DEPARTMENT OF DEFENSE
POLYGRAPH INSTITUTE
7540 PICKENS AVENUE
FORT JACKSON, SOUTH CAROLINA 29207

February 24, 2003

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER, 8725 JOHN KINGMAN ROAD, SUITE 0944, FORT BELVOIR, VIRGINIA 22060-6218

SUBJECT: Report Submission

The Department of Defense Polygraph Institute (DoDPI) submits the following report, Ability of the Vericator™ to Detect Smugglers at a Mock Security Checkpoint (DoDPI03-R-0002) for inclusion to your collection of scientific and technical information for the Department of Defense (DoD) community.

The DoDPI point of contact for this action is Rose M. Swinford, DSN 734-9163.

William F. Norris
WILLIAM F. NORRIS
Director

2 Attachments
1. SF 298 – Report Documentation Page
2. Report

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	February 2003	March 2001 - February 2003

4. TITLE AND SUBTITLE
Ability of the Vericator™ to Detect Smugglers at a Mock Security Checkpoint

5. FUNDING NUMBERS
DoDPI00-P-0024

6. AUTHOR(S)
Troy E. Brown, Ph.D., Stuart M. Senter, Ph.D. and Andrew H. Ryan, Jr., Ph.D.

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
DoD Polygraph Institute
7540 Pickens Avenue
Fort Jackson, South Carolina 29207

8. PERFORMING ORGANIZATION REPORT NUMBER
DoDPI03-R-0002

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
DoD Polygraph Institute
7540 Pickens Avenue
Fort Jackson, South Carolina 29207

10. SPONSORING / MONITORING AGENCY REPORT NUMBER
DoDPI03-R-0002

11. SUPPLEMENTARY NOTES
Public Release, Distribution Unlimited

12a. DISTRIBUTION / AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This study assessed the ability of Vericator™, a computer-based system that evaluates credibility through speech, to detect smugglers at a mock security checkpoint. A U.S. Federal inspector questioned participants while Vericator assessed their credibility. For some (N=77), the inspector followed a script of questions without follow-up (Scripted); for the remainder (N=93), follow-up questions were permitted (Field-like). Smuggling base rates were 34% and 35%, respectively. Few smugglers were correctly identified at the checkpoint (3 of 26 and 6 of 33, respectively) while many non-smugglers were correctly identified (41 of 51 and 47 of 60, respectively). Subsequent analyses produced widely disparate results but indicated that future improvements may be possible. However, the use of Vericator at security checkpoints is not supported at this time.

Keywords: credibility assessment; speech; voice stress analysis

14. SUBJECT TERMS
Credibility assessment; speech; voice stress analysis

15. NUMBER OF PAGES
72

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
U	U	U	None

Report No. DoDPI03-R-0002

DoD Polygraph Institute Research Division

Ability of the Vericator™ to Detect Smugglers at a Mock Security Checkpoint

Troy E. Brown, Ph.D., Stuart M. Senter, Ph.D., and Andrew H. Ryan, Jr., Ph.D.

Expect Success

Andrew H. Ryan, Jr.
Research Division Chief
(803) 751-5867
ryana@jackson-dpi.army.mil

Executive Summary

Law enforcement personnel at security checkpoints must perform quick assessments of individuals' credibility and intent. Vericator™, a commercially-available, computer-based system that evaluates credibility through conversational speech, could facilitate this work if shown to have utility. The purpose of this study was to assess the ability of Vericator to detect smugglers at a mock security checkpoint.

A mock security checkpoint was established amongst actual checkpoints in a Federal building. Some study participants were randomly chosen to smuggle Federal evidentiary material through this checkpoint. A U.S. Federal inspector conducted scripted or field-like interviews of participants while Vericator assessed their credibility. Participants were classified as smugglers if Vericator considered them deceptive during questioning.

Vericator was generally unable to discriminate between Smugglers and non-Smugglers, but future improvements in its detection capabilities may be possible. However, the use of Vericator at security checkpoints is not supported at this time.

Acknowledgments

The authors acknowledge a dedicated team of professionals who contributed to the success of this investigation. Special thanks go to Jose Silva, who traveled across country on short notice to spend 3 weeks in South Carolina. He served an essential role with the utmost professionalism. Special thanks also go to Kathleen Phelan for the many hours she spent editing and analyzing audio recordings. We are indebted to Douglas Patterson and William T. Johnson of the U.S. General Services Administration and the security force of the Strom Thurmond Federal Building in Columbia, South Carolina for their support while we administered this investigation. Bob Sanctis and Al Kinard of Modern Technologies Corporation in Dayton, Ohio provided us with essential investigative support. Our colleagues at the Department of Defense Polygraph Institute, Andrew B. Dollins, Ph.D., Donald J. Krapohl, Dean A. Pollina, Ph.D., Clint Shahan, Rose Swinford, and Kay Williams, deserve our praise for their support during this study. Finally, the authors would like to express our thanks to the scores of volunteers who participated; their efforts are appreciated.

Funds for this research were provided by the Technical Support Working Group (TSWG) under project number TSWG Task T-211. The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of Defense or U.S. Government.

Abstract

BROWN, T. E., SENTER, S. M., AND RYAN, A. H., JR. Ability of the Vericator™ to Detect Smugglers at a Mock Security Checkpoint. February 11, 2003, DoDPI03-R-0002, Department of Defense Polygraph Institute, Fort Jackson, SC 29207. This study assessed the ability of Vericator™, a computer-based system that evaluates credibility through speech, to detect smugglers at a mock security checkpoint. A U.S. Federal inspector questioned participants while Vericator assessed their credibility. For some (N=77), the inspector followed a script of questions without follow-up (Scripted); for the remainder (N=93), follow-up questions were permitted (Field-like). Smuggling base rates were 34% and 35%, respectively. Few smugglers were correctly identified at the checkpoint (3 of 26 and 6 of 33, respectively) while many non-smugglers were correctly identified (41 of 51 and 47 of 60, respectively). Subsequent analyses produced widely disparate results but indicated that future improvements may be possible. However, the use of Vericator at security checkpoints is not supported at this time.

Keywords: credibility assessment; speech; voice stress analysis

Table of Contents

Title Page i

Executive Summary ii

Acknowledgments iii

Abstract iv

Table of Contents v

Introduction 1

Method 3

Vericator System 3
Online Mode *3*
Offline Mode *5*
Graph System Parameters *6*
Participants 8
Experimental Design 9
Checkpoint Location *9*
Procedure *9*
Registration 9
Briefing 11
Questioning 14
Debriefing 17
Data Analyses 18
Vericator *18*
U.S. Federal Inspector *21*
Statistics *21*

Results 22

Participants 22
Online Mode 24
Offline Mode 26
Logistic Regression 28

Discussion 30

Vericator Utility 31
Decision Accuracy 33
Potential Limitations 34
VSA's Future 35

References 37

Appendix A 40

Appendix B 41

Appendix C 42

Appendix D 44

Appendix E 46

Appendix F **50**

Appendix G **54**

Appendix H **55**

Appendix I **58**

Appendix J **61**

Appendix K **62**

Appendix L **63**

Appendix M **64**

Appendix N **66**

The research mission of the Department of Defense Polygraph Institute (DoDPI) is to advance and communicate the body of knowledge in the field of behavioral and psychophysiological detection of deception (PDD). At DoDPI, developmental research is conducted on PDD techniques, instrumentation, and analytical methods. One area of research that has sparked lively debate within the PDD community has been the use of vocal signals to detect stress and deception. The broad spectrum of efforts to analyze stress in human speech is commonly termed voice stress analysis (VSA).

Speech is composed of two mechanical functions, articulation and phonation. Articulation is achieved by positioning the structures of the mouth, i.e., lips, tongue, and soft palate, to produce meaningful utterances. Phonation is achieved by vibrating the vocal cords to produce sounds. Numerous laryngeal muscles stretch and position the vocal cords so that the appropriate phonation, pitch or frequency, is emitted (Guyton, 1981). Neuromuscular spinal reflex arcs sense and control the contraction of the laryngeal muscles via a feedback control mechanism that oscillates about a set point at approximately 10 cycles/second. This oscillation is found in voluntary muscles and is generally termed 'physiological tremor' (Lippold, 1971), but for VSA, is termed 'microtremor' (Shipp & Izdebski, 1981). The autonomic nervous system has been shown to innervate the larynx (Hisa et al., 1999). In VSA, the working hypothesis is that microtremors are suppressed, via autonomic mechanisms, when psychological stress is created (Reeves, 1980).

The first significant product to analyze vocal signals, introduced in 1971, was the Psychological Stress Evaluator or PSE (Dektor Counterintelligence and Security, Inc., Springfield, Virginia). The patent for the PSE claimed it could be "…useful in detecting efforts at deception" and described a system that analyzed microtremors of the vocal signal (U.S. Patent No. 3,971,034, 1976). Ultimately, the PSE never gained favor within the PDD community,

partly because it lacked supporting evidence that validated its ability to detect deception (Brenner, Branscomb, & Schwartz, 1979; Hollien, Geison, & Hicks, Jr., 1987; Horvath, 1978, 1979; Timm, 1983) and partly because it was marketed as a replacement for the polygraph (Cestaro & Dollins, 1996).

In the late 1980s, another significant VSA device was introduced, the Computer Voice Stress Analyzer (CVSA™)(National Institute for Truth Verification, Inc., West Palm Beach, FL). Like the PSE, the CVSA analyzes microtremors in the vocal signal and is marketed as a convenient replacement for the polygraph. Unlike the PSE, the CVSA provides real-time graphical outputs or charts that examiners can score; PSE required playback of previously recorded audio at a reduced tape speed. CVSA enjoys widespread use in the law enforcement community (National Institute for Truth Verification, 2002). DoDPI performed a number of studies on the CVSA to determine whether this device performed as a valid measure of stress or deception. The authors of these studies concluded that the CVSA did not correlate with well-validated physiologic responses to acute social stress (DoDPI Research Division Staff, Meyerhoff, Saviolakis, Koenig, & Yourick, 2001) and did not detect deception better than chance (Cestaro, 1996a, 1996b; Janniro & Cestaro, 1998).

In 2000, a new VSA device, called Vericator™ (Integritek Systems, Tampa, FL), was introduced. Originally produced as TrusterPro™ (Trustech, Herzliya, Israel), the Vericator™ is a computer-based system marketed as “an investigative focus tool, which evaluates subject credibility through narrative, or conversational speech” (Integritek Systems, 2001). It has not been marketed in a manner that suggests direct competition with the polygraph, but in a manner that emphasizes its flexibility and utility across a wide range of situations and circumstances. In fact, Vericator can be used in the strict question format often used in polygraph examinations.

Unlike the PSE and CVSA systems that use microtremors, Vericator extracts information from the entire vocal signal to produce decisions (Vericator™ User Manual, 2000). Interest has grown in the possible use of the Vericator as a tool to facilitate the work of inspectors at security checkpoints, e.g., customs. However, systematic studies on its validity and utility have not been published. Therefore, the purpose of this study was to assess the ability of the Vericator to detect smugglers at a security checkpoint environment. One key goal of this study was to determine whether Vericator operated at better than chance levels. A second key goal of this study was to determine whether Vericator could discriminate between Smugglers and non-Smugglers. A secondary goal of this study was to determine how Vericator's decisions compared to a U.S. Federal inspector's decisions.

Method

Vericator System

The Vericator system used for this investigation consisted of the Vericator software (version 6.30) installed on a laptop computer (Inspiron 7500, Dell Computer, Round Rock, TX) with standard audio capabilities (Maestro-2, ESS Technology, Fremont, CA) and a supercardioid external microphone (AKG.Emotion D 880, AKG Acoustics, Vienna, Austria) connected to the microphone jack of the computer. Vericator software is designed to operate in one of three modes: Online, Offline, and Interrogation. Only the Online and Offline modes were assessed.

Online Mode

The Online mode, which was used at the mock security checkpoint, performs real-time analysis of vocal signals. Once initiated, a 5-15 second calibration is first performed on the individual to be tested. During calibration, the individual must speak continuously; other voices must not be present. After calibration, Vericator performs ongoing assessments on the calibrated individual's vocal signals; other voices may be present. These assessments are updated

approximately every 2-3 seconds. Each 2-3 second segment is assigned one of ten messages (Vericator™ User Manual, 2000) found in Table 1. An option to store the vocal signals as wave ('.wav') files is provided.

Table 1

Vericator Online Mode Messages

Assessment	Description
Truthful	No stress
Excitement	Emotional stress
High excitement	Emotional stress at high level
Extreme emotion	Emotional stress at extreme level
Subject is not sure	Cognitive stress, mostly due to lack of information
Voice manipulation	Intentional manipulation of voice
High stress	Probable truthfulness, unless high stress is not expected
Stress relief	Cynicism or lack of attention
Inaccuracy	Medium lie stress, inaccurate details
False statement	Deception indicated

At the completion of an interview, Vericator produces a final report that summarizes the results into eleven categories (see Table 2). A prominent part of this report indicates whether deception was indicated during the interview or whether there was no indication of deception. An example of a report with no deception indicated (NDI) is located in Appendix A and an example of a report with deception indicated (DI) is located in Appendix B. For this study, the

Online mode of the Vericator was used to assess the overall credibility of participants during their entire interviews. Data products included electronic and hardcopy reports of the Vericator assessments and wave file and digital audio recordings of interviews.

Table 2

Vericator Online Report Summary

Assessment	Description
Global honesty rate	No stress
Excited	Emotional stress
Highly excited	Emotional stress at high level
Stress	Probably truthful, but sensitive area
Medium stress	Probably truthful, but sensitive area
High stress	Probably truthful, but sensitive area
Confusion/Uncertainty	Cognitive stress, mostly due to lack of information
Voice manipulation	Intentional manipulation of voice
High confidence (sarcastic)	Cynicism or lack of attention
Inaccuracies rate	Inaccurate details, probably not deceptive intent
Deception rate	Deception indicated

Offline Mode

The Offline mode, which was used in this investigation for post-hoc analysis, performs analysis on previously recorded audio (wave) files. Wave files must first be edited to ensure that extraneous voices and background noises are removed; only the voice of the individual of interest should remain. In addition, relevant portions of the recording must be identified, e.g., answers to critical questions. Segment-by-segment assessments and a test report summary are

produced in a fashion similar to the Online mode; however, the presentation is qualitatively different and the results are quantitatively different, i.e., parameters are interpreted differently. The Offline mode is purported to offer "a more efficient, more accurate and more expedient manner in which to analyze wave files" (Vericator™ User Manual, 2000). An example of an Offline test report is located in Appendix C.

Graph System Parameters

Vericator performs assessments based upon three levels of Graph System Parameters: Raw-Values, First Grade, and Algorithmic. The best description of the Graph System Parameters comes not from the Vericator User Manual, but from its developer and patent holder A. Liberman (personal communication, February 12, 2002). The Raw-Values graphs display "the very basic numerical numbers of the various parameters as they were picked by the system, before any comparison is made, and any analysis is done with them." These parameters (see Table 3) are used to determine a person's general state of mind. First Grade graphs display "the CALCULATED results of a SINGLE parameter (Such as SPT, SPJ) against its own calibration value, for the purpose of finding the deviation in the specific emotion" represented by a Raw-Values parameter. Algorithmic graphs combine the results of all First Grade parameters and some of the Raw-Value parameters. All of the Graph System Parameters described in Table 3, are only qualitatively defined in Vericator's literature and there is no discussion of the criteria Vericator uses to determine when deception is indicated. While the Offline mode of Vericator permits a visual review of the Graph System Parameters in tabular form, access to these data for further analyses is not a feature of the system. However, a software patch, provided by the developer, permitted access so that alternative decision criteria could be explored.

Table 3

Vericator Graph System Parameters

Parameter	Description
Raw-Values	
SPT	Relatively high frequency range (emotional level)
SPJ	Relatively low frequency range (cognitive level)
JQ	Distribution uniformity of relatively low frequency range (global stress level)
AVJ	Average range of relatively low frequency range (thinking level)
SOS	Say or Stop – fear or breaking point of subject
Fmain	Most significant frequency in the frequency range (concentration)
FX	Additional significant frequencies in the spectrum (evidence of deception)
FQ	Uniformity of spectrum (evidence of deception)
Fflic (harmonic)	Frequency spectrum harmonics (evidence of deception or embarrassment)
First Grade	
Emotional Stress	Reflects emotional content
Cognitive Stress	Reflects logical conflict between what the mouth is saying and what the brain is thinking
Thinking Level	Reflects mental power of subject
Frequency Modulation	Describes overall frequency modulation of voice
Anticipation Level	Reflects anxiety

Table 3 (continued)

Parameter	Description
Algorithmic	
Lie Probability	Accounts for all psychological parameters (compared to population)
Lie Stress	Accounts for all psychological parameters (compared to control)
Global Stress	Accounts for parameters associated with arousal

Participants

Two hundred forty-seven individuals were recruited in March of 2000 from the University of South Carolina and the local Columbia, South Carolina community for this study that was approved by the University of South Carolina Institutional Review Board. Some were recruited via a DoDPI subject database while others were recruited via campus and community newspaper advertisements. Ads were placed approximately one week prior to the start of the study and continued for three weeks. The text of the advertisements follows (the telephone number has been rendered meaningless):

Credibility Assessment Study

Individuals needed. Salary is $5 per ½ hour for up to 2 hours and the potential to earn a bonus of $50. Call 803-466-xxxx for info.

Callers were told (see Telephone Script for Prospective Participants in Appendix D) that the Department of Defense Polygraph Institute was conducting a study to test whether a new technology was able to assess a person's credibility through their speech. They were also told that the study would require up to 2 hours to complete and that they would be compensated for their time at a rate of $5 per ½ hour plus the potential to earn a $50 bonus. Parking was provided

at no cost. All callers that remained interested were asked some preliminary questions to determine their eligibility. Eligible individuals were required to: be 18 years of age or older; have graduated from high school or obtained their GED; be fluent in English; be able to read and answer questions aloud; be ambulatory; and have valid picture identification such as a driver's license. No other eligibility requirements were enforced. Those interested and eligible were scheduled to appear on a particular date and time at a designated room in a Federal building in downtown Columbia, South Carolina. All were asked to leave their portable communication devices outside the Federal building to eliminate confusion and interference during the study. Of the 247 subjects scheduled, only 180 actually reported for this study.

Experimental Design

Checkpoint Location

The Strom Thurmond Federal Building and U.S. District Court complex in Columbia, South Carolina was chosen as the site of the study. This was a logical location since actual security checkpoints exist there; one requirement of this utility study was to test the Vericator in an environment similar to its intended use. The mock checkpoint was established next to an existent entry checkpoint located in the lobby of the Federal building. This mock checkpoint served as an exit checkpoint for the subject participants and was staffed with actual security personnel and a U.S. Federal inspector; hereafter, referred to as Inspector.

Procedure

The flow of the study was divided into four distinct steps: Registration, Briefing, Questioning, and Debriefing.

Registration. Participants were instructed to report on a particular date and time to a designated room on the sixth floor in the Federal building. They were scheduled to report at one of three staggered times: 8:30 AM, 9:30 AM, or 10:30 AM. Up to thirty subjects per day could

be scheduled with no more than ten per staggered report time. Over the 13 days that the mock security checkpoint was operational, an average of nineteen individuals per day were scheduled with about fourteen per day actually participating. A registrar checked participants' identifications to verify their identities, recorded their names and arrival times, validated their parking tickets (free parking was provided at a nearby parking garage), and asked them to be seated until they were instructed to proceed to their briefing. The registration room was equipped with a closed circuit video system to document activities in that room.

Four rooms on the fourth floor were used to brief participants. A briefing room monitor prepared each room with either a Smuggler or a non-Smuggler briefing packet according to a randomly assigned predetermination known only to the monitor. The monitor did not know who would be assigned to those rooms. When the rooms were prepared, the monitor notified the registrar, via two-way radio. The registrar then randomly assigned participants to the briefing rooms. In this way, neither registrar nor monitor biased the selection process. There was no attempt to control for demographic variables such as sex, age, race, or education level; however, this information was solicited.

Immediately before instructing participants to proceed to the briefing rooms, the registrar informed them that for security purposes, they each must sign for a bright red armband, wear it on the left arm above the elbow throughout the study, and return it to study personnel before getting paid. The armbands served three purposes. First, they helped building security to recognize study participants and to provide them appropriate assistance if necessary, i.e., provide directions should they get lost in the building. Second, they served as an important prop for the smuggling scenario (discussed later). Third, they helped the Inspector at the mock security checkpoint know who should be tested and who should not be tested. This was important because the mock checkpoint was located in the front lobby of the Federal building next to an

actual checkpoint. Once armbands were issued, participants were instructed to proceed to their assigned rooms, enter the room without knocking, close the door behind them, and follow the instructions found on the table in the room.

Briefing. When participants entered their assigned briefing rooms, they discovered that they were alone in a room with only a chair and a table. A Smuggler or non-Smuggler briefing packet containing documents pertaining to participants' assigned roles in the study was on the table. In rooms with Smuggler briefing packets, an evidence box with mock evidence for a Federal trial was also on the table. A note on top of all briefing packets issued the following instructions:

> Make sure that the door is closed.
>
> Open the envelope under this note.
>
> Read all documents carefully.
>
> Follow directions completely.
>
> Do not leave until <u>you</u> have completed <u>all</u> directions.

Participants assigned to be Smugglers first read the Study Explanation and Instructions for Deceptive Participants (see Appendix E) while participants assigned to be non-Smugglers first read the Study Explanation and Instructions for Truthful Participants (see Appendix F). All were told that new technology was in use at the Federal building to prevent the loss of classified material and Federal evidence for upcoming trials. Furthermore, they were told that visitors, such as themselves, to areas that house such materials must wear armbands while in the building and must be cleared prior to leaving the building. The clearance process required that they pass through a checkpoint where an Inspector asked them a number of questions for identification purposes, some questions about classified or evidentiary material in their possession, and some

questions about points of contact while at the Federal building. Vericator assessed the credibility of their answers.

Participants assigned to be Smugglers were informed that they were randomly chosen to smuggle evidence for an upcoming Federal trial past the checkpoint. Information about the indictment pertaining to this trial was provided in a Mock Press Release (see Appendix G). The instructions informed them that if they were able to get past the checkpoint undetected, then they would have effectively circumvented the new security measures and would be permitted to leave the building. They were to exit the building, find a discreet location to remove the red (Secret Service) evidence sticker from the smuggled evidence, and dispose of the evidence. After at least 10 minutes, they were to return to the Federal building with the red evidence sticker concealed in their clothing and meet their point of contact to receive payment. When they presented the red evidence sticker, the point of contact would pay them a $50 bonus. Participants were told that if they were detained at the checkpoint, they would be escorted to a private room for further questioning. At that time, they were to ask security to contact the investigator. The contact information was provided on a copy of the consent form (see Appendix H) that the participants were instructed to take with them.

In reality, participants were not allowed to leave the Federal building during the study. After passing through the checkpoint, a guard at the checkpoint escorted them all to the debriefing rooms in a seventh floor suite. This was designed to prevent Smuggler participants from leaving the building to dispose of mock evidence sealed with actual Secret Service evidence stickers. This also prevented the possibility of participants defeating the study scenario by hiding the mock evidence in the building, going through the mock security checkpoint without the evidence, and then collecting the evidence afterwards.

After completing the study explanation and instructions, the Smuggler participants were asked to carefully review the Informed Consent Form for Deceptive Participants (see Appendix H) and to sign it if they chose to participate in the study. They were then asked to open the evidence box on the table and choose one of the items in the box to smuggle out of the Federal building. All items were wrapped and sealed with actual Secret Service evidence stickers. The mock evidence included a small videocassette, a diskette mailer with 3.5" diskettes, a small jewelry box, and a sealed envelope containing documents. They were told to carefully conceal the item on their person and not in a purse, backpack, briefcase, or any carried item since these items were likely to be inspected. Upon completion of this task, participants were directed to place the signed consent form in an envelope and then slide the envelope underneath the door from which they entered the room. At this point, participants were asked to carefully review their instructions until directed to proceed to the checkpoint.

Participants assigned to be non-Smugglers were asked to answer all questions truthfully at the checkpoint. They were also informed that they would receive a $50 bonus if they convinced the voice-based assessment technology that their answers were credible. After completing the study explanation and instructions, the non-Smuggler participants were then asked to carefully review the Informed Consent Form for Truthful Participants (see Appendix I) and sign it if they chose to participate in the study. Participants were directed to place the signed consent form in an envelope and slide the envelope underneath the door from which they entered the room. At this point, they were asked to carefully review their instructions until directed to proceed to the checkpoint.

Individuals who did not wish to participate were instructed to open the door of the room and wait inside for study personnel to arrive. Only one person chose not to participate. This

individual was debriefed and paid ($5 per ½ hour). The reason given for withdrawal was that the study did not involve the use of polygraphy.

The room monitor performed many essential tasks during this study. As described above, the monitor prepared briefing rooms with the appropriate (Smuggler/non-Smuggler) briefing packets according to a randomly assigned predetermination. Once participants arrived in their assigned rooms, the room monitor monitored each of them from a nearby room via a closed circuit video system. In this way, the room monitor could immediately know when a problem arose or when a subject had completed the consent form and was ready to proceed. The monitor would review the completed consent forms that had been placed outside the room by the participants to ensure that signatures had been properly rendered. Because the briefing time for a Smuggler usually took longer than the briefing time for a non-Smuggler, the monitor would randomize the time that participants were released to proceed to the checkpoint. This was important to prevent checkpoint personnel from assuming that the first participants to arrive at the checkpoint were non-Smugglers. The monitor never had direct contact with participants, but signaled them to proceed by sliding directions to the checkpoint under the briefing room door. Once participants left the room, the monitor would inform checkpoint personnel, via two-way radio, that participants were proceeding to the checkpoint. The briefing packets with signed consent forms were forwarded to personnel responsible for debriefing participants after they passed through the checkpoint. Then, the room monitor prepared the briefing rooms for the next group of participants as described earlier; this process repeated until all participants had passed through the checkpoint. The monitor was the only person able to identify Smugglers and non-Smugglers; this information was never relayed to any other study personnel.

Questioning. As participants entered the checkpoint, they were provided the following instruction via a sign, “Please remain behind the line until directed to proceed.” Participants

proceeded to a yellow line on the floor where they waited until the Inspector motioned for them to proceed to his station for questioning. While waiting behind the yellow line, participants could view but not hear the Inspector conduct his questioning of an antecedent participant. When motioned forward to the Inspector's station, participants were directed to stand in front of a short counter with their toes on another yellow line on the floor; this was to optimally position them in front of microphones. The Inspector always began questioning behind the counter. Armed security personnel guarded the exit of this mock checkpoint and were visible to participants. All of these factors were designed to enhance the realism of the scenario to the participants and to provide a realistic environment to test Vericator's utility.

The Inspector, who was familiar with this study's design, was never told which participants were Smugglers and which were non-Smugglers or the base rate of Smugglers. After he motioned participants forward, he greeted them and asked for their picture identification. He input the identifying information and armband number on an Inspector Assessment form (see Appendix J) and then passed the picture identification to the Vericator operator stationed in full-view at a nearby table but behind the participant. The Vericator operator input the information into the Vericator system and signaled the Inspector to proceed with questioning. The Inspector never used the Vericator during questioning and could not see the Vericator screen, but relied solely on his own skills for decision-making. The Inspector asked participants to read aloud a series of statements indicating their agreement to participate in the study (see Appendix K). These statements served as the calibration period necessary for Vericator's Online mode. The calibration tuned the system to participants' voices. A digital audio recorder archived the vocal signals of participants. After the calibration period, the Inspector asked participants a series of questions (see Appendix L). Some related to personal information, e.g., name, address, and telephone number, some to classified or evidentiary

material in their possession, and the rest to points of contact while at the Federal building. After the checkpoint questioning was completed, participants were asked to sit down next to a standing guard. Then, the Inspector filled out the Inspector Assessment form with his assessment of participants' veracity. A seven-point Likert scale was provided for this assessment with an area for discussion about the assessment. During this time, the results of Vericator's Online assessment were printed (see Appendixes A and B for examples). The critical piece of information provided in this report was Vericator's decision of deception indicated or no deception indicated. The Vericator operator highlighted this for debriefing purposes. The report was placed in an enclosed document pouch with the Inspector Assessment form and handed to the guard. The guard then escorted the participant and delivered the pouch to the debriefing suite. All participants were escorted to the debriefing suite; none were allowed to leave the building, contrary to the briefing instructions. Checkpoint results were not discussed with the Inspector until after the study's completion.

The Inspector asked the series of questions (see Appendix L) in two different manners. On 6 test days (Days 1, 2, 3, 5, 6, 13), he strictly followed the fifteen scripted questions and never asked follow-up questions or moved from behind the counter or threatened to take participants to rooms where pat-downs would be performed. All answers were accepted at face value. This method was termed "Scripted" questioning. During the study, the median duration of Scripted questioning was 2 minutes 48 seconds (Range: 2:09 – 3:45). On the other 7 test days (Days 4, 7, 8, 9, 10, 11, 12), he asked the same list of questions, but also asked follow-up questions as needed for him to make an assessment. In addition, the Inspector would walk around his counter and approach subjects and threaten to take participants to rooms where pat-downs would be performed. In reality, physical contact by the Inspector with the participants never occurred and pat-downs never occurred. The intent of this method was to permit the

Inspector to act more like he does in the field. Because of this, it was termed "Field-like" questioning. During the study, the median duration of Field-like questioning was 3 minutes 9 seconds (Range: 2:02 – 4:50).

There was a two-fold purpose for using two questioning methods. First, the Inspector was much more comfortable with the Field-like mode since this most closely resembled his normal method of operation. He felt like he would be able to make better assessments if he was free to question participants' answers. Yet, highly controlled questioning was desired. Scripted and Field-like questioning would satisfy both requirements. Second, Kircher, Horowitz, and Raskin (1988) found that, in the context of PDD, the more a study replicated field-like conditions, the better its diagnostic accuracy. An assertive Inspector performing Field-like questioning would increase the perception of threat; thereby, alleviating concern about insufficient jeopardy.

Debriefing. Participant debriefing was conducted in a suite that contained a receptionist area, a holding room, four debrief rooms, and a monitoring room. A second security guard occupied the receptionist area and received participants and document pouches that were escorted and delivered, respectively, by the security guard working at the checkpoint. The debrief suite guard escorted participants to the holding room but retained the document pouches. Another person, named the "paymaster," controlled the flow of the debrief process. The paymaster was responsible for obtaining document pouches and escorting participants to one of the four available debrief rooms. Once escorted to a room, the paymaster asked participants to fill out a Participant Debriefing Questionnaire (see Appendix M). The paymaster then left participants in the room alone with the door closed and placed the document pouch outside the door. All debriefing rooms were equipped with a closed circuit video system. Participants were observed from the monitoring room in the debriefing suite.

After questionnaires were completed, a DoDPI scientist debriefed participants. The debrief included discussion about the decision made by the Vericator, discussion about the participant's answers to the questionnaire, and review of the Debriefing Form (see Appendix N) that participants took home. In addition, the debriefer responded to participant questions, asked for return of evidence, if applicable, and discussed participant compensation. All participants were paid $5 per ½ hour of time (rounded up to the next ½ hour) plus a $50 bonus if the Vericator analysis found no indication of deception in their responses to the Inspector's questions at the checkpoint. This bonus was available to both Smugglers and non-Smugglers. The debriefer then directed the paymaster to pay the participant the appropriate amount in cash. The paymaster escorted the participant out of the debrief suite to conclude the study for that participant.

Data Analyses

Vericator

A decision was made to consider all questions asked at the checkpoint to have equal merit even though some were very specific about smuggling. This conservative approach was based upon two factors. First, at a real checkpoint, an inspector cannot assume that any question is irrelevant; for example, biographical or point of contact information may be falsified. Second, physiological responses to one interview question cannot always be assumed to be unrelated to those of succeeding interview questions even though the questions may be unrelated because released catecholamines may still be exerting an influence (Delius, & Kellerová, 1971; Steptoe, 1987). This is especially true in an unstructured interview when sufficient time between questions is not allotted.

Vericator's Online mode assessed the overall credibility of participants during their entire interviews. Resultant test reports (see Appendixes A and B) provided Vericator's global

assessments of participant answers to the Inspector's questions at the checkpoint. A prominent part of these reports indicated whether deception was indicated during the interview or whether there was no deception indicated. In fact, the $50 bonus was only paid to subjects with a global assessment of 'No Deception Indicated' on their Online test reports. This approach was deemed reasonable because of the following Vericator decision rule: If a 'False Statement' is assigned to any segment of the interview, there will never be a call of 'No Deception Indicated' (Personal communication, A. de Vries, February 12, 2001). Because non-Smugglers were truthful to all questions they would theoretically fall into the 'No Deception Indicated' category and because Smugglers provided false statements they would theoretically fall into the 'Deception Indicated' categories. Offline evaluations were based upon different decision criteria that yielded the additional assessment of 'Inconclusive.'

Contingency tables were constructed for Scripted and Field-like questioning for both Online and Offline assessments. Contingency tables for the Online mode were 2x2 in construction while contingency tables for the Offline mode were 2x3 in construction. Examples of each are found in Table 4. From these contingency tables, four key relationships were derived to describe Vericator's accuracy. These included sensitivity, specificity, positive predictive value, and negative predictive value:

$$\text{Sensitivity} = a/(a + c)$$

$$\text{Specificity} = d/(b + d)$$

$$\text{Positive predictive value} = a/(a + b) \text{ for Online or } a/(a + b + e) \text{ for Offline}$$

$$\text{Negative predictive value} = c/(c + d) \text{ for Online or } c/(c + d + f) \text{ for Offline}$$

Sensitivity was defined as the probability that Vericator detected false statements by a Smuggler. This is the true positive rate or chance that a Smuggler was assigned to the DI category.

Specificity was defined as the probability that Vericator detected no false statements by a non-Smuggler. This is the true negative rate or chance that a non-Smuggler was assigned to the NDI category. Positive predictive value was defined as the probability that a participant assigned to the DI category was actually a Smuggler while negative predictive value was defined as the probability that a participant assigned to the NDI category was actually a non-Smuggler.

Table 4

Vericator Contingency Tables

Online mode			Offline mode			
	DI	NDI		DI	NDI	INC
Smugglers	a	b	Smugglers	a	b	e
non-Smugglers	c	d	non-Smugglers	c	d	f

Following the analyses of Online and Offline modes, the possibility of improving Vericator's decision criteria was explored via multiple logistic regression. Logistic regression (SigmaStat Statistical Software, version 2.03, SPSS, Inc., Chicago, IL) was used to model the probability of occurrence of a binary (DI/NDI) outcome (Zelterman & Louis, 1992). Vericator Graph System Parameters data (described earlier) of known Smugglers and non-Smugglers were used to derive multiple equations to classify Smugglers and non-Smugglers via DI/NDI outcomes, respectively. The end-goal was to maximize the number of correct classifications, regardless of Smuggler or non-Smuggler status. These optimal classification results were then placed in a contingency table where the key relationships were derived as described earlier. Results from multiple logistic regression analysis must be carefully weighed since this is a post-hoc analysis on data with a known outcome; therefore, the results will be positively biased. The optimal equations were not tested with a novel set of data.

U.S. Federal Inspector

The role of the Inspector at the checkpoint was described earlier, but his role in the assessment of Vericator's results has not been addressed. The Inspector did not use the Vericator at any time during the study. He was asked to conduct questioning and then come to an independent decision about participants' veracity based upon skills and aptitudes honed during multiple years in the field. The Inspector completed a 7-point Likert scale on the Inspector Assessment form (see Appendix J) with his assessment of the participants' veracity. A score of one represented a 'Highly Unlikely' assessment while a score of seven represented a 'Highly Likely' assessment. Following the study, the Inspector verified that assessments of five, six, or seven represented people he considered smugglers. The Inspector's opinion was considered an important source of comparison for the Vericator. Currently, an inspector's opinion in the field is the only reference point for success in identifying smugglers so it is the de facto 'gold standard.' It was, therefore, important to determine how the Vericator compared to the Inspector.

Contingency tables, similar to the Online mode contingency tables (see Table 4), were constructed for the decisions of the Inspector. From these contingency tables, the same four key relationships, described previously, were derived to describe the Inspector's accuracy. The sensitivity, specificity, positive predictive value, and negative predictive value of the Inspector were compared to the same Vericator relationships.

Statistics

A variety of statistical tests were performed to address Vericator's utility at checkpoints. One key goal of this study was to determine whether Vericator operated at better than chance levels. To address this goal, the z-test of proportions was used for Smugglers and non-Smugglers, respectively. A second key goal of this study was to determine whether Vericator

could discriminate between Smugglers and non-Smugglers. To address this goal, the chi-square test was used. However, for the chi-square test to be reliable, contingency tables must have five or more observations in each cell. When this constraint was violated, the Fisher exact test was used. A secondary goal of this study was to determine if Vericator's decisions compared to the Inspector's decisions. To address this goal, McNemar's test was used. Yates continuity correction was used in all of these tests to compensate for the small calculated *p* values that result from statistical tests that use a chi-square distribution with one degree of freedom. Discussions on the use of these various statistical tests can be found elsewhere (Norman & Streiner, 2000). All tests were performed with the same statistical software package (SigmaStat Statistical Software, version 2.03, SPSS, Inc., Chicago, IL).

A measure of association for categorical data was used to assess the effectiveness of the logistic regression models. The phi coefficient, Φ, was calculated to determine the correlation between predicted and actual Smugglers and non-Smugglers. Phi is similar to the Pearson product-moment correlation coefficient, r, a measure of association for parametric data. Its *p* value is equivalent to the chi-square *p* value. The proportion of variance explained by the optimized logistic regression equations is Φ^2 (Norman & Streiner, 2000).

Results

Participants

Two hundred forty-seven individuals were scheduled to participate in this study that was conducted in March 2000. Of these, only 180 reported for the study. Ten participants and/or their data sets were excluded for a variety of reasons. As discussed previously, one participant chose not to continue after realizing that the study did not incorporate polygraphy. Three participants completed the study but were dropped due to technical problems with the recording devices. Of the remaining six, two had foreknowledge of the study's design and purpose, two

did not follow instructions properly, and two confessed during questioning. So, data from only 170 participants were actually used for analyses; 77 for Scripted questioning and 93 for Field-like questioning.

During post-hoc analyses, two data sets from the Field-like questioning, one from a Smuggler and one from a non-Smuggler, could not be properly edited by Vericator's Offline analysis routines; portions of the participants' responses were clipped. Because of this, results from only ninety-one participants are presented in the Offline mode results and the logistic regression results.

The base rate for the Smugglers was dictated by two competing requirements. One was to drive the Smuggler base rate to the lowest possible level. The intent was to mimic the low base rate expected at security checkpoints. The other was to obtain the number of Smugglers estimated by power analysis for adequate statistical interpretation. Sample size estimates were performed prior to the study to determine the minimum sample size for a chi-square test. Assuming a sensitivity and specificity of 70% (power = .80, alpha = .05, and Yates correction factor accounted), the minimum sample size estimate was 26 for Smugglers and non-Smugglers during Scripted and Field-like questioning, respectively. An additional constraint to meeting both requirements was the limited time window available for operation of the mock checkpoint in the Federal building. A total of 15 days was allotted for operation, 1 day for setup, 13 days for operation, and 1 day for breakdown. Sample sizes and base rates for the study are presented in Table 5.

There was no attempt to control for demographic variables, such as sex, age, race, or education level since these variables would not be controlled at an actual checkpoint. However, this information was tracked on the Informed Consent Forms for Deceptive and Truthful Participants, respectively (see Appendixes H and I). They are presented in Table 6. On the

consent forms, participants were also asked to provide information about their current medication. Seventy-five percent of Scripted questioning participants self-reported being unmedicated while sixty-eight percent of Field-like questioning participants self-reported being unmedicated. Those that reported only acetaminophen, aspirin, contraceptive pills, or topicals were classified as unmedicated. A breakdown of the reported medications being used by some of the participants revealed treatments for a broad spectrum of conditions. These included: allergy/cold; cardiovascular (hypertension/rhythm disturbance); gastric; mental health (anxiety/ depression); metabolic (diabetes/female hormone replacement/thyroid); and rheumatic.

Table 5

Sample Sizes and Base Rates

	Sample size		Base rate
	Smuggler	non-Smuggler	
Scripted questioning N = 77	n = 26	n = 51	34%
Field-like questioning N = 93	n = 33	n = 60	35%

Online Mode

Vericator's decisions using the Online mode analysis are presented in Table 7. The results indicate a strong bias towards NDI calls with little difference between Scripted and Field-like questioning. Sensitivity, specificity, positive predictive power, and negative predictive power calculated from the Scripted and Field-like contingency tables, respectively, are presented in Table 8. Vericator's ability to detect Smugglers was poor ($p > .05$), but its ability to detect non-Smugglers was statistically significant ($p < .05$). The proportion of Smugglers and non-Smugglers in the DI and NDI categories were not statistically significant ($p > .05$). When the

Table 6

Demographic Information

	Scripted (N = 77)	Field-like (N = 93)
Sex		
Female	57%	60%
Male	43%	40%
Age		
18-29 years	40%	38%
30-39 years	18%	17%
40-49 years	18%	22%
50-59 years	16%	13%
60+ years	8%	10%
Race		
Asian	1%	8%
Black	26%	36%
White	64%	51%
Other (mixed, non-reporting)	9%	5%
Education completed		
High school or GED	27%	20%
College, 1-3 years	42%	53%
College, 4+ years	31%	27%

base rates and error rates were considered, 23% and 32% of DI calls were correct for Scripted and Field-like questioning, respectively, while 64% of NDI calls were correct. When compared to the Inspector's results. Vericator's Online mode performance was significantly sub-par for both Smugglers and non-Smugglers ($p < .01$).

Table 7

Online Mode Contingency Tables

	Scripted (N = 77)			Field-like (N = 93)	
	DI	NDI		DI	NDI
Smugglers	3	23	Smugglers	6	27
non-Smugglers	10	41	non-Smugglers	13	47

Offline Mode

Vericator's decisions using the Offline mode analysis are presented in Table 9. The results indicate a strong bias towards DI calls with little difference between Scripted and Field-like questioning. Sensitivity, specificity, positive predictive power, and negative predictive power calculated from the Scripted and Field-like contingency tables, respectively, are presented in Table 8. Vericator's ability to detect Smugglers was statistically significant ($p < .05$), but its ability to detect non-Smugglers was poor ($p > .05$). The lack of significance ($p = .08$) for the Scripted sensitivity was probably from too few participants (β-statistical error) since the power of the test was somewhat low (power = .41). When the base rates and error rates were considered, 43% and 40% of DI calls were correct for Scripted and Field-like questioning, respectively; there were too few NDI calls for the negative predictive power to have much meaning.

Table 8

Sensitivity, Specificity, and Predictive Power

	Sensitivity	Specificity	Positive Predictive Power	Negative Predictive Power
Online mode				
Scripted	.12	.80[a]	.23	.64
Field-like	.18	.78[a]	.32	.64
Offline mode				
Scripted	.77	.60	.43	.60
Scripted[b]		.49		.81
Field-like	.78[a]	.00	.40	.00
Field-like[b]		.36		.75
Logistic regression				
Scripted	.42	.96[a]	.85	.77
Field-like	.38	.90[a]	.67	.73
Inspector				
Scripted	.50	.67	.43	.72
Field-like	.55	.65	.46	.72

[a]Statistically significant (z-test, $p < .05$). [b]Calculated with NDI and INC categories collapsed.

Table 9

Offline Mode Contingency Tables

	Scripted[a] (N = 77)				Field-like (N = 91)		
	DI	NDI	INC		DI	NDI	INC
Smugglers	20	2	4	Smugglers	25	0	7
non-Smugglers	26	3	22	Non-Smugglers	38	0	21

[a]Smugglers and non-Smugglers differ significantly (chi-square test with NDI and INC collapsed, $p < .05$).

A review of the INC calls (see Table 9) revealed that the proportion of non-Smugglers with INC calls was significantly greater than Smugglers with INC calls ($p < .05$). Therefore, the NDI and INC categories were collapsed to enable direct comparisons to the Inspector's decisions. When compared, Vericator's Offline mode performance, using collapsed NDI and INC categories, was better for Smugglers ($p < .05$ for Scripted; $p < .001$ for Field-like), but worse for non-Smugglers ($p > .05$). Specificity for the collapsed categories was still sub-par (see Table 8), but NDI calls were correct 81% and 75% of the time for Scripted and Field-like questioning, respectively. The proportion of Smugglers and non-Smugglers in the DI and NDI (and INC) categories were significantly different for the Scripted questioning ($p < .05$), but not for the Field-like questioning ($p > .05$). Once again, the lack of significance might have been the result of too few participants (β-statistical error; power = .19).

Logistic Regression

Logistic regression analyses were performed on the three categories of Vericator's Graph System Parameters (see Table 3) as discussed in the Methods section. Equations were derived with all combinations of parameters within a category, i.e., Raw-Values, First Grade, or

Algorithmic, to predict Smugglers and non-Smugglers via DI/NDI classifications. The end-goal was to maximize the correct number of total classifications, regardless of Smuggler status or parameter category.

Optimally derived equations for Scripted and Field-like questioning both came from Raw-Values parameters (see Table 3). Their resulting DI/NDI classifications are presented in Table 10. For the Scripted regression equation, all Raw-Values parameters were incorporated but one, the Fflic (harmonic). For the Field-like regression equation, only four Raw-Values parameters were incorporated, SPT, SPJ, JQ, and SOS. Sensitivity, specificity, positive predictive power, and negative predictive power calculated from the Scripted and Field-like contingency tables are presented in Table 8. Decision accuracy for Smugglers was still not statistically significant ($p > .05$), but decision accuracy for non-Smugglers was highly significant ($p < .001$). The proportion of Smugglers and non-Smugglers in the DI and NDI categories were significantly different for the Scripted questioning ($p < .001$) and for the Field-like questioning ($p < .01$). A review of the positive predictive values reveals that 85% and 67% of the DI calls were correct for Scripted and Field-like questioning, respectively. A review of the negative predictive values reveals that over 70% of NDI calls were correct. The phi coefficients (Φ) for the logistic regression equation results of Table 10 were .48 for Scripted ($p < .001$) and .33 for Field-like ($p < .01$) questioning. These results reveal moderately positive to small positive relationships, respectively, between predicted and actual Smugglers and non-Smugglers. The proportion of variance explained in the correlation (Φ^2) was .23 for Scripted questioning and .11 for Field-like questioning.

Table 10

Logistic Regression Contingency Tables

	Scripted[a] (N = 77)			Field-like[b] (N = 91)	
	DI	NDI		DI	NDI
Smugglers	11	15	Smugglers	12	20
non-Smugglers	2	49	non-Smugglers	6	53

[a]Smugglers and non-Smugglers differ significantly (chi-square test, $p < .001$); $\Phi = .48$ ($p < .001$); $\Phi^2 = .23$. [b]Smugglers and non-Smugglers differ significantly (chi-square test, $p < .01$); $\Phi = .33$ ($p < .01$); $\Phi^2 = .11$.

Discussion

We studied the ability of the Vericator to detect smugglers at a security checkpoint. One key goal of this study was to determine whether Vericator operated at better than chance levels. Another was to determine whether Vericator could discriminate between Smugglers and non-Smugglers. A secondary goal was to determine if Vericator's decisions compared to the Inspector's decisions. The major finding was that Vericator's standard operating modes performed disparately; the Online mode had poor sensitivity (few DI decisions), but statistically significant specificity while the Offline mode had statistically significant sensitivity but poor specificity (few NDI decisions). Neither Online nor Offline modes discriminated between Smugglers and non-Smugglers based on Vericator's original calls. When compared to the Inspector, Vericator's performance was significantly sub-par in almost all cases. Clearly, these results do not support the use of Vericator at security checkpoints, but our logistic regression of the Graph System Parameters greatly improved its detection capabilities. Whether future

modifications to Vericator's decision algorithms could sufficiently improve this device is unclear.

Vericator Utility

One key question we addressed was whether Vericator operated at greater than chance levels at a security checkpoint. This was an essential component in determining its utility. The original intent of the study was to test only Vericator's Online mode, i.e., real-time component of the Vericator system. However, after the Online mode contingency tables (see Table 7) were reviewed, it became readily apparent that this mode was heavily biased towards NDI decisions. Very few DI decisions were made. This resulted in highly skewed results with sensitivity below .20 and specificity about .80 (see Table 8). Specificity was statistically significant, but the positive (.23 and .32 for Scripted and Field-like questioning, respectively) and to a small extent, the negative (.64 for both types of questioning) predictive values were reflective of the Online mode's poor decision accuracy.

Because of the poor Online mode results, we decided to test the Vericator system's Offline mode capabilities. This decision resulted in a lengthy continuation of the study because of the extended time required to edit and analyze the stored audio files. The resulting contingency tables (see Table 9) provided a reverse image of the Online contingency tables, i.e., a heavy bias towards DI decisions. In fact, there were no NDI decisions from the Field-like questioning; however, a large number of INC decisions were made (not an option in the Online mode). This resulted in highly skewed results with statistically significant sensitivity at about .78 and specificity near .00 (see Table 8). Even though sensitivity was significant, the positive (.43 and .40 for Scripted and Field-like questioning, respectively) and negative (.60 and .00 for Scripted and Field-like questioning, respectively) predictive values were reflective of the Offline mode's poor decision accuracy. An attempt was made to collapse the categories from three (DI,

NDI, and INC) to two (DI and NDI/INC) when we observed that most INC decisions were applied to non-Smugglers. This post-hoc manipulation dramatically improved specificity and negative predictive accuracy suggesting that Offline mode and, possibly, all Vericator system decision algorithms were incorrectly calibrated.

The second key question we addressed was whether Vericator discriminated between Smugglers and non-Smugglers. This was another essential component in determining its discriminatory ability. For the Online mode, the proportion of Smugglers and non-Smugglers in the DI and NDI categories was not significantly different; this indicated an inability to differentiate between the two. These were also the results for the Offline mode without collapsed categories. However, when we collapsed the Offline mode NDI and INC categories, there was a significant differentiation in the Scripted questioning. This also supported our growing belief that the Vericator decision algorithms were not properly calibrated.

A secondary question we addressed was whether Vericator's decision accuracy compared to the Inspector's decision accuracy. This was intended to help generalize our results to an accepted 'gold' standard, the U.S. Federal inspector. Even though we used the Inspector's results as a standard for Vericator, care must be taken not to extrapolate the Inspector's decision accuracy in this study to performance in the field; the study design would have been drastically different had we tested field performance of U.S. Federal inspectors. When compared to the Inspector's results, Vericator's standard Online and Offline modes were significantly sub-par (see Table 8). However, results were more equivalent for the Offline mode after the NDI and INC categories were collapsed. A cursory effort was made to determine whether Inspector and Vericator decisions could be combined in some way to improve decision accuracy, but no obvious improvement was observed.

Decision Accuracy

Because of our concerns with Vericator's decision algorithms, we attempted to create our own decision algorithms to maximize overall decision accuracy. We were unconcerned whether improvement occurred in the DI or NDI categories. Logistic regression analysis was performed on all possible combinations of parameters within each category of Graph System Parameters, i.e., Raw-Values, First Grade, or Algorithmic (see Table 3). This constraint was established because parameters from one category are derived from parameters in other categories in unknown ways. We do know that First Grade parameters are generated from Raw-Values parameters and Algorithmic parameters are generated from First Grade and Raw-Values parameters. Raw-Values parameters are extracted directly from the vocal signal and are not, supposedly, mathematically manipulated (Vericator™ User Manual, 2000). The best decision accuracy came from logistic regression of the Raw-Values parameters for both Scripted and Field-like questioning (see Table 10). Even so, sensitivity did not become statistically significant (see Table 8). However, specificity improved to the .90 range and was statistically significant. The predictive capabilities of these logistic regression equations were much improved as well, ranging from .67 to .85. All of these factors lend credence to our belief that the Vericator decision algorithms were not properly calibrated and open the door to the possibility that Raw-Values Graph System Parameters may, in fact, yield information capable of discriminating between deceptive and non-deceptive individuals at checkpoints. Specifically, these results indicate that when a NDI decision was made, it was correct most of the time. This piece of information could have value at a checkpoint by at least eliminating some people from consideration.

A major caveat must be placed here. We used logistic regression analyses to fit our data to known and desired outcomes. This heavily biased the outcomes to yield the most favorable

results. In order to test the derived decision algorithms' respective accuracies without bias, a new study would have to generate new data to test the algorithms. This was well beyond our original intent and scope. Another point of concern we have with the ability to generalize these results to new data stems from the fact that the derived decision algorithms for Scripted and Field-like questioning were quite different. The Scripted algorithm used eight of the nine Raw-Values parameters while the Field-like algorithm used only four. This raises concerns that these algorithms are based upon highly variable data. As a result, cross-validation with new data is questionable.

Potential Limitations

In their meta-analysis of mock crime studies, Kircher et al. (1988) found that diagnostic accuracy was directly related to the realism of the conditions, i.e., perception of threat or jeopardy makes a difference. We addressed this by creating a controlled study in the field; the entire scenario mimicked reality, minus an actual crime. First, we conducted the study in an actual Federal building, constructed the checkpoint in an actual checkpoint security area, and staffed the checkpoint with an actual U.S. Federal inspector and Federal building guards. Second, we developed a smuggling scenario that was believable and actively involved the participants. They were required to hide items on their person that they were led to believe was actual Federal evidence, pass through a checkpoint that they were led to believe was an actual checkpoint, and to leave the building to destroy the evidence. All were warned that they would be taken to a room for questioning and interrogation if they did not convince the Inspector of their veracity. Third, we provided monetary bonuses to all participants, both Smugglers and non-Smugglers, who successfully passed through the security checkpoint as an incentive. This was important in order to produce higher decision accuracies (Kircher et al., 1988). All of this was done within the ethical framework established by the Declaration of Helsinki as instituted by

the University of South Carolina Institutional Review Board. Whether these elaborate steps to generate a sense of jeopardy were successful can be debated; however, participants' responses to the Participant Debriefing Questionnaire (see Appendix M) provided a subjective indication that they felt a moderate to high involvement in the scenario.

There were instances where the power of the statistical tests was somewhat low (see Results). Even though the minimum number of, at least 26, participants per category was achieved (see Table 4), more Smuggler participants may have helped to alleviate this concern.

The base rate of 34% and 35% for Scripted and Field-like questioning, respectively, was higher than desired (see Results). Originally, we had desired to drive the base rate down to mimic the lower base rate expected at security checkpoints. An exaggerated base rate will overstate the positive predictive value of the approach (Killeen, 1999).

VSA's Future

Undoubtedly, the allure of VSA will continue into the foreseeable future for a number of reasons. First, the acquisition of vocal signals does not require sensors or transducers to come in contact with or be visible to the person being monitored. This non-contact characteristic permits remote and clandestine acquisition and analysis, if necessary. Second, the acquisition of vocal signals does not require expensive and cumbersome equipment. Set up time and space requirements are minimal. In addition, the increasing computational power and decreasing size of computers have facilitated these advantages. This permits sophisticated algorithm development and functional deployment at a relatively low cost. Third, the acquisition of vocal signals can be made during various formats, e.g., interrogations, interviews, and unstructured conversations. A fourth reason VSA will continue into the foreseeable future is that there is an established VSA industry that has been in operation for over 30 years. This industry has made numerous contacts in law enforcement as witnessed by the widespread use of VSA devices in

law enforcement. This creates an inherent culture to support future VSA use. A fifth reason VSA will continue is the pressure on legislators and program managers to provide quick solutions to long-term problems. Without other solutions readily available, VSA becomes an easy stopgap and a perceived solution. A sixth and powerful reason for VSA's allure is the intuitive belief that stress and deception can be determined by listening to a person speak. VSA, therefore, becomes a magical 'silver bullet' in people's minds. Unfortunately, to date, VSA still has not proven to be a valid and reliable indicator of stress or deception. Whether a system that outperforms inspectors, i.e., a 'silver bullet,' will ever be discovered remains to be seen.

References

Bell, Jr., A. D., Ford, W. H., & McQuiston, C. R. (1976). *U.S. Patent No. 3,971,034.* Washington, DC: U.S. Patent and Trademark Office.

Brenner, M., Branscomb, H. H., & Schwartz, G. E. (1979). Psychological stress evaluator- two tests of a vocal measure. *Psychophysiology*, 16, 351-357.

Cestaro, V. L. (1996a). A comparison between decision accuracy rates obtained using the polygraph instrument and the computer voice stress analyzer (CVSA) in the absence of jeopardy. *Polygraph*, 25, 117-127.

Cestaro, V. L. (1996b). *A comparison of accuracy rates between detection of deception examinations using the polygraph and the computer voice stress analyzer in a mock crime scenario* (Report No. DoDPI95-R-0004). Fort McClellan, AL: Department of Defense Polygraph Institute. (DTIC# ADA318985)

Cestaro, V. L., & Dollins, A. B. (1996). An analysis of voice responses for the detection of deception. *Polygraph*, 25, 15-34.

Delius, W., & Kellerová, E. (1971). Reactions of arterial and venous vessels in the human forearm and hand to deep breath or mental strain. *Clinical Science*, 40, 271-282.

DoDPI Research Division Staff, Meyerhoff, J. L., Saviolakis, G. A., Koenig, M. L., & Yourick, D. L. (2001). *Physiological and biochemical measures of stress compared to voice stress analysis using the computer voice stress analyzer (CVSA)* (Report No. DoDPI01-R-0001). Fort Jackson, SC: Department of Defense Polygraph Institute. (DTIC #ADA393408)

Guyton, A. C. (1981). *Textbook of Medical Physiology* (6th ed.). Philadelphia: W. B. Saunders.

Hisa, Y., Koike, S., Tadaki, N., Bamba, H., Shogaki, K., & Uno, T. (1999). Neurotransmitters and neuromodulators involved in laryngeal innervation. *Annals of Otology, Rhinology & Laryngology Suppl,* 178, 3-14.

Hollien, H., Geison, L., & Hicks, J. W., Jr. (1987). Voice stress evaluators and lie detection. *Journal of Forensic Sciences*, 32, 405-418.

Horvath, F. (1978). An experimental comparison of the psychological stress evaluator and the galvanic skin response in detection of deception. *Journal of Applied Psychology*, 63, 338-344.

Horvath, F. (1979). Effect of different motivational instructions on detection of deception with the psychological stress evaluator and the galvanic skin response. *Journal of Applied Psychology*, 64, 323-330.

Integritek Systems. *The Facts*. Retrieved May 30, 2002, from http://www.integritek.com/the_facts.htm

Janniro, M. J., & Cestaro, V. L. (1998). Effectiveness of detection of deception examinations using the computer voice stress analyzer. *Polygraph*, 27, 28-34.

Killeen, A. A. (1999). *The effect of disease prevalence on the predictive value of diagnostic tests.* Retrieved October 3, 2002, from http://ipathology.com/disease%20prevalence%20notes.htm

Kircher, J. C., Horowitz, S. W., & Raskin, D. C. (1988). Meta-analysis of mock crime studies of the control question polygraph technique. *Law and Human Behavior*, 12, 79-90.

Lippold, O. (1971). Physiological Tremor. *Scientific American,* 224, 65-73.

National Institute For Truth Verification. *Welcome to the official website of the NITV*. Retrieved May 30, 2002, from http://www.cvsa1.com/index.php

Norman, G. R., & Streiner, D. L. (2000). *Biostatistics: The Bare Essentials* (2nd ed.). Hamilton, Ontario, Canada: B. C. Decker.

Reeves, T. E. (1980). Audio-stress analysis: a means of truth verification in forensic practice. *Medical Trial Technique Quarterly,* 27, 430-455.

Shipp, T., & Izdebski, K. (1981). Current evidence for the existence of laryngeal macrotremor and microtremor. *Journal of Forensic Sciences,* 26, 501-505.

Steptoe, A. (1987). The assessment of sympathetic nervous function in human stress research. *Journal of Psychosomatic Research*, 31, 141-152.

Timm, H. W. (1983). The efficacy of the psychological stress evaluator in detecting deception. *Journal of Police Science and Administration*, 11, 62-68.

Vericator™ User Manual (Version 6.30). (2000). Tampa, FL: Integritek Systems.

Zelterman, D., & Louis, T. A. (1992). Contingency tables in medical studies. In J. C. Bailar III & F. Mosteller (Eds.), *Medical Uses of Statistics* (2nd ed., pp. 293-310). Boston: NEJM Books.

Appendix A

Vericator – Online Mode – Test Report – No Deception Indicated

Vericator – Online Mode – Test Report

>> Test Started on:2/16/01 9:33:34 AM

There was no indication of Deception in this conversation.

>> Voice Manipulation Samples: 0% of the test.
>> 'Confusion'/'Uncertainty' Samples:0% of the test.

>> Excited samples:13%
>> Highly Excited Samples:0%

>> Stress Samples:5%
>> Medium Stress Samples:0%
>> High Stress Samples :0%

** No relevant segments were marked.

***GLOBAL HONESTY RATE: 98%
***DECEPTION RATE: 0%
***INACCURACIES RATE: 2%

---> Suggested Analysis :

>> The subject probably did not lie.
Some LOW STRESS was detected.
>> The subject was inaccurate about some of the details.

(Test Length:00:03:18)

Appendix B

Vericator - Online Mode – Test Report – Deception Indicated

Vericator – Online Mode – Test Report

>> Test Started on:2/16/01 10:09:42 AM

>> DECEPTION INDICATED IN THIS CONVERSATION<<

- Precentage (sic) of FALSE STATEMENTS:1.6% (From the conversation)

>>> Deception attributed to an extreme EMOTIONAL state :0% (From deceptive statements)
>>> Deception attributed to extreme COGNITIVE activity:0% (From deceptive statements)
>>> Deception attributed to extreme STRESS:0% (From deceptive statements)
>>> Deception & INTENSIVE THINKING :0% (From deceptive statements)
>> Voice Manipulation Samples: 0% of the test.
>> 'Confusion'/'Uncertainty' Samples:10% of the test.

>> Excited samples:0%
>> Highly Excited Samples:0%

>> Stress Samples:16%
>> Medium Stress Samples:1%
>> High Stress Samples :1%

** No relevant segments were marked.

***GLOBAL HONESTY RATE: 96%
***DECEPTION RATE: 1%
***INACCURACIES RATE: 3%

---> Suggested Analysis :

The subject appeared uncertain about several bits of information s/he gave.
.. The subject was relatively stressed during the WHOLE TEST, but not too stressed in general.

(Test Length:00:02:56)

Appendix C

Vericator - Offline Mode – Test Report – Deception Indicated

*** Vericator Analysis Report ***

>> Calibration Info. >>
> EMO. Level : (C-456), (R-1), (W-6)
> COG. Level : (C-304), (R-1), (W-7)
> STR. Level : (C-27), (R-2), (W-7)
> FRG. Level : (C-23), (R-2), (W-6)
- The EMO. Factor was NOT very stable. A significant EMOTIONAL CHANGE was detected
- The COG. Factor was relatively stable. A Logical Conflict was not detected.
- The STR. Factor was relatively stable. Extreme stress was not detected.
- The FRG. Factor was relatively unstable. A slight guilt complex response was detected.

>> Detection Summary. >>
'TRUTH' Samples: 12
'STRESSED' Samples: 9
'EXCITED' Samples: 2
'NOT SURE' Samples: 5
'HIGHLY STRESSED' Samples: 5
'HIGH TENSION' Samples: 3
'EXTREME TENSION' Samples: 6
'INACCURACY' Samples: 6
'PROBABLY LYING' Samples: 3

>> Deceptions and Suspected Segments >>
*> Inconclusive (INC) Result on Segment No. 10 (Issue:)
*> Inconclusive (INC) Result on Segment No. 13 (Issue:)
*> Inconclusive (INC) Result on Segment No. 36 (Issue:3 Rel. place of birth)

REL (22):'3 Rel.' – STRESSED <NDI>
REL (23):'3 Rel.' – INACCURACY <INC>
REL (24):'3 Rel.' – NOT SURE <INC>
REL (25):'3 Rel.' – EXTREME TENSION <INC+>
REL (26):'3 Rel.' – TRUTH <NDI>
REL (27):'3 Rel.' – TRUTH <NDI>
REL (28):'3 Rel.' – TRUTH <NDI>
REL (29):'3 Rel.' – STRESSED <NDI>
REL (30):'3 Rel.' – NOT SURE <INC>
REL (31):'3 Rel.' – TRUTH <NDI>
REL (32):'3 Rel.' – EXTREME TENSION <INC+>
REL (33):'3 Rel.' – EXCITED <NDI>
REL (34):'3 Rel.' – STRESSED <NDI>
REL (35):'3 Rel.' – EXTREME TENSION <INC+>

REL (36):'3 Rel.'place of birth' – PROBABLY LYING <DI>
REL (37):'3 Rel.' – INACCURACY <INC>
REL (38):'3 Rel.' – TRUTH <NDI>
REL (39):'3 Rel.' – EXTREME TENSION <INC+>
REL (40):'3 Rel.' – TRUTH <NDI>
REL (41):'3 Rel.' – TRUTH <NDI>
REL (42):'3 Rel.' – High Anticipation <INC>
REL (43):'3 Rel.' – HIGH TENSION <NDI>
REL (44):'3 Rel.' – TRUTH <NDI>
REL (45):'3 Rel.' – TRUTH <NDI>
REL (46):'3 Rel.' – INACCURACY <INC>
REL (47):'3 Rel.' – TRUTH <NDI>
REL (48):'3 Rel.' – EXTREME TENSION <INC+>
REL (49):'3 Rel.' – HIGHLY STRESSED <INC>
REL (50):'3 Rel.' – INACCURACY <INC>
REL (51):'3 Rel.' – HIGH TENSION <NDI>
REL (52):'3 Rel.' – NOT SURE <INC>

>> Final Analysis >>

> Deceptive Segments:
> Probably Deceptive Segments: 3
- DECEPTION WAS DETECTED IN RESPONSE TO A RELEVANT ISSUE (0.54)
Average Lie Probability: 21

(Remarks)
- If you use Deception Pattern #1. 1 Lies will be added.

*** Manual Analysis ***

Lie S	Lie P	Cog	Emo	Glb	Frg	Ant
109	24	98	99	131	112	10
109	19	102	101	115	94	6

Appendix D

Telephone Script for Prospective Participants

(DoDPI00-P-0024)

A telephone coordinator will conduct a brief interview with the following script.

"The Department of Defense Polygraph Institute will be conducting a study over the next few weeks to test whether a new technology is able to assess a person's credibility through their speech. The specific purpose of this study is to determine whether this new voice-based credibility assessment technology can assist Federal inspectors at security checkpoints. The location of the study is the Strom Thurmond Federal Building in downtown Columbia, South Carolina. We are recruiting subjects to fill slots between March 13 and March 30. We estimate that the study will require about 2 hours to complete. For some, it might be a bit longer; for others, it might be a bit shorter. As the advertisement stated, you will be compensated for your time at a rate of $5 per ½ hour plus the chance to receive a $50 bonus. It is important for you to understand that you will only be paid for time spent in the study. Transportation time does not count toward payment. You will also not be reimbursed for transportation costs, although parking will be provided for free. There are eligibility requirements that you must meet to participate, but let me first ask if you interested in proceeding."

If the answer is yes, the telephone coordinator will continue with the following script.

"In order to be eligible, you must meet all of the following conditions."

"Are you 18 years of age or older?"

"Have you graduated from high school or earned a GED?"

"Are you fluent in English?"

"Are you able to read and answer questions aloud?"

"Are you ambulatory (able to walk without assistance)?"

"Do you have a valid picture identification such as a driver's license or school id.

<u>If all answers were yes, the telephone coordinator will continue with the following script.</u>

"You are eligible for the study. Would you like to schedule a time?

<u>Once a time and date has been scheduled and personal contact information has been taken, the telephone coordinator will continue.</u>

"Let me go over all of the details. Your name is _____. Your address is _____. Your telephone number is _____. You have been scheduled to participate in a Department of Defense Polygraph Institute credibility assessment study. Please write down the following details. You are scheduled to appear on <u><day of week></u>, March __ at ___ AM/PM in Room 610 of the Strom Thurmond Federal Building at 1835 Assembly Street in downtown Columbia, South Carolina. Please arrive promptly. Parking will be provided at the Bank of America Plaza parking garage located diagonally from the courthouse at the intersection of Assembly and Richland Streets. This parking garage is located behind the Bank of America Plaza building between Main and Assembly streets. Enter through the alley connecting to Calhoun & Richland streets. Park your vehicle in any available (unreserved) space on the top (6th) floor. Be sure to bring the parking stub so that we can validate it before you leave. I have three more items to relay to you. First, please leave all of your portable communication devices outside the Federal Building. They can create a great deal of confusion during the study. Second, please do not bring acquaintances with you to the study. Third, please bring a valid picture id. You must have one to participate. Do you need for me to repeat anything for you?"

Repeat any additional details and conclude the conversation.

Appendix E

Study Explanation and Instructions for Deceptive Participants
(DoDPI00-P-0024)

Name:_____ Date:_____

The following explanation will provide you with information about this study. Take your time in reading this. Some details were discussed on the phone, but many details will be new to you. Before you start, the investigators would like to thank you ahead of time for your willingness to participate in this credibility assessment study.

PLEASE READ VERY CAREFULLY!

Study Explanation
Federal security officers in the Strom Thurmond Federal Building have begun a new program to prevent the loss of classified documents and Federal evidence for upcoming trials at the adjacent Federal courthouse. The key to this new program is a technology that can assess people's credibility through their speech. This program requires that all visitors granted access to what are termed 'risk areas' must now wear special armbands. (You were issued an armband because you are in a 'risk area.') When ready to leave, these visitors must successfully pass through a checkpoint where a Federal inspector will test them with this new technology before being cleared to leave the building. At the checkpoint, the inspector will ask them a number of questions; some for identification purposes, some about the possession of classified documents or Federal evidence, and some about points of contact while at the Federal Building. The new voice-based technology will be used to assess the credibility of the visitors' answers.

The Department of Defense Polygraph Institute is conducting this study to determine how well this new voice-based credibility assessment technology works. In other words, can this technology detect smugglers at security checkpoints? In order to test this, we will randomly select some participants to smuggle items out of the Federal Building and some to pass through without smuggling items. You have been chosen to be a smuggler for this study. This will require that you smuggle one piece of evidence for an upcoming Federal trial past an actual Federal inspector who will be using this technology at a security checkpoint in this building, the Strom Thurmond Federal Building. The inspector will ask you a number of questions. To avoid being caught, you must convince the inspector and the voice-based technology that you are not a smuggler. This will require you to answer some questions deceptively and convincingly. If you are cleared at the checkpoint, you must leave the Federal Building and dispose of the evidence.

We estimate that the study will require about 2 hours to complete. For some, it might be a bit longer; for others, it might be a bit shorter. You will be compensated for your time at a rate of $5 per ½ hour. You will only be paid for time spent in the study. The timer started when you registered with the study representative in the previous room and will stop when you are dismissed from the study. You will also receive a $50 bonus if you complete the study and if you convince the voice-based credibility assessment technology at the checkpoint that you gave credible answers.

Now, please answer the questions below to make sure that you are eligible to participate in this study (circle answers):

- Are you 18 years of age or older? Yes No
- Have you graduated from high school or obtained your GED? Yes No
- Are you fluent in English? Yes No
- Are you able to read and answer questions aloud? Yes No
- Are you ambulatory (able to walk without assistance)? Yes No

Initials _____

If you answered 'Yes" to all questions, then you are eligible. If you answered 'No' to any questions, please open the door to your room and remain in the room until study personnel contact you.

Consent Form

We now ask you to carefully read the attached Consent Form and answer the following questions (circle answers):

- Did you read the Consent Form? Yes No
- Did you choose to participate in this study? Yes No
- Did you sign and date the appropriate line of the Consent Form? Yes No
- Did you take your copy of the Consent Form for your records? Yes No

Initials_____

If you chose not to participate in this study, please open the door to your room and remain in the room until study personnel contact you.

Instructions

We ask for your cooperation on the following very important issues:

- Turn off all portable communication devices you may have brought with you.
- Do not communicate with any acquaintances during the study.
- Do not communicate with any other study participants during the study.
- Do not remove your armband during the study.
- Follow all instructions you receive very carefully.

A few items to remember:

- Remember that you are a volunteer and have the right to withdraw from this study at any time and for any reason without penalty or punishment. Please note that if you do quit before completing the study, you will be paid only for the time you have spent up to that point and no bonus will be awarded to you.

- You may be audio- and videotaped at any time during the study.

- There are no known risks associated with the use of this technology.

- Do not admit guilt to the Federal inspector or any security personnel.

- Do not discuss the study with the Federal inspector or any security personnel.

- Do not indicate that you are smuggling an item of evidence.

- Should you be taken for further questioning by security, remember that your point of contact is the study's investigator, Troy E. Brown, Ph.D. This information is on your copy of the consent form.

- You must turn in your armband and the evidence to study personnel before getting paid.

Please perform the following tasks in order (check them off as you complete them):

- Open the evidence box on the table. You will notice a number of items in the box are sealed with U.S. Secret Service Evidence stickers. This is evidence for an upcoming Federal trial. A press release about the indictment is found in the manila folder in the box.

  Completed:_____

- Choose any one item of evidence that you will smuggle past the security checkpoint. **Remember that you must conceal this item on your person,** not in anything that you may be carrying such as a purse, briefcase, or backpack. Carried items may be separately inspected. Conceal the item on your person. Tape has been provided if needed.

  Completed:_____

- Place your copy of the Consent Form in a your belongings. **You do not want your consent form to be visible.**

  Completed:_____

- Put <u>only</u> the signed Consent Form in the envelope.

  Completed:_____

- Place the envelope in the envelope holder on the outside of the door that you used to enter the room. Make sure the door is closed.

  Completed:_____

Do not proceed to the checkpoint until directions are provided to you. They will be slid under the door that you used to enter the room.

Carefully read the following instructions and make sure you understand them.

When you arrive at the checkpoint, you will see a sign that says "Armbands." Follow the arrow. Wait in line until the Federal inspector calls you up to his station for the interview. The inspector will first ask for your identification card. Then, he will ask you to read a statement aloud. Next, he will ask you to answer aloud a number of questions related to your identification. Answer these questions accurately. You will then be asked to answer aloud a series of questions about classified documents or Federal evidence in your possession. Do not admit to the possession of any Federal evidence. Finally, you will be asked about your contacts while in the Federal Building. Do not admit that anyone gave you any items or asked you to destroy evidence. If you should get past the checkpoint undetected, then you have effectively circumvented the new security measures and will be permitted to leave the building. You are then to immediately exit the building, find a discreet location, remove the red evidence sticker from the smuggled item, and dispose of the evidence in a trashcan. After at least 10 minutes, return to the Federal building with the red evidence sticker concealed in your clothing and proceed to Room 720. When you present the red evidence sticker and if you have successfully passed the security checkpoint with the new technology, you will be paid a $50 bonus in addition to your time. If by some chance, you are detained at the checkpoint, you will be escorted to a private room for further questioning. At that time, you are to ask security to contact your point of contact, Troy E. Brown, Ph.D.

Read the previous paragraph as many times as necessary to completely understand your instructions.

- I have read and understand the previous instructions.

Completed:_____

- I have received the directions from under the door and am ready to proceed.

Completed:_____

- I have left this instruction form on the desk.

Completed:_____

Proceed to the security checkpoint.

Thank you once again for you participation.

Troy E. Brown, Ph.D.
Principal Investigator
Department of Defense Polygraph Institute

Appendix F

Study Explanation and Instructions for Truthful Participants
(DoDPI00-P-0024)

Name:_____ Date:_____

The following explanation will provide you with information about this study. Take your time in reading this. Some details were discussed on the phone, but many details will be new to you. Before you start, the investigators would like to thank you ahead of time for your willingness to participate in this credibility assessment study.

PLEASE READ VERY CAREFULLY!

Study Explanation
Federal security officers in the Strom Thurmond Federal Building have begun a new program to prevent the loss of classified documents and Federal evidence for upcoming trials at the adjacent Federal courthouse. The key to this new program is a technology that can assess people's credibility through their speech. This program requires that all visitors granted access to what are termed 'risk areas' must now wear special armbands. (You were issued an armband because you are in a 'risk area.') When ready to leave, these visitors must successfully pass through a checkpoint where a Federal inspector will test them with this new technology before being cleared to leave the building. At the checkpoint, the inspector will ask them a number of questions; some for identification purposes, some about the possession of classified documents or Federal evidence, and some about points of contact while at the Federal Building. The new voice-based technology will be used to assess the credibility of the visitors' answers.

The Department of Defense Polygraph Institute is conducting this study to determine how well this new voice-based credibility assessment technology works. In other words, can this technology detect smugglers at security checkpoints? In order to test this, we will randomly select some participants to smuggle items out of the Federal Building and some to pass through without smuggling items. You have been chosen to pass through the checkpoint without smuggling items. At the checkpoint, the inspector will ask you to answer a number of questions. We ask you to be honest in your answers.

We estimate that the study will require about 2 hours to complete. For some, it might be a bit longer; for others, it might be a bit shorter. You will be compensated for your time at a rate of $5 per ½ hour. You will only be paid for time spent in the study. The timer started when you registered with the study representative in the previous room and will stop when you are dismissed from the study. You will also receive a $50 bonus if you complete the study and if you convince the voice-based credibility assessment technology at the checkpoint that you gave credible answers.

Now, please answer the questions below to make sure that you are eligible to participate in this study (circle answers):

- Are you 18 years of age or older? Yes No
- Have you graduated from high school or obtained your GED? Yes No
- Are you fluent in English? Yes No
- Are you able to read and answer questions aloud? Yes No
- Are you ambulatory (able to walk without assistance)? Yes No

Initials _____

If you answered 'Yes" to all questions, then you are eligible. If you answered 'No' to any questions, please open the door to your room and remain in the room until study personnel contact you.

Consent Form

We now ask you to carefully read the attached Consent Form and answer the following questions (circle answers):

- Did you read the Consent Form? Yes No
- Did you choose to participate in this study? Yes No
- Did you sign and date the appropriate line of the Consent Form? Yes No
- Did you take your copy of the Consent Form for your records? Yes No

Initials_____

If you chose not to participate in this study, please open the door to your room and remain in the room until study personnel contact you.

Instructions

We ask for your cooperation on the following very important issues:

- Turn off all portable communication devices you may have brought with you.
- Do not communicate with any acquaintances during the study.
- Do not communicate with any other study participants during the study.
- Do not remove your armband during the study.
- Follow all instructions you receive very carefully.

A few items to remember:

- Remember that you are a volunteer and have the right to withdraw from this study at any time and for any reason without penalty or punishment. Please note that if you do quit before completing the study, you will be paid only for the time you have spent up to that point and no bonus will be awarded to you.

- You may be audio- and videotaped at any time during the study.

- There are no known risks associated with the use of this technology.

- Do not discuss the study with the Federal inspector or any security personnel.

- Should you be taken for further questioning by security, remember that your point of contact is the study's investigator, Troy E. Brown, Ph.D. This information is on your copy of the consent form.

- You must turn in your armband to study personnel before getting paid.

Please perform the following tasks in order (check them off as you complete them):

- Place your copy of the Consent Form in a your belongings. **You do not want your consent form to be visible.**

Completed:_____

- Put only the signed Consent Form in the envelope.

Completed:_____

- Place the envelope in the envelope holder on the outside of the door that you used to enter the room. Make sure the door is closed.

Completed:_____

Do not proceed to the checkpoint until directions are provided to you. They will be slid under the door that you used to enter the room.

Carefully read the following instructions and make sure you understand them.

When you arrive at the checkpoint, you will see a sign that says "Armbands." Follow the arrow. Wait in line until the Federal inspector calls you up to his station for the interview. The inspector will first ask for your identification card. Then, he will ask you to read a statement aloud. Next, he will ask you to answer aloud a number of questions related to your identification, classified documents or Federal evidence in your possession, and your contacts while in the Federal Building. Answer all questions truthfully and accurately. When you get past the checkpoint, proceed to Room 720. If for some reason you are detained at the checkpoint, you will be escorted to a private room for further questioning. At that time, you are to ask security to contact your point of contact, Troy E. Brown, Ph.D.

Read the previous paragraph as many times as necessary to completely understand your instructions.

- I have read and understand the previous instructions.

Completed:_____

- I have received the directions from under the door and am ready to proceed.

Completed:_____

- I have left this instruction form on the desk.

Completed:_____

Proceed to the security checkpoint.

Thank you once again for you participation.

Troy E. Brown, Ph.D.
Principal Investigator
Department of Defense Polygraph Institute

Appendix G

Mock Press Release

Department of General Inspector for Defense

Assistant General Inspector for Investigations
Defense Service for Criminal Investigation

PRESS RELEASE (December 18, 2000)

An indictment was returned against Gabriel S. O'Shea, owner and operator of G.S.O. Manufacturing, Inc. of Starksville, South Carolina, charging him with 27 counts of fraud against the Government and 2 counts of bribery of a Federal employee. The indictment alleges that under Mr. O'Shea's direction, G.S.O. Manufacturing bribed a Federal employee to win a $482,000 contract to sell new parts to the Department of Defense. The indictment also alleges that surplus parts were repackaged and sold instead.

Appendix H

Informed Consent Form for Deceptive Participants
(DoDPI00-P-0024)

Current Date (M/D/Y):____/____/____ Subject #:_____

Name:_____ SSN:_____

Home Address:_____

_____

Home Phone Number:_____

Date of Birth (M/D/Y):___/___/___ Place of Birth:_____

Gender: Male Female Ethnicity:_____

Education completed: High school/GED (College years): 1 2 3 4 5+

General Statement of Health:_____

_____

Current medications:_____

Have you ever taken a polygraph examination: Yes No

Have you ever had a Federal security clearance: Yes No

This form is affected by the Privacy Act of 1974.

AUTHORITY: 10 USC 3013, 44 USE 3101 and 10 USC 1071-1087, and E.O. 9397.

PRINCIPLE PURPOSE: To document voluntary participation in a Department of Defense Polygraph Institute Research Program.

ROUTINE USES: The SSN and home address and phone number will be used for identification and contact purposes. Information derived from the study will be used to document the study, decisions regarding claims, and for mandatory record keeping associated with human use in government research. Information may be furnished to federal agencies.

VOLUNTARY DISCLOSURE: Failure to furnish requested information would prevent your voluntary participation in this investigational study.

Research Project Explanation

The Department of Defense Polygraph Institute is conducting this study to determine how well a new voice-based credibility assessment technology works at security checkpoints. Federal inspectors hope that this new technology will help them identify people trying to smuggle items past checkpoints. In order to test this, we will randomly select some participants to smuggle an item past a checkpoint in the Federal Building and some to pass through without smuggling items. You have been chosen to be a smuggler for this study. This will require that you smuggle an item past a Federal inspector who will be using this technology at a security checkpoint in this building, the Strom Thurmond Federal Building. At the checkpoint, the inspector will ask you a number of questions for identification purposes, some questions about items in your possession, and some questions about your contacts while at the Federal Building. The new voice-based technology will be used to assess the credibility of your answers. To avoid being caught, you must convince the inspector and the voice-based technology that your answers are credible and that you are not a smuggler.

You may be audio- and videotaped at any time during the study today.

Note, that there are no known risks associated with the use of this technology. However, some individuals are uncomfortable with lying to a Federal inspector.

We estimate that the study will require about 2 hours to complete. For some, it might be a bit longer; for others, it might be a bit shorter. You will be compensated for your time at a rate of $5 per ½ hour. You will only be paid for time spent in the study. The timer started when you registered with the study representative in the previous room and will stop when you are dismissed from the study. You will also receive a $50 bonus if you complete the study and if you convinced the voice-based credibility assessment technology at the checkpoint that you gave credible answers at the checkpoint.

You are a volunteer and have the right to withdraw from this study at any time and for any reason without penalty or punishment. Please note that if you do quit before completing the study, you will be paid only for the time you have spent up to that point and no bonus will be awarded to you. If you have any questions or concerns, please feel free to bring them to the attention of Dr. Troy Brown or Dr. Andrew Ryan, Research Division Chief, of the Department of Defense Polygraph Institute. Both can be reached at 803-751-9100.

Personal Statement

I am at least 18 years old and do hereby volunteer to participate in a research study entitled, "Ability of the Vericator™ to Detect Smugglers at a Mock Security Checkpoint." The Department of Defense Polygraph Institute at Fort Jackson is conducting this project under the direction of Dr. Troy E. Brown.

1. I understand that I am participating in a research project that will use a new technology that operates on vocal signals to detect stress and deception. The purpose of this study is to test whether this new technology may be useful to the Federal Government.
2. I understand that I will be required to read aloud a series of statements and questions and then answer them aloud.
3. I understand that I am being asked to be deceitful in my responses to some of these questions.
4. I understand that I am being asked to smuggle an item past a Federal inspector at a security checkpoint.

5. I understand that I am not being asked to break any laws, perform any illegal acts, or hurt the United States government.

6. I understand that my participation will require approximately 1-2 hours of my time.

7. I understand that I will be paid on the spot and in person for my participation at a rate of $5 per 1/2 hour plus a $50 bonus should the new technology determine that I gave credible answers.

8. I understand that I will receive no other direct benefits for my participation; although, I will indirectly receive the benefit of learning about a new technology and the satisfaction of assisting my government.

9. I understand that there are no known dangers or risks arising as the result of my participation in this study.

10. The nature of my participation, the purpose of the investigation, and the methods by which it is to be conducted, have been explained to me.

11. I understand that I may terminate my involvement in this project at any time and for any reason. If I do terminate my involvement, I will be paid only for the time I have spent and I waive the right to any and all bonuses.

12. I understand that I may be video and audio recorded during any and all phases of my participation in this study. These recordings and all other identifying documents will be used for research purposes only and will be erased or destroyed seven years after the completion of this study.

13. I understand that my participation in this project will be terminated if I discuss the details of my participation with anyone except project supervisory personnel. NOTE: Discussion of details with any person within the study or with other participants would invalidate the data collection.

14. I have been provided a copy of this form (marked COPY) for my reference.

15. I understand that if I have any questions, complaints, or suspect that I have sustained a physical injury during this study I should contact the Principal Investigator, Dr. Troy Brown or the Department of Defense Polygraph Institute Research Division Chief, Dr. Andrew Ryan at 803-751-9100. I can also write to these individuals at: Department of Defense Polygraph Institute, Research Division, 7540 Pickens St., Fort Jackson SC 29207-5100.

_____	_____
Participant Signature & Date	Witness Signature & Date
_____	_____
Printed Name	Printed Name

Appendix I

Informed Consent Form for Truthful Participants
(DoDPI00-P-0024)

Current Date (M/D/Y):____/____/____ Subject #:_____

Name:_____ SSN:_____

Home Address:_____

_____

Home Phone Number:_____

Date of Birth (M/D/Y):___/___/___ Place of Birth:_____

Gender: Male Female Ethnicity:_____

Education completed: High school/GED (College years): 1 2 3 4 5+

General Statement of Health:_____

_____

Current medications:_____

Have you ever taken a polygraph examination: Yes No

Have you ever had a Federal security clearance: Yes No

This form is affected by the Privacy Act of 1974.

AUTHORITY: 10 USC 3013, 44 USE 3101 and 10 USC 1071-1087, and E.O. 9397.

PRINCIPLE PURPOSE: To document voluntary participation in a Department of Defense Polygraph Institute Research Program.

ROUTINE USES: The SSN and home address and phone number will be used for identification and contact purposes. Information derived from the study will be used to document the study, decisions regarding claims, and for mandatory record keeping associated with human use in government research. Information may be furnished to federal agencies.

VOLUNTARY DISCLOSURE: Failure to furnish requested information would prevent your voluntary participation in this investigational study.

Research Project Explanation

The Department of Defense Polygraph Institute is conducting this study to determine how well a new voice-based credibility assessment technology works at security checkpoints. Federal inspectors hope that this new technology will help them identify people trying to smuggle items past checkpoints. In order to test this, we will randomly select some participants to smuggle an item past a checkpoint in the Federal Building and some to pass through without smuggling items. You have been chosen to pass through the checkpoint without smuggling items. At the checkpoint, the inspector will ask you a number of questions for identification purposes, some questions about items in your possession, and some questions about your contacts while at the Federal Building. We ask you to be honest in your answers. The new voice-based technology will be used to assess the credibility of your answers.

You may be audio- and videotaped at any time during the study today.

Note, that there are no known risks associated with the use of this technology.

We estimate that the study will require about 2 hours to complete. For some, it might be a bit longer; for others, it might be a bit shorter. You will be compensated for your time at a rate of $5 per ½ hour. You will only be paid for time spent in the study. The timer started when you registered with the study representative in the previous room and will stop when you are dismissed from the study. You will also receive a $50 bonus if you complete the study and if you convince the voice-based credibility assessment technology at the checkpoint that you gave credible answers at the checkpoint.

You are a volunteer and have the right to withdraw from this study at any time and for any reason without penalty or punishment. Please note that if you do quit before completing the study, you will be paid only for the time you have spent up to that point and no bonus will be awarded to you. If you have any questions or concerns, please feel free to bring them to the attention of Dr. Troy Brown or Dr. Andrew Ryan, Research Division Chief, of the Department of Defense Polygraph Institute. Both can be reached at 803-751-9100.

Personal Statement

I am at least 18 years old and do hereby volunteer to participate in a research study entitled, "Ability of the Vericator™ to Detect Smugglers at a Mock Security Checkpoint." The Department of Defense Polygraph Institute at Fort Jackson is conducting this project under the direction of Dr. Troy E. Brown.

1. I understand that I am participating in a research project that will use a new technology that operates on vocal signals to detect stress and deception. The purpose of this study is to test whether this new technology may be useful to the Federal Government at security checkpoints.

2. I understand that I will be required to read aloud a series of statements and questions and then answer them aloud.

3. I understand that I am being asked to be truthful in my responses to all questions asked.

4. I understand that my participation will require approximately 1-2 hours of my time.

5. I understand that I will be paid on the spot and in person for my participation at a rate of $5 per 1/2 hour plus a $50 bonus should the new technology determine that my responses are credible.

6. I understand that I will receive no other direct benefits for my participation; although, I will indirectly receive the benefit of learning about a new technology and the satisfaction of assisting my government.

7. I understand that there are no known dangers or risks arising as the result of my participation in this study.

8. The nature of my participation, the purpose of the investigation, and the methods by which it is to be conducted, have been explained to me.

9. I understand that I may terminate my involvement in this project at any time and for any reason. If I do terminate my involvement, I will be paid only for the time I have spent and I waive the right to any and all bonuses.

10. I understand that I may be video and audio recorded during any and all phases of my participation in this study. These recordings and all other identifying documents will be used for research purposes only and will be erased or destroyed seven years after the completion of this study.

11. I understand that my participation in this project will be terminated if I discuss the details of my participation with anyone except project supervisory personnel. NOTE: Discussion of details with any person within the study or with other participants would invalidate the data collection.

12. I have been provided a copy of this form (marked COPY) for my reference.

13. I understand that if I have any questions, complaints, or suspect that I have sustained a physical injury during this study I should contact the Principal Investigator, Dr. Troy Brown or the Department of Defense Polygraph Institute Research Division Chief, Dr. Andrew Ryan at 803-751-9100. I can also write to these individuals at: Department of Defense Polygraph Institute, Research Division, 7540 Pickens St., Fort Jackson SC 29207-5100.

_____	_____
Participant Signature & Date	Witness Signature & Date
_____	_____
Printed Name	Printed Name

Appendix J

Inspector Assessment
(DoDPI00-P-0024)

Current Date (M/D/Y): **03/ /01** Time: _____

Name:_____ Armband #:_____

Do you believe the participant to be smuggling an item past the checkpoint?
(Circle number below)

Highly unlikely						**Highly likely**
1	**2**	**3**	**4**	**5**	**6**	**7**

Briefly state your reasons below.

Appendix K

Statement of Understanding

My name is (Full Legal Name). I live in (City, State). I understand that I am about to test a new technology that uses vocal signals to detect deception. The new technology does not use or require any information other than the sounds that I produce with my voice. In order for the instrument to function properly and accurately, it is important for me to speak as clearly as possible. Finally, I understand that there are no known physical or psychological risks associated with the operation of the instrument.

Appendix L

Questions to Participants
(DoDPI00-P-0024)

Remember to respond aloud in complete sentences.

Please state your complete legal name.

Please state your current address with zip code.

Please state your current home telephone number starting with the area code.

Please state the month, day, and year of your birth.

Please state the city, state, and country of your birth.

Was your visit to the Strom Thurmond Federal Building for personal or business reasons?

Do you currently have any classified material on your person or in your possession?

Do you currently have any Federal evidence on your person or in your possession?

Have you intentionally failed to identify any classified or Federal evidence that you have on your person or in your possession?

Indicate the approximate length of time you have been at the Strom Thurmond Federal Building during this visit today?

Who was your point of contact for this visit to the Strom Thurmond Federal Building?

Since arriving at the Strom Thurmond Federal Building, have you been asked to remove any items from the building that do not belonging to you?

Are you trying to remove any classified material from this building?

Are you trying to remove any Federal evidence from this building?

Have you answered these questions with complete honesty?

Appendix M

Participant Debriefing Questionnaire
(DoDPI00-P-0024)

Date: **3/ /01** Armband #: _____

1. In this study, did you smuggle Federal evidence through the security checkpoint?

___No (Go to question 6.)
___Yes

Questions 2-5 are for those who smuggled Federal evidence in this study. If you did not do this, go to question 6.

2. Do you think the voice-based credibility assessment technology was able to detect your deception about smuggling Federal evidence past the checkpoint?

___No
___Yes
___Not sure

3. How exciting was this scenario to you?

___Not at all
___Somewhat
___Very
___Too much

4. Do you think you could defeat the voice-based credibility assessment technology if you wanted to?

___No
___Yes (describe how)_____

_____

5. Did you try to beat the voice-based credibility assessment technology?

___No
___Yes (describe how)_____

_____

6. What were you thinking about during the test?

_____

_____

7. Did you attempt to alter your voice or control your emotions while speaking into the microphone?

___No
___Yes (describe how)_____

_____

8. Do you have any comments regarding this project that you'd like for me to pass on to the scientists who designed it?

_____

_____

_____

9. As a condition of participation, you are requested to refrain from discussing the details of the study with anyone before March 30 when the experiment is completed. Will you discuss this study with anyone before that date?

___No, I will abide by the confidentiality agreement.

___Yes, I intend to disclose the study details to others before March 30.

_____
Participant Signature & Date

_____
Printed Name

_____
Name of debriefer

Appendix N

Debriefing Form
(DoDPI00-P-0024)

On behalf of the entire project staff, I would like to take the opportunity to thank you for your participation in this project. Your participation here today was more important than you may realize. Depending on the results of this study, we may be able to significantly improve and expand current federal and state security procedures and help to prevent or reduce the flow of illegal and unreported contraband across our borders.

For those of you who smuggled items through our checkpoint, we would like to assure you that you in no way violated any rules or laws. The activities were strictly for the purpose of deceiving the instrument. We want to emphasize that you have broken no laws, you have performed no illegal acts, and you have in no way hurt the United States government.

For those of you who did not smuggle items through our checkpoint, your role was equally important. No credibility assessment device is useful if it improperly identifies truthful people as deceptive.

We hope you enjoyed your participation. We hope you were not made uncomfortable in any way. If you have any questions or concerns, please feel free to bring them to the attention of Dr. Troy Brown or Dr. Andrew Ryan, Research Division Chief, of the Department of Defense Polygraph Institute. Both can be reached at 803-751-9100.

We ask that you please do not discuss what you did here today with anyone before March 30. Many people from the community will be participating in this project, perhaps relatives or friends of yours. It is very important that they do not have any prior information regarding the project. Knowledge of the study might seriously damage the results of this project. Thank you for your understanding and cooperation.

_____ _____
Project Representative Date