, just as participants with higher state anxiety scores.

The study was conducted using the modified test procedure of McCloskey and Zaragoza. Instead of presenting answer choices that were present both in the events pictured and the narrative, we instead presented an answer choice in the events pictured and a novel answer choice. The purpose of this modified procedure was to deduce whether participants are correctly encoding misinformation in the study. Additionally, we also included the use of a filler task between the picture events and the narrative, and again between the narrative and the start of the questions. These filler events are usually presented in misinformation studies and serve to distract the participants from events that have just been witnessed (Loftus, 1979; McCloskey & Zaragoza, 1985). We hypothesized that participants who are presented with misinformation will have poorer response performance and longer reaction times than participants who are presented with factual information. We also hypothesized that the additional workload of deceptive responding would further exaggerate these effects, creating a clearly distinguishable misinformation effect that is interacting with the process of deception.

These filler tasks were comprised of two questionnaires designed to assess participant anxiety levels and number of cognitive failures. Their purpose was to assess individual difference variables and determine if they had an impact on deception that can not be found in truth telling. Specifically the areas we examined have been correlated to executive functioning. We expected to find that participants with higher task anxiety levels and more cognitive failures would show longer reaction times only when responding deceptively.

Methods

Participants

Participants consisted of 78 (51 females, 27 males) University of South Carolina undergraduate volunteers of a mean age of 21 years with a standard deviation of 5.16

years. Ages ranged from 18 to 54 years old. Approximately 71.8% of participants were Caucasian, 24.4% African-American, 0.01% Asian, and 0.02% other. Participants were chosen by volunteering online through the USC psychology participant pool.

Materials

The materials are presented in the order in which participants viewed them. Figure 1 depicts the order of presentation.

Questionnaires

Anxiety, handedness and cognitive failures were assessed with questionnaires. Handedness was assessed at the beginning of the study by the Annett Handedness Scale (Annett, 1970) while the State Trait Anxiety Inventory (Speilberg, Gorsuch, & Luchene, 1970) was administered between the slide show and the narrative. Participants received the Cognitive Failures Questionnaire (Broadbent, Cooper, Fitzgerald, & Parker, 1982) upon completion of the Misinformation Narrative. Most participants took approximately five minutes to answer each questionnaire. Questionnaires also served as a filler distraction activity between tasks. The following questionnaires were administered:

Annett Handedness Scale (AHS; Annett, 1970). The AHS is a twelve item self-report scale in which participants indicate handedness for a variety of typical tasks. The scale for each item ranges from -2 (left hand only) to +2 (right hand only) and the possible range of scores on the AHS range from -24 to +24. Test re-test reliability of the AHS was significant over a period of 14 weeks (McMeekean & Lishman, 1975).

Spielberg State Trait Anxiety Inventory (STAI; Spielberg, Gorsuch, & Luchene, 1970). The inventory consists of two scales with twenty items each: one scale measures state related anxiety and the other scale assesses trait anxiety. Individuals are asked to rate anxiety related to each item on a one to four scale. The possible scores on the STAI range from 20 (low anxiety) to 80 (high anxiety). Although the validity of the STAI is strong, the long-term test re-test reliability of the STAI has been questioned (Van der Ent, Smorenburg, & Bonke, 1987).

Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, Fitzgerald, & Parker, 1982). This questionnaire measures self-reported lapses in attention across perception, memory, and motor systems (Broadbent et al, 1982). It consists of twenty items that participants rate on a 4-point self-report scale ranging from 0 (never had cognitive failures) to 4 (always have cognitive failures). Factor analysis of the CFQ identified two strongly defined factors predicted by the CFQ: cognitive failures and stress vulnerability or neuroticism (Larson, Alderton, Neideffer, & Underhill, 1997; Mahoney, Dalby, & King, 1998; Matthews, Coyle, & Craig, 1990). Moderate correlations were identified between CFQ scores and scores on the visual search task; although, some theorists have explained these correlations in terms of trait anxiety scores (Smith, Chappelow, & Belyavin, 1995). Test re-test reliability for the CFQ has not been reported in the literature.

Manipulation Check. This questionnaire assessed self-reported confidence of memory regarding truthful information for each item in the study. Participants rated their confidence on a 5 point scale with 1 representing no confidence and 5 representing full confidence. Additionally all participants were asked to truthfully report the items they remembered from the slides.

MZ-Mod Slides

The MZ-Mod slides consist of a slide sequence depicting a crime followed by a written narrative that describes the events in the slide sequence. The crime slide sequence consists of the 76 slides originally used by McCloskey and Zaragoza (1985). The slides were presented on a PC using Microsoft Power Point at a rate of 5 sec per slide. They depict an event in which a maintenance man enters an office to repair a broken chair. The man rummages through the room's contents and steals $20 and a calculator before fixing the chair. The man then leaves the office with the contents otherwise undisturbed. Four slides contained potential misinformation items: 1) Coffee presented (Maxwell House or Folgers), Magazine (Glamour or Vogue), Soda (7-Up or Sprite), and Tool (Screwdriver or Wrench).

MZ-Mod Narrative

The Misinformation Narrative described the events the participants witnessed in the MZ-Mod Slides . The narrative consisted of 3 written slides, which were presented along with a narrator reading through the text. Imbedded within the narrative are two pieces of misinformation related to two of the critical information slides.

Deception Instructions

Following the narrative, participants were either instructed to respond truthfully to subsequent test items, or instructed to lie to the same test items. Specifically, participants in the deception condition read a series of instructions that informed them that the man portrayed in the slides was their partner and that they witnessed his actions from a window. He had subsequently been picked up by the police, and now the participant is wanted for questioning concerning his/her involvement in the incident. Participants were told that the police viewed the events via a camera placed in the room. They were further instructed that they should convince the police that they were not involved in the incident, and that it was best for them to lie to all test items.

Post-Test

Final testing of the misinformation effect was completed using E-Prime programming software (Psychology Software Tools, Inc). Participants answered a series of 100 randomly ordered test items about the crime slides; ten different items repeated ten times. These questions were of three main types: filler (6 items), factual (2 items), and misinformation (2 items). The results contained 60 filler, 20 factual, and 20 misinformation questions. Filler questions contained information from the slide presentation, but did not cover information contained in the four critical slides. Factual questions contained information from the two slides that were accurately described in the Misinformation. Misinformation questions contained information from the two slides that were presented were inaccurately described in the Misinformation Narrative.

For each test item participants were instructed to complete a sentence with one of two words: the correct answer or a novel incorrect answer. Novel incorrect items (items neither present in the slides or the narrative) were imbedded in the forced choice procedure along with the standard correct item. Participants responded by key press ("1" or "3") to indicate answer choice (see Figure 2 for example trial).

Procedure

Upon arrival in the lab participants were given a brief informed consent along with demographic inventory and the AHS (Annett, 1970). The experimenter described the procedure, and answered any questions. Participants were brought into a room and sat down in front of a PC and viewed the MZ-Mod Slides. At the end of the slide sequence the experimenter came into the room and administered the STAI filler task. Following the completion of the STAI, participants were instructed to read through the Misinformation Narrative. The CFQ was administered as a secondary filler.

The Post-Test instructions were then presented to all participants. Half of the participants were randomly assigned to the deception instructions, while the other half were assigned to the truthful condition (See Figure 1). The post-test took approximately thirty minutes to complete. Participants were instructed to read through each test item and then respond according to the instructions that they viewed at the start of the program. They responded using the 1 and 3 keys on the keyboard. Inter-trial intervals were self paced. Reaction times and errors were measured during the test items. Following the study all participants answered the question on the manipulation check inventory.

Results

Previous misinformation work has used accuracy measurements to report successful misinformation effects. However deception research has primarily focused on reaction time comparisons between truthful and deceptive responses. In order to test the hypotheses that participants would have poorer response performance when presented with misinformation than when presented with factual information, and that participants who were instructed to be deceptive perform more poorly than participants who were instructed to be truthful, two mixed two-way 2 X 2 (Deception by Misinformation) ANOVAs were conducted for the error and reaction time data.

With respect to accuracy, participants who were instructed to deceive were instructed to choose the answer opposite the preferred one within the deception instructions. We conducted a manipulation check following the study to assess individuals' confidence in memory for the correct information. During the manipulation check we asked all participants to respond with their confidence in the truthful information. There were no significant difference regarding participant's confidence in their knowledge of the truthful information between deceivers and truth tellers (Factual [p > .56]), Misinformation [p > 1.0], and Filler [p > .98]). This finding suggests that both truthful and deceptive participants had equal confidence in their knowledge of the information presented. Both groups reported the same items as truthful. As expected, overall participants were less confident regarding misinformation items than factual items, t (85) = 3.69, p = .001.

Participants made less errors when responding to factual information (M = 7.40, SE = .17) than when responding to misinformation (M = 6.26, SE = .29, F (1, 80) = 12.37, p = .001) as seen in Figure 4. As stated this effect was small (η_p^2=.13). Follow up t-tests showed this was significant for both truth tellers and for deceivers (p = .021, p = .013, respectively). Because those individuals who were deceptive were expected to respond with the incorrect answer, data for deceivers were reverse scored. There were no main effects for deception, or interactions between deception and narrative type.

As expected, participants who were asked to respond deceptively had longer reaction times (M = 878.66, SE = 42.40) than participants who were asked to respond truthfully (M = 726.84, SE = 37.80). To normalize skewness and kurtosis the reaction time data were logarithmicallytransformed for analysis. The results indicate that deceptive responses took significantly longer than truthful responses (F (1, 68) = 4.64, p = .035). This effect was small (η_p^2 = .064). There was also a main effect for narrative content such that when responding to misinformation participants had longer reaction times (M = 870.98, SE = 42.22) than when responding to factual information (M = 734.52, SE = 26.75. After log transforming the data this effect was found to be significant (F (1, 68) = 8.74, p = .004). This effect was slightly larger than that found for deceptive responding, though it was still a small effect (η_p^2 = .114). A significant interaction was also found between deceptive responding and narrative content (F (1,68) = 6.56, p = .013) as seen in Figure 5. This effect was also small (η_p^2 = .084). Follow up t-tests showed deception and narrative content significantly impacted reaction times only when responding to factual questions ($p < .001$).

In order to assess the effects of individual differences in anxiety and cognitive failures on deception and misinformation, standard multiple regressions were performed between scores on the questionnaires and reaction time to factual and misinformation items.

Figure 6 shows the distributions of the scores for the questionnaires across all participants. Normality of the data was examined with normal probability plots, as shown in figure 7. All three questionnaires met the assumptions of normality. As expected the two versions of the STAI were found to be strongly positively correlated (r = .72, $p < .0001$). Also as expected the CFQ was found to be moderately positively correlated with the trait anxiety subscale (r = .26, p =.019), and strongly positively correlated with the state anxiety subscale (r = .42, $p < .0001$).

The standard regression performed on reaction times for factual items was not found to be significant for either deceptive or truthful individuals. However, scores on the CFQ contributed significantly to reaction times for misinformation items in deceptive participants, F (3, 38) = 3.02, p = .043. Table 1 displays the standardized and unstandardized regression coefficients along with their significance tests, as well as the *R*, R^2, and R^{2Adj} for the overall model. Neither trait anxiety nor CFQ contributed to reaction times for misinformation items in truthful participants. We ran a post-hoc Fisher's *z'* test of the difference between truthful and deceptive *R's* for misinformation reaction times regressions and found no significant difference between them although there is a clear trend (see Figure 8). Although an increased sample size may have identified significant results; we decided not to add more participants than suggested by our original power analysis. The z' test is susceptible to illusory power advantages (Type 1 errors), particularly when a small variance is associated with larger sample sizes (Leventhal & Huynh, 1996).

Discussion

We found significant effects for reaction time data for both misinformation and deception in this study. The data support our hypothesis that deception is a cognitive process closely tied with the central executive functions. In addition, the data appears to show that the misinformation effect may be limited to memory impairment, as proposed by McCloskey and Zaragoza, rather than memory updating, as proposed by Loftus. If By failing to find significant differences in response errors between deceptive and truthful responders we can rule out the possibility that participants were unable to adequately understand and respond to the questions heing asked. This in turn indicates that the reaction times found measured the differences in responding that were due to the effects of deception and misinformation.

As indicated in the results section we found no significant differences between deceptive and truthful responders in terms of response errors. We did find a significant difference for both groups when responding factually or when responding to misinformation. This result was expected, and closely replicates the results found by McCloskey and Zaragoza in their 1985 study. The use of the modified paradigm appears to have answered the question concerning whether or not the accuracy performance of deceivers was based upon their ability to more readily encode misinformation (thereby responding with the incorrect answer), or whether it was due to failure to determine the correct answer. Theoretically, if the original stimulus had been replaced with the narrative stimulus, the subjects should have lacked the ability to respond above chance when presented the two response choices. Due to their ability to still respond accurately, it appears that the effects of misinformation are due more to impairments that cause longer retrieval patterns, as indicated by reaction time data.

The data also show a significant interaction between deception and narrative content. Specifically, the reaction time data indicated that participants took significantly longer to respond deceptively than truthfully on factual information questions. This replicates previous research done by Vendemia and colleagues (Vendemia, Buzan, & Simon-Dack, 2005) that shows individuals take longer to respond deceptively than they do to respond truthfully. Data indicates a significant increase in reaction time among truthful participants when responding to misinformation versus factual information. However, no significant difference was found between truthful and deceptive responders when responding to misinformation, though reaction times were still longer for deceptive participants. This finding is positive for the utilization of reaction time as a measure of intention to deceive, because it suggests that intentional deceptive behavior can be statiscally separated from inaccurate recollection on the basis of response latency.

When the reaction time results are combined with the information from the questionnaires, which indicate a relationship between higher scores on the state portion of the STAI and CFQ and length of response for deceptive participants responding to misinformation, it supports our hypothesis that deception is a cognitive process that adds to workload in the central executive. As discussed in the introduction, this matched our theories concerning the effects of higher levels of state anxiety and cognitive failures on deceptive reaction times to misinformation items. Participants required longer processing times to respond deceptively, but the same effect was not found in participants who responded truthfully. Therefore response times to misinformation were either not influenced, or were influenced in such a manner that participants were more willing to accept the misinformation and respond accordingly.

Additionally, we had anticipated that the effects of misinformation and deception would be additive, and the findings partially support this hypothesis. Both deception and misinformation processing increase RT, and the combined effects of misinformation and deception increase RT cumulatively (but not significantly). We believe that misinformation processing and deceptive responding occur in parallel, each adding workload to central executive processing. The finding that cognitive failures frequency, a measure of working memory load proficiency, explains performance variance within the deception by misinformation condition supports this conclusion.

The results of this study indicate that the data we are finding matches our current set of hypotheses, as well as replicates the original misinformation effect from McCloskey and Zaragoza. The next step of this research is to further the measure of the individual difference variables through more comprehensive questionnaires. We plan on using the CANTAB neuropsychological battery as well as creating a deception condition to the CFQ questionnaire. We would also like to combine this research with current ERP studies investigating the effects of deception on executive function, specifically looking at the N4 and P3b waveforms.

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Tables

Table 1. *The Regression Coefficients, Intercepts, R, R^2, and R^{2Adj} of Reaction Times for Misinformation Items in Deceptive Participants (n=43).*

Model	B	SEM	β	T
Intercept	2.819	.173		16.304***
CFQ	-.009	.004	-.350	-2.198*
R = .454, R^2 = .206, R^{2Adj} = .138				

* $p \leq .05$, *** $p \leq .005$

Figure Captions

Figure 1. Depicts the procedure followed in the study. Note the addition of the filler tasks between the slide show and narrative, and again between the narrative and test responses.

Figure 2. Depicts a typical trial during the response portion of the experiment.

Figure 3. Example of critical item slide, factual item identification "Vogue", misinformation item name "Glamour". Reprinted from McCloskey and Zaragoza (1985).

Figure 4. Graph of number of correct responses by narrative content across levels of deception.

Figure 5. Graph of log transformed reaction times for responses by narrative content across levels of deception.

Figure 6. Distributions of scores for STAI Y-1, STAI Y-2, and CFQ showing the normal distribution of scores on each measure in this sample (N = 78).

Figure 7. Normal probability plots of the distribution of scores for STAI Y-1, STAI Y-2, and CFQ demonstrating normality of the data.

Figure 8. Prediction of log transformed reaction times to misinformation questions from CFQ scores in truthful (left panel) and deceptive (right panel) participants.

Figures

Figure 1.

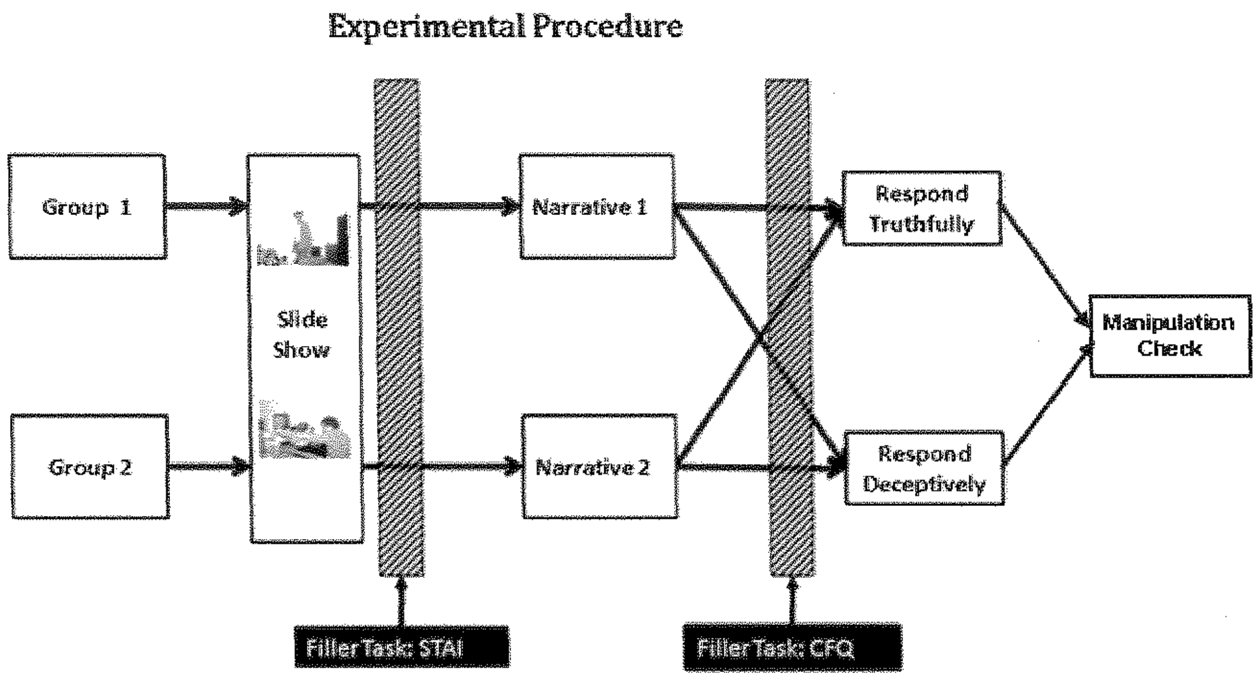


Figure 2.

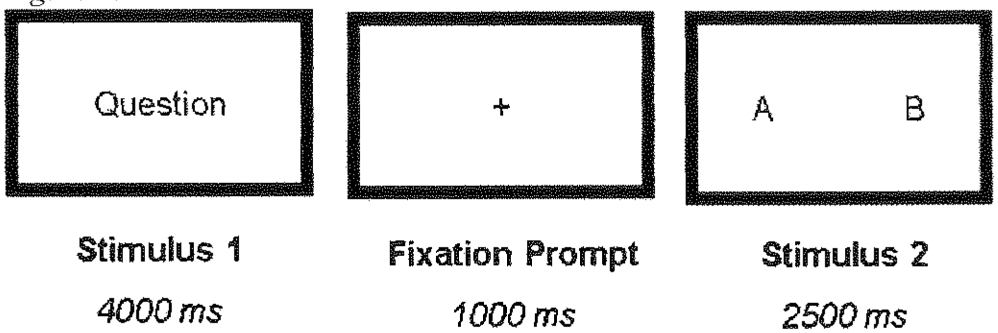
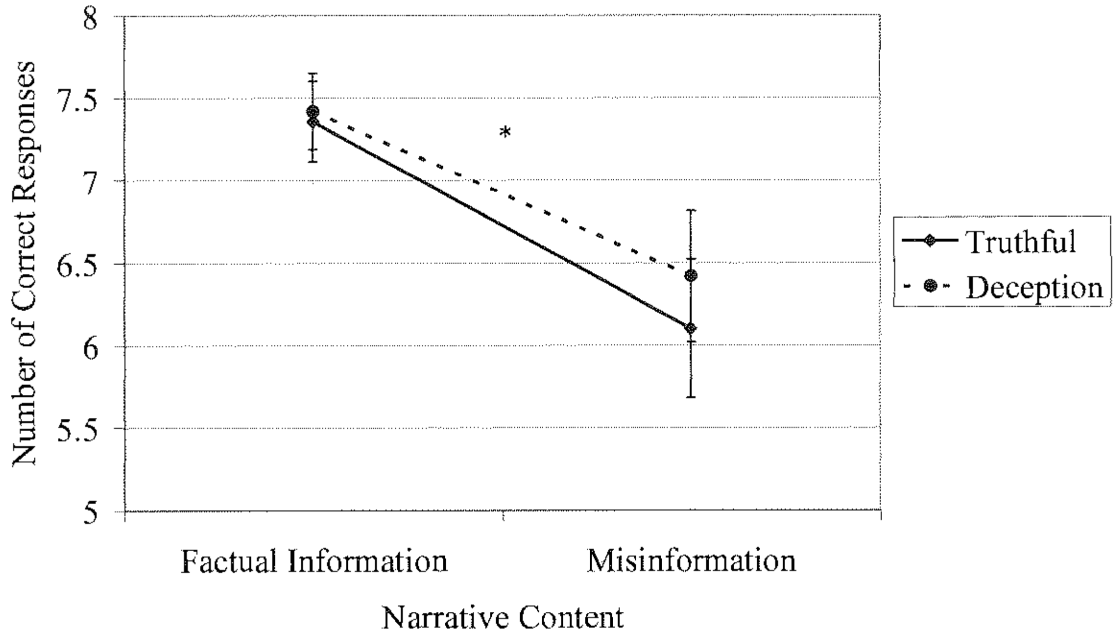

Question
+
A
B
Stimulus 1
4000 ms
Fixation Prompt
1000 ms
Stimulus 2
2500 ms

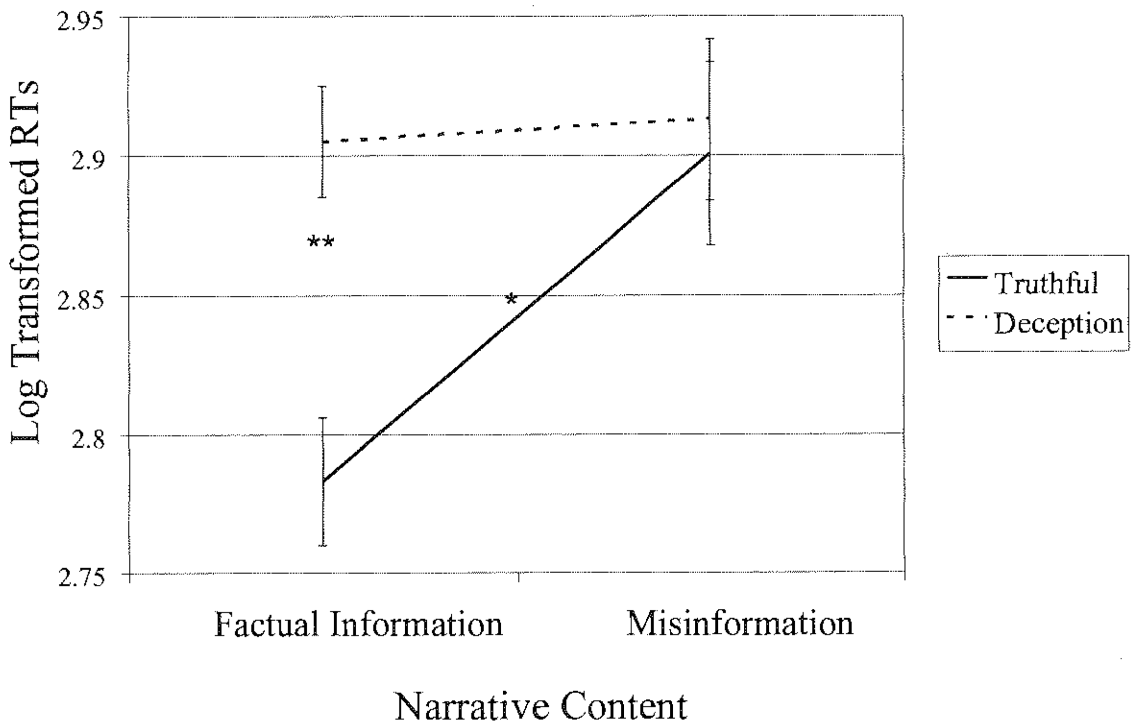
Figure 3.

Figure 4.


8
7.5
7
6.5
6
5.5
5
Number of Correct Responses
*
Truthful
Deception
Factual Information
Misinformation
Narrative Content

* $p < .01$

Figure 5.



*$p < .01$, **$p < .001$

Figure 6.

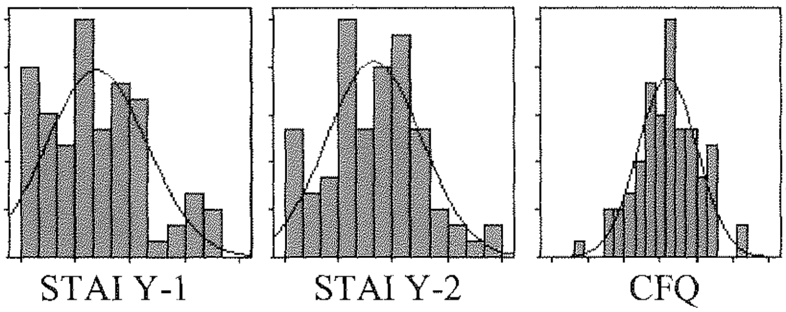
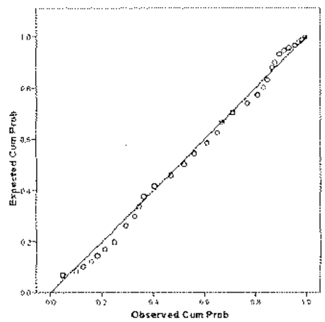
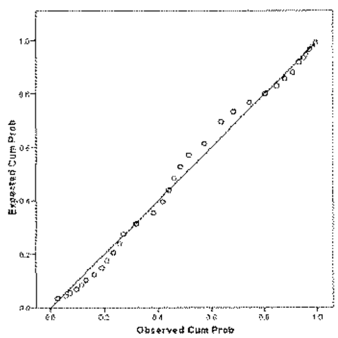


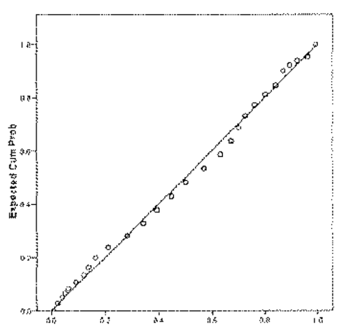
Figure 7



STAI Y-1

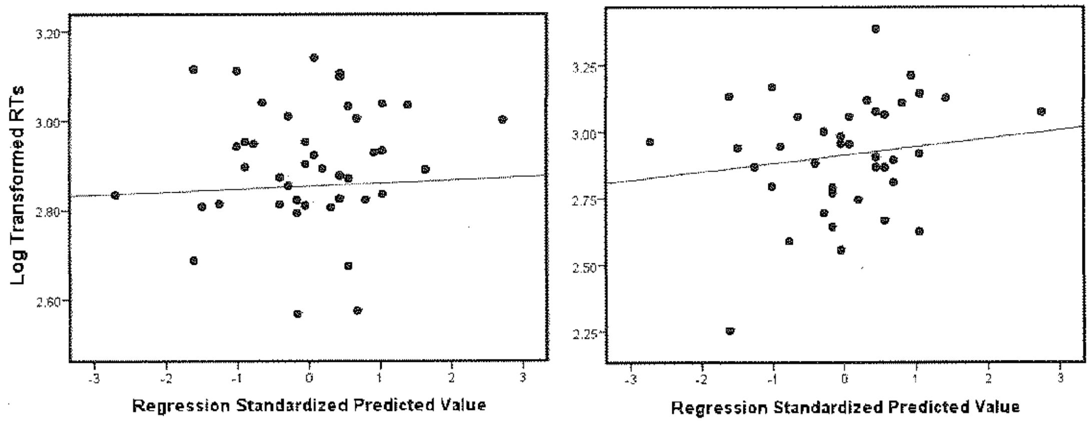


STAI Y-2



CFQ

Figure 8


Log Transformed RTs
3.20
3.00
2.80
2.60
-3
-2
-1
0
1
2
3
Regression Standardized Predicted Value
3.25
3.00
2.75
2.50
2.25
-3
-2
-1
0
1
2
3
Regression Standardized Predicted Value

Parsing the Effects of Stimulus Salience, Attention-switching And Workload on Deceptive Responses

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Abstract

This study demonstrated that interactions between stimulus salience, attention-switching and workload affect reaction time (RT) and accuracy of truthful and deceptive responses by manipulating the frequency of deceptive responding. Participants completed a two-stimulus sentence verification task with trials that cued them to respond truthfully or deceptively. Participants were randomly assigned to one of 11 groups, which varied in the ratio of truthful to deceptive response cued trials. Replicating findings from other deception studies, deceptive responses showed significantly longer RT and lower accuracy than truthful responses (Goldstein, 1923; Seymour et al., 2000; Vendemia, Buzan & Green, 2005a; Vendemia, Buzan & Simon-Dack, 2005b). When participants responded truthfully and deceptively with low-frequency, RT for low-frequency deceptive responses was significantly longer. These two findings indicate that stimulus salience and attention-switching impact deceptive responses more than truthful responses.

Parsing the Effects of Stimulus Salience, Attention-switching And Workload on Deceptive Responses

Behavioral measures of deceptive responses, such as reaction time (RT) and accuracy, indicate that deceiving is a more challenging cognitive activity than telling the truth (Vrij & Heaven, 1999), but the underlying processes involved are unclear. Stimulus salience, the amount of information a stimulus provides in relation to the required response, may play a role in producing differences in RT and accuracy for deceptive and truthful responses, because deception-related stimuli capture exogenous attention due to the high demand in cognitive processing required subsequent to presentation (Vendemia, Buzan & Green, 2005a; Vendemia, Buzan & Simon-Dack, 2005b). Workload may also play a role, as deceptive responses require holding both truthful and deceptive information in working memory in order to compare them and formulate a deceptive response (Vendemia et al., 2005a). Attention-switching may influence these differences as well, because typical contexts in which one would deceive often require switching between telling truths and telling lies. The purpose of the current study is to elucidate which of these processes produce the differences in RT and accuracy by parsing the effects of stimulus salience, attention-switching and workload using a two-stimulus directed-lie paradigm.

Krapohl and Sturm (2002) define deception as the "act of deliberately providing or omitting information with the intention of misleading," (p. 23)[1]. The bulk of deception research focuses on measuring physiological indices, such as heart and respiratory rate, galvanic skin response, blood pressure and pupillary dilation, associated with the emotional component of deception (see Podlesny & Raskin, 1977 for review). Relatively few studies, in comparison, examine cognitive indices of deception (see Gombos, 2006 for review).

RT is a behavioral measure that reflects cognitive processing and is a promising indicator of the cognitive component of deception (Marston, 1920; Goldstein, 1923; Allen, Iacono & Danielson, 1992; Seymour et al., 2000; Vendemia et al., 2005a; Vendemia et al., 2005b). In a study comparing psychophysiological responses before and after stimulus onset in simple, go/no go and choice RT tasks, Miller and Low (2001) demonstrated that the duration of motor preparation and motor response remains the same across tasks. They concluded that differences in RT reflected the cognitive processing involved in each task. The current study requires systematically manipulating variables associated with three cognitive processes operating within the same cognitive task. Sternberg proposes that cognitive processes have an additive effect (reviewed in Kosinski, 2006), but Massaro (1993) demonstrates that systematically manipulating variables associated with individual cognitive processes is possible. Therefore, differences in RT for truthful and deceptive responding should accurately capture the additional cognitive processing involved in deception.

Studies examining RT associated with deception originated in the early part of the 20th Century and focused on the emotional impact of deception. Marston (1920) demonstrated that RT for deceptive responses could be either longer or shorter than RT for truthful responses, but the majority of participants demonstrated the former. Marston attributed shorter RT to a natural aptitude for deceiving characterized by a lack of emotion, but in a replication of this study Goldstein (1923) concluded that the participants with shorter RT for deceptive responses were unaware of their deception. When participants were fully aware of their deceptive behavior, all participants displayed longer RT for deceptive responses. This set the historical precedent that deception requires conscious awareness on the part of the deceiver.

Krapohl and Sturm (2002) also include intentionality as a crucial component of the definition of deception. Intentionality includes both awareness of deceptive information, as demonstrated by Goldstein (1923), in addition to a deliberate plan to mislead others. While intentionality is vital in classifying one as deceptive, experimental paradigms which eliminate the planned act of misleading are capable of producing response demands that increase RT. The "directed lie comparison test" (DLC) is a paradigm which instructs participants to lie to selected questions and tell the truth to others (Honts & Raskin, 1988), therefore eliminating the need to plan deception. Research utilizing this paradigm with questions pertaining to autobiographical, semantic, and episodic information has replicated the findings of increased RT for deceptive responding found previously (Vendemia, 2003; Vendemia et al., 2005a; Vendemia et al., 2005b).

The "Concealed Information Test" (CIT) has been used to examine RT for participants in possession of concealed knowledge of a crime. A series of studies conducted by Seymour et al. (2000) demonstrated that the possession of concealed knowledge is associated with longer RT even when deception is not involved. Participants were instructed to engage in one of two mock computer crimes, and then view words associated with the crime scenario in which they participated and words associated with a different crime scenario. Participants were asked to classify each word as familiar or unfamiliar. In one study, they were asked to respond truthfully. In two other studies, they were asked to respond deceptively. RT for classifying crime-related probe words was significantly longer than RT for classifying crime-irrelevant probe words even when participants responded truthfully. Participants without concealed knowledge of a crime produced no differences in RT for classifying crime-related and crime-irrelevant probe words. A theoretical disadvantage of this paradigm is RT is an index of episodic memory rather than deception (Allen, Iacono & Danielson, 1992). Within real-world settings this means that witnesses to a crime may be considered "guilty", as their responses would be similar to someone involved in the crime (Krapohl & Sturm, 2002; Vendemia et al., 2005a; Vendemia et al., 2005b).

It is clear from previous studies, that formulating a deceptive response takes significantly more time than formulating a truthful response. The purpose of the current study is to determine why this occurs. Figure 1 depicts a typical timeline for truthful and deceptive responding. Early visual processing occurs at approximately 100ms following the presentation of a stimulus. This results in an alerting response, which is followed by motor preparation to respond. Based upon the finding of Miller and Low (2001), we know that motor preparation should be equal for both truthful and deceptive responding, and that the duration between motor preparation and response is affected by the number of possible response choices. The time it takes to make a decision increases linearly with the number of choices available (Hick's law, 1952). In the context of truthful and deceptive responding presented, the time to make a decision should remain constant. Participants are only given two options – to respond truthfully or deceptively. The factor(s) causing the difference in RT between truthful and deceptive responding must occur during the alerting process and/or the interval between decision and response. Two cognitive theories of deception suggest that stimulus salience, attention-switching and working memory load may influence the difference between truthful and deceptive responding.

Brain measures of deception, such as event-related potentials (ERPs), have provided data on which these two cognitive theories of deception are based. One theory of deception focuses on working memory load associated with deception processing while the other concerns attentional capture and salience of deception-related stimuli. The salience of a stimulus is the result of its properties which capture exogenous attention. Stimulus properties that influence salience can be physical (luminance, color, motion, etc.) or non-physical. Non-physical properties include novelty, task relevance, presentation probability, and amount and usefulness of information conveyed by the stimulus (Pritchard, 1981). The factors contributing to the salience of the deception-related stimuli used in this study will be defined as the probability of presentation and the amount of cognitive processing required following stimulus presentation (collectively referred to as "stimulus salience" throughout this paper). The physical properties of stimuli used in this study will be held constant across truthful and deceptive conditions.

ERP waveforms associated with working memory load, such as the P3b, have been shown to be affected by deception (Vendemia, Buzan, Schillaci & Green, 2006). In summarizing the results of multiple visual search studies, Kok (2001) reports that RT increased with increased working memory load. This result may reflect working memory load's influence on subsequent decision processes. These findings relate to the study of deception, because deception is a complex cognitive process that is viewed as requiring more cognitive effort than telling the truth (Vrij & Heaven, 1999). While formulating a deceptive response, both deceptive and truthful information must be held within working memory, while telling the truth requires only the truthful information be held within working memory. This increase in working memory load is thought to produce the findings of longer RT for deceptive responding. In support of the working memory load theory of deception, Vendemia et al. (2005a) found that RT and error rates for deceptive responding were consistently greater than truthful responding after repeated trials of testing over a two-week period, suggesting deception is a more difficult cognitive process than truth telling.

The attention theory of deception concerns the role of attentional capture and stimulus salience in deception processes. ERP waveforms associated with attention, such as the P3b, have been shown to be affected by deception (Vendemia et al., 2006). Low-frequency events, or oddballs, capture exogenous attention due to their low probability (Pritchard, 1981). These stimuli also elicit longer RT and greater error rates than equal- or high-frequency stimuli (Jones, Cho, Nystrom, Cohen & Braver, 2002). In addition to the relative frequency of a stimulus, the amount of cognitive processing required following stimulus presentation can also impact ERP waveforms associated with attention (Donchin, Kubovy, Kutas, Johnson & Herning, 1973). Since deception requires more cognitive processing than telling the truth, stimuli associated with deception should display the same effects as low-frequency stimuli. Vendemia, et al. (2005b) found that decreased preparedness to deceive produced more pronounced differences in RT for deceptive and truthful responding. These findings suggest that decreased preparedness to deceive influences stimulus salience by increasing the cognitive processing required following stimulus presentation.

ERP waveforms associated with attention-switching, such as the P3a, have been shown to be affected by deception (Vendemia et al., 2006). This waveform can be evoked by switching from a difficult task to a more easy task (Comerchero & Polich, 1999; Harmony et al., 2000). This attention-switching theory is supported in deception research as switching from the easier task of telling the truth to the more difficult task of deceiving produces an increase in RT (Vendemia et al., 2006).

Currently our lab works from a cognitive theory of deception that includes salience, attention-switching, and workload as factors contributing to deceptive response formation. Figure 2 displays a diagram of this current cognitive theory of deception. Our theory proposes a competition between endogenous attention and exogenous attention for initiation of the alerting response to a stimulus. Both attentional constructs draw on working memory. Attention-switching is a product of endogenous attention shifting between truthful and deceptive responses.

Frequency of stimulus presentation directly influences all three constructs, therefore providing one variable to manipulate. As a result, previous research in our lab using the DLC (Vendemia et al., 2005a; Vendemia et al., 2005b) has equated the frequency of deceptive responding and truthful responding in order to control for confounds of workload and attentional factors. The present study intended to parse the effects of stimulus salience, workload, and attention-switching by varying the frequency of trials on which participants were cued to respond deceptively. The three constructs should impact the data as follows: a) stimulus salience should influence RT maximally when deceptive responses are cued infrequently b) the effect of workload should be maximal when deceptive responses are cued most frequently and c) the effect of attention-switching should be greatest when deceptive responses are cued equally with truthful responses.

Since some ratio groups will require participants to lie to a much larger proportion of trials than to tell the truth, practice or fatigue may impact RT. Ando, Kida and Oda (2002) demonstrated that RT to a visual stimulus decreased over a three week time period, and the effect of practice influenced RT for three weeks following initial testing (Ando, Kida & Oda, 2004). Sanders (1998) determined that individual RT variability decreases "with an adequate amount of practice," (p. 21). Practice, therefore, should impact high-frequency deceptive and truthful responding, producing shorter RT and reduced variability of RT over the course of testing.

Singleton (1953) demonstrated that fatigue causes an increase in RT, and this increase becomes more pronounced as task difficulty increases. Fatigue, therefore, may impact the RT for deceptive responding more than truthful responding, because deception is a more difficult cognitive process. As the frequency of deceptive responding increases, the effect of fatigue may become even more pronounced.

Hypotheses

We hypothesize that the data will support the stimulus salience and attention-switching theories. We expect the difference between truthful and deceptive RT to be significantly different when responding truthfully and deceptively infrequently and equally frequently. We also expect deceptive RT to be significantly longer than truthful RT, and accuracy of deceptive responses to be significantly less than truthful responses regardless of the frequency of response.

We hypothesize that a split-half comparison of the data will reflect the effects of both practice and fatigue. When cued to respond truthfully to a majority of trials, RT and individual variability will decrease from the first half of the trials to the second half of the trials. There should be a floor effect, because truthful responding is relatively easy. When cued to respond deceptively to a majority of trials, RT and individual variability will increase during the second half of trials due to fatigue. When deceptive and truthful responses are cued equally, RT and individual variability should increase for both deceptive and truthful responses during the second half of trials. Because deception requires greater workload, deceptive RT and individual variability should increase more than truthful RT and individual variability. Accuracy should improve for deceptive and truthful responding in all groups except when deception is cued equally or a majority of the time. In these groups, accuracy should decrease slightly over the course of testing due to fatigue.

Method

Participants

Two-hundred seventy-nine participants were recruited from the USC Psychology Participant Pool. The sample consisted of 203 females and 76 males with a mean age of 19.920 years (*SD* = 3.90). All participants received course credit for their participation.

Materials

Spielberger State-Trait Anxiety Inventory (STAI). Originally developed in 1970, the STAI is a questionnaire, which includes two forms with 20 questions each. Form Y-1 measures state anxiety by assessing how an individual feels presently (e.g., "I feel calm"; Spielberger, 1983). State anxiety is transient and changes from one situation to the next based upon the perceived threat of the situation (Spielberger, 1972). Form Y-2 measures trait anxiety by assessing how an individual feels generally (e.g., "I am a steady person"; Spielberger, 1983). Trait anxiety is a relatively stable personality trait and reflects a general level of autonomic nervous system arousal (Spielberger, 1972). The STAI uses a four point Likert-type scale from *not at all* to *very much so* to indicate how well each statement accurately describes the individual. Scoring entails adding up the points on each form after reverse-scoring applicable questions. A high score on the respective form reflects a high level of state or trait anxiety. The internal validity of the STAI is high for measures of both state and trait anxiety ($\alpha = 0.93$, $\alpha = 0.90$) (Spielberger, 1983). Additionally, it has a test-retest reliability rate of 0.16 to 0.62 and 0.73 to 0.86 for state and trait anxiety respectively (Spielberger, 1983). The former rate is acceptable, because state anxiety is transient.

Cognitive Failures Questionnaire (CFQ). The CFQ is a 25-item questionnaire, which measures deficits in completion of normal cognitive tasks by self-report. Deficits include cognitive failures of attention, memory, perception, and motor function. The questionnaire asks individuals to estimate how often they commit these errors using a Likert-type scale from 0 (never) to 4 (very often). The CFQ is scored by adding up the ratings, with a higher score reflecting a higher frequency of cognitive failures. The internal validity of the CFQ is high ($\alpha =$

0.91) with high stability over time (Broadbent et al., 1982). Wallace, Kass, and Stanny (2002) report a test-retest reliability rate of 0.82.

Task

Participants were seated in a comfortable chair in front of a Dell 580 Optiplex computer with a 16" color LCD monitor displaying at 1280 horizontal and 1024 vertical pixels. The computer operated E-prime (Psychology Software Tools, Pittsburgh, PA), which displayed the task and captured RT and accuracy measures.

A two-stimulus paradigm was used with the DLC, in which participants evaluated the first stimulus and responded to the second stimulus. The first stimulus was a short statement randomly drawn from a pool of 50 designed to access declarative knowledge and to be easily evaluated as either true or false (ex. "I am human."). These statements were taken from a set evaluated unanimously by undergraduate students from the university as "true" or "false." The second stimulus was the word "true" or "false."

The first stimulus was presented for 2500ms, followed by a 750ms fixation point, and then the second stimulus for 2500ms. Following the onset of the second stimulus, the participant responded by making a button-press with his/her dominant hand that indicated whether his/her evaluation of the first stimulus agreed or disagreed with the second stimulus. RT latency was measured from the onset of the second stimulus until response. RT for correct responses only was included in data analysis.

Sentence color was used to cue the participants to respond truthfully or deceptively. Deceptive responses were cued by the color red, and truthful responses were cued by the color blue. Participants were prompted to respond equally by agreeing and disagreeing.

Participants responded to 200 statements with varying ratios of deceptive responding. The levels of interest were 10%, 15%, 20%, 25%, 40%, 45%, 50%, 55%, 60%, 80% and 90% and indicated how often deception was cued. Each participant was randomly assigned to a lie ratio group.

Procedure

Participants were briefed on the experimental procedure and asked to sign the consent form. Prior to beginning the task, each participant completed the STAI and CFQ. Subsequently, each participant practiced the task on a pen and paper form. After successful completion of the paper practice, participants completed a computer practice to familiarize themselves with the appropriate button-presses and the 2500ms time constraint on response. The computer practice consisted of 12 items, and a 67% accuracy score was required to begin the experiment. The experimental testing phase lasted approximately 25 minutes.

Results

RT and Accuracy

The RT and accuracy data were analyzed with two 11 (10%, 15%, 20%, 25%, 40% 45%, 50%, 55%, 60%, 80%, or 90%) x 2 (truthful and deceptive) factorial ANOVAs. As expected, individuals had longer RT for deceptive responses than truthful responses, F (1, 268) = 83.082, $p < .001$, $\eta^2 = .24$ (see Figure 3). This was a moderate effect with individuals having a mean RT of 1036.74ms (*SE* = 19.50) for deceptive responses and 966.14ms (*SE* = 14.87) for truthful responses. Additionally, individuals displayed less accuracy for deceptive responses than truthful responses, $F(1, 268) = 85.99$, $p < .001$, $\eta^2 = .24$ (see Figure 4). This was a moderate effect with individuals having a mean accuracy of 88.30% (*SE* = 0.008) for deceptive responses and 93.90% (*SE* = 0.004) for truthful responses.

The mean RT data for truthful and deceptive responses were plotted to examine any visible trends within the data. Figure 5 shows the trends resulting from the combination of truthful and deceptive response processes. Three separate trends are visible in the data, representing stimulus salience, attention-switching and workload. The combination of low-frequency deceptive responding and high-frequency truthful responding results in a decrease in RT differences as the frequency of deceptive responding increases. This suggests that stimulus salience impacts the data maximally when deception is cued infrequently and truth is cued frequently. When truth and deception are cued equally or with nearly equal frequency, the differences between RT for truthful and deceptive responses increases as switching becomes more frequent. This effect of attention-switching is maximal when truth and deception are cued with equal frequencies. The combination of high-frequency deceptive responding and low-frequency truthful responding produces differences in RT that increase and level off as the frequency of deception increases. This effect of workload is maximal when deception is cued on 80% of trials.

In order to determine whether the RT differences in deceptive and truthful responding were the result of presentation frequency, we matched truthful and deceptive RT by ratio. That is, we compared those that told the truth on 10% of trials (and lied on 90%) to those that lied on 10% of trials. The RT data were analyzed using a 7 (10%, 20%, 40%, 50%, 60%, 80%, or 90%) x 2 (truthful or deceptive) between-subjects ANOVA. RT were significantly different at 10% and 50%, $t(52) = 2.24, p < .05$; $t(23) = 2.66, p < .05$.

These results show that the effect of stimulus salience significantly impacted RT at 10% presentation frequency, with individuals having a mean RT of 1103.09ms ($SE = 49.86$) for deceptive responses and 966.50ms ($SE = 37.70$) for truthful responses. Additionally, the effect of attention-switching impacted RT at 50% presentation frequency, with individuals having a mean RT of 1083.70ms (*SE* = 53.86) for deceptive responses and 1006.29ms (*SE* = 40.72) for truthful responses. Attention-switching impacted both truthful and deceptive RT, but deceptive RT increased significantly more than truthful RT.

The between-subjects mean RT data were also plotted to examine any visible trends within the data. Figure 6 shows three trends for deceptive responses and three trends for truthful responses. The three trends represent stimulus salience, attention-switching and workload. Truth and deception show similar trends when presentation frequencies are equal or high. This suggests that increased attention-switching and increased workload impact truth and deception similarly. However, attention-switching has more of an impact on deception when the two response types are cued equally. Low-frequency truthful and deceptive responding show different trends with the differences in RT increasing between truth and deception as presentation frequency decreases. RT for truthful responding remains the same while RT for deceptive responding increases. This suggests that stimulus salience impacts deceptive responding more than truthful responding.

Practice and Fatigue

A series of split-half comparisons were conducted to evaluate the effects of practice and fatigue. Mean RT, individual RT variability, and accuracy for the first 80 trials of the task were compared with the last 80 trials for truthful and deceptive responses in the 10%, 50%, and 90% groups. The data were analyzed with three 3 (10%, 50% or 90%) x 2 (first and last) x 2 (truthful and deceptive) mixed factorial ANOVAs.

The mean RT data displayed a significant three-way interaction between ratio, response type, and data split, $F(2, 75) = 6.58, p < .01, \eta^2 = 0.15$. Post hoc analysis indicated that in the

10% group deceptive responding took significantly longer in the first 80 trials than in the last 80 trials, $t(27) = 3.29$, $p < .01$. This result indicates a moderate practice effect for deceptive responding in the 10% group. Additionally, in the 50% group truthful responding took significantly longer in the last 80 trials, $t(23) = -2.88$, $p < .01$. This result indicates that participants responding truthfully 50% of the time became fatigued during truthful trials. Figure 7 displays the practice effect and fatigue effect for the 10% deceptive condition and 50% truthful condition respectively.

The mean individual RT variability data displayed a significant three-way interaction between ratio, response type, and data split, $F(2, 75) = 7.64$, $p < .01$, $\eta^2 = 0.17$. Post hoc analysis indicated that in the 10% group RT for deceptive responses varied significantly more during the first 80 trials than during the last 80 trials, $t(27) = 4.75$, $p < .001$. This result further supports a moderate practice effect for deceptive responding in the 10% group. Additionally, in the 50% group RT for truthful responses varied significantly more during the last 80 trials, $t(23) = -2.28$, $p < .05$. This result further supports a fatigue effect for truthful responding in the 50% group. Figure 8 displays the practice effect and fatigue effect for the 10% deceptive condition and 50% truthful condition respectively.

The mean accuracy data displayed a main effect of data split, $F(1, 75) = 8.49$, $p < .01$, $\eta^2 = 0.10$. Post hoc analysis indicated that accuracy improved significantly from the first 80 trials to the last 80 trials for truthful responding in the 10% group and deceptive responding in the 50% group, $t(27) = -3.35$, $p < .01$; $t(23) = -3.44$, $p < .01$ (see Figure 9). Although this indicates a practice effect for truthful responding in the 10% group and deceptive responding in the 50% group, these results were not reflected in the mean RT and mean individual variability data.

STAI and CFQ

Participants who were randomly assigned to the 20% group had significantly lower mean scores for state and trait anxiety ($M = 45.84$, $SE = 1.86$; $M = 46.40$, $SE = 1.68$) when compared to participants in other groups ($M = 63.22$, $SE = 0.61$; $M = 65.83$, $SE = 0.54$); therefore, anxiety scores for the 20% group were dropped when computing the correlation between RT and anxiety, $F(10, 268) = 9.08$, $p < .001$; $F(10, 268) = 12.75$, $p < .001$. Trait anxiety scores from the STAI were negatively and weakly correlated with RT for truthful and deceptive responses, $r = -.15$, $p < .05$; $r = -.13$, $p < .05$. State anxiety scores and CFQ scores were not correlated significantly with RT. This finding suggests that individuals with high trait anxiety tended to respond quicker overall, regardless of ratio level or response condition.

Discussion

The current data are consistent with the previous findings of longer RT for deceptive responding than truthful responding (Goldstein, 1923; Vendemia et al., 2005a; Vendemia et al., 2005b) and decreased accuracy for deceptive responding in comparison to truthful responding (Vendemia et al., 2005a).

The data support both the influence of stimulus salience and attention-switching on RT and accuracy. RT and accuracy were significantly different for deceptive and truthful responding at the 10% group, with deceptive responses displaying significantly longer RT and poorer accuracy. This indicates that stimulus salience impacts RT for deceptive responding significantly more than for truthful responding when participants told the truth or deceived 10% of the time. This finding suggests that deception-related stimuli are significantly more salient than truth-related stimuli due to factors beyond presentation frequency. Most likely, this is due to the increased cognitive processing required following the presentation of deception-related stimuli. Practice decreased RT and RT variability and increased accuracy significantly for deceptive responding in the 10% group only. Practice did not influence truthful responding. This finding indicates that repeated deception produces improvement in deception-specific processes but not in those related to RT alone.

RT and accuracy were significantly different for deceptive responses and truthful responses in the 50% group, with deceptive responses displaying the same RT and accuracy trends. Truthful responses also displayed an increase in RT at the 50% group relative to low- and high-frequency truthful responses. These findings indicate that switching attention from responding deceptively to responding truthfully impacts both deceptive and truthful RT, but attention-switching influences deceptive RT significantly more. This indicates that deception is a more cognitively challenging task than telling the truth. In summary, both stimulus salience and attention-switching contribute to an increase in RT and a decrease in accuracy for deceptive responding, which accounts for the ubiquitous finding of significant differences in RT and accuracy for truthful and deceptive responding (Marston, 1920; Goldstein, 1923; Vendemia et al., 2005a; Vendemia et al., 2005b).

The data do not support a solitary influence of working memory load on deceptive responses. When working memory load was highest, high-frequency deceptive and truthful responding displayed no significant differences in RT. Fatigue did not influence high-frequency responding, as RT, variability, and accuracy did not differ significantly from the first half of trials to the second. This could indicate that working memory load is similar for both truthful and deceptive responding, which contradicts the attention-switching findings. More likely, this indicates that working memory load is not increased in deceptive responding to the extent that it would impact RT without additional factors, such as attention-switching and stimulus salience.

This study was limited by a sample of convenience as well as some minor methodological issues. The sample consisted of only undergraduate students at the University of South Carolina, which is not representative of the population. A methodological issue arose due to several researchers leading the participants through the task. Although all researchers tried to explain the task in a similar manner, participants may have used slightly different methods of completing the task due to differing explanations of the task. A possible resolution to this issue would be to create an online tutorial to explain the task in the same manner to all participants. Another limitation to the study was the lack of a control task without the element of deception. The finding that deception-related stimuli are more salient would be more credible if a non-deceptive task similar in workload and attention-switching demands found no difference between the salience of two types of stimuli. Future research in our lab will aim to eliminate these limitations.

The current behavioral findings lend credence to our current cognitive working model of deception. As a result, the current direction of the lab is to use this experimental paradigm with ERP measures and fMRI to further parse the effects of stimulus salience, attention-switching, and workload at the structural level. In order to determine whether these behavioral findings are unique to deception, we have developed a two-stimulus Stroop-based task which lacks the element of deception. We hope to see results that differ from the current findings, which would indicate that deception is a qualitatively different and perhaps a specialized task.

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Footnotes

[1] Several researchers define deception; however, this reference is the most widely accepted among the communities of deception researchers and lay persons.

Figure Captions

Figure 1. Timeline for deceptive and truthful responding across multiple studies.

Figure 2. The current working cognitive theory of deception is refined for the purposes of this study by removing the constructs for which we controlled. This refined theory proposes a competition between endogenous attention and exogenous attention for initiation of the alerting response with both attentional constructs drawing on working memory. Attention-switching is a product of endogenous attention shifting between truthful and deceptive responses. Frequency of stimulus presentation directly influences all three constructs, therefore providing one variable to manipulate.

Figure 3. Participants displayed significantly longer RT for deceptive responses than for truthful responses. Error bars represent standard error.

* $p < .001$.

Figure 4. Participants displayed significantly poorer accuracy for deceptive responses than for truthful responses. Error bars represent standard error.

* $p < .001$.

Figure 5. Truth and deception combine to display three trends within the RT data. Response ratios are presented with the deception ratio in bold and truth ratio in plain text. Points represent mean RT in milliseconds. Top error bars indicate the standard error for deceptive responses, and bottom error bars indicate standard error for truthful responses. Boxes represent the differences in deceptive and truthful RT. Connecting lines show the three separate trends appearing at different ratio groups.

Figure 6. Truth and deception show similar trends when presentation frequencies are equal or high. Low-frequency truthful and deceptive responding shows different trends, suggesting

stimulus salience impacts deception more than truth-telling. Response ratios are presented with the deception ratio in bold and truth ratio in plain text. Points represent mean RT in milliseconds. Top error bars indicate the standard error for deceptive responses, and bottom error bars indicate standard error for truthful responses. Boxes represent the differences in deceptive and truthful RT. Connecting lines show the three separate trends appearing at different ratio groups.

* $p < .05$.

Figure 7. The split-half comparison of the mean RT data displayed a significant fatigue effect for truthful responding in the 50% group (left panel) and a significant practice effect for deceptive responding in the 10% group (right panel). Response ratios are presented with the deception ratio in bold and truth ratio in plain text. Error bars represent standard error.

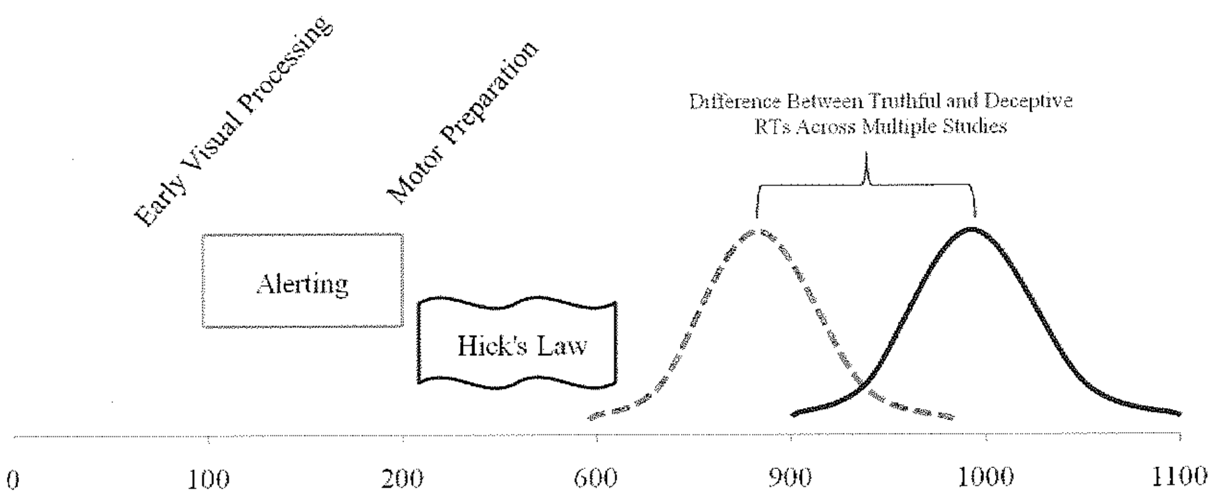
* $p < .01$.

Figure 8. The split-half comparison of the mean individual RT variability displayed a significant fatigue effect for truthful responding in the 50% group (left panel) and a significant practice effect for deceptive responding in the 10% group (right panel). Response ratios are presented with the deception ratio in bold and truth ratio in plain text. Error bars represent standard error.

* $p < .05$. ** $p < .001$.

Figure 9. The split-half comparison of mean accuracy data displayed a significant practice effect for both response types in the 10% group. Response ratios are presented with the deception ratio in bold and truth ratio in plain text. Error bars represent standard error.

* $p < .01$.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Motor Preparation
Difference Between Truthful and Deceptive
RTs Across Multiple Studies
Alerting
Hick's Law
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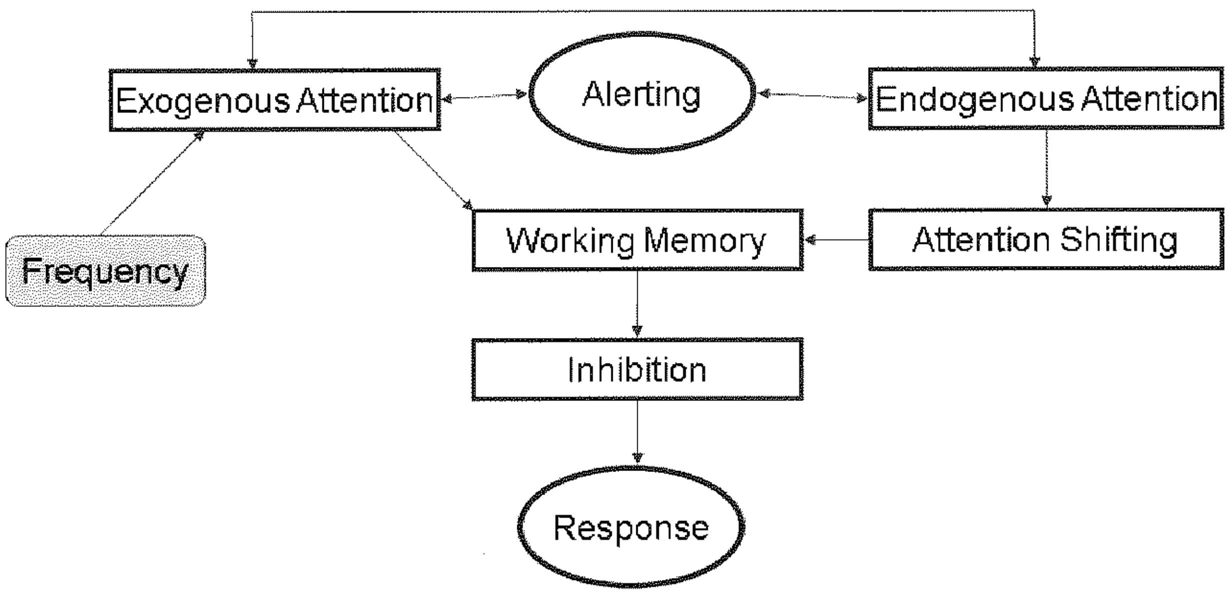
100
200
600
900
1000
1100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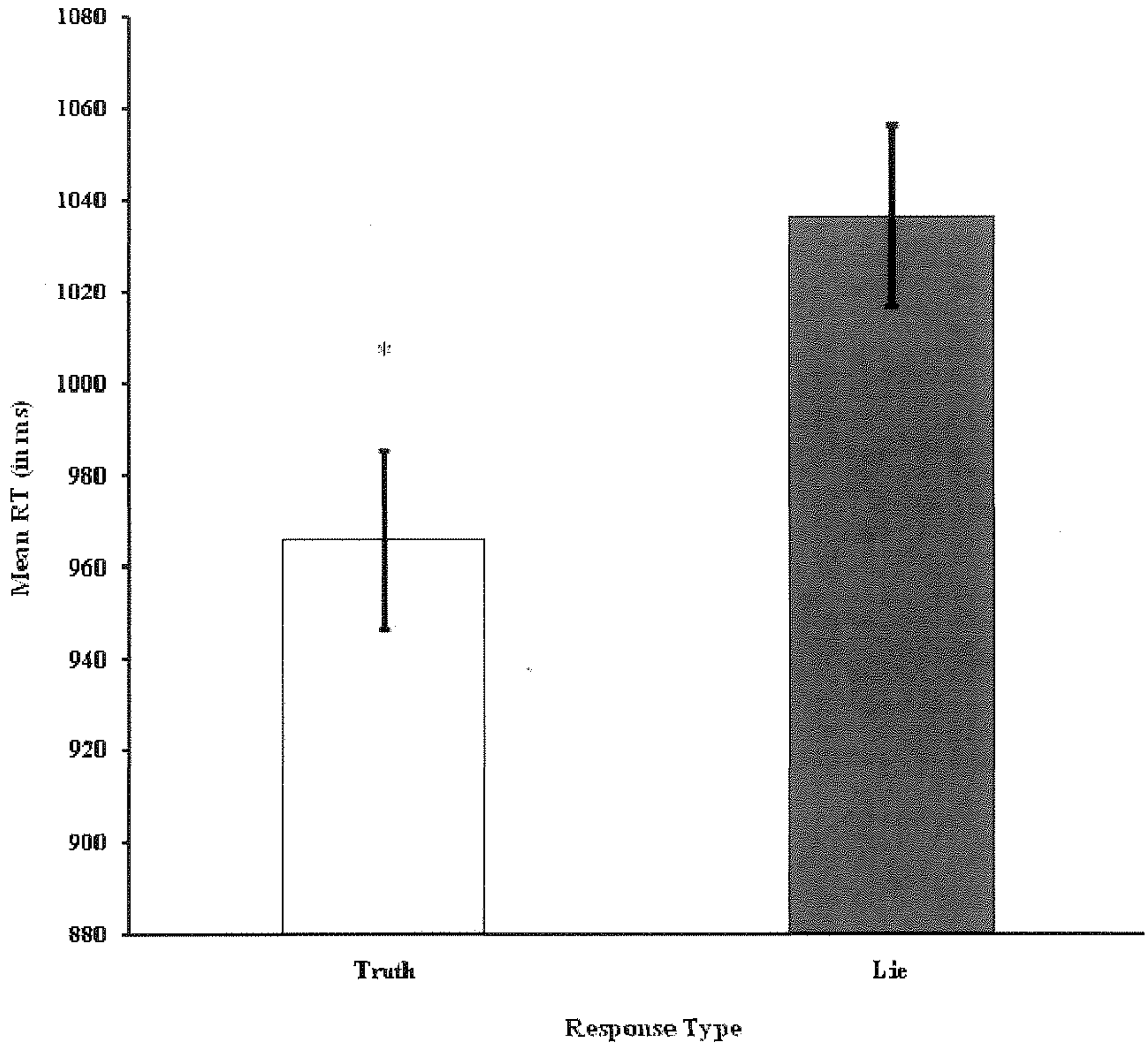
Alerting
Endogenous Attention
Frequency
Working Memory
Attention Shifting
Inhibition
Response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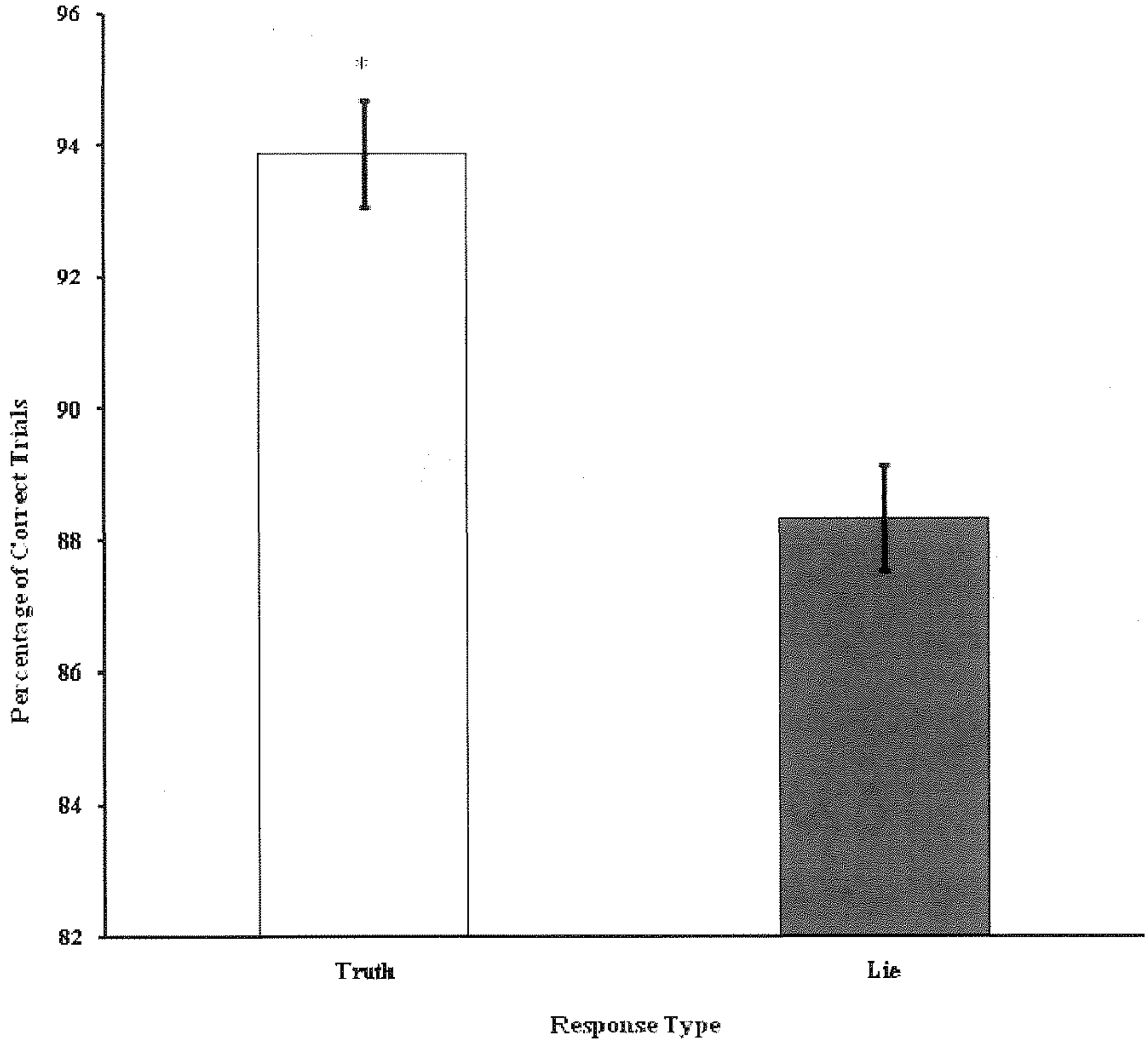
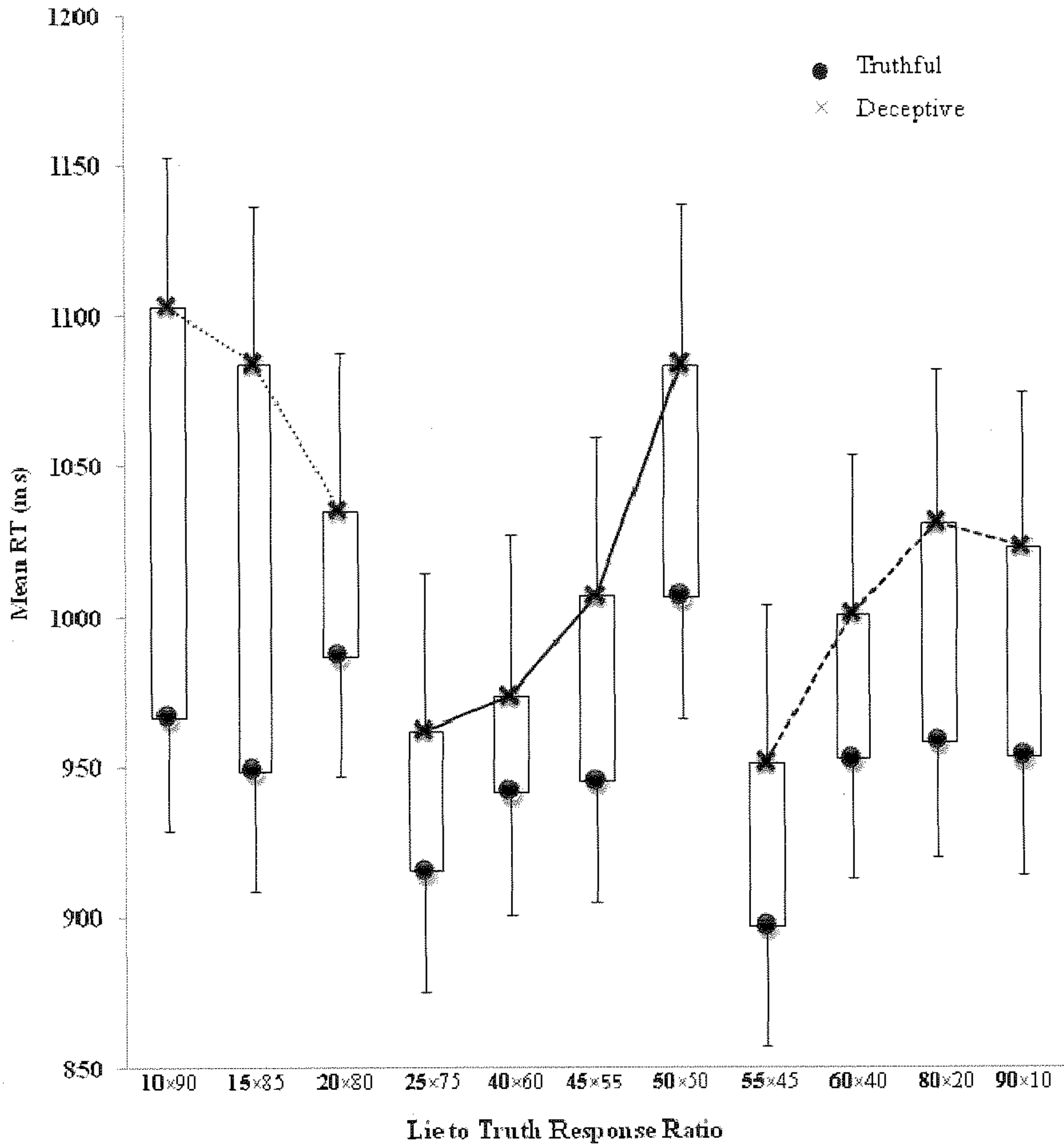
1060
1040
1020
1000
980
960
940
920
900
880
Mean RT (in ms)
*
Truth
Lie
Response Type


96
94
92
90
88
86
84
82
Percentage of Correct Trials
*
Truth
Lie
Response Type



Mean RT (ms)
1200
1150
1100
1050
1000
950
900
850
Truthful
Deceptive
10x90
15x85
20x80
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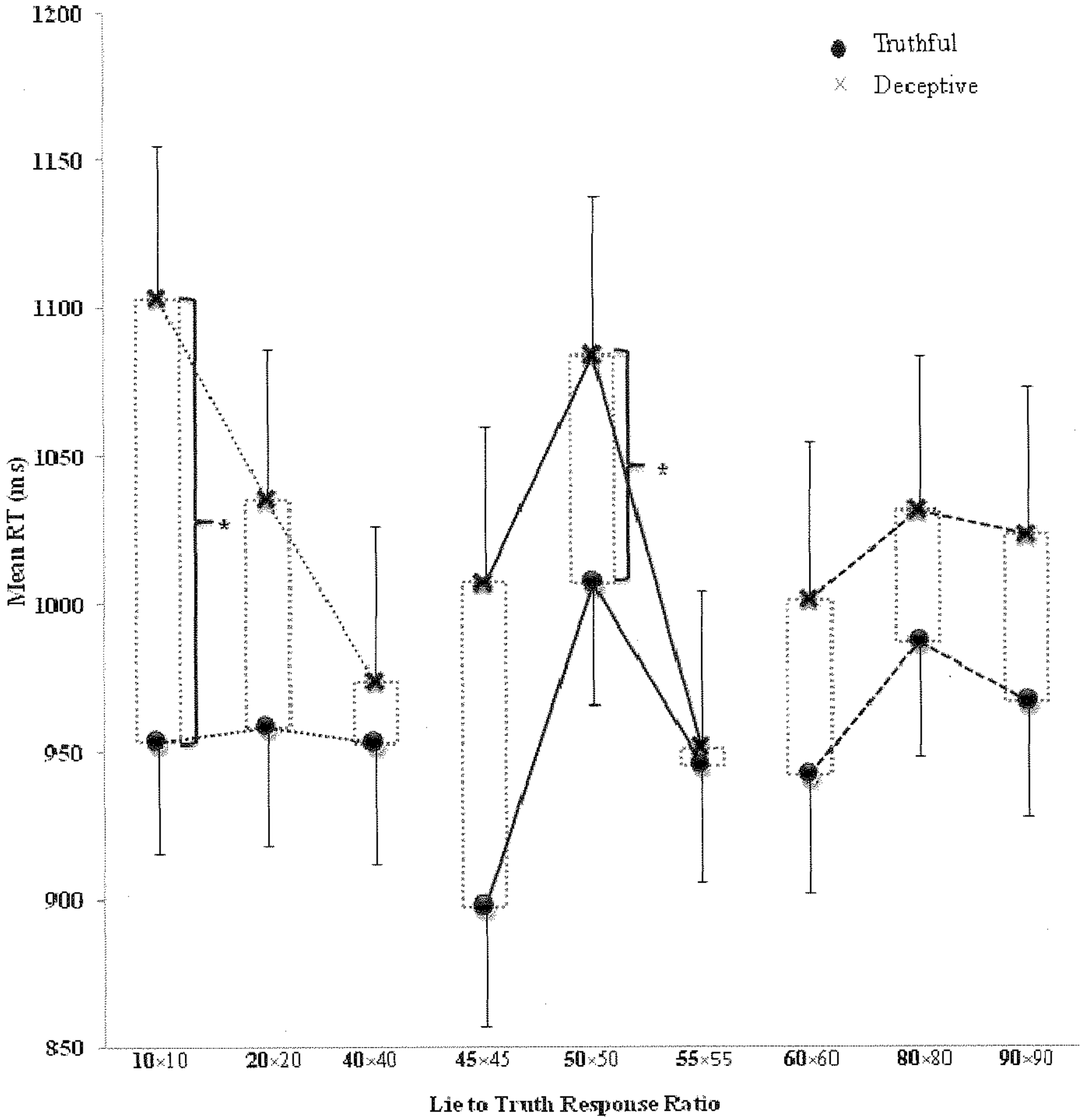
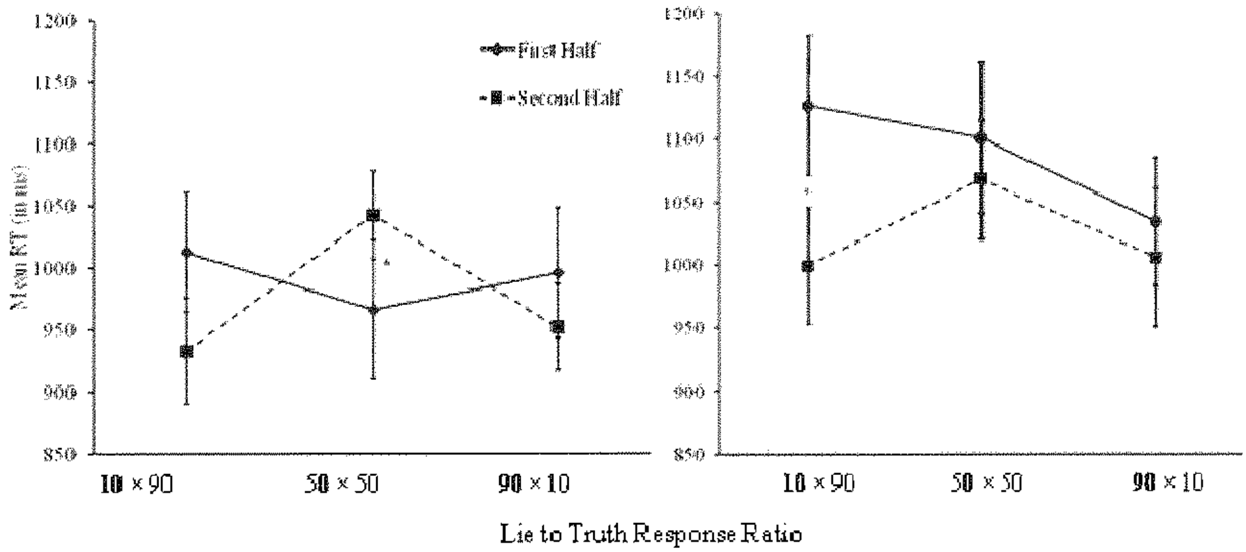
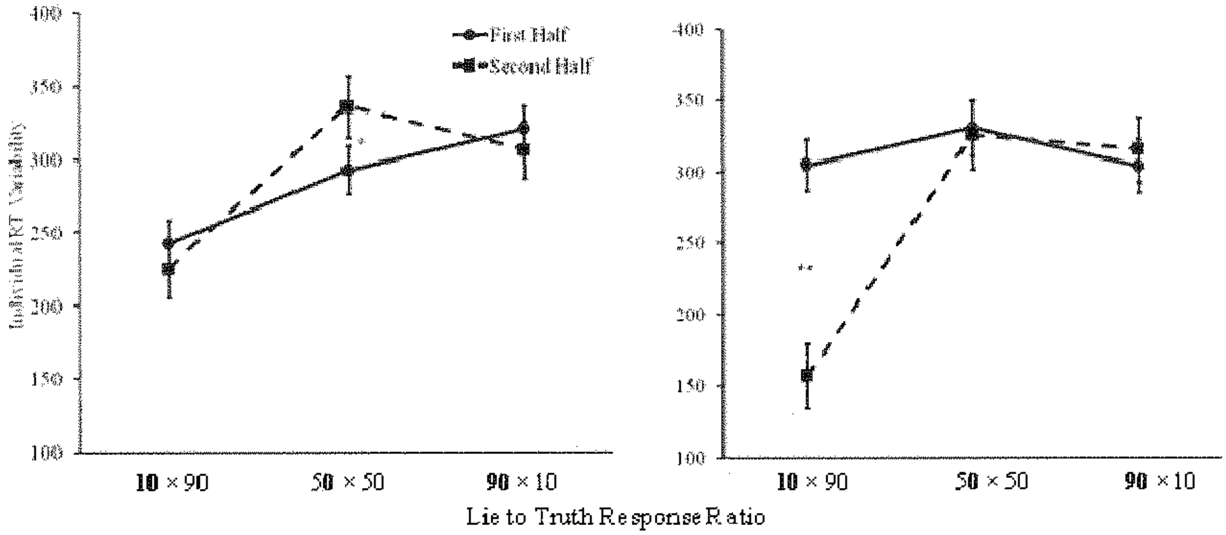
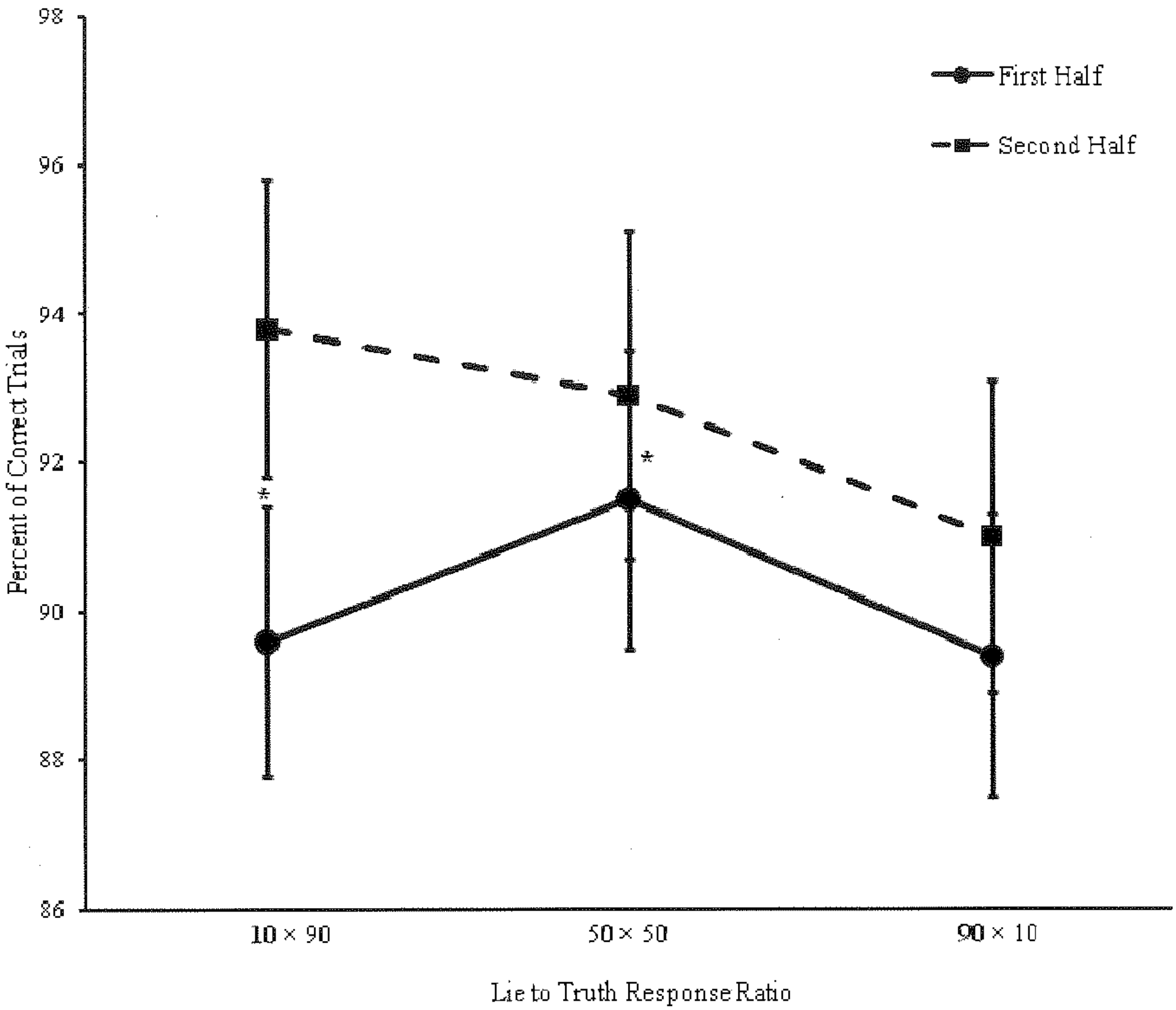
60x40
80x20
90x10
Lie to Truth Response Ratio



Truthful
Deceptive
Mean RT (ms)
1200
1150
1100
1050
1000
950
900
850
*
*
10×10
20×20
40×40
45×45
50×50
55×55
60×60
80×80
90×90
Lie to Truth Response Ratio


1200
1150
1100
1050
1000
950
900
850
Mean RT (in ms)
First Half
Second Half
10 × 90
50 × 50
90 × 10
Lie to Truth Response Ratio


400
350
300
250
200
150
100
First Half
Second Half
Individual RT Variability
*
**
10 × 90
50 × 50
90 × 10
Lie to Truth Response Ratio


98
96
94
92
90
88
86
Percent of Correct Trials
First Half
Second Half
*
*
10 × 90
50 × 50
90 × 10
Lie to Truth Response Ratio

Individual Differences in Comparison Question Anxiety

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Abstract

The comparison question polygraph test (CQT) is a well-known technique for the detection of deception in legal and criminal settings. An important issue in the effective use of comparison questions (CQs) in polygraph examinations is the proper selection and phrasing of CQs to suit each examinee. The standards for choosing these questions have not changed since 1955. The current study examined, in a group of average college students, differences in anxiety levels elicited by a group of CQs. Anxiety was used as a measure of guilt primed through the CQs. The study investigated three potential mechanisms associated with priming guilt through CQs as well as sex differences in responding to four specific types of questions. Participants were 369 (296 women) undergraduate college students. The questions could be placed into 10 content categories based on how much anxiety they elicited. In addition, the situational salience mechanism seemed to be the best explanation for the observed pattern of differences. Men reported more anxiety toward questions related to small and shameless law and rule breaking. Implications for current CQT administration as well as possibilities for future research are discussed.

Individual Differences in Comparison Question Anxiety

The comparison question polygraph test (CQT) is a well-known technique for the detection of deception in legal and criminal settings (Raskin et al., 1989). According to Raskin and colleagues, the CQT was developed to address the limitations of the relevant-irrelevant (R-I) test, which uses only two types of questions, relevant and neutral. In the R-I test, neutral questions do not have any salience (i.e. are not relevant) for the innocent examinee. In this sense, they function as a "control" condition. However, there is no method for determining if observed reactions to relevant questions are caused by deception or other factors, such as anxiety, examiner demeanor, or simply the accusatory nature of the questions. In the CQT, according to Raskin and colleagues, examinees are presented with three types of questions, relevant, comparison, and irrelevant questions. Comparison questions (CQs) are designed to give innocent examinees a chance to be more concerned with questions other than the relevant questions. In this way, they function as a "placebo" condition (hence the term comparison instead of control). CQs are salient to innocent examinees, but do not directly relate to the specific event probed by relevant questions.

Honts (1994) addressed a series of fundamental assumptions that must be upheld in order for a CQT to be sensitive to deception on relevant questions. The first assumption is that individuals attempting to lie to the central issues will respond with greater physiological reactivity to the relevant questions. The second assumption is that although innocent individuals know that the relevant questions are important, they will have greater responses to the CQs. Examiners base this assumption on the reasoning that innocent examinees know they did not commit the crime in the relevant questions, but they are either lying or uncertain about their responses to the CQs. In order to create conditions of uncertainty, CQs must be similar to the central issue but be more vague, cover more time, and be more general (Raskin et al., 1989).There are two types of CQs, exclusive and non-exclusive or inclusive. An exclusive comparison is a question of the same type or category as the relevant issue but excludes the relevant issue by use of a time constraint (Krapohl, Sturm, 2002). An example of an exclusive comparison question would be "Did you ever rob a bank before October 15th, 2005?" A non-exclusive or inclusive comparison question overlaps the relevant issue by time or location (Krapohl, Sturm, 2002). An example of a non-exclusive comparison question would be "Have you ever stolen anything in your life?"

The purpose of the comparison question is to elicit a fear of consequences (Reid, Inbau, 1977; Gustafson, Orne, 1963; Davis, 1961) or guilt in the innocent examinees.
The elicitation of guilt is loosely based on the on the concept of guilt complexes as originally discussed by Jung and Wertheimer (see Wetheimer et al., 1992 for a review). Both researchers separately applied association texts to deception detection using the word association test. This test delivers a prime word, and then participants respond with the word that most quickly comes to mind. The cognitively based spreading-activation theory of semantic processing (see Collins, Loftus, 1975 for a review) suggests that semantic primes elicit information organized within a loose construction of ideas. Priming words within a semantic network triggers activation of the entire network. For guilty individuals, relevant questions are associated with and activate information related to the central issue. For innocent individuals, the relevant questions deliver a less intense prime to the association network. The goal of the comparison question construction is to maximize primes associated with "guilt complexes" for innocent individuals.

Arising from the nature of CQT construction, an important issue in the effective use of CQs in polygraph examinations has been the proper selection and phrasing of CQs to suit each examinee (Harmon, Reid, 1955; Reid, 1947). Along those lines, Reid points out that if the examiner has information concerning an offense or situation involving the subject (of less importance than the pertinent crime), a comparison question based on the information will serve as a good indicator of the subject's responsiveness and will thus provide a good comparative response. According to Harmon and Reid, in selecting a section of CQs, an examiner should follow the following principles:

> 1. The question must be one to which the subject will answer "no".
>
> 2. Either the examiner should know from the facts in his possession that the subject's "no" answer is a lie, or he should be reasonably certain the answer is untrue.
>
> 3. The examinee should believe that the question is important to the procedure and the final test results.
>
> 4. The question should concern a matter of lesser weight than the pertinent questions. (p. 579).

Since 1955, the general guidelines for constructing such CQs have remained unchanged and little work has been done to examine how individual differences influence responses to CQs. The overall goal of the current behavioral study is to examine, in a group of average college students, differences in guilt (as measured by anxiety related to responding) elicited by a group of CQs. Three potential mechanisms associated with priming guilt through comparison questions have been proposed. The first goal of the present study is to distinguish the mechanism that best describes the patterns of anxiety shown in this testing situation.

The first mechanism proposes that situational salience is responsible for differential patterns of responding to the questions (Vendemia, 2002). In a specific setting or situation, innocent examinees will show the strongest reactions to questions that are the most salient or threatening in that particular situation (Vendemia, 2002). For example, in a scenario where the CQT is given in a workplace setting, examinees are likely to show the strongest reactions to CQs concerning workplace infractions.

A study done by Bradley and Black (1998) provides evidence for the situational salience mechanism. This study manipulated the types of CQs given to students in a mock-crime study. Half of the students received CQs about cheating and plagiarism from a professor and half of the students received standard CQs. Bradley and Black reasoned that students would feel that it was undesirable or dangerous for a professor to conclude that they were cheaters or plagiarists. Results showed that the CQs oriented toward the academic context better distinguished between guilty and innocent individuals than standard questions. Therefore, participants were more likely to score as innocent when actually innocent. This was presumably because in a school setting, students are more likely to be concerned by infractions related to cheating and plagiarism than infractions present in the standard CQs.

The second mechanism stems from Kohlberg's theory of moral development (Kohlberg, Hersh, 1977; Snarey et al., 1985). Kohlberg proposes discreet stages of moral development, which every child passes through. In the first level, the preconventional level, children see right and wrong in terms of physical or hedonic consequences (e.g. reward and punishment) or in terms of the authority and power of those who enforce the rules (e.g. "If I do this, Mommy will yell at me"). In the second level, the conventional level, adolescents see right and wrong in terms of loyalty to social order and actively maintaining, supporting, and justifying the social order. In the third and last level, the postconventional level (reached by age 18 or later), there is an effort to define moral values and principles that have validity apart from social order or the authority of those enforcing the rules. This includes the development of universal principles of justice and respect for human rights.

This mechanism emphasizes one's current understanding of ethical reasoning as accounting for specific patterns of responding to CQs. This mechanism hypothesizes that the examinee's current stage of ethical development will determine which questions elicit the most guilt. For example, if someone is currently operating in the second, conventional level of moral reasoning, he/she will probably react most strongly to questions probing small violations that are designed to maintain the social order (e.g. substance use infractions).

Based on a moral reasoning theory developed by Carol Gilligan (Gilligan, 1982, 1987, 1999), men and women develop different approaches to moral reasoning. Specifically, in her view, men see morality more in terms of justice. This concept of justice is based on abstract, rational principles by which all individuals will end up being treated fairly. Women, on the other hand, see morality more in terms of compassion, human relationships, and special responsibilities to those with whom an intimate relationship is shared. Women are more inclined to see morality as an issue of caring and relationships rather than of justice and rights.

The second goal of the present study is to examine possible sex differences in anxiety elicited by the different CQs. Examining sex differences is especially important and relevant because currently, the CQT is given without regard for sex differences in physiological responding. Despite this, sex has been identified as an important characteristic of the interviewee which may play a role during the interrogation process (Vendemia, 2002). Therefore, examining sex differences in responding to CQs may help polygraph examiners better structure their interviews to suit individual differences. Because they develop different approaches to moral reasoning, men and women should see different types of questions as more threatening. Based on

Gilligan's (Gilligan, 1982, 1987, 1999) theories, one would expect women to respond more strongly to questions that deal with wrongs done to friends and family and questions that have less to do with fairness and justice and more to do with violating one's own moral standards. In contrast, one would expect men to react more strongly to questions that don't bear heavily on one's own moral code but are still considered "breaking the law" and can be punished.

The third mechanism proposes that examinees will show the strongest reactions to questions that deal will societal taboos. Questions that deal will societal taboos are likely to include infractions that are considered by society to be shameful. These questions are therefore likely to bring up feelings of shame and guilt in examinees and, as a result, evoke large physiological reactions. Recent work by Thonney and colleagues provides evidence for this mechanism. They conducted two studies, which compared the use of shame-arousing stimuli and neutral stimuli with the Guilty Knowledge Test. In both Thonney et al. (2005) and Thonney et al. (2006), the polygraph tests in both studies yielded significantly higher accuracy rates when the shame-arousing stimuli were used compared to when the neutral stimuli were used. In other words, examinees showed larger physiological responses to shame-arousing stimuli, which boosted the test's ability to classify individuals based on responsiveness.

We administered a questionnaire to undergraduates asking them to rate how anxious they would feel if faced with answering questions about their actions and character with negative consequences for "wrong" answers. The present study asks several research questions. Do the questions fall into different content categories based on participants' responses? Because the CQs vary quite widely, we predict that for a given group of people, the questions do fall into different content categories. Based on three potential mechanisms associated with priming guilt through comparison questions, the present study hypothesizes three possible specific patterns of differences among the predicted categories. First, if situational salience is operating in this case, students should rate questions concerning infractions likely to be committed by college students (minor legal infractions and rule breaking (e.g. substance use, cheating) as evoking higher anxiety than those less likely to be committed by college students. Second, if level of ethical reasoning is operating in this case, based on the theory that people change from social order maintenance to an independent ethical code as a moral guideline around age 18, students should rate questions pertaining to personal ethics and integrity as evoking higher anxiety than other questions. Third, if societal taboos are operating in this case, questions pertaining to shameful conduct should be rated as evoking higher anxiety than other types.

Do men and women respond differently to these questions? Because women and men develop different approaches to moral reasoning, it is expected that their behavior to certain types of questions will be different. Specifically, it is expected that men will respond with more anxiety to questions pertaining to societal rules and regulations (not necessarily shameful or serious). It is also expected that women will respond with more anxiety to questions pertaining to wrongs against other people and one's own moral code.

Methods

Participants

Three hundred sixty nine undergraduates at the University of South Carolina (USC) volunteered to participate in this online study. Of the original 386 respondents, 17 respondents were dropped because they failed to follow experimental procedure. Ages in the final sample ranged from 18 – 24 (M =19.06, SD = .83; women = 296, men = 73). The sample was 78% Caucasian, 14% African-American, 2% Asian, 2% Hispanic, 1% Native American, and 3% Other Ethnicity. This sample matched the demographic stratification of the university population. All participants received course credit and were recruited through the USC Psychology Department's online participation pool.

Measures

The measure used in this study was a questionnaire designed by members of our lab to assess anxiety elicited by polygraph test CQs. The measure consisted of 178 commonly used CQs. Questions were excluded from the measure if they contained offensive material or were incomprehensible by the average college student. Each question was followed by five possible answer choices: No Anxiety, Some Anxiety, Average Anxiety, Strong Anxiety, and Extreme Anxiety. In addition to the CQs, the questionnaire included five questions about demographic information. See Appendix A for a copy of the questions.

Procedure

Once participants signed up for the study via the online participation pool, they were directed to a website where they could fill out the questionnaire. Three different versions of the questionnaire were constructed. All three versions had the same questions but in a different order. Participants were randomly assigned to fill out one of the three versions. Once at the website, participants first read an informed consent page and then agreed to consent to the study. Following this, they completed the questionnaire.

After completing the demographic information, the instructions told participants to

> Imagine that you have just entered a room in which a man is seated behind a desk. He is reading from a folder labeled with your name. He asks you to take a seat. During the next hour, he will be asking you personal questions about your actions and character. 'Wrong' answers to these questions could have extremely negative consequences for your future. Please answer these questions and rate them as to how much anxiety each one would

cause you to feel under those circumstances. Answer honestly. Your responses are completely anonymous.

Participants then completed the 178 items. After completing the questionnaire, they read a debriefing page explaining the purpose of the study and were thanked for their participation.

Results

The first part of the data analysis process consisted of basic data screening. The data were evaluated for mean, standard deviation, Skewness, and Kurtosis. Two of the questions, specifically "Were you ever involved in anything that would cause me to question your integrity?" and "Did you ever take any government supplies for your own use?", had very high Skewness and Kurtosis values as compared to the other questions in the data set. Histograms of these two questions were examined and they were both highly positively skewed. Because there were a large number of questions (178), these two questions were deleted from further analysis. In addition, during the original data entry, the data for nine questions were accidentally omitted, leaving 167 questions.

To potentially categorize the questions, a factor analysis extraction with an oblique Promax rotation was performed with SPSS on 167 items for the 369 participants. Factors with an Eigenvalue greater than one were retained. Ten factors were subsequently retained. After examining which questions loaded highest on each of the ten factors (factor loading of .5 and above), we labeled the factors based on the content of these questions. The resulting ten categories were Shameless Legal Infractions, Small Rules/Regulations Infractions, Personal Ethics Infractions, Personal Gain Infractions, Workplace Infractions, Moral Code Infractions, Shameful Infractions, Acquaintance Infractions, Integrity Infractions, and General Infractions (e.g. Did you ever break the law?). These categories explained approximately 56% of the variance in the ratings. An average rating to the questions in each category was computed for each person. A new variable was then created to represent each category, the values of which were each person's average anxiety score to the subset of questions that represent each category.

A 2 X 10 MANOVA was used to assess the effects of infraction category and sex on average anxiety scores. Pairwise comparisons (Tukey's post-hoc tests) were used to compare the categories in order to test the three hypotheses for specific patterns of differences among the categories. Because sphericity could not be assumed, multivariate F-tests are reported. Overall, the anxiety scores to the questions tended to be low to moderate. As predicted, the main effect of infraction category was significant (F (9, 359) =13.68, $p < .05$, $\acute{\eta}^2 = .26$). The effect size indicates a moderate effect of infraction category. Means (with error bars representing one standard error) for the infraction categories are presented in Figure 1. below.

(Figure 1. here)

Using Tukey's post-hoc tests, pairwise comparisons were performed on all the categories in order to compare them and test the three hypotheses for specific patterns of differences among the categories. Results of the pairwise comparisons are presented in Table I below. The first mechanism predicted that participants should rate questions concerning infractions likely to be committed by college students (shameless or minor legal infractions and rule breaking (e.g. substance use infractions) as evoking higher anxiety than those unlikely to be committed by college students. In line with this explanation, General, Shameless Legal, and Small Rules/Regulations infractions, while not significantly different from each other, were significantly higher than most of the other categories. They also had the three highest means (Figure 1.).

The second mechanism predicted that students should rate questions pertaining to personal ethics and integrity as evoking higher anxiety than other questions. In contrast to this explanation, the personal ethics category was actually significantly lower than all other categories. In addition, individuals rated the integrity category as significantly more anxiety provoking than only three other categories and its mean was in the middle of the category means (Figure 1.). The third mechanism predicted that questions pertaining to shameful conduct should be rated as evoking higher anxiety than other types. In contrast, the Shameful category was significantly higher than only two other categories. In addition, the mean for shameful infractions was at the lower end of the category means (Figure 1.).

While the main effect of sex was significant (F (1, 367) = 4.42, $p < .05$, $\acute{\eta}^2 = .012$), with men ($M = 2.11$, $SE = .07$) reporting on average more anxiety than women ($M = 1.95$, $SE = .04$), as expected, the interaction between infraction category and sex was significant (F (9, 359) = 2.88, $p < .05$, $\acute{\eta}^2 = .067$). This indicates that the effect of sex differed as a function of category.

(Table I. here)

Follow-up independent samples t-tests were done on the four categories that represented the hypothesized sex differences. The first hypothesis predicted that men would react with more anxiety to the Shameless Legal and Small Rules/Regulations categories. As predicted, men did react with more anxiety (mean difference = -.275, SE = .132) to the Shameless Legal category (t (367) = -2.077, $p < .05$, d = .267). The effect size indicates a small effect for this category. Although not significant, the anxiety increase in men for the Small Rules/Regulations category (mean difference = -.209, SE = .113) did approach significance. The second hypothesis predicted that women would react with more anxiety to the Acquaintance and Moral Code categories. In contrast to this prediction, men and women did not react differently to the Acquaintance category or the Moral Code category. Power analyses were conducted for these two effects using Monte Carlo power simulations and the power to find each effect was .835 and .835 respectively.

Discussion

Overall, the anxiety scores tended to be low to moderate. This is presumably because the questions were not given in a formal exam scenario. In a formal exam scenario, where the stakes are higher, elicited anxiety and presumably, level of guilt may be greater. As expected, the questions could be put into content categories based on how much anxiety they elicited. This supports the notion alluded to earlier that for a given group of people, the nature of the reactions elicited by the CQs vary as a function of their content. The present study investigated three possible mechanisms associated with priming guilt through comparison questions as an explanation for specific patterns of differences among the categories. Situational salience (Vendemia, 2002) seems to be the best explanation for this situation. General, Small Rules, and Shameless Infractions, infractions commonly committed by college students, were rated higher than most other categories. These results are also in line with the findings in Bradley and Black (1998). Understanding of ethical reasoning and societal taboos do not seem to be appropriate explanations for the pattern of responses seen in this study.

Concerning understanding of ethical reasoning, it is possible that the students in this study have not progressed to the last level of ethical development and therefore the Personal Ethics and Integrity categories did not elicit higher levels of anxiety than the other categories. In fact, Kohlberg and Hersh (1977) point out that some people do not ever reach the third level of ethical reasoning. Concerning the societal taboos explanation, it seems that the students in this study did not find the Shameful Infractions more anxiety provoking than other categories. This is in contrast to findings in Thonney et al. (2005) and Thonney et al. (2006). One possible reason why the Shameful Infractions did not elicit higher levels of anxiety compared to the other categories is that the present study did not include very shameful infractions that are obvious societal taboos (e.g. sexual offenses). These were not included because they were deemed inappropriate for the present study. Overall, however, it is plausible that the categories involved in the second and third explanations may not have elicited the highest levels of anxiety because unlike General, Small Rules, and Shameless Infractions, college students do not commit them frequently.

The present study hypothesized sex differences in four of the 10 categories. Specifically, we predicted that men would react with more anxiety to questions pertaining to shameless and minor law and rule breaking (Small Rules and Shameless) categories. As predicted, men did report more anxiety to the Small Rules and Shameless categories. However, these effects were small. These results are in line with Gilligan's (Gilligan, 1982, 1987, 1999) theories regarding sex differences in development of moral reasoning.

It was also hypothesized that women would react more strongly to questions that deal with wrongs done to friends and family and questions that have less to do with fairness and justice and more to do with violating one's own moral standards (Acquaintance and Moral categories). Contrary to what was expected, women did not react with more anxiety to the Moral or Acquaintance categories. These results are not in line with Gilligan's (Gilligan, 1982, 1987, 1999) theories. Power analyses were conducted on both these effects and this study had adequate power to find both effects. It seems, then, that in the data there were no differences between men and women in these two categories. It is possible that women were engaging in more self-monitoring than men. That is, women might have been reporting less anxiety than they actually felt because it would be more socially appropriate in this situation. In fact, several studies have found that women engage in more self-monitoring than men (e.g. Hall, 1984; Cole, 1986). Future research should include a self-monitoring scale to explore this possibility.

This study has several implications for the field of polygraph examination. The fact that the questions could be placed into content categories based on how much anxiety they elicit emphasizes that for an individual or group, not all CQs are created equal. Some may elicit more physiological arousal than others may during a polygraph exam. The findings emphasize the role of individual differences in the CQT and in turn the importance of taking into account those individual differences when constructing an exam. Specifically, it seems that Vendemia's (Vendemia, 2002) situational salience theory may currently be the best explanation for the pattern of differences in arousal seen during an exam. While more research clearly needs to be done, this may be the most efficient technique for polygraph examiners when constructing an exam for an individual as the examiners will want to choose CQs that produce the largest amount of physiological arousal in the innocent examinee.

Although the findings produced mixed results concerning sex differences, it seems that there may be some differences in men and women concerning physiological arousal during an exam. While women may be self-monitoring during a low-stakes survey such as the present one, they may not be doing so in a true forensic exam scenario. Future endeavors should attempt to exam sex differences in a higher-stakes situation. The present study in combination with future research on the CQT may warrant a revision of administration of the CQT that takes into account sex differences in arousal levels.

Important to note is that the present investigation included only inclusive CQs. There has been an ongoing debate for some time regarding the relative importance of inclusive versus exclusive CQs in the CQT (see Gordon, Fleisher, 2006 for a recent discussion of this issue). While recent work suggests they may work equally well in a forensic exam scenario (F. Horvath, personal communication, January 25, 2008), it may be important for future research to take into account both types of questions.

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Appendix A. Questionnaire Items

1. Did you ever do anything illegal?
2. Are you absolutely trustworthy?
3. Did you ever make false entries on an official form or document?
4. Did you ever violate a traffic law?
5. Did you ever commit a sin (and not ask forgiveness)?
6. Did you ever say something derogatory about another person behind his or her back?
7. Are you really an honest and trustworthy person?
8. Did you ever pass a bad check knowing you did not have adequate money in the bank?
9. Have you ever done anything which could cause scandal in your church?
10. Did you ever lie to a personal friend?
11. Did you ever lie to a previous supervisor?
12. Did you ever ask someone to cover up for you?
13. Did you ever posses anything illegally?
14. Did you ever lie to get even?
15. Did you ever reveal anyone's personal secret?
16. Did you ever disclose a secret that was told to you in confidence?
17. Did you ever lie to someone in a position of authority?
18. Have you ever misused police equipment?
19. Did you ever deliberately conduct yourself in a dishonorable manner?
20. Have you ever falsified your qualifications?
21. Did you ever intentionally lie to anyone about anything?
22. Have you ever spoken disrespectfully of other church members?
23. Have you ever witnessed a violation of the law and not taken appropriate action?
24. Did you ever knowingly violate any company rules or policies?
25. Did you ever lie for your protection?
26. Did you ever lie to protect your status?
27. Did you ever lie to suit your own interests?
28. Did you ever steal anything from your work place?
29. Did you ever lie to someone who trusted you?
30. Did you ever knowingly possess any stolen property?
31. Did you ever violate your own integrity?
32. Did you ever deliberately do anything dishonest?
33. Did you ever say something that you later regretted?
34. Did you ever lie to a child about anything?
35. Are you the type of person who would betray a friend?
36. Did you ever involve yourself in black-market activity?
37. Did you ever violate a hunting law?
38. Did you ever lie to get out of trouble?
39. If there were something that might limit your access to classified information would you tell me about it?
40. Did you ever lie to a policeman?
41. Did you ever hide any information from a personal friend?
42. Did you ever spread malicious gossip or rumors about anyone?
43. Did you ever do anything in your personal life of which you are not proud?

44. Did you ever violate your own professional ethics code?
45. Did you ever lie to a cop?
46. Did you ever do anything for which you could lose your job?
47. Did you ever deliberately lie to your boss?
48. Did you ever do anything in school (college) that you are now ashamed of doing?
49. Would anyone that knows you well describe you as a difficult person?
50. Were you ever involved in anything that would cause me to question your integrity?
51. Have you ever accepted anything of value from business people?
52. Did you ever say anything about someone that wasn't true?
53. Did you ever do anything to get even?
54. Did you ever reveal a confidence entrusted to you by a relative?
55. Are you the type of person who would take credit for someone else's work?
56. Did you ever lie to make yourself important?
57. Have you ever falsely represented your background data?
58. Did you ever misrepresent the facts to gain some benefit?
59. Did you ever betray anyone who placed total trust in you?
60. Did you ever commit a criminal offense?
61. Did you ever steal anything from a friend?
62. Are you the type of person who occasionally drinks too much?
63. Did you ever fail to accept responsibility for your own actions?
64. Did you ever spread malicious gossip about anyone?
65. Have you ever padded an expense account?
66. Are you the kind of person that feels it is acceptable to lie to get what you want?
67. Do you ever gossip or rumor about other church members?
68. Did you ever possess anything for which you could have been arrested?
69. Did you ever take any government supplies for your personal use?
70. Did you ever falsify any document to obtain credit or a loan?
71. Did you ever cheat in school?
72. Did you ever misrepresent the facts to protect yourself?
73. Did you ever cheat?
74. Did you reveal information entrusted to you by a friend or relative?
75. Did you ever take credit for something you really did not do?
76. Did you ever take police equipment for your personal use?
77. Did you ever do anything that could bring shame upon yourself or your family?
78. Have you ever disrespectfully criticized your minister (Priest, Rabbi, etc)?
79. Did you ever steal government property?
80. Did you ever lie to a close friend about anything?
81. Did you ever try to deceive someone by lying?
82. Did you ever hide a safe combination in an unauthorized location for your personal convenience?
83. Did you ever lie to make yourself look important?
84. Did you ever take credit for something you did not do?
85. Are you the type of person that talks about people behind their backs?
86. Could you be accused of not working a full day while receiving a full day's pay?
87. Did you ever steal anything from your employer?
88. Have you ever mistreated a person under arrest?

89. Did you ever speak disrespectfully of any boss or supervisor?
90. Did you ever possess any item you weren't supposed to?
91. Did you ever lie to avoid the responsibilities for your actions?
92. Did you ever hide any information from a relative?
93. Have you ever padded your expense account?
94. Did you ever make false entries on a claim?
95. Did you ever possess any contraband?
96. Did you ever ask someone to lie for you?
97. Did you ever steal anything from someone who trusted you?
98. Would anyone that knows you describe you as a person who enjoys manipulating friends?
99. Have you ever lied to a superior officer?
100. Did you ever lie to get out of an obligation?
101. Did you ever abuse a position of trust?
102. Did you ever disclose a personal secret furnished to you by a friend?
103. Did you ever deliberately lie to someone who really trusted you?
104. Are you the type of person who would betray the trust of a friend?
105. Did you ever lie to get out of an obligation?
106. Did you ever steal anything from a relative?
107. Are you the type of person who would lie if you made a mistake?
108. Did you ever do anything while drinking that you are now ashamed of doing?
109. Did you ever take any company supplies for your personal use?
110. Have you ever lied to a co-worker (partner)?
111. Did you ever deliberately do anything unethical?
112. Did you ever misuse your position for personal profit or gain?
113. Have you ever make any false claim for reimbursement?
114. Have you ever submitted a false claim for expenses?
115. Did you ever violate an honor code?
116. Did you ever make false entries on an employment application?
117. Are you the type of person who cannot be trusted with a personal secret or confidence?
118. Did you ever deliberately lie to someone in authority for any reason at all?
119. Did you ever disclose a friend's secret that had been told to you in confidence?
120. Have you ever shoplifted anything from a store?
121. Did you ever lie to make yourself more important?
122. Did you ever cheat on your time card?
123. Did you ever deliberately provide false or misleading information on any official document?
124. Did you ever steal anything from your government?
125. Have you ever lied on a deposition?
126. Did you ever violate any of the laws of the US?
127. Are you completely honest with others who trust you?
128. Did you ever misrepresent the truth to gain some benefit?
129. Did you ever betray the trust of a friend?
130. Did you ever lie to a relative about anything?
131. Have you ever discussed sensitive police information with persons who did not have the need to know?

132. Did you ever do anything illegal in your country?
133. Did you ever falsify a form for personal gain?
134. Did you ever steal anything and not get caught?
135. Have you ever falsified your accomplishments?
136. Have you ever conducted personal business on company time?
137. Did you ever lie to keep from getting in trouble?
138. Did you ever make false entries on a report?
139. Did you ever say something in anger that you later regretted?
140. Did you ever possess any illegal substance?
141. Did you ever reveal a confidence entrusted to you by a friend?
142. Have you ever lied on a police document or report?
143. Did you ever obtain anything by unlawful means?
144. Did you ever lie to a relative?
145. Did you ever cheat in school?
146. Did you ever steal anything of value?
147. Did you ever disregard a rule or regulation because you thought it was necessary?
148. Did you ever cheat on your time card?
149. Did you ever lie because you thought you would not get caught?
150. Did you ever deliberately do anything dishonest?
151. Would any of your fellow employees describe you as someone who is difficult to work with?
152. Did you ever falsify a form for personal gain?
153. Did you ever betray the trust of a relative?
154. Did you ever lie to protect your position?
155. Did you ever violate any of the laws of your country?
156. Did you ever violate a fishing law?
157. Did you ever say anything about someone that wasn't true?
158. Did you ever take credit for something you did not do?
159. Did you ever reveal the answers to an examination?
160. Did you ever involve yourself in customs violations activity?
161. Have you ever lied in court?
162. Did you ever help a fellow officer cover up a mistake?
163. Did you ever do anything that you would be ashamed to tell someone about?
164. Did you ever do anything that could cause you a loss of position or status?
165. Did you ever lie to a previous coworker?
166. Did you ever misrepresent the facts for personal gain?
167. Did you ever lie to cover up a mistake?
168. Did you ever steal company property?
169. Did you ever disregard or flaunt a rule or regulation because you thought it was foolish or unnecessary?
170. Would anyone that knows you well describe you as someone they did not trust?
171. Did you ever hurt someone who trusted you?
172. Did you ever intentionally mislead or deceive your friends?
173. Did you ever do anything for which you could be fired?
174. Did you ever violate your own code of ethics?
175. Did you ever do anything that you want to keep hidden?

176. Have you ever done anything that would cause me to question your integrity?
177. Would any of your co-workers characterize you as being dishonest, unethical, or incompetent?
178. Did you ever do anything which would reflect negatively on your character?

Running Head: SELF-REPORT INSTRUMENT FOR DECEPTION

Development of a Self-Report Instrument for Assessing Deceptive Behaviors

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Abstract

The main goal of this present study was to develop a self-report instrument for the assessment of deceptive behaviors. The secondary goal of the present study was to investigate individual differences in deceptive behavior, specifically the interaction between personality characteristics and types of lies. We employed a multi-method approach to instrument development. After developing nine categories of deceptions, we created and administered a self-report instrument to undergraduate college students (Experiment 1) that assessed use of the categories as well as several self-report personality measures. Results revealed that one of the categories was not necessary and that some of the personality measures were also superfluous to our goal. The instrument was revised and re-administered to a new group of undergraduate college students in Experiment 2. Our hypothesis that a unique set of personality characteristics could predict each type of lie was supported for six of the eight categories.

Development of a Self-Report Instrument for Assessing Deceptive Behaviors

The main goal of this project was to create an instrument for the assessment of deceptive behaviors. Deception is a multidimensional construct, although, researchers are in contention regarding the classification of those dimensions. Researchers who apply a taxonomy approach typically use one or two dimensions based on a priori assumptions without regard to population norms while researchers who employ open-ended assessment techniques have not moved beyond basic descriptive methodologies. In this study, we employed a multi-method or converging lines of evidence approach to instrument development including lexical search, novice and expert ratings, and test administration as suggested in Pedhauzer and Schmelkin (1991). A secondary goal of this project was to investigate individual differences in deceptive behavior, specifically the interaction between personality characteristics and types of lies. While a few studies have attempted this, we feel that our attempt builds upon and extends those results with a broader range of lie types and personality characteristics.

Original attempts at taxonomies of deception in the social sciences were done in the 1970s and 80s. Goffman (1974) made a distinction between exploitative fabrications, lies that are intended to serve the deceiver and harm the other and benign fabrications, lies that are in the interest of the deceived or do not harm him or her. Linskold & Walters (1983), in two studies, created six categories of lies based on students' judgments of their acceptability, rank ordered from most to least acceptable. The lies were described in terms of the social motivations underlying each category. To date, this is the most comprehensive taxonomy that has been attempted. However, these taxonomies are limited by the assumptions of the dimensions underlying the behavior (e.g. acceptable or unacceptable, harmful or not harmful, self or other directed).

Since the 1980s, most research has focused on students' self-reports of their own deceptive behavior in various contexts rather than formation of a complete taxonomy. Bella DePaulo and colleagues are at the forefront of this research. Several of their studies ask participants to keep a lie journal in which they write down all of the lies they tell in a certain period. DePaulo, Kashy, Kirkendol, Wyer, and Epstein (1996) found that people lie overwhelmingly about themselves, compared to lying about others or impersonal topics. In addition, the motive behind the lies was mostly self-serving and many more lies were told for psychological reasons (e.g. protection from embarrassment) rather than for personal advantage (e.g. material gain). In addition, participants felt that their lies were generally not serious lies and required little effort to plan. In addition to the journal method, DePaulo and colleagues use a feedback scenario (i.e. one in which one person gives feedback to another person regarding his or her performance on a task) to investigate lies. DePaulo and Bell (1996) found that in a feedback setting, outright lies occurred infrequently. Instead, when the true opinion was negative, participants tended to mention many positive things and only a few negative things to hide their true feelings. In addition, participants used different methods of implying positive feelings without actually stating them. Bell and DePaulo (1996) found that people will also tend to use kinder lies when giving feedback to someone they like.

DePaulo and colleagues also record verbal autobiographical reports from subjects in order to investigate more serious lies. DePaulo, Ansfield, Kirkendol, and Boden (2004) identified different motive, origin, and content categories of serious lies. These lies seemed to originate most often from "bad" behavior viewed as immoral, illegal, and unjustifiable. The most frequently used motives were generally related to covering up said behavior. Less frequently used motives included identity management, self-presentation, and lying specifically to hurt another person. While, taken together, studies by DePaulo and colleagues cover a wide range of deceptive behavior; they have never attempted to investigate the full range of deceptive behavior in one comprehensive study utilizing something other than a purely descriptive approach. Their work, then, is incomplete.

The goal of this initial investigation was expand the conceptual framework from previous research into an assessment tool for a comprehensive range of deceptive behaviors. The identification of unique classes of deceptions is especially important to researchers attempting to understand the neural correlates of deception. In addition to behavioral differences in lies, not all lies may have the same neurocognitive substrates. For example, telling a lie for personal gain may not create the same pattern of cortical activity as telling a white lie. A lie for personal gain may require more planning, more working memory resources, and more overall cognitive effort than a white lie.

One recent study has investigated the neural correlates of different kinds of lies. Ganis, Kosslyn, Stose, Thompson, and Yurgelun – Todd (2003) classified lies based on whether they were previously memorized and whether they fit into a coherent story. They found that well-rehearsed lies that fit into a coherent story elicited more activation in right anterior frontal cortices than spontaneous lies that do not fit into a coherent story, whereas the spontaneous lies elicited more activation in the anterior cingulate and posterior visual cortex (e.g. cuneus). The results of this study suggest that there are differences in the neural processes underlying different kinds of lies and pave the way for future research to examine different deceptive categories. We developed, through a series of steps designed to maximize construct validity, different categories of deceptions. This approach included a lexical search, novice ratings, and expert ratings. In Experiment 1, we developed questions to assess use of each category and evaluated their validity as measures of each category. This multi-method approach to instrument development is one suggested by Pedhauzer and Schmelkin (1991).

A secondary goal of this project was to investigate individual differences in the use of these categories. Specifically, our goal was to explore the interactions between personality characteristics and types of lies in order to determine if a unique set of personality variables can predict each of our categories. Two studies have attempted to explore possible interactions between personality and type of lie. Kashy and DePaulo (1996) used the journal method to investigate the relationships between several self-report personality measures and two types of lies: self-serving and other-oriented lies. Generally, they found that people who scored higher on measures of manipulativeness and impression management told more lies overall than those who scored lower on these scales. Social anxiety was not related to overall rate of lying, responsibility was weakly negatively correlated with overall rate, and a concern with self-presentation was not associated with overall rate. Those high on manipulativeness told especially more self-serving lies than those low on this scale.

Recently, McLeod and Genereux (2008) attempted to further investigate these interactions by predicting individual differences in acceptability and likelihood of four types of lies (altruistic, conflict avoidance, social acceptance, and self-gain) with six different personality measures (honesty, kindness, assertiveness, approval motivation, self-monitoring, and Machiavellianism). They found that for each type of lie, a unique set of personality variables significantly predicted lying acceptability and likelihood. While the present study focuses only on frequency of lying (akin to likelihood), we hope to extend the idea that a unique set of personality variables can significantly predict a type of lie using a greater number of more specific categories and a broader range of personality variables. In Experiment 1, along with questions to assess use of each deceptive category, we administered a broad range of self-report personality measures. These included: several scales from the International Personality Item Pool (Goldberg, 1999) including Agreeableness, Deliberateness, Extraversion, Fairness, Impression Management, Integrity, Machiavellianism, Neuroticism, Responsibility, Risk-Taking, Self-Monitoring, and Sincerity, the State-Trait Anxiety Questionnaire (STAI) (Spielberger *et al.*, 1970), and the Center for Epidemiological Studies – Depression Scale (CES-D) (Radloff, 1977). The anxiety and depression scales were developed for use in general population research as opposed to research in a clinical setting. The STAI yields two response variables--state anxiety and trait anxiety. In Experiment 2, after evaluation of the results from Experiment 1, we re-administered a revised instrument and looked specifically at interactions between the relevant personality characteristics and the lie categories.

Category Development

Lexical Search and Novice Evaluation

A multi-step process generated the different categories of deception. First, a lexical search of seven American English dictionaries[1] identified 111 potential words related to deception. Performing dictionary searches has been used extensively in the development of cross-cultural taxonomies of personality traits (e.g. Saucier *et al.*, 2005; Saucier *et al.*, 2000; Szarota *et al.*, 2007), therefore we felt it was an appropriate place to start. A list of 21 potential descriptors (e.g. verbal, nonverbal, written, personal gain, detriment of others, protection of others, etc.) was created from the dictionary definitions of the words. Each of the potential deception words was rated dichotomously based on whether the descriptor was appropriate (0=not appropriate, 1 = appropriate) by two novice raters. No descriptors were considered

[1] American Heritage Dictionary

mutually exclusive from one another (i.e. it was possible to receive 1's in both verbal and non-verbal). After this procedure, a principal components analysis was performed on the 21 categories for each of the 111 words. This analysis was deemed appropriate, as we were not making a priori assumptions about the dimensions underlying the measure. The goal of the procedure was to identify groups of words that were similar with respect to their descriptors.

A ten-component solution explained 88.06% of the variance in ratings. The first component explained 21.13% of the variance. The words in this component were Distort, Embellish, Fable, Fabricate, Juggle, Profess, Tale, Bear False Witness, Concoct, Falsehood, Fib, Hyperbole, Tale Story, and Warp. Because most of the words in this category were more generally related to deception, as compared to the other categories that were more specific, this component was not submitted to further analyses.

Expert Evaluation

Words were grouped based on the components, and a judging form was created for evaluation by 14 expert practitioners in the field of deception detection. These individuals have had a wide range of experience with deceptive behaviors. One expert's data was thrown out because the questionnaire was filled out incorrectly. This form first asked the experts to come up with a definition that they thought best fit each group of words (e.g. "lies for gain"). Next, they were asked to read through all of the words in each group and rate them based on how well they thought the word matched their definition on a scale of 0 – 4 (0 = not related, 1 = poorly related, 2 = moderately related, 3 = highly related, and 4 = perfectly related). DePaulo, Kashy, Kirkendol, Wyer, and Epstein (1996)

We used the expert evaluations to refine the categories. We checked each word for belongingness to our original component structure by performing intercorrelations for each word list. Each category contained a category exemplar, the word with the single largest intercorrelation with all other words in the category. In some cases, words which originally belonged to the category based on the principal components analysis did not meet the criteria of the expert evaluation (i.e. no or negative correlation with category exemplar and/or no or negative correlation with other category words) and were thrown out. We completed this process for all nine components. The expert definitions (Table 1) and correlation graphs of word belongingness (Figure 1) are displayed for component two as an example of the process. The original words in component two were Pose, Phony, Queer, Put On, Mock, Put up a Front, Whopper, Bull, Bunk, Plant, Cant, and Simulate. The category exemplar was Mock. Based on experts' open-ended definitions, "Interpersonal Ploy" was the descriptor given to this category. The final word list became Queer, Put On, Mock, Put up a Front, Whopper, Bull, Bunk, Cant, and Simulate. The outcome of this process for the other eight components is shown in Table 2.

The final categories on which we constructed inventory items were Avoidance, Concealment, Gainful Malice, Gainful Misleading, Interpersonal Ploys, Social Enhancements, Verbal Malice, and Verbal Trickery. Avoidance lies involve attempts to escape or minimize penalties associated with a specific incident of inappropriate behavior. Concealment lies involve ongoing deceptions in which people misrepresent a quality within themselves. Gainful malice deceptions are a class of verbal malice deceptions in which the extraction of benefit becomes the key element of the deception. Gainful misleading refers to lies that are employed to extract a specific benefit from another person. Interpersonal ploys involve deceptions employed within the space of an ongoing interaction to improve the pleasantness of that interaction. Social enhancements are similar to interpersonal ploys, however, the goal of a social enhancement is to improve one's social standing by impressing others or gaining sympathy from others. Verbal malice deceptions are told for self-serving purposes, and typically involve a specific harm to another person. Verbal trickeries involve lies in which one endorses a particular course of behavior and then proceeds to engage in a less socially desirable behavior.

All of the words in our list were uploaded into the Latent Semantic Analysis (Landauer *et al.*, 1998) web interface in order to generate semantic distance classifications. The classification patterns were similar to our categories.

Experiment 1

Based on the initial category development we designed an inventory with questions targeting nine of the ten deception domains. As mentioned previously, the first component contained words too general for categorization into types of deceptions. The research goals for the first study were to establish construct validity for each category and to determine a pool of personality inventories that were related to the lie categories under investigation.

Methods

Participants

Participants were 446 undergraduates (317 females) at the University of South Carolina recruited through the Psychology Department's online participant pool. They received course credit in exchange for their participation.

Design and Materials

For each deception domain, we developed questions containing the words from the expert refined components. We asked two types of questions: frequency and accuracy. We measured frequency questions with a four-point Likert-type scale, which ranged from Rarely or None of the Time to Most or All of the Time. We used a five-point Likert-type scale, which ranged from Very Inaccurate to Very Accurate for how self-descriptive each item was. Examples of the questions for each deception category are presented in Table 3. for example questions from each category. The remainder of the questionnaire included the self-report personality measures as described above.

Personality Measures

Descriptive data for all the scales in this study are provided in Table 6.

International Personality Item Pool (IPIP). The IPIP (Goldberg, 1999) is a public domain personality inventory consisting of over 2000 items designed to be administered in a common item format. The development strategy for the inventory is based on a large-scale multinational collaboration of interested researchers, the data from which are freely available to all interested academics (http://ipip.ori.org/ipip). Participants read a series statements and indicate how accurately each statement describes them with a five-point Likert scale ranging from Very Inaccurate to Very Accurate. We administered 12 scales from the IPIP including Agreeableness, Deliberateness, Extraversion, Fairness, Impression Management, Integrity, Machiavellianism, Neuroticism, Responsibility, Risk-Taking, Self-Monitoring, and Sincerity.

Agreeableness assesses the tendency to be accommodating and pleasant in social situations. Deliberateness assesses thoughtfulness in action or decision. Extraversion assesses a tendency to be predominantly concerned with and obtain gratification from what is outside the self. Fairness assesses the tendency to follow rules and behave in a manner that is fair and just within society. Impression Management assesses the degree to which an individual attempts to control the impressions formed by others. Integrity assesses the degree of adherence to a strict moral or ethical code. Machiavellianism measures an individual's tendency to deceive and manipulate others for personal gain. Neuroticism assesses the degree to which an individual experiences negative emotional states. Responsibility assesses the tendency to be accountable for one's actions and their consequences. Risk-Taking measures the tendency to engage in behaviors that pose a risk to the individual or others associated with that individual. Self-Monitoring measures the tendency to regulate one's behavior in order to "look good" and be perceived by others in a favorable manner. Sincerity measures openness and truthfulness with others.

The State-Trait Anxiety Inventory (STAI)

The STAI (Spielberger *et al.*, 1970) is an instrument for measuring two types of anxiety in adults, State Anxiety, which can be described as the transitory nervousness that a person feels during testing and other situations and Trait Anxiety, which refers to a general and long-standing personality trait of nervousness. The State scale evaluates how participants feel "right now, at this moment". The Trait scale evaluates how participants feel "generally". Individuals respond to each item on a four-point Likert scale ranging from Not at all to Very Much So.

Center for Epidemiological Studies – Depression Scale (CES-D)

The CES-D (Radloff, 1977) is a common screening test used to determine an individual's level of depression. The scale measures depressive feelings and behaviors during the past week of the individual's life with questions such as, "I felt everything I did was an effort", which participants respond to with a four-point Likert scale ranging from Rarely or none of the time (< 1 day) to Most or all of the time (5-7 days).

Procedure

The questionnaire was posted online with the Flashlight™ Online questionnaire software provided by Washington State University (Washington State University Center for Teaching, 2005). Once they signed up via the participant pool, participants were directed to a website that contained the informed consent information. If they agreed to participate, they were directed to another website that contained the questionnaire. Participants were asked to respond to each item as accurately as possible and were given brief instructions for each section of the questionnaire.

Results

All questions were rescaled to a range of 1-4 before analysis.

Convergent Validity

Analyses examined whether each question was meaningfully correlated with its total category measure (sum). We defined a meaningful correlation as .5 and above based on Cohen's (1988) criteria for a strong correlation. These correlations are presented in Table 5. Some questions with correlation coefficients close to .5, ranging from .450 to .486, were still considered viable. Only three of the seven questions in the Gainful malice category passed this test. Overall, the other eight categories demonstrated consistent convergent validity. However, Concealments of the Truth and Verbal Trickery both contained one question that did not pass this test.

Discriminant Validity

Analyses examined whether the questions' correlations with their own categories were significantly higher than their correlations with the other categories. In order to test this, we computed each question's correlation with the total category measure for the other eight categories. We computed the mean of those correlations to get each question's average correlation with the other categories and then computed the mean of all of the questions in each category to get an average extracategory correlation. We then performed nine paired-samples t-tests to test the difference between the intercategory and extracategory correlations for each category. The results of those t-tests and the overall mean extracategory and intercategory correlations are presented in Table 6. Every category except for Gainful malice showed significant intercategory correlations, further suggesting the questions in that category do not demonstrate construct validity and giving further weight to the construct validity of the other eight categories.

Personality Variables

We performed correlations between each category's total sum and the summed score from each of our personality scales. Only those scales that were meaningfully correlated with at least one category were retained. Because of the large sample size, almost all correlations were significant, therefore, we defined a meaningful correlation as above .3, based on Cohen's (1988) cutoff for a moderate correlation. These correlations are presented in Table 7. The scales not meaningfully correlated with any of the categories were Extraversion, Machiavellianism, Risk-Taking, and Self-Monitoring.

Discussion

With the exception of the two questions regarding perjury (which we felt were not valid for a college population), the questions in Gainful malice were actually better representatives of other categories. We dropped that category from the next study. Two questions from the Concealment and Verbal Trickery categories, which did not show construct validity, were also eliminated. The Extraversion, Risk-Taking, and Self-Monitoring scales were excluded, as they do not inform the deception categories. The IPIP Machiavellianism scale did not provide explanatory variance; however, the construct of Machiavellianism has been consistently associated with lying behavior in the literature. In experiment 2, we adopted a new scale of Machiavellianism.

Experiment 2

In Experiment 2, we administered the remaining eight deceptive categories and re-administered the remaining personality scales including a new Machiavellianism scale, the MACH-IV (Christie & Geis, 1970) to a second sample of college students. McLeod and Genereux (2008) used this scale and we felt it was more comprehensive. The goal of the second experiment was to test the hypothesis that a unique combination of personality variables could predict each of our eight deceptive categories.

Methods

Participants

Participants were 286 (206 females) undergraduates at the University of South Carolina. Ages ranged from 18 – 51 with a mean age of 19.86 years (SD = 2.78). Participants were recruited in the same manner as experiment 1.

Design and Materials

In the second study we utilized frequency type questions with a four-point Likert-type scale, which ranged from Never to Frequently. Content of the questions remained the same from Experiment 1 to Experiment 2. The remainder of the questionnaire included the self-report personality measures as described above.

Procedure

The questionnaire was posted online with the open-source Lime Survey program. Participants were redirected to the questionnaire through the experiment pool in the same manner as experiment 1. Participants were asked to respond to each item as accurately as possible and were given brief instructions for each section of the questionnaire.

Results and Discussion

Means and standard deviations for the raw scores of the personality scales are presented in Table 8. Data assumption checks revealed one multivariate outlier, which was deleted from further analyses. Scores from several scales were normalized: Agreeableness, Fairness, Responsibility, and Sincerity (reflection and sqrt), Depression, Gainful Misleading, Gainful Falsification of Record (log), Verbal Trickery and Verbal malice (sqrt).

Descriptive statistics for the lie categories are presented in Table 9. Gainful Misleading was the least frequently used lie and Social Enhancement was the most frequently used lie. Bivariate correlations for the personality scales are presented in Table 10. Correlations between the personality scales ranged from -0.11 to 0.86 for state and trait anxiety.

Using the personality measures as predictor variables, standard multiple regression analyses were conducted to predict the frequency of each of the eight lie categories separately. Results of the eight regression analyses are summarized in Table 11. The results of Experiment 2 support our hypothesis that a unique combination of personality characteristics is associated with each type of lie. We expected that sincerity would be involved in most types of deception as the measure explicitly assesses truthfulness and openness with others. Two categories of lies did not involve lower scores on sincerity: gainful misleading and gainful falsification of record. These two categories contain items that does not include direct social interaction. Each of the categories is discussed in detail below.

Avoidance

Individuals with lower scores on sincerity, responsibility, and integrity tended to employ more avoidance lies than individuals with high scores on these measures. Avoidance lies involve attempts to escape or minimize penalties associated with a specific incidence of inappropriate behavior. The relationship of lower scores on responsibility, a measure of personal accountability, and integrity, a measure of adherence to a strict moral code to avoidance lies was predicted. Lower scores on sincerity was a predictor of higher frequencies of avoidance lies.

Concealment

Individuals with lower scores on integrity and sincerity, but higher scores on depression tended to have higher scores on concealment. Concealment lies involve hypocritical acts in which people misrepresent a quality within themselves. Unlike avoidance lies which occur after a specific act, concealment lies involve ongoing deceptions. Lower scores on integrity, a measure of strict adherence to a moral code, and sincerity, openness and truthfulness with others are predictors of this type of deception. Depression is positively associated with greater use of concealment lies.

Gainful Misleading

Individuals with lower scores on fairness combined with higher scores on impression management tended to report higher scores on Gainful Misleading. Gainful misleading refers to lies that are employed to extract a specific benefit from another person. Unlike avoidance lies, which occur after an act, and concealment lies, which occur in an ongoing manner; gainful misleading lies represent a deception during a specific action such as a fraud. Higher reported frequencies of gainful misleading are associated with lower scores on fairness, the tendency to follow rules and behave in a manner that is fair and just within society. Gainful misleading lies depend on a person's ability to control the impressions formed by others generally in the attempt to extract undeserved benefits from them. Individuals who cannot successfully employ impression management cannot successfully employ gainful misleading lies.

Interpersonal Ploys and Social Enhancements

Individuals with lower scores on sincerity combined with higher scores on depression and impression management tended to report a greater usage of interpersonal ploys. Interpersonal ploys involve deceptions within social interactions. Unlike social enhancements, which have an underlying motivation of improving one's social standing by impressing others or gaining sympathy from others, the underlying motivation of an interpersonal ploy is to manage the quality of an ongoing conversation by avoiding unpleasant information. Low scores in sincerity and high scores in impression management predicted both interpersonal ploys and social enhancements; however, only the use of interpersonal ploys was associated with higher self-reported depression.

Verbal Malice

Individuals with low scores on sincerity, fairness, and integrity reported a greater usage of verbal malice lies. Verbal malice lies involve deceptions that tend to cause harm to another person while simultaneously benefiting the person causing the harm. A higher frequency of verbal malice lies was predicted by lower scores in sincerity, fairness and integrity. As verbal malice lies are told in order to benefit oneself or to harm another person without the consideration of that person's feelings, the relationship between integrity and verbal malice was predicted. Verbal malice lies are also told to gain an unjust advantage or to cause unwarranted harm, and for that reason the relationship between fairness and verbal malice was predicted. The relationship between sincerity and verbal malice was predicted in that lower scores in sincerity are related to all categories of verbal lies.

Verbal Trickery

Individuals who self-reported greater impression management and agreeableness scores combined with lower scores on sincerity and fairness reported a greater usage of verbal trickeries. Verbal trickeries involve lies in which one states that one will engage in one behavior while proceeding to engage in a less socially desirable behavior. Unlike avoidance lies, verbal trickeries involve future behaviors and typically less severe infractions. Unlike, concealment lies verbal trickeries involve single instances of a behavior or a specific sub-set of a behavior rather than an emotional state. Higher rates of verbal trickeries are associated with high scores on impression management and agreeableness suggesting that an underlying motivation of verbal trickeries is to smooth social interaction. However, unlike interpersonal ploys and social enhancements the motivation of verbal trickery is clearly to avoid confrontation about a socially unacceptable act one intends to perform.

General Discussion

Our attempt at creating a measureable taxonomy of deception was relatively successful. We were able to create eight categories of deceptions and questions to assess their use. We feel that it is an improvement over previous attempts because it is much more comprehensive. It also goes beyond a purely descriptive approach by allowing the language to guide the categorization process. However, we would like to point out that there is not just one correct way of classifying deception.

Overall, the results of Experiment 2 supported our hypotheses. However, we were surprised to find poor relationships between Machiavellianism and several categories of deceptions, particularly social enhancement, verbal malice, and verbal trickery.

We feel that out results support and extend those of McLeod and Genereux (2008). (MICHELLE THIS bit is IS BACK TO YOU)

Another eventual goal of this work is to investigate cross-cultural differences in deceptive behavior. These differences are an important topic in present day and previous research suggests these differences may exist. Lalwani, Shavitt, & Johnson (2006) reported that frequency and type of lying as a function of maintaining socially appropriate behavior differed between those in collectivist and individualist cultures. Chunsheng (2002) reported differences between Chinese and American participants regarding likelihood to tell lies in general and those that were not perceived as harmful. Finally, Sims (2002) reported differences between United States and Israeli employees regarding attitudes toward deception for gain in the workplace. These studies and others provide strong support for an investigation of cross-cultural differences in a comprehensive deceptive behavior questionnaire such as our own.

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Table 1

Examples of open-Ended Definitions of Deceptive Word Categories from expert practitioners in the field of deception detection (N=14).

Expert's Definitions
1. Lie; misinformation; patronize/politicize; poke fun at; insincere; covert operative; act/pretend; deceive; odd; black lie
2. Lie for fun
3. Lies people use to bolster their social interaction
4. Verbal comments made to give a false impression of the actual truth
5. Misrepresentation
6. An exaggeration without doing any real harm
7. Fake
8. Misleading lies
9. To be somebody you're not
10. Exaggeration
11. Relates more to a personality ploy, i.e. lie like a car salesman
12. Lies to misrepresent oneself
13. A lie that is made up or fabricated

Table 2

Refinements of the component loadings of deception categories based on expert ratings from practitioners in the field of deception detection (N=14).

Category Exemplar	Evasion	Palter	Fraud	Perjury	Fraud	Embellish	Deception	Dissimulation
	Equivocate	[illegible]	Cheat	Perfidious	[illegible]	Mask	Backbite	[illegible]
	[illegible]	Song-and-dance	[illegible]	Pervert	Dupe	Exaggeration	Deception	Misinformation
	Play Down	Chicanery	Fraud	Deception	Fraudulent	Embroider	Guile	Self-serving
	Evasion	Mislead	Fraudulent	Disguise	Duplicity	Embellish	Obloquy	Dissimulation
	Color	Prevaricate	Con	Deceit	Calumny	Slant		Dissemble
	Gloss	Guile	Counterfeit	Defame	Delude			Casuistry
	[illegible]	Color	Forgery	Sabotage	Frame			Wile
	Bluff	Hypocrisy	Fake	Forswear	Con			Feign
		Spoof		Aspersion	Hoax			
		Falsify		Smear	Libel			
		Mendacity		Vilify	Fraud			
		Break Promise		Perjure	Lie			
		Misrepresent		Perjury	Slander			
		Palter		Sell Down the River	Smear			
				Malign				
				Fib				
Final Category Name	Avoidance	Concealment	Careful Falsification of Record	Careful Malice	Careful Misleading	Social Enhancement	Verbal malice	Verbal Trickery

Note: Words that contain a strikethrough were eliminated based on experts' ratings

Table 3

Scale properties and Descriptive statistics for lie scales in Experiment 1 (N=446).

Deception Category	Sample Question	Item Count	Score Range	Descriptive Statistics	
				M	SD
Avoidance	How often do you change the subject in a conversation in order to avoid telling the truth?	4	4-16	8.44	2.20
Concealment	How often do you leave out the details of a story to lead someone to the wrong conclusion?	5	5-20	10.98	2.59
Deceitful Falsification of Record	I would lie to an insurance company to get money.	5	5-20	8.70	2.89
Deceitful Malice	I would smear another person's reputation if it meant getting something I want.	7	7-28	6.58	2.25
Deceitful Misleading	How often do you pretend to be someone else on the internet?	4	4-16	6.63	1.96
Interpersonal Ploy	How often do you put up a front?	4	4-16	7.84	2.45
Social Enhancement	How often do you exaggerate a story to impress others?	5	5-20	11.77	3.72
Verbal Trickery	How often do you feign illness to get out of an obligation?	5	5-20	10.27	2.85
Verbal Malice	How often do you say untrue, hurtful things about someone else in order to gain revenge?	5	5-20	7.14	2.25

Table 4
Intercategory Correlations in Experiment 1 (N=446) Between the Scores for each Item in a Deception Category and the Total Score for the Category.

Intercategory Item Number	Deception Category								
	Avoidance	Concealment	Guileful Falsification of Record	Guileful Malice	Guileful Misleading	Interpersonal Ploy	Social Enhancement	Verbal Malice	Verbal Trickery
1	0.71	0.75	0.64	0.63	0.62	0.72	0.77	0.77	0.49
2	0.72	0.73	0.76	0.48	0.62	0.80	0.62	0.80	0.45
3	0.75	0.47	0.80	0.45	0.54	0.71	0.77	0.79	0.67
4	0.52	0.65	0.70	0.40	0.66	0.68	0.75	0.70	0.28
5		0.18	0.67	0.27			0.63	0.74	0.61
6				0.28					
7				0.38					

Table 5

Mean Extra- and Intercategory Correlations, and Extra-Intercategory T-Tests for each Deception Category for Experiment 1 (N=446)

Deception Category	Category Means		t-value
	Extra-	Inter-	
Avoidance	0.39	0.68	-5.49*
Concealment	0.29	0.57	-21.15***
Careful Fabrication of Record	0.33	0.69	-17.13***
Careful Malice	0.39	0.41	-0.63
Careful Misleading	0.29	0.61	-5.42*
Interpersonal Play	0.34	0.73	-4.57*
Social Enhancement	0.38	0.71	-17.73***
Verbal Trickery	0.24	0.50	-3.66*
Verbal Malice	0.39	0.76	-22.13***

*$p < .05$
***$p < .001$

Table 6

Scale Properties and Descriptive statistics (N=446) for IPIP, STAI, and CES-D Measures in Experiment 1.

	Scale Characteristics		Sample Descriptors	
Name	Items	Score Range	M(N=446)	SD
IPIP				
Agreeableness	20	20-100	77.80	12.84
Deliberateness	10	10-50	33.15	6.45
Extraversion	20	20-100	67.78	12.58
Fairness	10	10-50	37.88	6.90
Impression Management	20	20-100	65.45	9.78
Integrity	9	9-45	35.11	5.80
Machiavellianism	6	6-30	19.20	4.09
Neuroticism	20	20-100	54.08	13.09
Responsibility	10	10-50	37.35	6.12
Risk-Taking	10	10-50	28.93	6.62
Self-Monitoring	10	10-50	30.33	5.62
Sincerity	10	10-50	35.96	7.33
STAI				
State	20	20-80	39.80	12.52
Trait	20	20-80	40.25	10.58
CES-D				
Depression	20	0-60	35.09	10.58

Table 7
Correlations between sub-categories of deception and personality inventories in a college population (N=446).

Personality Inventory	Deception Category							
	Avoidance	Concealment	Deceitful Falsification of Record	Deceitful Misleading	Interpersonal Play	Social Enhancement	Verbal Malice	Verbal Trickery
IPIP								
Agreeableness	-0.17	-0.37	-0.54	-0.40	-0.25	-0.52	-0.56	-0.14
Deliberateness	-0.36	-0.38	-0.30	-0.36	-0.38	-0.49	-0.34	-0.26
Extraversion	-0.34	-0.19	-0.19	-0.34	-0.25	-0.19	-0.24	0.00
Fairness	-0.26	-0.43	-0.56	-0.51	-0.23	-0.47	-0.52	-0.28
Impression Management	-0.36	-0.44	-0.40	-0.45	-0.36	-0.49	-0.45	-0.36
Integrity	-0.57	-0.52	-0.59	-0.49	-0.41	-0.55	-0.64	-0.30
Machiavellianism	0.11	0.10	0.04	0.17	0.14	0.21	0.05	0.25
Neuroticism	0.28	0.28	0.19	0.15	0.42	0.31	0.29	0.21
Responsibility	-0.30	-0.47	-0.47	-0.52	-0.30	-0.46	-0.54	-0.29
Risk-Taking	0.23	0.16	0.21	0.29	0.11	0.26	0.13	0.18
Self-Monitoring	-0.06	0.03	0.01	0.10	-0.03	0.11	-0.02	0.03
Security	-0.41	-0.47	-0.48	-0.46	-0.53	-0.67	-0.55	-0.53
STAI								
State	0.25	0.27	0.24	0.17	0.35	0.27	0.32	0.13
Trait	0.29	0.32	0.25	0.20	0.45	0.33	0.36	0.18
CES-D								
Depression	0.28	0.35	0.29	0.23	0.41	0.29	0.35	0.19

Table 8

Descriptive statistics for IPIP, STAI, and CES-D Measures in Experiment 2 (N=286).

SCALE	*M*	*SD*
IPIP		
Agreeableness	79.54	11.09
Deliberateness	31.16	5.35
Fairness	40.61	6.50
Impression Management	67.19	10.20
Integrity	36.23	4.48
Responsibility	39.04	5.54
Machiavellianism	53.13	8.40
Neuroticism	53.74	14.09
Sincerity	38.09	6.74
STAI		
Trait anxiety	40.99	10.27
State anxiety	40.28	10.88
CES		
Depression	34.78	8.39

Table 9
Scale properties and Descriptive statistics for lie scales in Experiment 2 (N=286).

Deception Category	Item Count	Score Range	*M*	*SD*
Avoidance	4	4-16	8.09	1.57
Concealment	4	4-16	7.68	1.99
Careful Falsification of Record	5	5-20	7.23	2.05
Careful Misleading	4	4-16	6.52	2.01
Interpersonal Ploy	4	4-16	9.40	2.00
Social Enhancement	5	5-20	10.41	2.84
Verbal Malice	5	5-20	7.96	2.59
Verbal Trickery	5	5-20	9.11	2.43

Table 10
Correlations among personality measures in Experiment 2 (N=286).

Name	AG	DE	FA	IM	IN	MA	NR	RS	SN	SA	TA
IPIP											
Agreeableness											
Deliberateness	0.44										
Fairness	0.52	0.42									
Impression Management	-0.47	-0.55	-0.71								
Integrity	0.63	0.51	0.63	-0.66							
Machiavellianism	-0.54	-0.33	-0.56	0.54	-0.53						
Neuroticism	-0.17	-0.33	-0.09	0.25	-0.36	0.25					
Responsibility	0.61	0.44	0.80	-0.71	0.66	-0.53	-0.13				
Sincerity	0.44	0.46	0.57	-0.67	0.64	-0.52	-0.28	0.60			
STAI											
State	-0.12	-0.24	-0.11	0.15	-0.29	0.16	0.65	-0.11	-0.17		
Trait	-0.39	-0.28	-0.14	0.19	-0.38	0.23	0.74	-0.13	-0.23	0.86	
CES-D											
Depression	0.44	-0.31	0.42	0.24	-0.42	0.28	-0.33	-0.24	-0.26	0.78	0.77

Note: AG = Agreeableness, DE = Deliberateness, FA = Fairness, IM = Impression Management, IN = Integrity, MA = Machiavellianism, NR = Neuroticism, RS = Responsibility, SN = Sincerity, SA = State Anxiety, TA = Trait Anxiety

Table 11

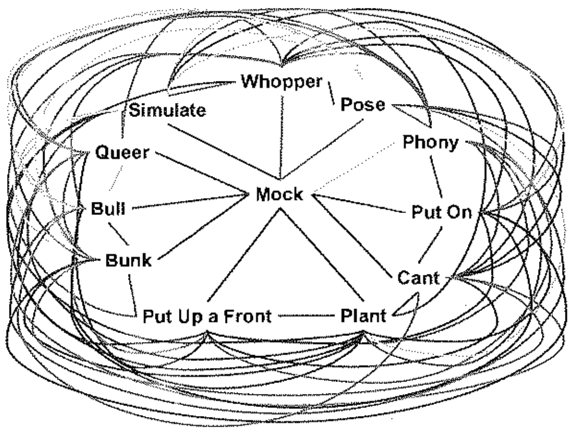
Results of the standard multiple regression analyses of personality inventories on deception categories in experiment 2 (N=286).

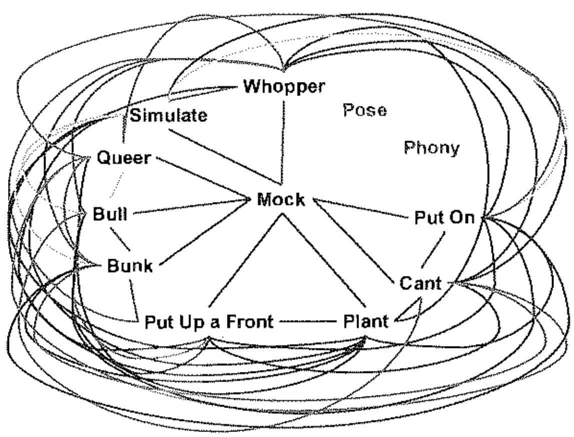
Type of lie and predictors	R	R^2	Adj. R^2	F	B	β
Avoidance	0.52	0.27	0.26	34.13***		
Sincerity					-0.35	-0.22**
Responsibility					-0.37	-0.20**
Integrity					-0.05	-0.18*
Concealment	0.65	0.42	0.41	66.69***		
Integrity					-0.17	-0.39***
Sincerity					-0.47	-0.24***
Depression					2.72	0.14**
Careful Falsification of Record	0.65	0.42	0.42	69.07***		
Fairness					-0.03	-0.25**
Integrity					-0.01	-0.27***
Responsibility					-0.03	-0.20*
Careful Misleading	0.55	0.30	0.30	60.36***		
Fairness					-0.04	-0.33***
Impression Management					0.09	0.26***
Interpersonal Ploys	0.61	0.37	0.37	55.54***		
Sincerity					-0.60	-0.34***
Depression					4.24	0.27***
Impression Management					0.06	0.21**
Social Enhancement	0.69	0.47	0.47	126.02***		
Sincerity					-1.18	-0.43***
Impression Management					0.09	0.34***
Verbal Malice	0.72	0.52	0.52	101.33***		
Sincerity					-0.14	-0.31***
Fairness					-0.12	-0.26***
Integrity					-0.02	-0.24***
Verbal Trickery	0.75	0.56	0.55	87.36***		
Impression Management					0.01	0.30***
Sincerity					-0.13	-0.32***
Fairness					-0.12	-0.30***
Agreeableness					0.04	0.12*

*p<.05
**p<.01
***p<.001

Figure Captions

Figure 1. Correlation clouds of word belongingness for component two. Top graph shows original component structure. Bottom graph shows final structure with two words eliminated.





.60 – 1.00 .30 - .60 .10 - .30 .0-.10 Negative Correlation

Appendix A. Questions for Assessment of Deceptive Categories.

Avoidance
How often do you/would you change the subject while in conversation in order to avoid telling the truth?
How often do you/would you play it down when someone hurts your feelings?
How often do you/would you lie to protect someone else's feelings?
How often do you/would you leave out the details of a story to mislead someone?

Concealment
How often do you/would you leave out the details of a story to lead someone to the wrong conclusion?
How often do you/would you confuse the details of a story to stop someone from understanding the truth?
How often do you/would you tell someone how to live his/her life while not following the same rules?
How often do you/would you make a promise you have no intention of keeping?

Interpersonal Ploy
How often do you/would you hide your true feelings in front of others?
How often do you/would you put up a front?
How often do you/would you add fictitious details to or make up a story about something that happened to you?
How often do you/would you exaggerate when retelling a rumor?

Gainful Falsification of Record
How often do you/would you play a practical joke intended to mislead someone?
How often do you/would you copy someone else's work and present it as your own?
How often do you/would you purchase someone else's work and present it as your own?
How often do you/would you lie to an insurance company to receive money?
How often do you/would you write a check even though you know it will bounce?

Gainful Misleading
How often do you/would you dupe someone out of money or goods?
How often do you/would you pretend to be someone else on the internet?
How often do you/would you give false information on the internet?
How often do you/would you use a false I.D. to gain entrance to a place you are not allowed?

Social Enhancement
How often do you/would you exaggerate a story to impress others?
How often do you/would you exaggerate a situation in order to gain sympathy from others?
How often do you/would you put a positive slant on something to make it seem better than it was?
How often do you/would you lie to impress a date?
How often do you/would you make up a good story to impress others?

Verbal Malice

How often do you/would you start an untrue rumor about someone?
How often do you/would you say untrue, hurtful things about someone else in order to gain revenge?
How often do you/would you say untrue things about someone else in order to make yourself look better than him/her?
How often do you/would you lie to get ahead at work?
How often do you/would you start a rumor about someone if he/she started a rumor about you?

Verbal Trickery

How often do you/would you feign illness to get out of an obligation?
How often do you/would you cheat in school?
How often do you/would you use flattery to get ahead?
How often do you/would you cheat if you signed an oath saying you would not?
How often do you/would you befriend somebody because he/she has something you want?

Appendix 3: Curriculum Vita

Curriculum Vita

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EDUCATION

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Coplin, J. M. (nee Vendemia, J. M. C.), Knebel, T. F. & Crawford, H. J (1994). Cold pressor pain: EEG topographical pattern differences before and during dips as measured by cognitive variables. *Psychophysiology, 31 (Suppl. 1),* S36.

GRANT HISTORY

JAN2007-JAN2009 **Principal Investigator**. ***Continuation Brain Imaging Research: The Detection of Deception Utilizing HD-ERP, fMRI, and Pupillometry.*** ($1,250,000). *U.S. Army Medical Research Acquisition Activity, USAMRAA.* The goal of this project is to build a program of research directed towards deception modeling at the neuroscientific level with the ultimate objective of mapping the neurocognitive processes of lying, and to extend this research from the laboratory into the field environment. The program of study funded by this Congressional Earmark will extend an ongoing deception research program with a sequence of theoretically interlocking studies that measure ERPs and fMRIs in parallel designs. ERPs have good time resolution while fMRI measures have strong spatial resolution. Parallel acquisition allows us to map the time course of interacting cortical networks, and pin-point structures within these networks, critical to the act of deception. The proposed sequence focuses on the roles of the attention networks. Major hypotheses: Pre-stimulus preparatory ERPs in the anterior regions should occur preceding deceptive responses. fMRIs of the same paradigm should reveal activity in the anterior cingulate cortex. Task demands will modulate the activity of the posterior- and anterior- attention networks. When task demands elicit a deceptive response type on significantly fewer trials than a truthful response type, we anticipate a large positive waveform over the right posterior parietal region; however, when demands require similar rates of response types we predict suppression of this waveform. fMRI activations should reveal posterior parietal activity during infrequent deceptions and dorsolateral prefrontal activations during frequent deceptions. We predict that disengagement of the attention system in deceptive trials will be correlated with a strong negative component that occurs approximately 100 ms post-response and with fMRI activity in the anterior cingulate. We anticipate an N400 during successful retrieval from long-term memory, which will correlate with fMRI activations in the left superior temporal gyrus. The N400 amplitude should be smaller during retrieval failure, and be associated with diffuse activation over temporal and parietal regions.

DEC2005-DEC2008 Principal Investigator. ***Brain Imaging Research: The Detection of Deception Utilizing HD-ERP, fMRI, and Pupillometry.*** ($3,660,000). *U.S. Army Medical Research Acquisition Activity, USAMRAA.* This grant provides funding for a program of research that has the potential to greatly enhance existing national security efforts, especially in the realm of counterterrorism. Human deception is a complex process that traditional detection measures cannot validly assess. However, research conducted to-date on the neurocognitive processes underlying human deception suggests that the central nervous system, unlike the peripheral nervous system, may be a valid source of information about deception. That is why research on the neurocognitive processes involved in deception is so important.

JAN2006-OCT2006 Principal Investigator. ***Extension Brain Imaging Research: The Detection of Deception Utilizing HD-ERP, fMRI, and Pupillometry.*** ($300,000). *U.S. Army Medical Research Acquisition Activity, USAMRAA.* The purpose of the added funds is to provide a secondary line or research (in addition the existing cognitive research) to address personality correlates of deceptive responding. This research will build and extend the body of knowledge obtained from a series of studies conducted in this lab which delineate Event-Related Potential and functional Magnetic Resonance Imaging based markers of deceptive behavior to semantic and autobiographical questions. The overarching goal of this funding is to develop a technique for predicting individual truthful and deceptive statements about autobiographical information based on high-density event related potential technology and to develop a battery of personality tests that could potentially isolate error variance in current technologies utilized to detect deception and apply them in current studies.

SEP2003-SEP2005 Principal Investigator. ***Modeling the Neurocognitive Processes of Deception.*** ($487,000). *National Science Foundation.* Cognitive theorists argue that the process of deception may involve such constructs as attentional capture, working memory load, or perceived incongruity with memory, while psychophysiologists argue for stimulus salience, motivation, arousal, and emotion. The proposed sequence of studies will investigate a model of deception, utilizing high-density event related potentials and fMRI activation, that combines evidence from both arenas, and will combine measurement techniques from both fields of investigation.

JUN2002-DEC2004 **Principal Investigator**. ***Continuation Research Assistant Professor Research / Research Training in Cognitive Psychophysiology and Detection of Deception.*** ($350,000). *Department of Defense Polygraph Institute.* Based on research in the prior grant sources which have been located, and a potential theory of deceptive responding which has been developed based on activity in the right anterior cingulate (Brodmann's area 32), left superior frontal gyrus (Broadmann's area 6), right medial frontal gyrus (Brodmann's area 10), and bilateral regions of the medial temporal gyrus (Brodmann's area 21; Vendemia & Buzan, in press). Models of deception will be further investigated. It now may be possible to formulate new deception detection techniques that can use specific brain activity as an independent indicator of deception.

JUN2000-JUN2002 **Co-Investigator**. ***Research Assistant Professor Research / Research Training in Cognitive Psychophysiology and Detection of Deception.*** ($321,964). *Department of Defense Polygraph Institute.* This purpose of this grant was to support a Research Assistant Professor in the Department of Psychology at the University of South Carolina to do research and research training in cognitive psychophysiology and the detection of deception. Particular emphasis involved, the use of polygraphs and the measurement of peripheral physiological processes in the detection of deception supplemented by measurement of the electroencephalogram (EEG) and scalp-recorded event-related-potentials (ERP). This work proposed the EEG or ERP as a tool for forensic psychophysiology and in identifying the brain areas that may be involved in deception.

EMPLOYMENT HISTORY

AUG2007-AUG2015 **Associate Professor**. Department of Psychology, University of South Carolina. *Charlie Mactutus* Graduate and Undergraduate Instruction. Continue to conduct research program in neuroscientific modeling of deceptive behavior.

JUN2000-SEP2008 **Research Assistant Professor**. Department of Psychology, University of South Carolina. *2000-2004, JeanAnn Linney; 2004 - 2005, John E. Richards; 2005 - 2008, Charles H. Mactutus, Ph.D.* This position requires experience in maintaining an ongoing funded program of research, instructional experience, and experience interacting with national agencies for the purpose of developing research paradigms with real world applicability. Research Responsibilities: Maintain an ongoing program of research dedicated to the systematic neuroscienfic modeling of deception. From 2000 until 2004 the primary goals of this program were to conduct basic research in cognitive psychophysiology for the purpose of exploring brain-periphery relations during the detection of deception with electrophysiological measures. Research included investigating the High Density - Event Related Potential (HD-ERP) correlates of deceptive responses and mapping their time domains. The long-term goals of this project involved: 1) Investigate and localize deception-specific cortical sources with analyses of HD-ERP scalp topography, 2) investigate specific effects of deception on HD-ERP topography, and 3) use HD-ERP recording montages to localize the sources of topographical differences. Sponsors (2000-2004, Department of Defense Polygraph Institute; 2003-2005, National Science Foundation. In 2004, based on the success of the initial program, the program of research underwent a substantial theoretical and practical expansion--and was provided support to create and maintain a Center for Alternative Technologies for Deception Detection (CATDD). The new research goals are to: 1) Include extensive fMRI dependent variables within the neuroscientific level of deception modeling, 2) incorporate dependent variables measures of inindividual differences within the paradigms, 3) provide a centralized focus for the dissemination of relevant information to the professional community, 4) develop accurate testing strategies for use with alternative technologies, and 5) extend ongoing research into the field environment. The creation of the CATDD, the purchase of the Siemen's 3t magnet, and the acquisition of appropriate data analysis systems were made possible through a $3.66m Congressional Earmark (2005-2008, United States Army Medical and Material Command). An additional Earmark was granted in 2006 that extended the program a sequence of theoretically interlocking studies that measure HD-ERPs and fMRIs in parallel designs. ERPs have good time resolution while fMRI measures have strong spatial resolution (2007-2009, United States Army Medical and Material Command). Parallel acquisition allows us to map the time course of interacting cortical networks, and pin-point structures within these networks, critical to the act of deception. The proposed sequence focuses on the roles of the attention networks. Major hypotheses: Pre-stimulus preparatory ERPs in the anterior regions should occur preceding deceptive responses. fMRIs of the same paradigm should reveal activity in the anterior cingulate cortex. Task demands will modulate the activity of the posterior- and anterior-attention networks. When task demands elicit a deceptive response type on significantly fewer trials than a truthful response type, a large positive waveform over the right posterior parietal region is expected; however, when demands require similar rates of response types, suppression of this waveform is predicted. fMRI activations should reveal posterior parietal activity during infrequent deceptions and dorsolateral prefrontal activations during frequent deceptions. It is also predicted that disengagement of the attention system in deceptive trials will be correlated with a strong negative component that occurs approximately 100 ms post-response and with fMRI activity in the anterior cingulate. The N400 is predicted to appear dominantly in the HD-ERP during successful retrieval from long-term memory, which will correlate with fMRI activations in the left superior temporal gyrus. The N400 amplitude should be smaller during retrieval failure, and be associated with diffuse activation over temporal and parietal regions. In order to achieve the research goals of the CATDD as stipulated by the supporting agencies this position requires: 1) Research experience with HD-ERP, Pupillometry, fMRI, and behavioral measures, 2) extensive contacts within the intelligence and interrogator/examiner communities, and 3) a background in the neuroscienfic modeling of deceptive behaviors. Additionally, this position entails contributing to the training program at the Department of Psychology particularly instruction of students at the graduate and undergraduate levels within the areas of neuroscience, cognition, statistical modeling, and HD-EEG/ERP as well as fMRI.

AUG1999-MAY2000 **Instructor**. Department of Psychology, University of Georgia, Athens, GA. *Chester Karwoski, Ph.D.* Taught courses at the undergraduate and graduate levels in the areas of Advanced General Psychology, Introductory Psychology, Honors Introductory Psychology, and History of Psychology. Mentored undergraduate students.

AUG1998-AUG1999 **Postdoctoral Teaching and Research**. Department of Psychology, University of Georgia, Athens, GA. *Chester Karwoski, Ph.D.* Course instructor for graduate and undergraduate classes in the areas of Sensation/Perception, Cognition, Advanced General Psychology, Introductory Psychology, and Honors Instroductory Psychology. Designed and conducted research pertaining to response inhibition across spatial frequency patterns.

MAY1997-AUG1998 **Lab Coordinator**. Department of Psychology, Psychophysiological, Virginia Polytechnic Institute and State University, Blacksburg, VA. *Jack Finney, Ph.D.* Redesigned departmental lab space containing multiple EEG, eyetracking, psychophysiological and behavioral measurement systems. Developed of lab guidelines, repaired and maintened on 10 psychophysiological recording stations, identified damaged equipment including, but not limited to. EEG caps, leads, cords, bioamplifiers, computer cards and development of a new menu system for data handling. Requirements included familiarity with the following software and software driven systems: Windows 95, Windows 3.x, Neuroscan 3.0 & 4.0 EEG/ERP workstation, Lexicor Neurosearch-24 EEG/ERP workstation, Vision Lab, LC Technologies Eyegaze software, A-Codas and Dos 3.0, 5.0.

JAN1998-MAY1998 **Coordinator of Graduate Applications**. Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA. *Jack Finney, Ph.D.* Coordinated application materials to the Graduate Experimental, Clinical, and Industrial/Organizational programs, including maintaining a computer database of all demographic and scholastic information for applicants to the graduate psychology program, generating weekly status reports of applicants for each specialty area within psychology, communicating with all levels of faculty and staff regarding status of applicants, and answering all queries regarding applicant standing.

JAN1992-MAY1997 **Student Trainee**. Department of Psychology, Department of Veteran's Affairs Medical Center, Salem, VA. *James J. Lanter, Ph.D. and Jerome Gilmore, Ph.D.* Designed research projects and consulted with all levels of staff in regard to ongoing projects, assisted with statistical analysis on ongoing research projects and audited medical research projects for the Human Subjects Committee. Clinical responsibilities included program design and selection of therapeutic techniques to be used in the Smoking Cessation Program. Specific duties related to the Smoking Program included screening and scheduling of patients, formulating individual treatment plans, consulting with staff physicians on individual cases to arrange for prescriptions of Nicotine Replacement Patch, and design and maintenance of the Smoking Cessation Instruction Manual for use in the clinic. Additional clinical responsibilities included the yearly psychological evaluation of spinal cord patients.

AUG1995-MAY1997 **Instructor**. Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA. *Jack Finney, Ph.D. and Helen J. Crawford, Ph.D.* Designed course syllabus; selected of textbooks and other course materials; designed, lectured, administered and gradied exams for classes of 60 - 90 students. Courses taught: Research Methods, Psychology of Learning and Psychology of Personality.

MAY1997-DEC1997 **Graduate Research Assistant**. Department of Psychology, Neurocognition Laboratory, Virginia Polytechnic Institute and State University, Blacksburg, VA. *Helen J. Crawford, Ph.D.* Senior Research Assistant on grant-sponsored research consisting of a joint study (P.I.: Helen Crawford) between Virginia Polytechnic Institute and State University and the University of Virginia investigating functional Magnetic Resonance Imaging (fMRI) correlates of pain and non-pain conditions during different levels of attention, as modified by individual differences in attentional processes. As the project coordinator, duties included overall coordinating of daily activities, planning and execution of all research projects, conducting cold presser training, and supervision of undergraduate assistants receiving field study course credit for their participation. Other duties included working with the UVA team during recording and analyses of fMRI data, and maintaining ongoing education involving analysis of fMRI data.

JUN1995-SEP1996 **Research Assistant**. Endocrine Section, Department of Veteran's Affairs Medical Center, Salem, VA. *Kim Ragsdale, Ph.D.* Co-investigator in a study investigating the endocrine concomitants of cigarette smoking and smoking cessation in chronic smokers and matched controls.

JAN1994-MAY1995 **Graduate Research Assistant**. Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA. *Helen J. Crawford, Ph.D.* Conducted research for a NASA Langley Research Center grant involving the EEG descriptors of attentional performance in low and high sustained attention subjects performing computer simulated pilot decision making tasks under varying workload. Responsibilities included developing running the experimental paradigm, recording EEG data, screening EEG data for artifacts and preparing manuscripts. Position required complete familiarity with the Neurosearch-24 bioamplifiers and the Lexicor Recording System.

JAN1994-MAY1994 **Graduate Research Assistant**. Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA. *Helen J. Crawford, Ph.D.* NIH grant involving the EEG and SEP correlates of pain control in adults with chronic low back pain and matched control subjects. Operated Grass amplifiers and recording system and a Lexicor Neurosearch-24 EEG machine. Joint study with the Brain Center, Radford University, (Director: Karl Pribram, M.D.).

JAN1993-MAY1993 **Guest Lecturer**. Department of Psychology, Hollins College, Hollins, VA. *George Ledger, Ph.D.* Lectured on advanced topics in physiological psychology.

AUG1993-DEC1993 **Graduate Teaching Assistant**. Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA. *Mike Casey, M.S.* Lead discussion sections of approximately 50 students in which topics relevant to the main introductory psychology course were explored.

OCT1990-DEC1991 **Volunteer Research Student**. Department of Psychology, Department of Veteran's Affairs Medical Center, Salem, VA. *James Lanter, Ph.D. and David Harrison, Ph.D.* Screened elderly patients using the Mini-Mental Status for a study involving altered rates of positron emission across pseudo-depressive, alcohol related and Alzheimer's type dementias. Coordinated an experiment involving the effects of bright light exposure on accuracy and response time during a dichotic listening study in unilateral stroke patients.

SERVICE

- **Speaker and Discussant, (6/16/2003-6/19/2003).** *Steering Committee.* MITRE Corporation, U.S. Department of Defense. Analyst of the Future, *Neuroscientific Modeling of Deception with HD-ERP and fMRI*

- **Speaker and Panel,** (11/5/2004-11/6/2004). *DecDet Fall Workshop.* Georgetown University. Advanced Theoretical Models of Deception, *Models of Deceptive Behavior.*

- **Testimony to Congress,** (5/17/2005-5/17/2005). *Congressional Testimony.* American Psychological Association. Oral Testimony of Jennifer Vendemia, Ph.D. on behalf of the American Psychological Association, United States Senate Committee on Appropriations, Subcommittee on Defense, The Honorable Ted Steven, *The American Psychological Association to the Senate Subcommittee on Defense Appropriations regarding defense appropriations to the behavioral sciences for 2005*

- **Panel,** (7/18/2005-7/22/2005). *Cognitive Performance 2005.* Anteon Corporation, United States Army. Cognitive Performance in Man in the Loop Operations.

- **Expert Brief,** (7/25/2005-7/27/2005). *Briefing.* U.S. Department of Defense Polygraph Institute. House Permanent Select Committee on Intelligence , *Status of Deception Detection with Alternative Technologies*

- **Speaker,** (3/10/2006-3/10/2006). *Reading Minds: Lie Detection, Neuroscience, Law, and Society.* Stanford Center for Law and the Biosciences, part of the Stanford Program in Law, Science, & Techno. The Science of Lie Detection.

- **Planning Committee, Speaker,** (5/14/2007-5/16/2007). *Steering Committee.* U.S. Department of Defense Defense Academy for Credibility Assessment. Planning Session for May Summit, *Committee*

- **Speaker, Group Leader for Screening of Scenarios,** (5/22/2007-5/24/2007). *Steering Committee.* U.S. Department of Defense Defense Academy for Credibility Assessment. Summit for Credibility Assessment, *Research in the Area of Screening Scenarios*

- **IRB Representative,** (9/1/2006-8/31/2007). *2006 Science and Engineering Fair.* University of South Carolina. Science and Engineering Fair, *Committee*

- **Judge,** (9/1/2006-8/31/2007). *2005 Science and Engineering Fair.* University of South Carolina. Science and Engineering Fair.

- **Sub-Committee Screening Environments,** (9/15/2007-9/15/2007). *Steering Committee.* U.S. Department of Defense Defense Academy for Credibility Assessment. Draft Session for Credibility Assessment Research Agenda, *Sub-Committee Draft on Screening Environments*

- **Participant,** (10/14/2007-10/15/2007). *Science Advocacy Training.* American Psychology Association, Science Directorate. APA Science Leadership Conference, .

- **Sub-Committee on Screening Group Leader,** (11/12/2007-11/13/2007). *Steering Committee.* U.S. Department of Defense, Defense Academcy for Credibility Assessment. Draft Review for Credibility Assessment Research Agenda, *Committee*

- **Paricipant,** (11/26/2007-12/4/2007). *Annual Meeting.* American Anthropology Association. American Anthropology Association.

- **Participant, (12/10/2007-12/10/2007).** *Working Group.* The American Association for the Advancement of Science. Symposium and Working Meeting: Rights and Responsibilities: Scientific Associations and International Human Rights Norms, *None*

- **IRB Representative, (9/1/2007-8/31/2008).** *2008 Science and Engineering Fair.* University of South Carolina. Science and Engineering Fair, *Committee*

- **Judge, (9/1/2007-8/31/2008).** *2008 Science and Engineering Fair.* University of South Carolina. Science and Engineering Fair, *2008 Science and Engineering Fair*

- **Workgroup Coordinator and Leader, (1/30/2009-1/30/2009).** *Steering Committee.* U.S. Department of Defense Defense Academy for Credibility Assessment. Central Nervous Systems Measures for Credibility Assessment, *Handling the Issues of the NAS Report*

- **Speaker, (2/15/2009-2/15/2009).** *Briefing.* The Office of the Director of National Intelligence. Strategies for the Advancement of Credibility Assessment Utilizing Scientific Methods,

- **Speaker, (3/29/2000).** *Sagan Society.* University of Georgia. The Psychology of Cults, *The Psychology of Cults*

- **Extended Expert Brief, (7/11/2006).** *Brief.* U.S. Department of Defense Polygraphic Institute. Intructional Briefing on Alternative Technologies , *Instructional Presentation to representatives from Israeli Secret Service specifically targeting polygraph examination test design*

- **Extended Expert Brief, (7/25/2006).** *Brief.* U.S. Department of Defense Polygraphic Instutue. Intructional Briefing on Alternative Technologies , *Instructional presentation to representatives from the Ministry of Defense, Singapore, specifically targeting deception research utilizing fMRI technology*

- **Brief, (6/18/2005).** *APA Congressional Meeting.* American Psychological Associaiton. Intructional Briefing on Alternative Technologies , *Visitation with the Senior Legislative & Federal Affairs Officer,Science Public Policy Office of the American Psychological Association and staffers from Lindsay Graham's office regarding fMRI technology and detection of deception at USC*

- **Speaker, (10/17/2005).** *Dinner Series on Science.* Mensa. After Dinner Speech, *History and the Art of Deception*

- **Ad Hoc Reviewer, (2/6/2005).** *Grant Review.* Department of Defense. Agency Review, *Concealed Information Paradigm with fMRI Dependent Measure*

- **Speaker, (10/8/2004).** *USC College of Liberal Arts National Advisory Council .* USC College of Liberal Arts. Science Presentation, *Neuroscientific Detection of Deception*

- **Speaker, (9/28/2005).** *Second Annual Research Forum.* USC, Provost's Advosory Committee and the Office of Research and Health Science. Success in Grant Writing, *Motivation, Perseveration, Details, Contacts, and Ego: The B-Side of Writing Grants*

- **Speaker, (10/5/2004).** *Small Business and Innovative Technologies.* USC, Office of Research and Health Sciences. Joining Academic and Community Needs, *Detection of Deception: Real World Applications From the Laboratory to the Streets*

- **Discussant, (2/15/2005).** *Panel.* London Science Museum Dana Centre. Naked Science: The Truth Behind Lie Detection, *Panel Discussion with Tor Butler-Cole and Dr. Paul Matthews at the London Science Museum Dana Centre regarding the ethicality of advanced technology applications in the detection of deception. This debate was open to the public, and is maintained in the Dana Centre's public Web Archives for reference*

- **Extended Expert Brief, (1/1/2005).** *Brief.* U.S. Department of Defense, Counterintelligence Field Activity. Intructional Briefing on Alternative Technologies , *Instructional Presentation to the Chief, Credibility Assessment at Behavioral Sciences department regarding the major developments in credibility assessment technologies including thermal imaging, event-related potentials, and functional magnetic resonance imaging*

- **Written Brief, (1/1/2005).** *Brief.* Office of Science and Technology Policy of the President. Outline of Deception Detection Research Agenda, *Summary of the scientific potential for alternative technologies in the detection of deception for the periods between 2005-2007, 2007-2010, 2010-2015 for the Assistant Director for the Social, Behavioral and Educational Sciences at the Office of Science and Technology Policy.*

- **Extended Expert Brief, (1/15/2003).** *Extended Brief.* U.S. Department of Defense, National Security Agency. Credibility Assessment, *Instructional Presentation and Compiled Bibliography/Literature Review to the Technical Director of Polygraph, U.S. Department of Defense, National Security Agency regarding alternative technologies in the field of credibility assessment including voice stress analysis, pupillometry and eye-tracking, thermal imaging, exhaled gases, functional magnetic resonance imaging, event-related potentials, laser vibrommetry, and infrared.*

- **Extended Expert Brief, (3/15/2005).** *Extended Brief.* U.S. Department of Defense, Counterintelligence Field Activity. Intructional Briefing on Alternative Technologies , *Instructional Presentation to the Director of Behavioral Sciences Department of Defense CounterIntelligence Field Activity and the Senior Legislative Federal Affairs Officer of the Science Public Policy Office of the Impact of Religious Upbringing and Cultural Influences on Deceptive behavior, and cognitive constructs such as memory and attention on brain waves related to deceptive behavior*

- **Ad Hoc Reviewer, (10/4/2002).** *Grant Review.* Dartmouth College. Institute for Security Technology Studies.

- **Ad Hoc Reviewer, (10/4/2002).** *Grant.* National Science Foundation. National Science Foundation.

- **Ad Hoc Reviewer, (11/11/2001).** *Journal.* American Psychological Association. Journal of Experimental Psychology.

- **Reviewer, (1/1/2004).** *Journal.* International Society for Neuronal Regulation. Journal of Neurotherapy.
- **Reviewer, (8/31/2007-Present).** *University Grant Review.* University of South Carolina. University Review Panel, *Meeting*
- **Steering Committee, (1/1/2007-Present).** *Administrative Position.* McCausland Center. McCausland Center, *Meeting*
- **Director, (8/31/2007-Present).** *Administration Position.* Center for Advanced Technologies for the Detection of Deception. Director of CATDD, *Committee*
- **Member, (8/31/2007-Present).** *Department Committee.* Department of Psychology. Clinical Neuroscience Search Committee, *Committee*
- **Member, (8/31/2007-Present).** *Department Committee.* Department of Psychology. Undergraduate Curriculum Committee, *Committee*
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- **Member, (9/11/2006-Present).** *Research Opportunity Program standing subcommittee.* University of South Carolina, Office of Research and Health Sciences. Research Opportunity Program .
- **Alternative Technologies Specialist, (7/1/2006-Present).** *Steering Committee.* U.S. Department of Defense Polygraph Institute. Research Program Design for Department of Defense Credibility Assessment Programs.
- **Editor, Science and Technologies, (11/1/2001-Present).** *Journal* . American Polygraph Association. Polygraph.
- **Human Subjects Specialist, (3/8/2006-Present).** *Science and Engineering Fair.* University of South Carolina. IRB.

PRESENTATIONS

Invited Addresses

Vendemia, J. M. C. (August, 2007). *Theoretical Underpinnings of Polygraph Data.* . New Orleans, LA.

Vendemia, J.M.C.V. (May, 2007). *Screening Scenarios.* Credibility Assessment Research Summit. Washington, DC.

Vendemia, J. M. C., Schillaci, M. J., Buzan, R. F., & Meek, S. W.. (March, 2006). *The Future of Alternative Technologies for the Detection of Deception: Implications, Improbabilities, and Impossibilities.* Paper presented at the Annual Meeting of the Maryland Polygraph Association. Annapolis Junction, MD.

Vendemia, J.M.C., Meek, S. W., Schillaci, M. J. (July, 2006). *Neuroscientific Techniques of Studying Human Deception.* Paper presented at the Annual Meeting of the American Polygraph Association. Las Vegas, NV.

Vendemia, J. M. C., Schillaci, M. J., Buzan, R. F., Green, E. P., & Meek, S. W. (April, 2006). *ERP and fMRI Research in the Detection of Deception.* Talk presented at the U.S. Army Research Laboratory Seminar on the Deceptionof Deception. Aberdeen, MD.

Vendemia, J. M. C., Schillaci, M. J., Buzan, R. F., Green, E. P., & Meek, S. W. (June, 2006). *Examining the Underlying Assumptions of Neuroscientific Tests of Deception.* Talk presented at the Judicial Seminar on Emerging Issues in Neuroscnce hosted by the Association for the Advancement of Science. Washington, D. C..

Vendemia, J. M.C, & Buzan, R. F. (July, 2004). *Mapping the Brain During Deception: Extended Studies of Deception Using HD-ERP and fMRI* . Paper presented at the annual Meeting of the American Polygraph Association. Orlando, FL.

Vendemia, J. M. C., & Buzan, R. F. (July, 2001). *Brain Measurements During Deception.* Paper presented at the annual Meeting of the American Polygraph Association. Indianapolis, ID.

Crawford, H. J., Horton, J., Hirsch, T. B., Harrington, G. S., Plantec, M. B., Vendemia, J. M. C., Shamro, C., McClain-Furmanski, D., & Downs III, J. H. (October, 1998). *Attention and Disattention (Hypnotic Analgesia) to Painful Somatosensory TENS Stimuli Differentially Affects Brain Dynamics: A Functional Magnetic Resonance Imaging Study* . Paper for Symposium on "New Perspectives on Brain Imaging of Human Pain and Pain Control: Symposium in Remembrance of Bonica" (Chair: Andrew Chen), 9th World Congress of Psychophysiology. Sicily, Italy.

Presentations and Posters

Greer, T.M., Vendemia, J.M.C., Laseter, A., & Stancil, M. (February, 2008). *Physical Mental Health Impacts of Racism for African Americans: The Context of Gender.* Talk given at the 25th Annual Teachers College Winter Rountable on Cultural Psychology and Education: 25 Years of Racial-Cultural Issues in Psychology and Education: Honoring the Past and Anticipating the Future., New York, NY.

Wood, S. L., Vendemia, J., Yuliya, K., & Craig, A. (May, 2008). *Thinking Anew: Neural Correlates of Processing Innovative Options..* Poster presented at the 13th annual meeting of the Cognitive Neuroscience Society (CNS), San Francisco, CA.

Craig, A., Yuliya, K., Vendemia, J., & Wood, S. L. (May, 2008). *Neural Correlates of Deception Detection: A Bold Imaging Study..* Poster presented at the 13th annual meeting of the Cognitive Neuroscience Society (CNS), San Francisco, CA.

Meek, S. W., Phillips, M., Baucom, L., & Vendemia, J.M.C. (May, 2008). *Posterior Parietal Activity and Workload Capacity as Correlates of Frequency of Deceptive Responding:*

A BOLD Imaging Study. Poster presented at the 13th annual meeting of the Cognitive Neuroscience Society (CNS), San Francisco, CA.

Sanchez, C., Meek, S.W., Phillips, M., Craig, A., & Vendemia, J.M.C.V (May, 2007). *Anterior Cingulate and Prefrontal Activity as Carrelates of Attention Switching and Consideration of Multiple Relations during Truthful and Deceptive Responses: A BOLD Imaging Study.* Poster presented at the 12th annual meeting of the Cognitive Neuroscience Society (CNS), New York, NY.

Phillips, M., Meek, S.W., Craig, A., Sanchez, C., & Vendemia, J. M. C. (May, 2007). *Event-Related Potential Correlates of Switching Between Truthful and Deceptive Responses.* Poster presented at the 12th annual meeting of the Cognitive Neuroscience Society (CNS), New York, NY.

Buzan, R. F., Phillips, M., Meeks, S. W., Kirk, A., & Vendemia, J. M. C. (May, 2007). *ERN as an Index of Catastrophic Respoonse to Failure.* Poster presented at the 12th annual meeting of the Cognitive Neuroscience Society (CNS), New York, NY.

Meek, S. W., Phillips, M, Sanchez, C., Craig, A., & Vendemia, J. M. C. (March, 2007). *Misinformation & Deception.* Poster presented at the 12th annual meeting of the Cognitive Neuroscience Society (CNS), New York, NY.

Vendemia, J. M. C., Schillaci, M. J., Buzan, R. F., Green, E. P., & Meek, S. W. (May, 2006). *Lie Detection Using EEG and ERP.* Talk presented during Reading Minds: Lie Detection, Neuroscience, Law, and Society Conference hosted by The Standford School of Law, Stanford, CA.

Schillaci, M.J., Vendemia, J. M.C. , Buzan, R.F., & Green, E.P. (April, 2005). *A Two-Level Quantum Analysis of ERP Data for Mock-Interrogation Trials.* Poster presented at the 12th annual meeting of the Cognitive Neuroscience Society (CNS), New York, NY.

Vendemia, J.M.C., Brooke, J., Green, E.P., Schillaci, M.J., & Buzan, R.F. (April, 2005). *Practice Effects on ERP-Components Related to Deceptive Responses* . Poster presented at the 12th annual meeting of the Cognitive Neuroscience Society (CNS), New York, NY.

Cole, W. R., Schatz, J. S., Smith, B. H., & Vendemia, J. M. C. (June, 2005). *Behavioral Inhibition in College Students: Correlates with Event-Related Potentials (ERP)* . Poster presented at the biannual meeting of the International Research Society in Child and Adolescent Psychopathology, New York, NY.

Vendemia, J. M. C., & Schillaci, M. J. (February, 2004). *Neuroscientific Modeling of Deception with HD-ERPs and fMRI: Experimental and Computational Problems.* Colloquium Presented to the Department of Computer Science and Engineering, University of South Carolina, Columbia, SC.

Kilmann, P.R., Vendemia, J. M. C., Meyers, L. L., Kilmann, A., & Fitz, M. E. (April, 2004). *Personality Characteristics of Women Seeking Weight Reduction.* Poster presented at the Southeastern Psychological Association, Atlanta, GA.

Fitz, M.E., Kilmann, P.R., Vendemia, J. M.C., Wanlass, R.L., & Brown, G. E. (September, 2004). *Attitudes and Behaviors Associated with Masturbation: A 25-Year Contrast .* Poster presented at the Southeastern Psychological Association, Atlanta, GA.

Vendemia, J. M. C., & Buzan, R. F. (April, 2004). *HD-ERP Correlates of Workload During Deception in two Mock Crime Paradigms .* Poster presented at the 11th annual meeting of the Cognitive Neuroscience Society (CNS), San Francisco, CA.

Ryan, A., & Vendemia, J. M. C. (June, 2004). *Alternative Technologies in the Detection of Deception .* Paper presented at the American Psychological Association Annual Meeting, Honolulu, HW.

Kilmann, P. R., Pontinen, L. L., & Vendemia, J. M. C. (April, 2003). *Personality Characteristics of Obese Women Seeking Bariatric Surgery.* Poster presented at the Southeastern Psychological Association, New Orleans, LA.

Vendemia, J. M. C., & Buzan, R. F. (April, 2003). *The Effects of Response Predictability on HD-ERP Measures Across Studies of Deception .* Poster session presented at the 10th Annual Convention of the Cognitive Neuroscience Society, NewYork, NY.

Vendemia, J. M. C., & Buzan, R. F. (August, 2003). *The Effects of Response Predictability on HD-ERP and RT Measures Across studies of Deception.* Paper presented 11th Annual Conference for the Society of Neurotherapy, Houston, TX.

Vendemia, J.M.C., Caine, K. E., & Evans, J. (August, 2003). *Quantitative EEG Findings in Convicted Murderers.* Paper presented at the 11th Annual Conference for the Society of Neurotherapy , Houston, TX.

Vendemia, J. M. C., & Buzan, R. F. (September, 2003). *Neural Mechanisms of Deception and Response Congruity in a Visual Two-Stimulus Paradigm Involving Autobiographical Information.* Poster presented at the 43rd annual meeting of the Society for Psychophysiological Research, Chicago, Il.

Buzan, R. F., Sasine, G. M., Spade, A., & Vendemia, J. M. C. (April, 2002). *Source Localization of the Effects of Deception and Stimulus Congruity on Event-Related Potentials.* Poster session presented at the 9th Annual Convention of the Cognitive Neuroscience Society, San Francisco, CA.

Vendemia, J. M. C., & Buzan, R. F. (July, 2002). *Deception and Response Congruity in Visual Two-Stimulus Paradigms Involving Motor Response.* Paper presented at the 11th World Congress of Psychophysiology, Montreal, Canada.

Vendemia, J. M. C. & Buzan, R. F. (February, 2001). *ERP Correlates of Deception.* Talk presented at North Carolina Cognition Group, Greensboro, NC.

Rodriguez, D. P., Vendemia, J.M.C., & Crawford, H. J. (April, 2001). *EEG Differences Across Coping Styles.* Poster presented at the 8th Annual Convention of the Cognitive Neuroscience Society, New York, NY.

Vendemia, J.M.C., Buzan, R. F., Pollina, D., & Ryan, A. (April, 2001). *ERP Correlates of Deception Using a Two-Stimulus Paradigm.* Poster session presented at the 8th Annual Convention of the Cognitive Neuroscience Society, New York, NY.

Vendemia, J.M.C., & Buzan, R. F. (May, 2001). *ERP Correlates of the Attentional Processes Involved in Deception.* Paper presented at the South Carolina Bicentennial Symposium on Attention, Columbia, SC.

Crawford, H.J., Horton, J. E., Harrington, G. C., Vendemia, J. M. C., Plantec, M. B., Jung, S., Shamro, C., & Downs III, J. H. (June, 1998). *Hypnotic Analgesia (Disattending Pain) Impacts Neuronal Network Activation: An fMRI Study of Noxious Somatosensory TENS Stimuli* . Poster presented at the Cognitive Neuroscience Society, Toronto, Canada.

Downs III, J. H., Crawford, H. J., Plantec, M. B., Horton, J. E., Vendemia, J. M. C. Vendemia, Harrington, G. C., Yung, S., & Shamro, C. (June, 1998). *Attention to Painful Somatosensory TENS Stimuli.* Poster presented at the Cognitive Neuroscience Society , Toronto, Canada.

Vendemia, J. M. C., Karnasuta, M. A., & Crawford, H. J. (May, 1998). *Reaction Time and Errors During an Emotionally Valenced Computer Stroop Task* . Poster presented at the 10th Annual Convention of the American Psychological Society, Washington, DC.

Vendemia, J. M. C., Horton, J., & Crawford, H. J. (May, 1998). *Physiological Reactivity of Repressors and Non-Repressors on an Emotional Stroop Interference Task* . Poster presented at the 10th Annual Convention of the American Psychological Society, Washington, DC.

Lamas, J., Crawford, H. J., & Vendemia, J. M. C. (October, 1997). *MMN and Auditory Event-Related Potentials During Posthypnotically Suggested Deafness: Effect of Hypnotizability Level* . Paper presented at the 37th Annual Meeting of the Society for Psychophysiological Research , CapeCod, MA.

Vendemia, J. M. C., Ragsdale, K. G., & Iranmanesh, A. (July, 1995). *Activity of the Hypothalamic-Pituitary-Adrenal Axis and B-endorphin Secretory Dynamics in Men Habituated to Cigarette Smoking* . Poster presented at the 35th Annual Meeting of the Society for Psychophysiological Research , Toronto, Canada.

Crawford, H. J., Knebel, T. F., Vendemia, J. M. C., Kaplan, L., & Ratcliff, B. (April, 1995). *EEG Activation Patterns During Tracking and Decision-Making Tasks: Differences Between Low and High Sustained Attention Adults.* Paper presented at the 8th International Symposium on Aviation Psychology, Columbus, OH.

Crawford, H. J., Knebel, T., & Coplin, J. (October, 1994). *Hypnotic Analgesia is no Longer a Paradox: Neurophysiological and Cognitive Process Explored.* In A. Tellegen (Chair), Celebrating E. R. "Jack" Hilgard's 90th birthday: On individual differences in hypnotic ability and one individual's difference to the study of hypnosis, Symposium conducted at the 45th Annual Scientific Program of the Society for Clinical and Experimental Hypnosis, SanFrancisco, CA.

Crawford, H. J., Knebel, T., Coplin, J., Fulkerson, B., Scanlon, J., Sawyer, J., & Houzouris, N. (October, 1994). *EEG Topographic Map Differences in High and Low Sustained-Attention Adults: Tracking Tasks.* Poster presented at the 34th Annual Meeting of the Society for Psychophysiological Research, Atlanta, GA.

Coplin, J. M. (i.e., Vendemia, J.M.C), Knebel, T. F., & Crawford, H. J. (October, 1994). *Cold Pressor Pain: EEG Topographical Differences Before and During Dips as Moderated by Cognitive Variables*. Poster presented at the 34th Annual Meeting of the Society for Psychophysiological Research, Atlanta, GA.

Coplin, J. M., Lanter, J. J., & Ledger, G. J. (April, 1993). *The Quantification of Wandering Behavior in Alzheimer's Patients* . Paper presented at the spring convention of the Virginia Psychological Association, Emerald Isle, VA.

Coplin, J. M. , Harrison, D. W., & Lanter, J. J. (April, 1992). *The Effect of Light on Unilateral Stroke Patients in a Dichotic Listening Task: A Preliminary Report*. Paper presented at the Spring Convention of the Virginia Psychological Association, Emerald Isle, VA.

Bunce, V. L., Coplin, J. M., & Harrison, D. W. (June, 1991). *Child- or Adult- Directed Speech and Esteem: Effects on Performance and Arousal in Elderly Adults* . Poster presented at the Third Annual American Psychological Society Convention, Washington, DC.

PROFESSIONAL AFFILIATIONS

- American Association for the Advancement of Science
- International Society for Neuronal Regulation
- Cognitive Neuroscience Society
- American Psychological Association