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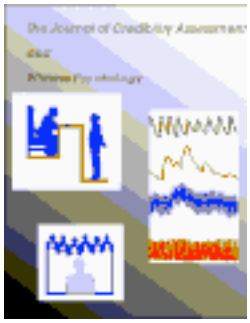

Special Issue:

Proceedings of the Workshop on the Use of Autonomic and Somatic Measures for Security Evaluations

Andrea K. Webb and John C. Kircher

University of Utah

Notes: Correspondence concerning the articles in the special issue should be directed to John C. Kircher, Department of Educational Psychology, University of Utah, Salt Lake City, Utah, 84112. Kircher@ed.utah.edu

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Introduction to the Special Issue

In the summer of 2005, the National Science Foundation sponsored a series of six workshops on security evaluations. One purpose of the workshops was to develop an agenda for research on credibility assessment. The articles in this special edition are the presentations given by the invited speakers at the Workshop on the Use of Autonomic and Somatic Measures for Security Evaluations. This workshop covered four areas: needs of government agencies charged with national security; current methods used for measuring stress and detecting deception with autonomic and somatic measures; contemporary theory and psychophysiological mechanisms underlying responses to stress and deception; and emerging, alternative, and auxiliary methods and measures for detecting stress and deception. The articles are organized into these four areas as follows:

1. Needs of government agencies charged with national security	
Polygraph Screening	Don Krapohl
2. Current methods used for measuring stress and detecting deception with autonomic and somatic measures	
Issues in the study of polygraph screening techniques	Michael Bradley
Using the Polygraph in Employment and National Security	David C. Raskin & Charles R. Honts
Emerging Technologies in Credibility Assessment	Andrew H. Ryan, Jr.
3. Contemporary theory and psychophysiological mechanisms underlying responses to stress and deception	
Toward a Neurocognitive Basis of Deception	Ray Johnson, Jr.
The Polygraph: One Machine, Two World Views	Stephen W. Porges
4. Emerging, alternative, and auxiliary methods and measures for detecting stress and deception	
Voice Stress	
The Use of Voice in Security Evaluations	Harry Hollien & James Harnsberger
Voice Stress	James Meyerhoff
Evaluating Voice-Based Measures for Detecting Deception	Mitchell S. Sommers
Thermal Imaging	
Emerging Methods and Measures for Detecting Stress and Deception: Thermal Imaging	Dean Pollina

Odor	
Body Odors as Biomarkers for Stress	Pamela Dalton
Radar, Laser Doppler Vibrometry	
Radar Technology for Acquiring Biological Signals	Gene Greneker
The Physiology of Threat: Remote Assessment Using Laser Doppler Vibrometry	John W. Rohrbaugh, Erik J. Sirevaag, John A. Stern, and Andrew H. Ryan, Jr.
Occulomotor Activity	
The Gaze Control System and Detection of Deception	John A. Stern
Eye Movement-Based Assessment of Concealed Knowledge	Frank M. Marchak
Multimethod Assessment of Deception on Personnel Tests: Reading, Writing, and Response Time Measures	Andrea K Webb, Sean D. Kristjansson, Dahvyn Osher, Anne E. Cook, John C. Kircher, Douglas J. Hacker, and Dan J. Woltz

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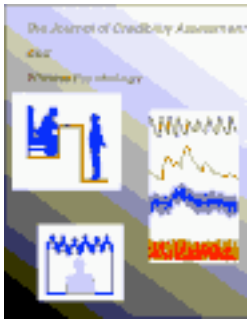

Polygraph Screening

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Polygraph Screening

Central Issues

1) To predict future actions based on recent and not-recent behaviors
2) To identify those behaviors that are predictive of future actions
3) To uncover the behaviors of interest as accurately as possible
4) To develop optimal decision rules
5) Minimize false negatives for the most serious threats

Role of the Polygraph in National Security

- Primarily: Provide decision-makers with information regarding past and current activities of those who seek security clearances or special accesses
- Reporting criteria established by Congress, policy makers, and agency adjudicators.
- Secondary: Deter poor security risks from entering the system

Polygraph Products

- Self-reporting from examinees who volunteer information before the testing
- Self-reporting from examinees after testing
- Polygraph results

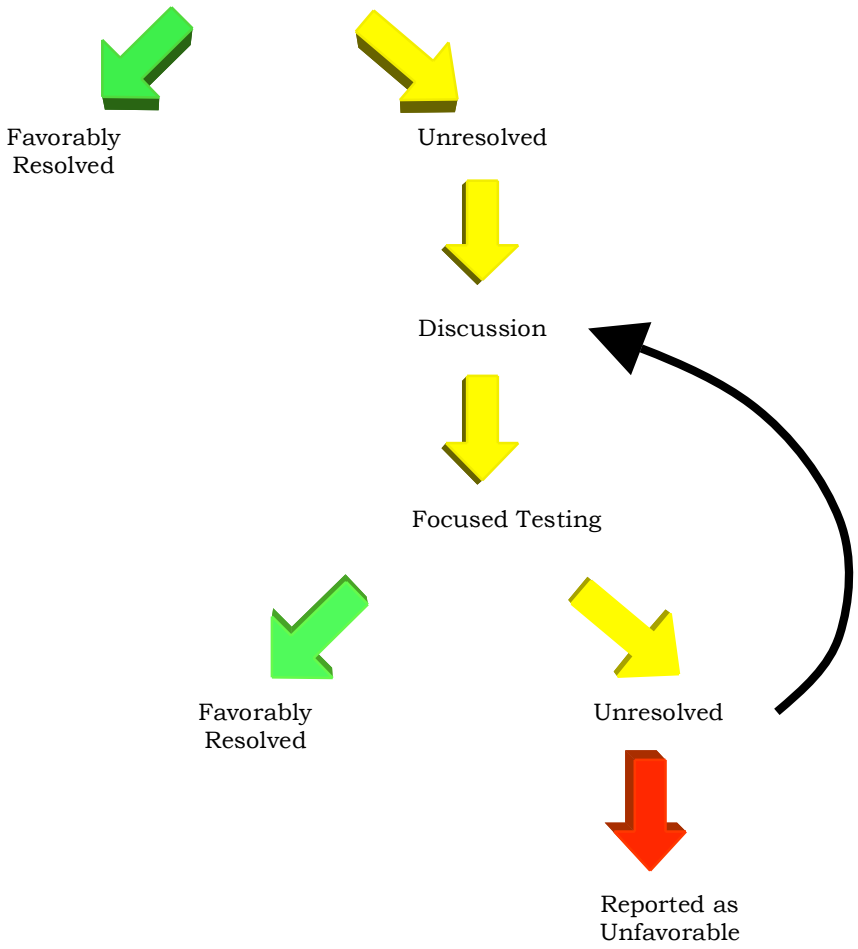
What Polygraph Screening is Not

- A single step
- A single technique
- Inclined toward false positive errors
- Final arbiter of employment fate

Important Factors

- Polygraph reactions trigger focused attention.
- Unfavorable polygraph results usually prompt other investigative methods.
- Polygraph screening in the Government uses several techniques, each with different strengths and weaknesses.

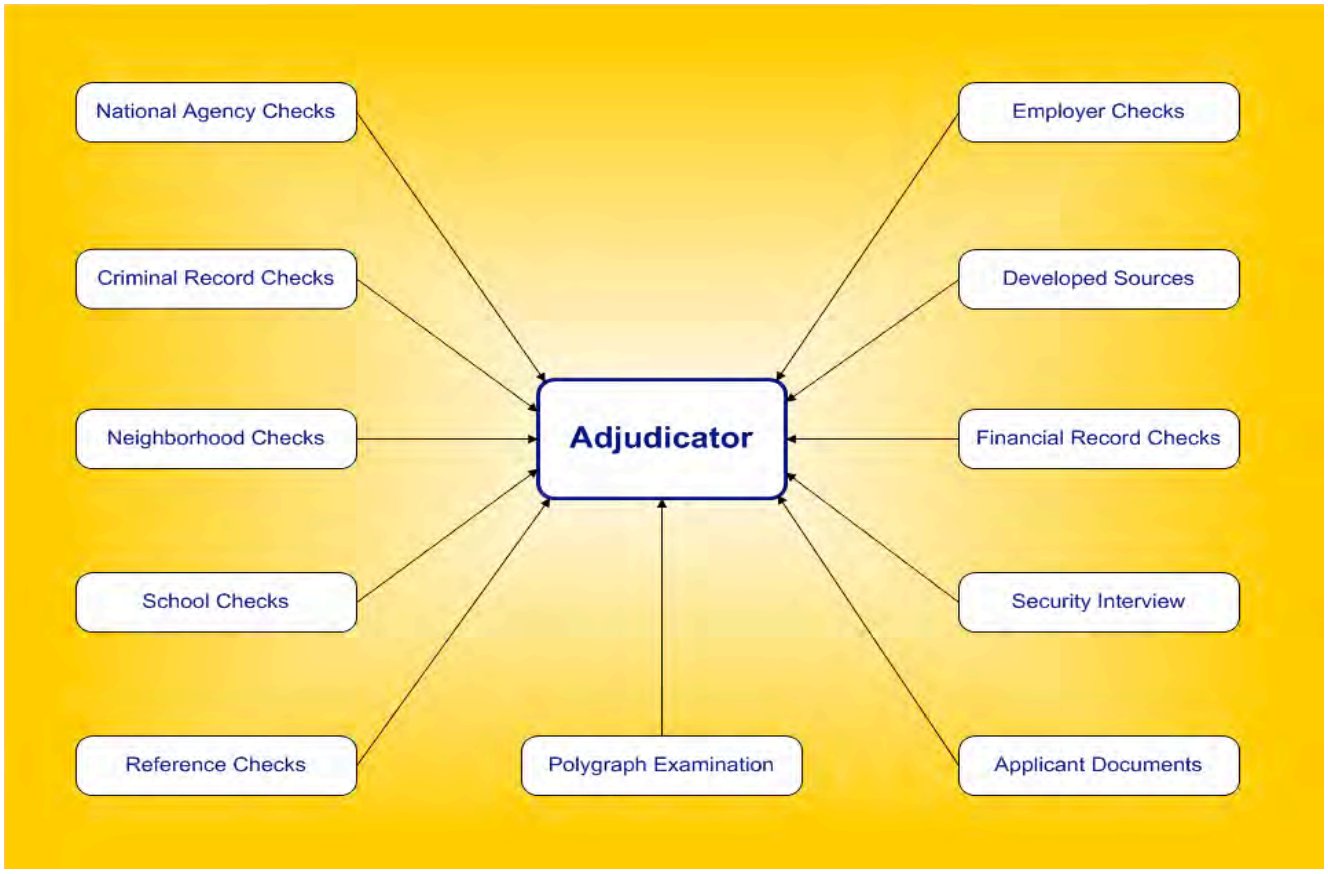
Screening Phase



Important Factors

- Error rates have not been conclusively established.
  - Accuracy may be affected by
    - base rates
    - test questions (number, time span, memory limits)
    - decision rules
    - post-screening testing
- Field validation of polygraph screening has proved difficult, and will be no less difficult for the replacement technologies.

Components to Security Decisions



Principal Counterintelligence Issues

- Espionage against the US
- Sabotage
- Disclosures of classified information to unauthorized persons

Secondary Issues

- Security violations
  - Unreported contact with foreign nationals
  - Unauthorized transportation of classified material
  - Unauthorized storage of classified material
  - Computer system misuse

Suitability Issues

- Serious criminal activities
- Excessive drug use
- Falsification of applicant documents

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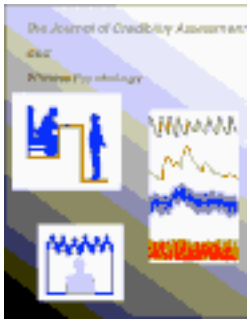


Issues In The Study Of Polygraph Screening Techniques

Michael Bradley

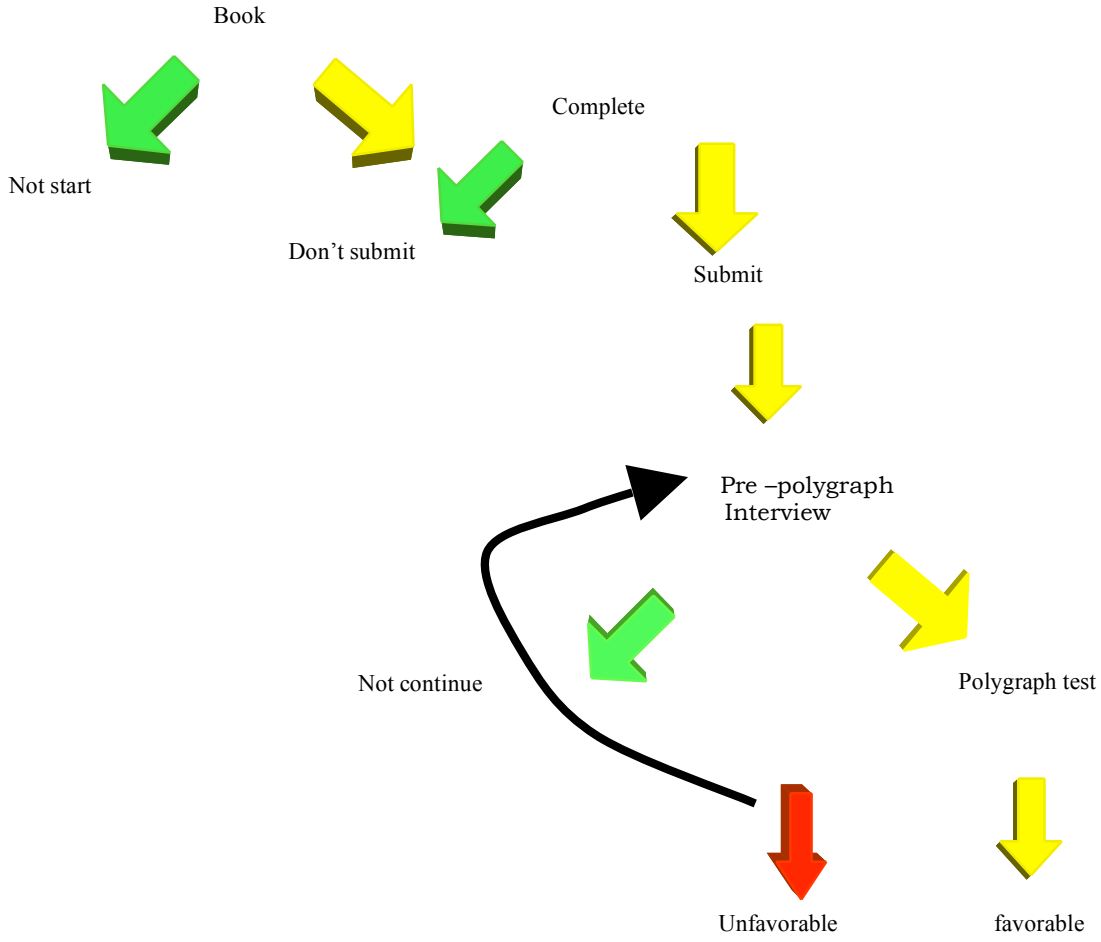
University of New Brunswick,
St. John, New Brunswick, Canada

Issues In The Study Of Polygraph Screening Techniques

My screening experience involved a police training program using:

1. A "Crime Issues Book" mailed to applicants
2. Return of book for interview
3. Interview
4. Polygraph test
5. Results & discussion

Voluntary applicant choices



Potential advantages of self selection

1. Crime book defines potential problem areas
2. Clear statement of polygraph test allows applicant to decide continue Yes / No
3. Pre-test interview allows participant to clarify issues & concerns – also applicant is told that if unresolved criminal issues are discovered these may be pursued
4. Review of questions
5. Polygraph test
6. Results and discussion

Possible studies

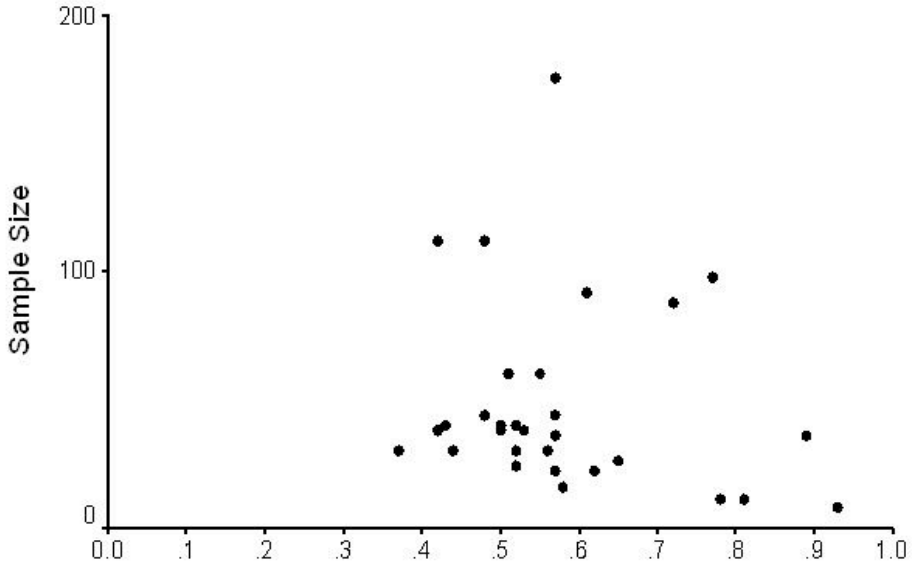
Test formats – all relevant questions or topic controls for key issues
Value of crime book – measure desire to continue process for group sent crime book vs those not (ie sent later)
Establish more base rate information

2 cautionary issues from lab research

1. Laboratory tests often treat the polygraph test in isolation of larger context
    a. Look at the list of events in the screening program / the polygraph test is anti-climatic/ the fact that it is in the interview is crucial for the interview but not the test itself
    b. –no other science looks at instruments in isolation – even a ruler has to be oriented in the proper direction for meaningful measurement
2. Studies results are reported in isolation or with selected comparisons from other studies –this is not an adequate way to proceed – a meta-analytic approach must be used **and** *the meta-analysis must be done considering various possible strategies.* (This point requires terms: effect size (eta) & number of measures (n))

2. continued: studies in isolation

GSR/ SCR & the CQT



Implications

- No one study is definitive
- The funnel graph shows CQT laboratory studies create a family of estimates that has a mean and standard deviation
- High and low estimates are expected with the imprecision that comes from small sample sizes

Implications for screening research

- Future lab studies will probably be done with small sample sizes – *ergo :* the results will be variable (those getting unfavorable results may suggest that screening is problematic whereas those getting favorable results will claim the technique is excellent)
- The argument is false - the truth will be in the middle

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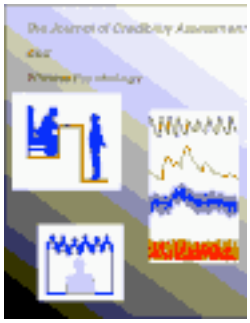

Using the Polygraph in Employment and National Security

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***Homer, Alaska**
†Boise State University, Boise, Idaho

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Using the Polygraph in Employment and National Security

Polygraph and Employment

- Three main applications:
  - Internal investigation
  - Pre-employment screening
  - Periodic evaluation

Pre-Employment Screening

- There are very few studies in the scientific literature to provide guidance
- In contrast with the criminal justice applications, research on screening has produced mixed results.
- Pre-Employment Screening addresses two questions:
  - Has the applicant been honest in his application and statements?
  - Do the applicant's polygraph results accurately predict his behavior in the workplace?

Possible Screening Issues

- Prior criminal behavior
- Drug and alcohol use
- Psychiatric and other health problems
- General honesty
- Education and work history
- Financial and life-style problems
- True identity and motives
- Possible security risks

Criminal Behavior

- *Have you ever been arrested or convicted of a criminal offense?*
- *Have you ever committed a serious criminal act for which you were not caught?*
- *Do you have a relationship with anyone that you know is involved in criminal activity?*

Drugs and Alcohol

- (In the past 5 years,) have you used an illegal drug or substance?
- Have you ever sold or distributed an illegal drug or substance?
- Do you frequently consume alcohol in substantially greater amounts than you have indicated?
- Have you ever received treatment for excessive use of drugs or alcohol?

Health

- *Do you have any serious illness or disease that you have not indicated?*
- *Have you ever received medical treatment for a serious psychiatric illness?*

Honesty

- Have you ever taken more than $_ from a place where you worked?
- Have you ever deliberately done something to cause your employer (agency, company) a serious loss or problem?

Education and Employment

- Have you accurately represented your educational history?
- Have you accurately represented your employment history?

Financial and Life Style

- Do you have any serious financial problems that you have not indicated?
- Is there anything in your background or present situation which someone could use to get you to violate the trust of your employer?

Identity and Security

- Have you accurately represented your identity?
- Have you ever knowingly had unauthorized contact with a representative of a foreign government or hostile organization?
- Have you ever knowingly disclosed important confidential or security information to an unauthorized person or organization?

Periodic Testing

- *Used in situations where there are serious consequences of undetected misbehavior by employees, for example, national security, industrial security, access to money or valuable commodities, drugs.*
- *Relevant questions take the form:*
  - ***Since your last polygraph, have you . . .***
- *Periodic testing should not be conducted more frequently than necessary.*

Research on Screening

- The U. S. Government is the world's largest user of polygraphs for employment screening.
- The U. S. Government research program includes a major focus on polygraph screening issues.
- Some research may be unavailable because of national security classification.

Pre-Employment Screening

- Pre-Employment Screening addresses two questions:
  - Has the applicant been honest in his application and statements?
  - Do the applicant's polygraph results accurately predict his behavior in the workplace?

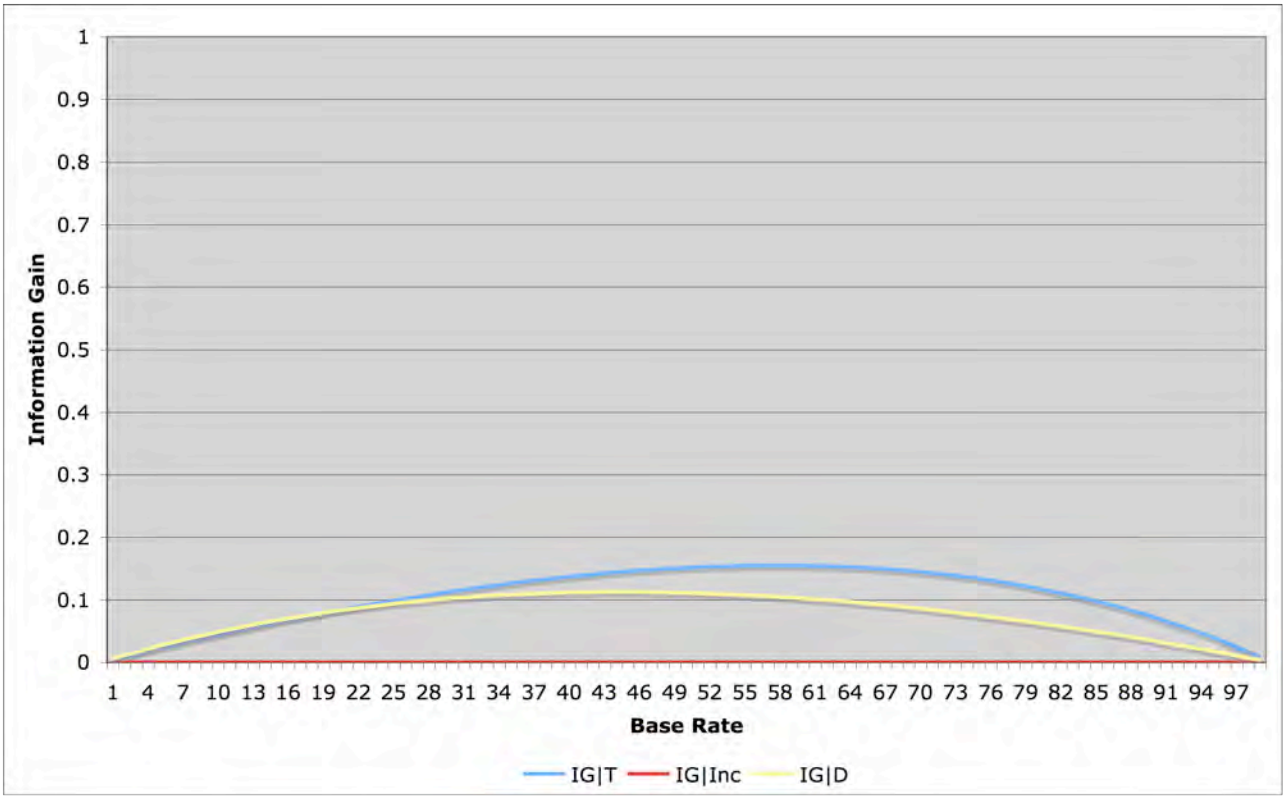
Base Rate

- The prevalence of the target in the population affects the confidence in the outcome of a diagnostic test.
- Base Rates may often be an important consideration in screening polygraph examinations.

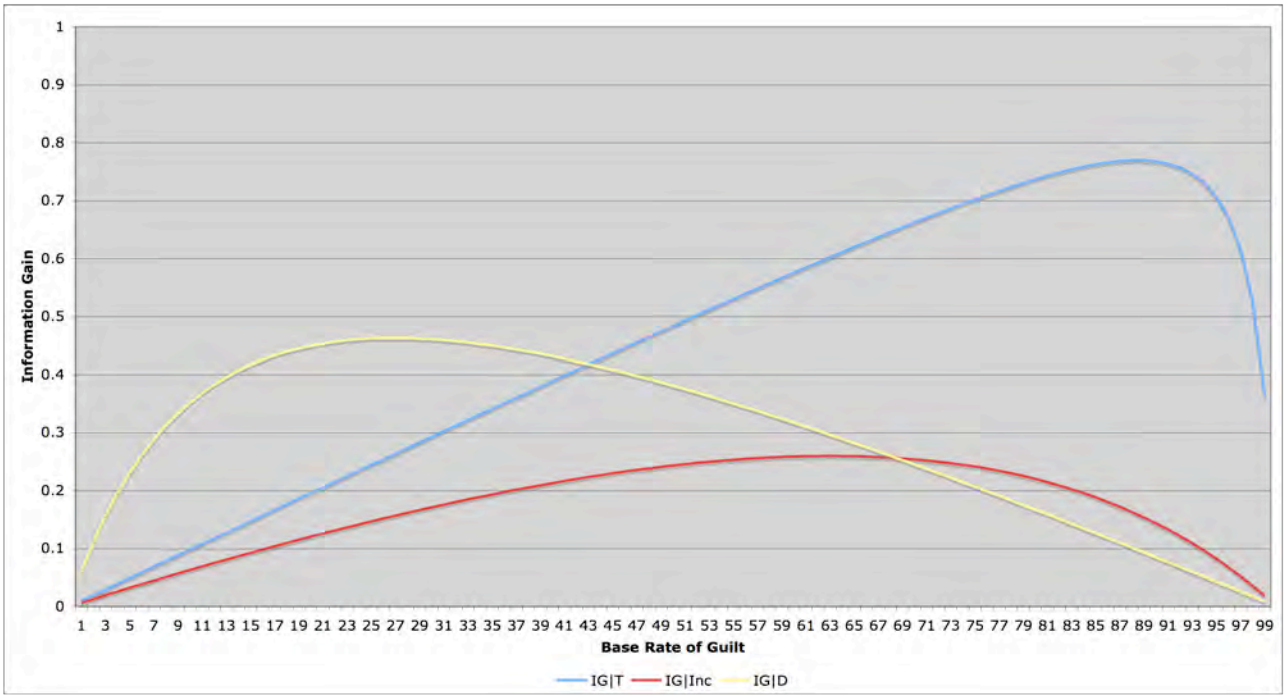
Information Gain

- Information Gain (Wells & Olson, 2002) is the difference between the probability that a person is of the target status before a diagnostic procedure and the probability that the person is of the target state after the diagnostic procedure.
- Information Gain is a Bayesian approach that produces a curve describing information gain across the range of prior probability.

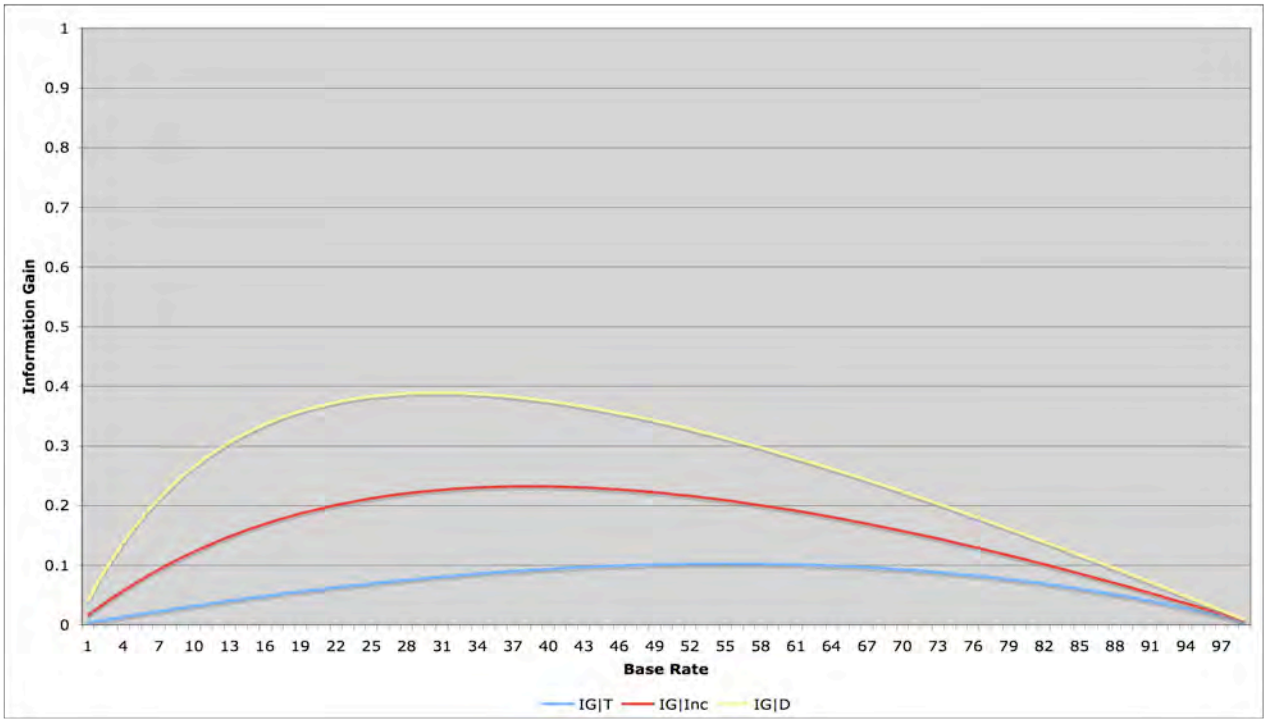
Information Gain - Lay Person Deception Detection



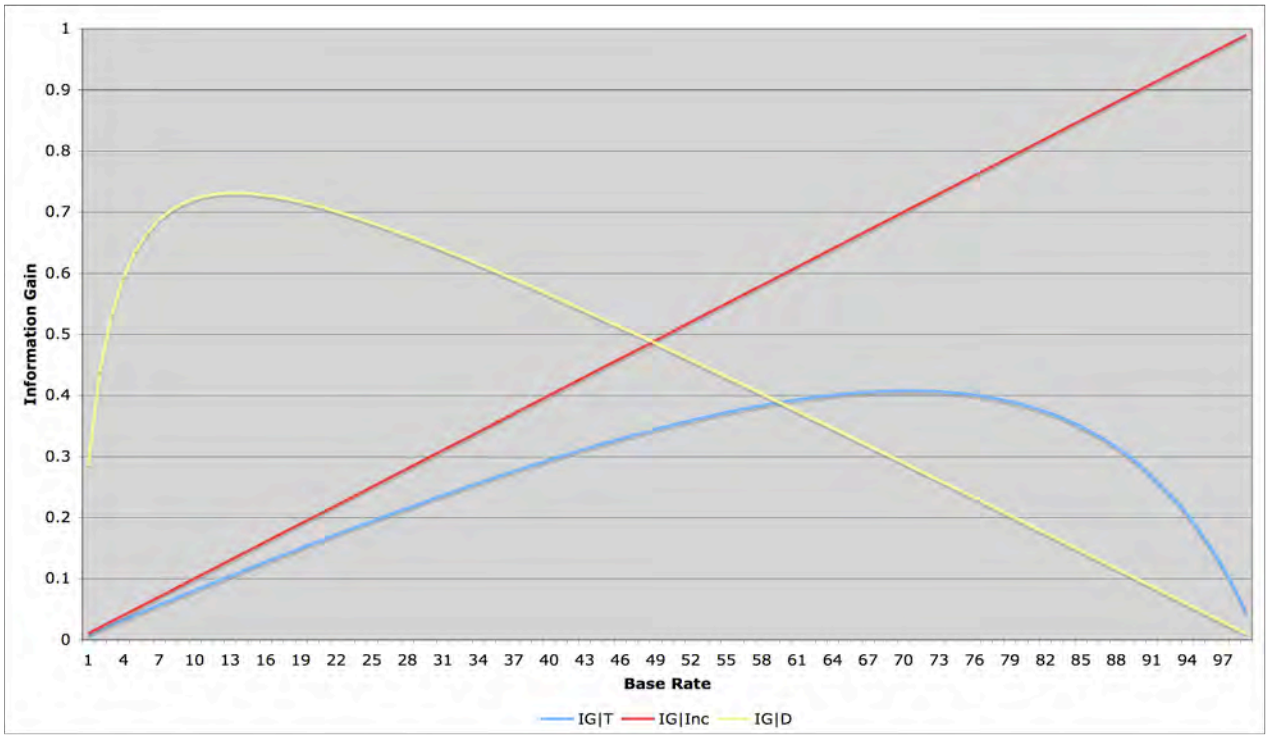
Information Gain / Forensic Field Data



Information Gain National Security
(Barland, Honts, & Barger, 1989)



Information Gain
National Security (TES)



Barland, Honts, & Barger, 1989

Source for Screening Research

- http://truth.boisestate.edu
- D. H. Krapohl in Kleiner, M. (Ed.) (2002). *Handbook of Polygraph Testing.* San Diego, CA: Academic Press

The Test For Espionage and Sabotage

- Research results such as those shown in the previous slides resulted in the U. S. Government conducting research to develop more accurate screening examinations.
- The result of that research was a test now known as the Test for Espionage and Sabotage (TES).
- The TES uses Directed Lie Comparison Questions
- Only one test is conducted where each of two relevant questions is repeated 3 times.
- The TES question sequence:
  - **N1, N2, D1, R1, R2, D2, R2, R1, D1, R1, R2, D2**

Other Issues and Problems

- Relevant questions in screening polygraph tests may be similar to comparison questions in forensic polygraph tests.
- Often there are too many relevant issues of interest for a single test session.
- Base-rate issues can pose problems for interpretation.

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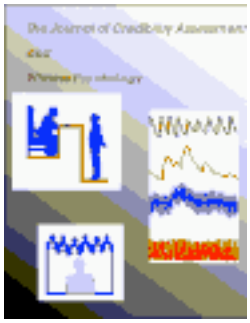


Emerging Technologies in Credibility Assessment

Andrew H. Ryan, Jr.

Department of Defense Polygraph Institute,
Ft. Jackson, South Carolina

Emerging Technologies in Credibility Assessment

- TRACKER
- THERMAL FACIAL SCREENING (The Booth)
- Laser Doppler Vibrometry
- Future Prototypes

Eye Movement–based
Memory Assessment (TRACKER)

Familiar/Unfamiliar Faces-Objects-Scenes

- Individual presentations of known and unknown faces, objects, or scenes

Concealed

Group

Source Verification

Crime Scene

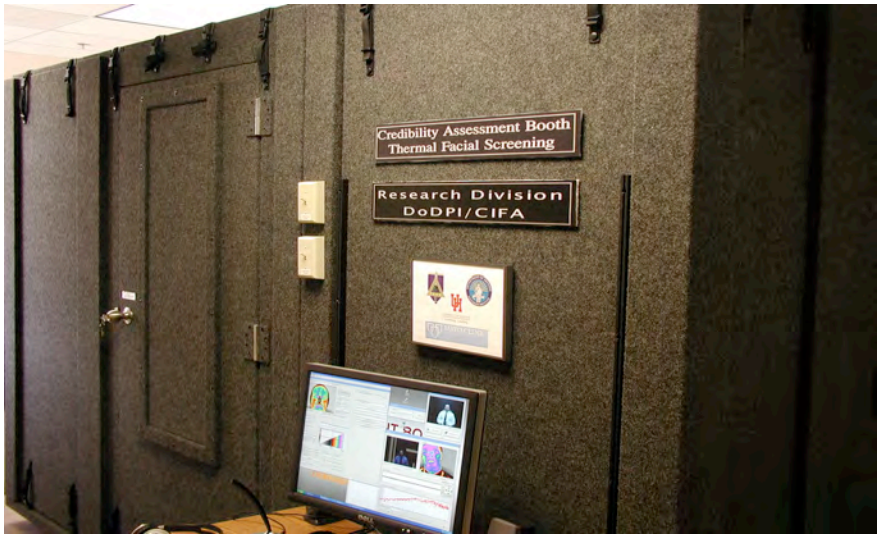
Relevant Objects

Locations of Interest

How would it be used to assess credibility?

- Use of eye movement data to categorize prior knowledge of presented images of faces, scenes and objects
- Certain 'acquisition' patterns or fixation duration can contribute to designation of prior knowledge or engaged behaviors
- These measures can indicate whether the person is viewing the face/scene/object for the first time…or whether the image exists in the memory of the examinee

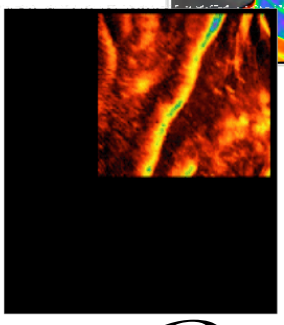
Thermal Facial Screening-"*The Booth*"

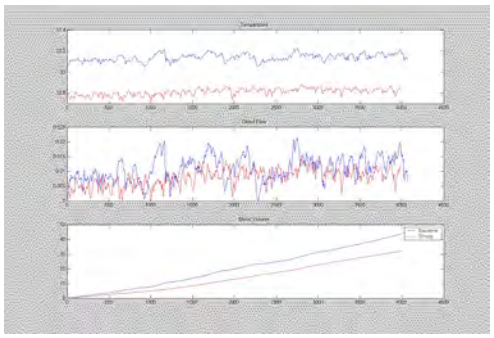


Research Division-DODPI

How We Do It :

Input : Thermal radiation
Localization : Tracking
Measurement : Modeling
Output : Physiological Variables





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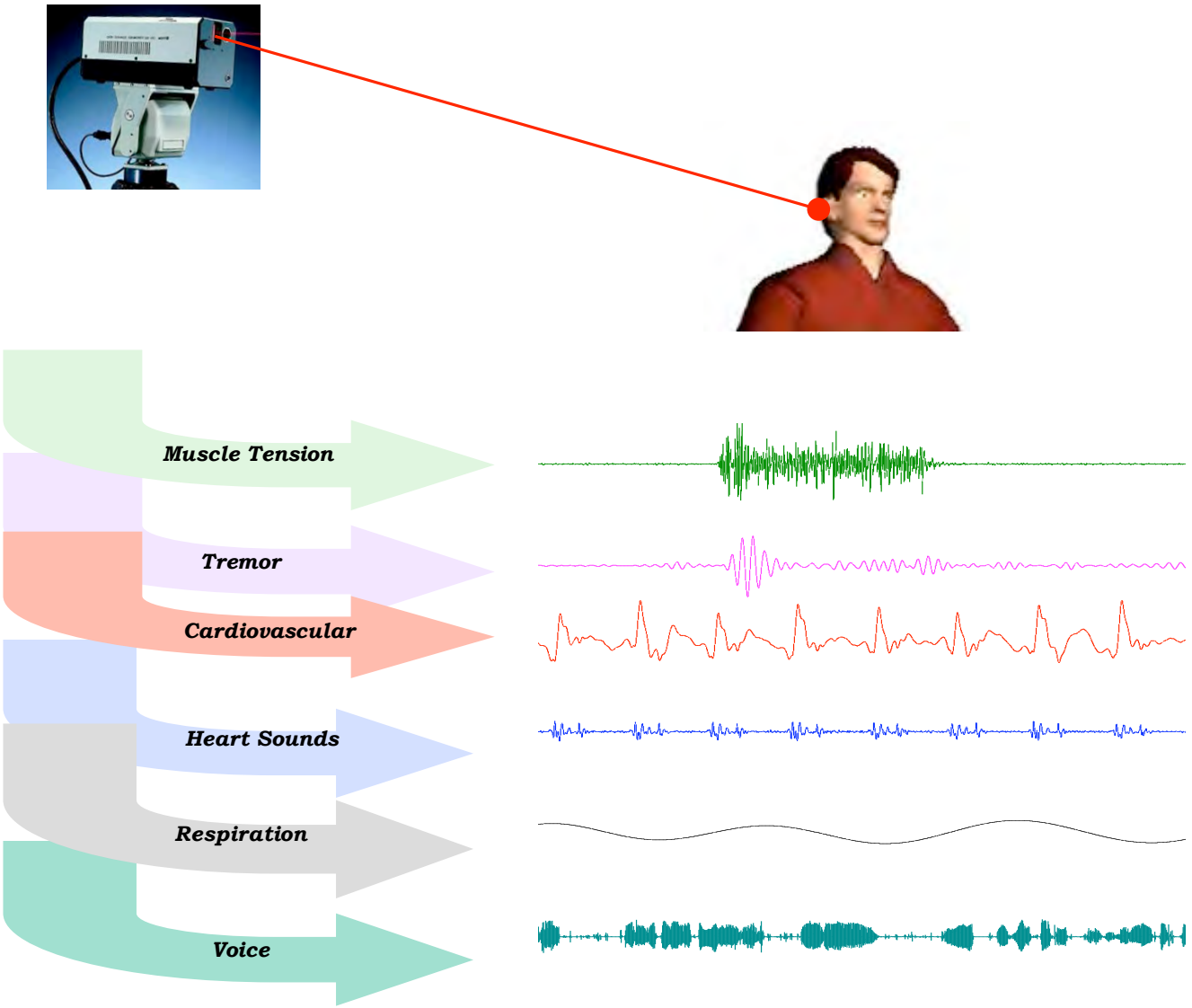
Muscle Tension
Tremor
Cardiovascular
Heart Sounds
Respiration
Voice

FUTURE PROTOTYPES

- Sensor Chair
- LDV Biometric
- 3rd Generation TRACKER

Status of Prototypes

Prototype	Alpha	Beta	Field	Battle-Lab
TRACKER	x	x	x	
Thermal Facial Screening	x	x		
Laser Doppler	x			

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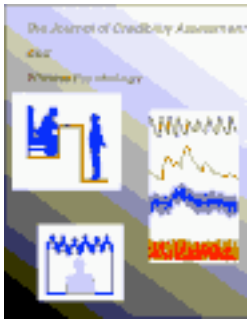

Toward a Neurocognitive Basis of Deception

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Toward a Neurocognitive Basis of Deception

Introduction

- The past 5 years has brought an explosion in our knowledge about the brain mechanisms underlying cognitive control and other higher-order processes.
  - These are exactly the kind of cognitive processes that are likely to be used when a person is being deceptive.
- Thus, now is a good time for a major effort aimed at identifying the cognitive and neural basis of deception.

Rationale

- We wanted to determine which cognitive processes are the antecedents of the ANS activity associated with deception.
- Identifying the cognitive processes that people use when they are deceptive could potentially provide:
  - Additional methods for detecting deception in individuals that could be used alone or in conjunction with ANS measures
  - A better understanding of deception-related ANS activity
- The cognitive approach outlined here is different from those used previously to reveal the presence of guilty knowledge in individuals.

Conceptual Framework for Studying Deception

- To begin creating a model of deception, we divided the possible cognitive processes that might be involved into two broad categories:
  - Those related to the intent or motivation for being deceptive
  - Those related to making deceptive responses
- Although motivations may vary across different types of deceptions and from day to day, making a response that is incompatible with the truth is a necessary component of all deceptions.
- Thus, we began by investigating how the response conflict generated by deceptive responses is controlled.

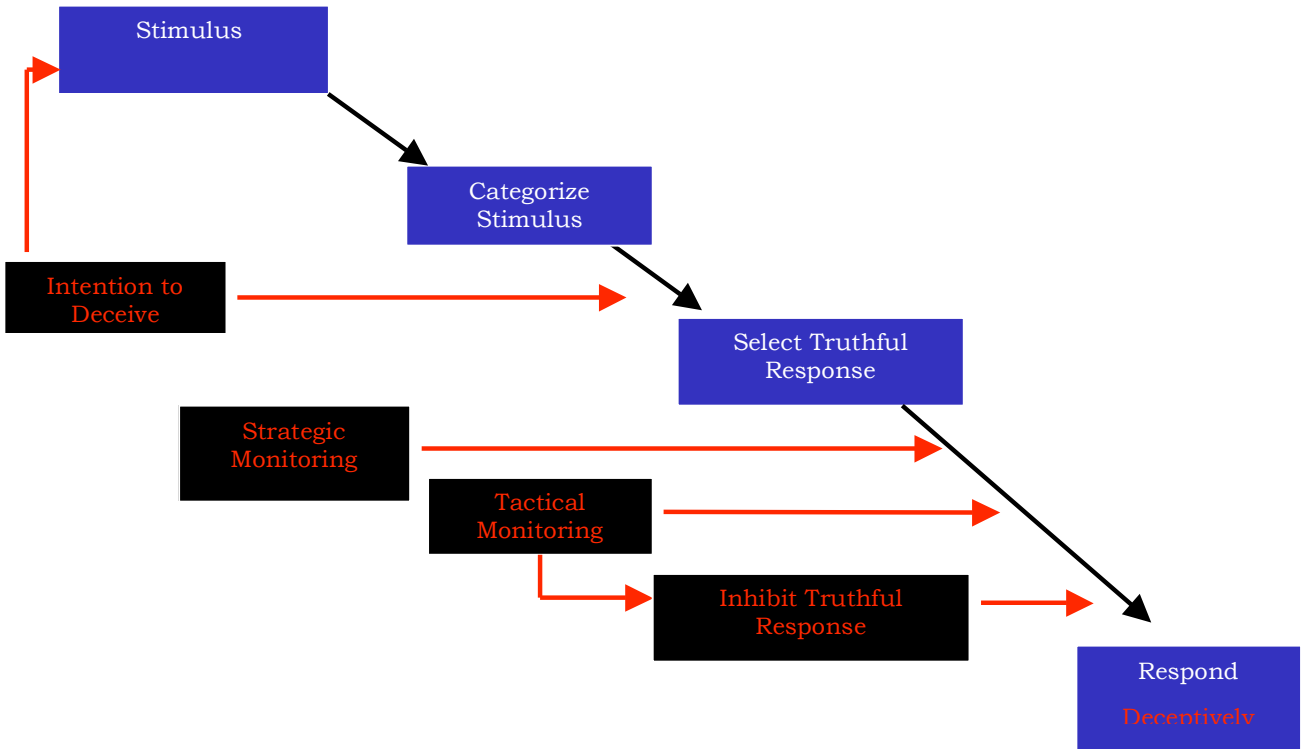
Role of Cognitive Control

- A central hypothesis was that cognitive control processes play a key role in all deceptions.
- Cognitive control is the term used to describe how, through a variety of executive processes, one is able to control the selection and execution of willed actions.
- Because truthful responses are pre-potent, making deceptive responses requires extra cognitive control to:
  - Inhibit the pre-potent truthful response
  - Overcome conflicting response tendencies (i.e., Tactical monitoring)

Strategic Monitoring

- We also hypothesized that additional control processes would be necessary if one wanted to monitor the long-term pattern of their responses to make them conform to an overall plan or goal (i.e., Strategic monitoring).
- Strategic monitoring processes are separate and provide the context in which tactical monitoring processes operate.
- Because both all cognitive control processes require attention, engaging them will place additional demands on the limited pool of attentional resources. Thus, being deceptive can be thought of as equivalent to performing a separate task concurrently with the task of being truthful.

Model of Truthful Responding
Deceptive



Initial Experiments

- Participants made truthful and deceptive responses about perceptual events and items in memory in a series of tasks. The tasks were structured to create comparisons that allowed us to isolate a variety of cognitive processes:
  - Perceptual vs. Conceptual (memory-based) response conflicts
  - Consistent Truthful vs. Consistent Deceptive responses
  - Tactical vs. Strategic monitoring processes
  - Effect of practice on truthful and deceptive responding
  - Effect of deceptive responding on retrieval-related processes

Results

- We found 26 differences between truthful and deceptive responses.
  - Behavioral measures revealed that deceptive responses were slower and more variable than truthful responses.
  - Multiple ERP effects were found that arose from different brain areas and in different temporal intervals.
  - Some ERP differences reflected activity in the anterior cingulate cortex (ACC), a brain area that plays a vital role in cognitive control.
  - In every case, the truthful-deceptive differences increased when responses were monitored strategically.

Conclusions

- Tactical and strategic monitoring processes were associated with different patterns of ACC activity.
- Both types of monitoring required additional processing resources over those normally used to make truthful responses.
- Although practice benefited truthful responses, it did not reduce the level of cognitive control needed for deceptive responses.
- Different patterns of ERP activity previously shown to reflect an item's memory status were not altered for deceptive responses. This indicates that they can provide a cognitively-based index of both guilty knowledge *and* confabulation.

Role of "Self" in Deception

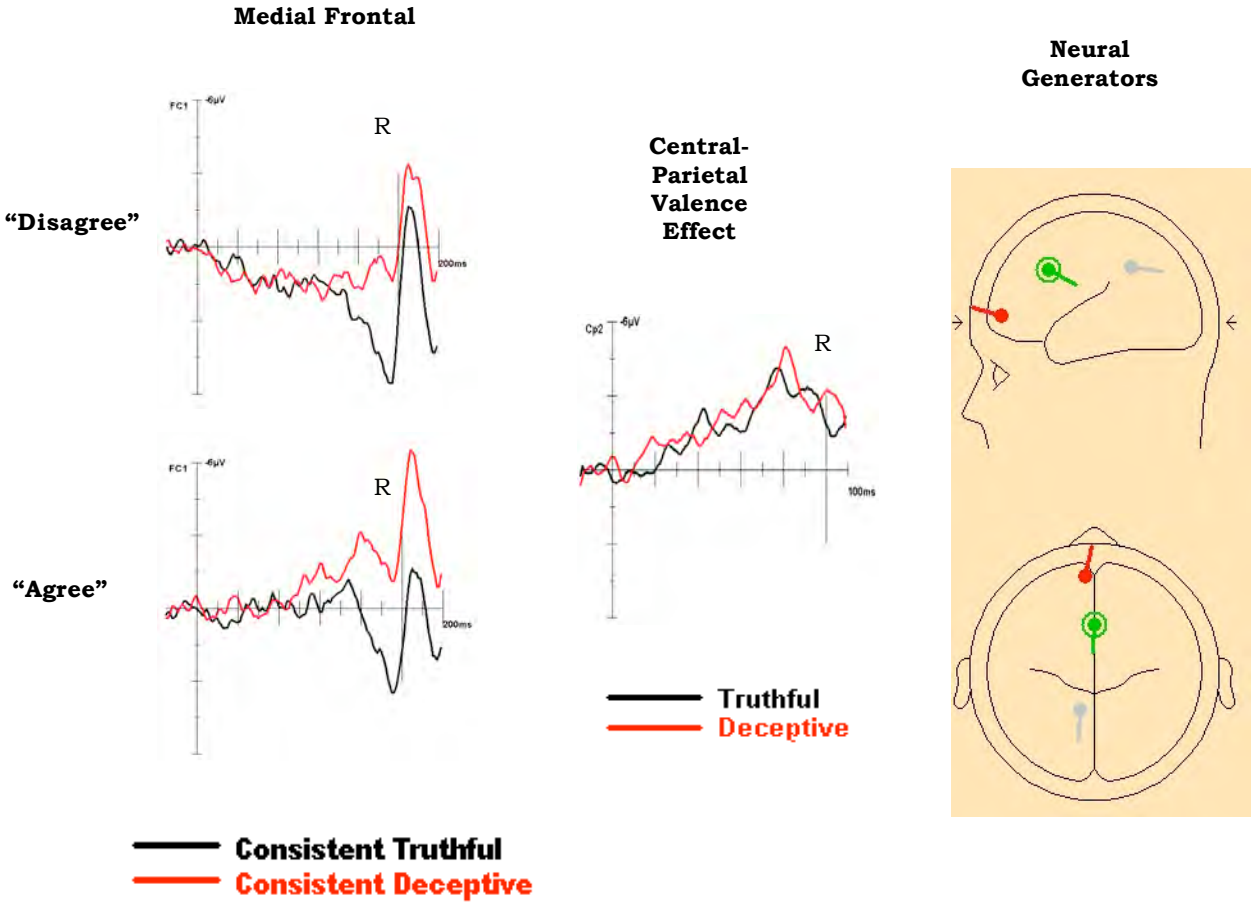
- Making evaluative judgments about social and physical aspects of our environment is an important aspect of everyday life.
- In contrast to memory retrieval, evaluative judgments are self-referential in that they draw on one's attitudes, beliefs, values and preferences.
- Evaluations on a good-bad dimension are known to evoke both automatic (unconscious) and controlled (conscious) processes.
- Making good/bad judgments bridges both cognitive and affective domains so will likely have both CNS and ANS effects.

Evaluative Judgment Paradigm

- Participants provided agree/disagree ratings on a wide variety of items:

AGREE ITEMS	DISAGREE ITEMS
Political-Social	Political-Social
Patriotism, Gun control, Bill Clinton, Welfare, Death penalty, Abortion	Al Q'aeda, Bin Laden, Traitors, Adultery, Racial profiling, Assisted suicide
Personal	Personal
Marriage, Birth control, Dancing, Basketball	Casual sex, Smoking, One night stands
Religion	Crimes
God, Angels, Heaven, Hell, Miracles	Treason, Murderers, Rapists, Shoplifting
Food Preferences	
Chocolate, Pizza, Meat, Coffee, Candy	

Evaluation Results



Conclusions

- The evaluation task elicited ERP activity related to both automatically activated and consciously controlled cognitive processes.
- The large response for deceptions about positively viewed items suggests that one component of at least some deceptions is a "denial of self" reaction that has its own characteristic pattern of brain activity.
- The brain activity in this task was shown to be generated in three midline brain areas shown to be involved in the processing of self.
- The pre-response valence-related (good/bad) ERP activity appears to be generated automatically and thus may provide an index of how items are unconsciously categorized as good and bad.

Future Directions

- Overall, these results demonstrate the utility of taking a cognitive approach to understanding the nature of deception.
- Studies measuring both ANS and ERPs in cognitive paradigms should further increase our understanding of the inter-relations between the cognitive and emotional aspects of deception.

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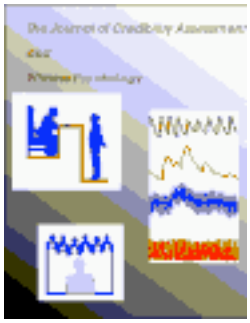

The Polygraph: One Machine, Two World Views

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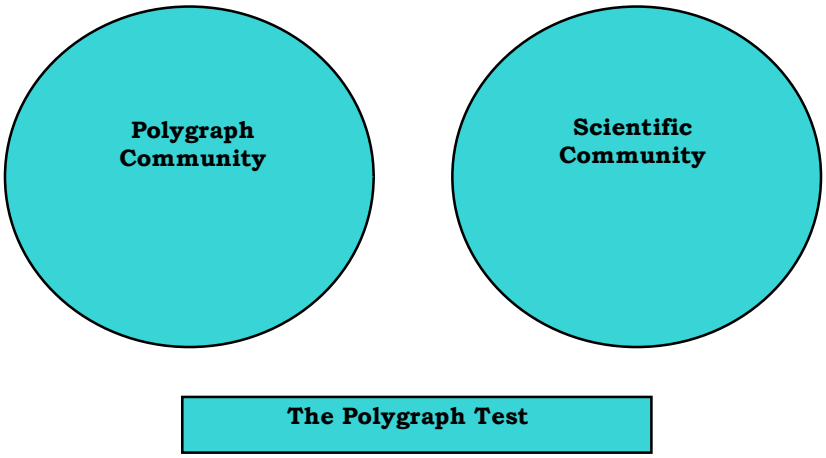
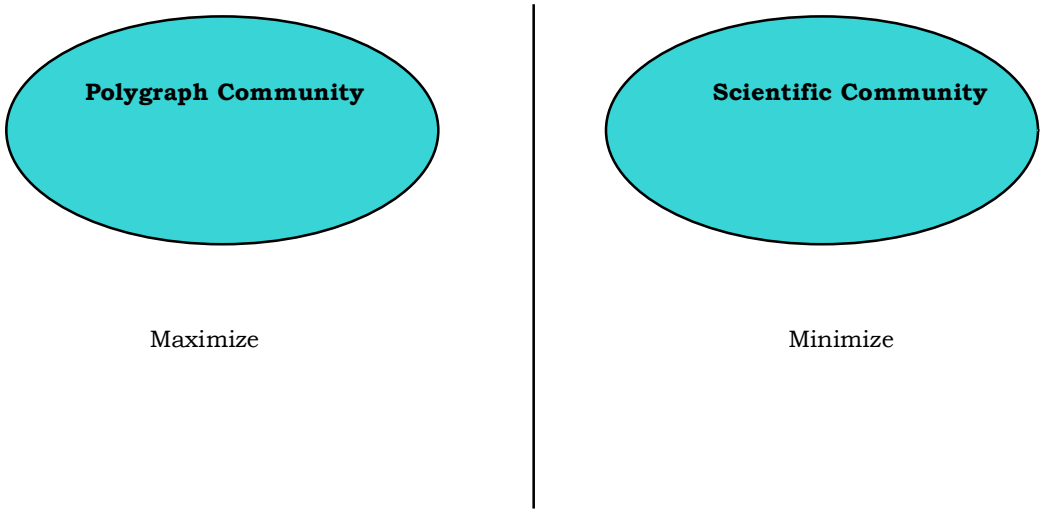
University of Illinois at Chicago, Chicago, Illinois

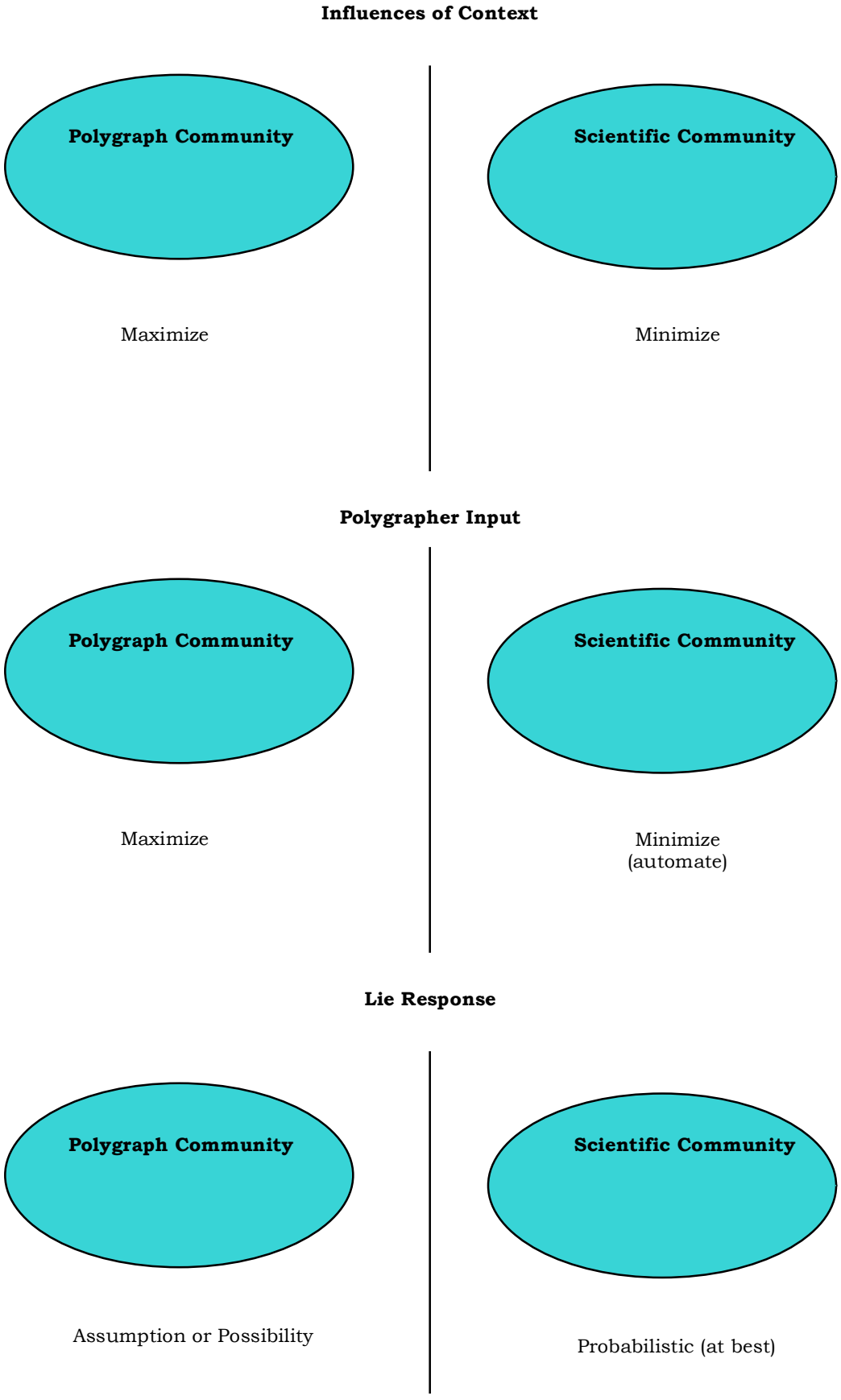
The Polygraph: One Machine, Two World Views

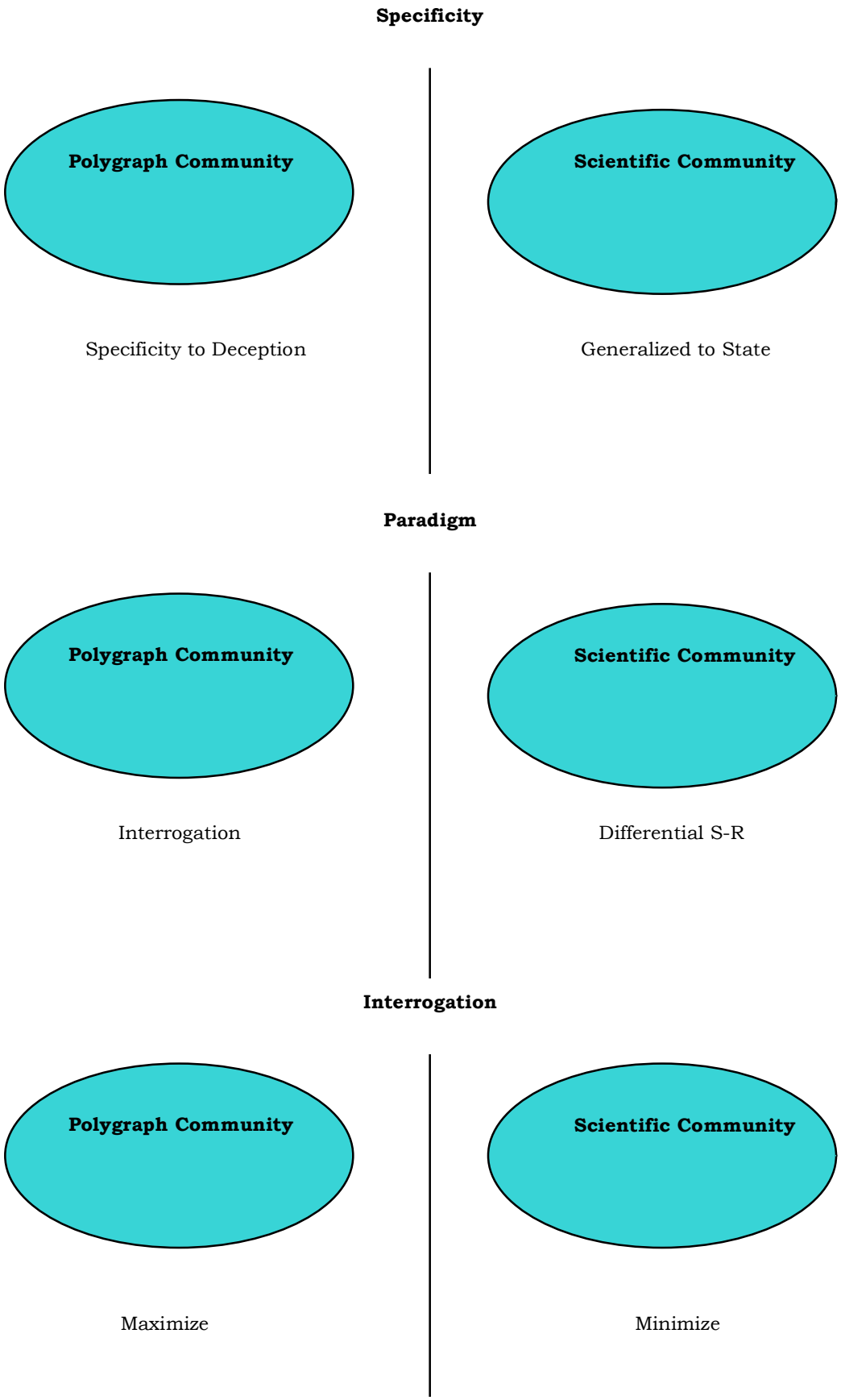
Allies or Adversaries



Interrogation




Influences of Context
Polygraph Community
Scientific Community
Maximize
Minimize
Polygrapher Input
Polygraph Community
Scientific Community
Maximize
Minimize
(automate)
Lie Response
Polygraph Community
Scientific Community
Assumption or Possibility
Probabilistic (at best)


Specificity
Polygraph Community
Scientific Community
Specificity to Deception
Generalized to State
Paradigm
Polygraph Community
Scientific Community
Interrogation
Differential S-R
Interrogation
Polygraph Community
Scientific Community
Maximize
Minimize

Evaluation Criteria

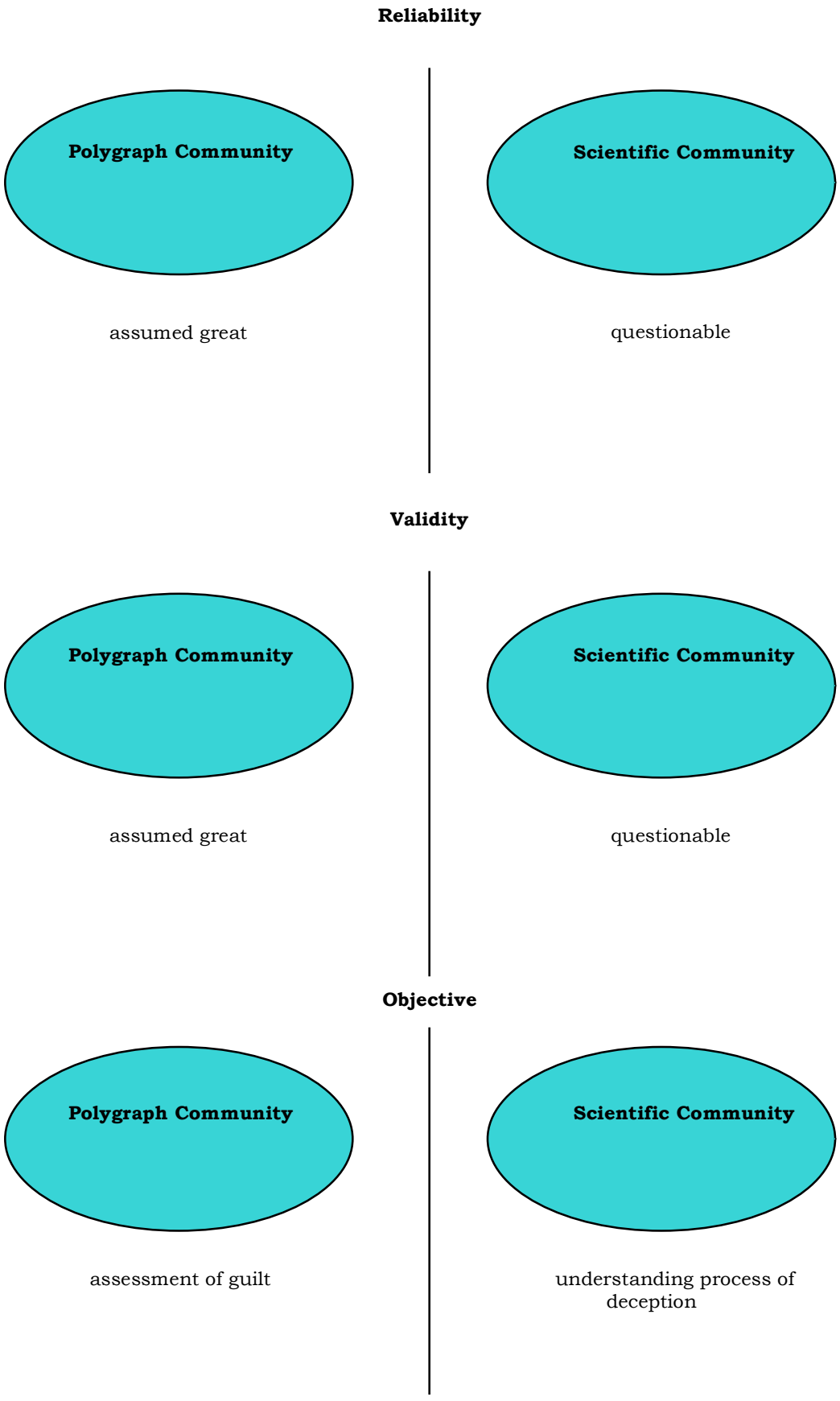
Polygraph Community	**Scientific Community**
Confession with chart Subjective	Chart Objective & Quantifiable (numerical/computer)

Expectation of Science

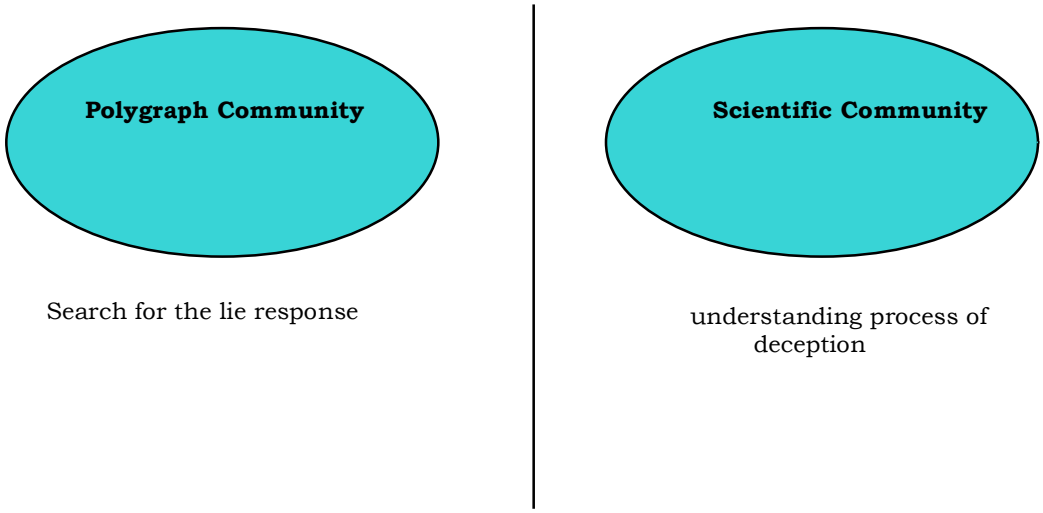
Polygraph Community	**Scientific Community**
a "lie" response	better methods of quantification better methods of data collection better models of explanation

Configuration of Polygraph

Polygraph Community	**Scientific Community**
works great	old technology - **limits specificity** - **imposes "blinders"** - **limits statistical inference**


Reliability
Polygraph Community
Scientific Community
assumed great
questionable
Validity
Polygraph Community
Scientific Community
assumed great
questionable
Objective
Polygraph Community
Scientific Community
assessment of guilt
understanding process of deception

Research Objectives



Conclusions

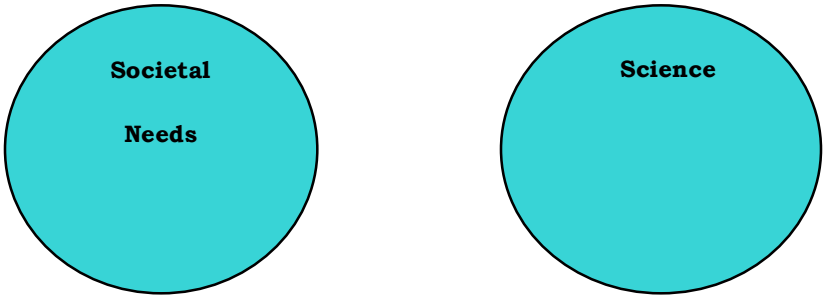
1. Better understanding of mutual objectives and competencies
2. New research agenda to provide appropriate tools for polygraphy
    a. The development of new paradigms
    b. Improvement of quantitative techniques

Emerging Technologies in Credibility Assessment

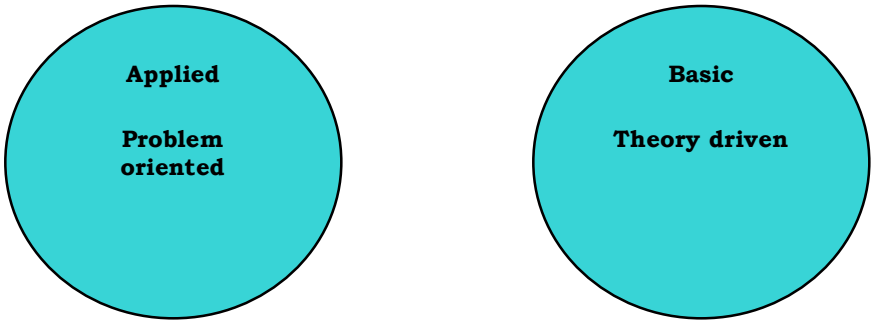
Are We Asking the Wrong Question?

Are we focusing on efficacy research when we should be investing in theory driven research?

Credibility Assessment

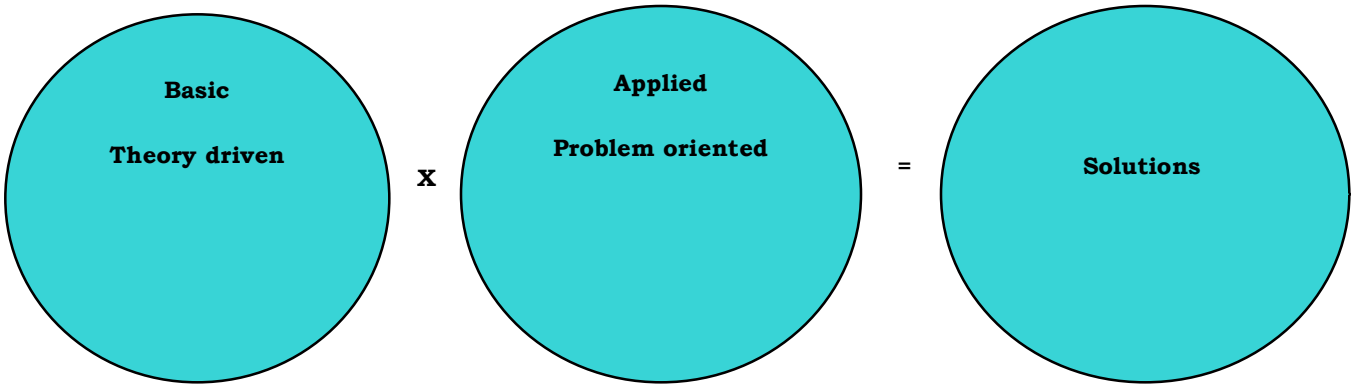


Credibility Assessment:
One Nervous System – Two Research approaches



Efficacy ***Mechanism***

Credibility Assessment:
The goal of translation research



How basic science can contribute to credibility assessment

1. Understanding neural processes
2. Theories of deception and credibility that are nervous system based
3. Translation of theory driven research to applications in the field
   a. Credibility
   b. Stress
   c. Pathology
   d. Work environment
   e. Medicine
   f. Social environment

What Do the New Technologies Provide?

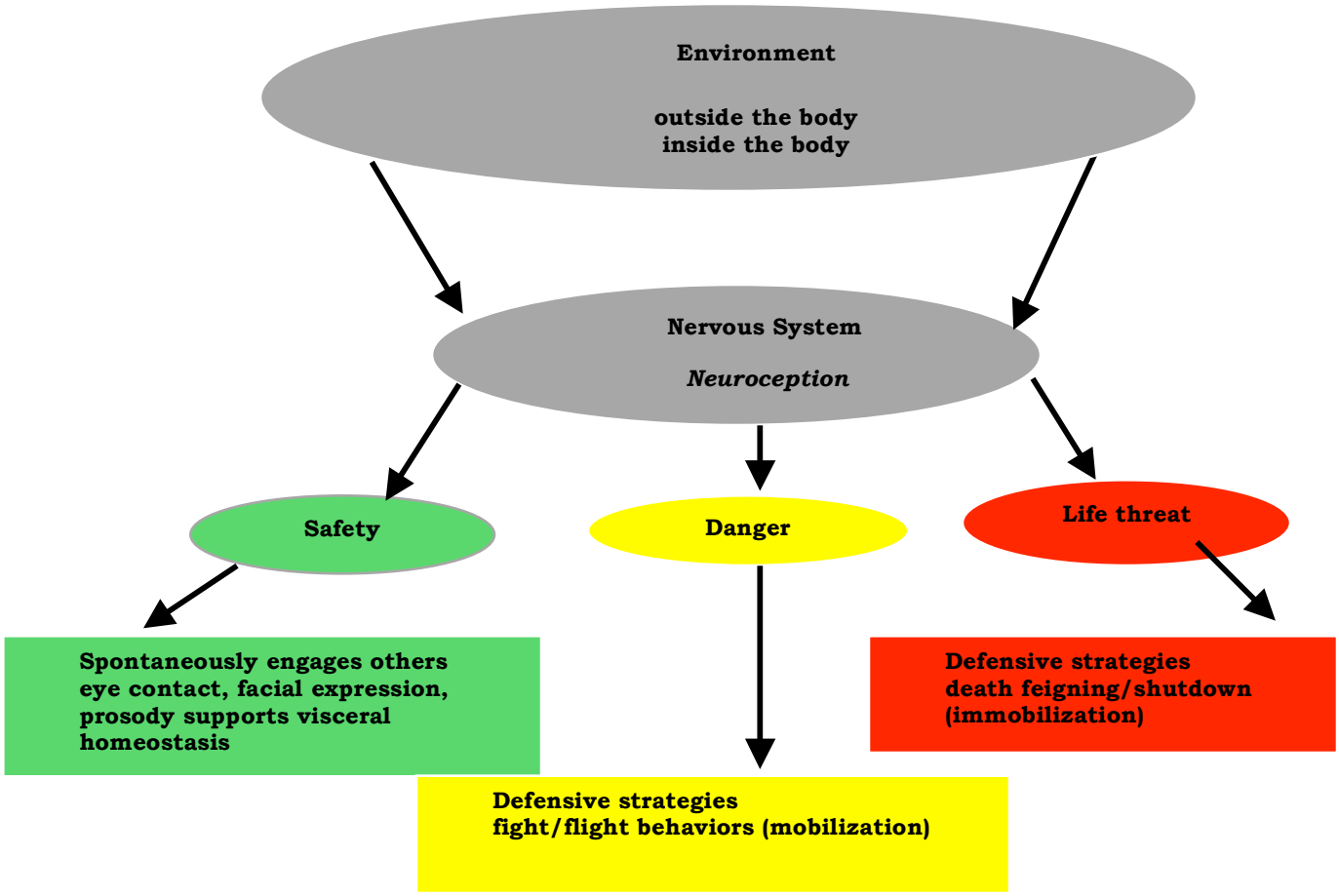
1. fMRI – basic mechanisms of how brain structures are involved in deception. Limited applications and paradigms.
2. Voice stress analyzers – theory is not well developed and data are weak
3. Laser Doppler and facial thermography - potentially broad applications in field research leading to the development of a theory driven model of deception/credibility

The Polyvagal Theory and the Social Engagement System:
Insights into the psychophysiology of deception

Overview: The Polyvagal Theory

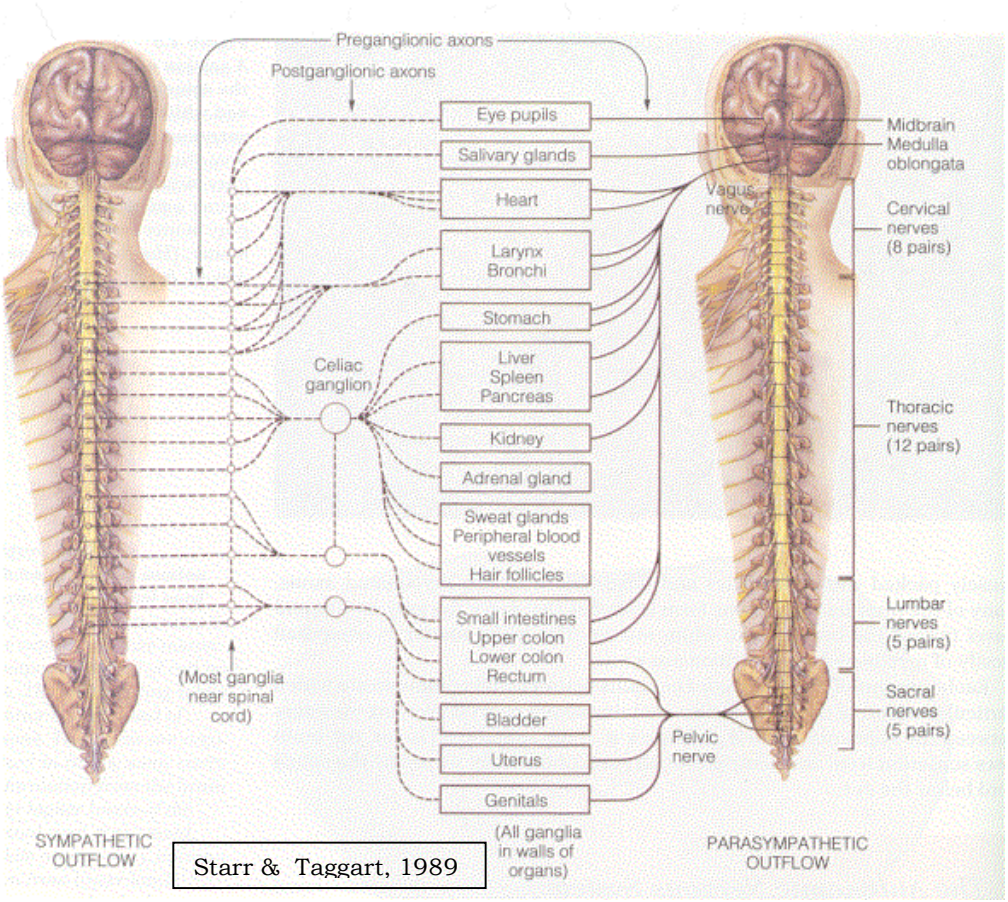
1. Evolution provides an *organizing principle* to understand neural regulation of the human autonomic nervous system.
2. Three neural circuits form a phylogenetically-ordered response hierarchy that regulate behavioral and physiological adaptation to safe, dangerous, and life threatening environments.
3. *"*Neuroception*"* of danger or safety or life threat trigger these adaptive neural circuits.

The metaphor of safety: A basic principle of our nervous system



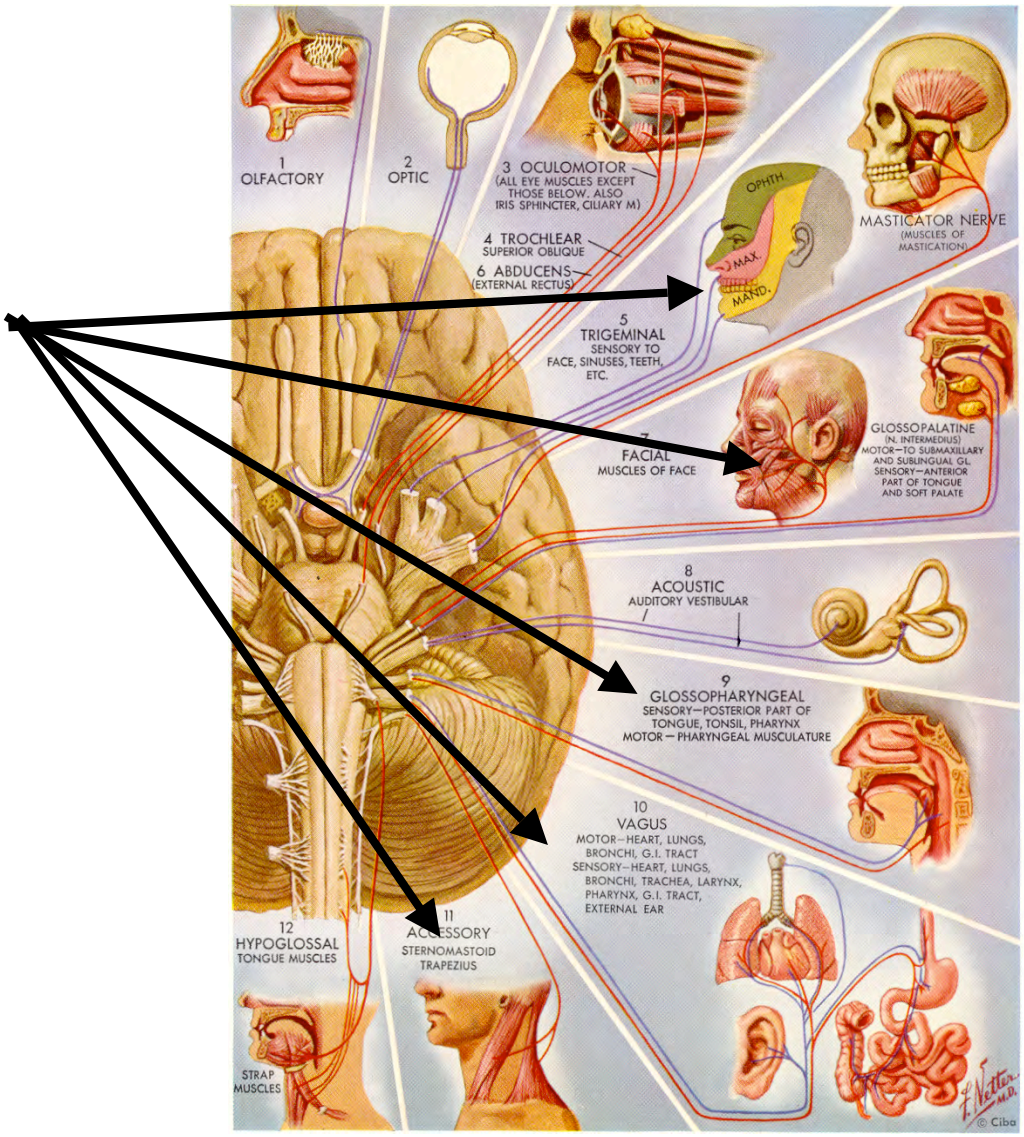
1. NOT Autonomic measures, but measures of the Autonomic NERVOUS SYSTEM
2. Characteristics of measures of the ANS
    a. Not merely arousal (SNS)
    b. Neural pathways
    c. Rhythmic features

Structures of the Nervous System: The Autonomic Nervous System



Starr & Taggart, 1989

Cranial Nerves:
"Stress" Reactivity



Evolution

Neural Regulation of the Heart in Vertebrates

	CHM	DMX	SNS	AD/m	NA
Cyclostomes	**X+**				
Elasmobranchs	**X+**	**X-**			
Teleosts	**X+**	**X-**	**X+**		
Amphibians	**X+**	**X-**	**X+**		
Reptiles	**X+**	**X-**	**X+**	**X+**	
Mammals	**X+**	**X-**	**X+**	**X+**	**X-**

Polyvagal Theory:
Three Adaptive Neural Circuits

	VVC	SNS	DVC
heart rate	+ / -	+	-
bronchi	+ / -	+	-
gastrointestinal		-	+
vasoconstriction		+	
sweat		+	
adrenal medulla		+	
tears	+ / -		
vocalization	+ / -		
facial muscles	+ / -		
eyelids	+ / -		
middle ear muscles	+ / -		

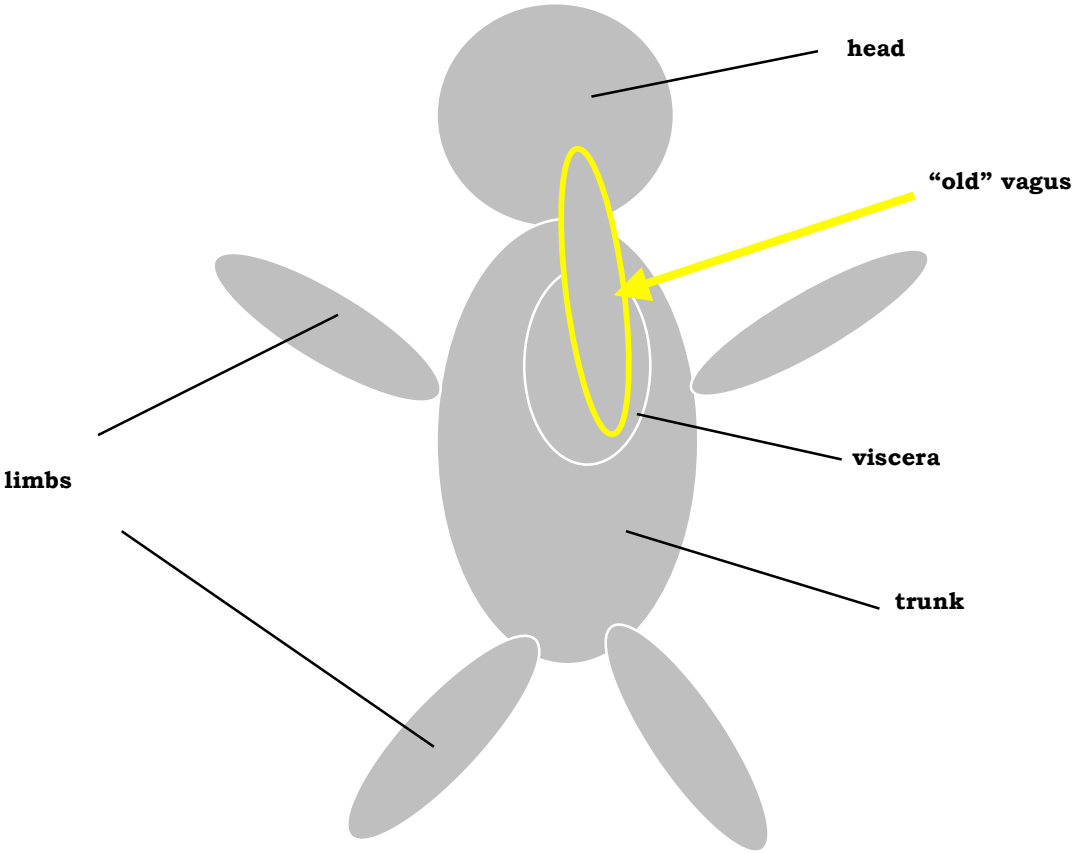
Polyvagal Theory: Phylogenetic Stages of Neural Control

Stage	ANS Component	Behavioral Function	Lower motor neurons
III	Myelinated vagus ***(VVC – ventral vagal complex)***	Social communication, self-soothing and calming, inhibit sympathetic-adrenal influences	Nucleus ambiguus
II	Sympathetic-adrenal system	Mobilization(active avoidance)	Spinal cord
I	Unmeyelinated vagus ***(DVC – dorsal vagal complex)***	Immobilization(death feigning, passive avoidance)	Dorsal motor nucleus of the vagus

Polyvagal Theory: A Phylogenetic Hierarchy of Response Strategies

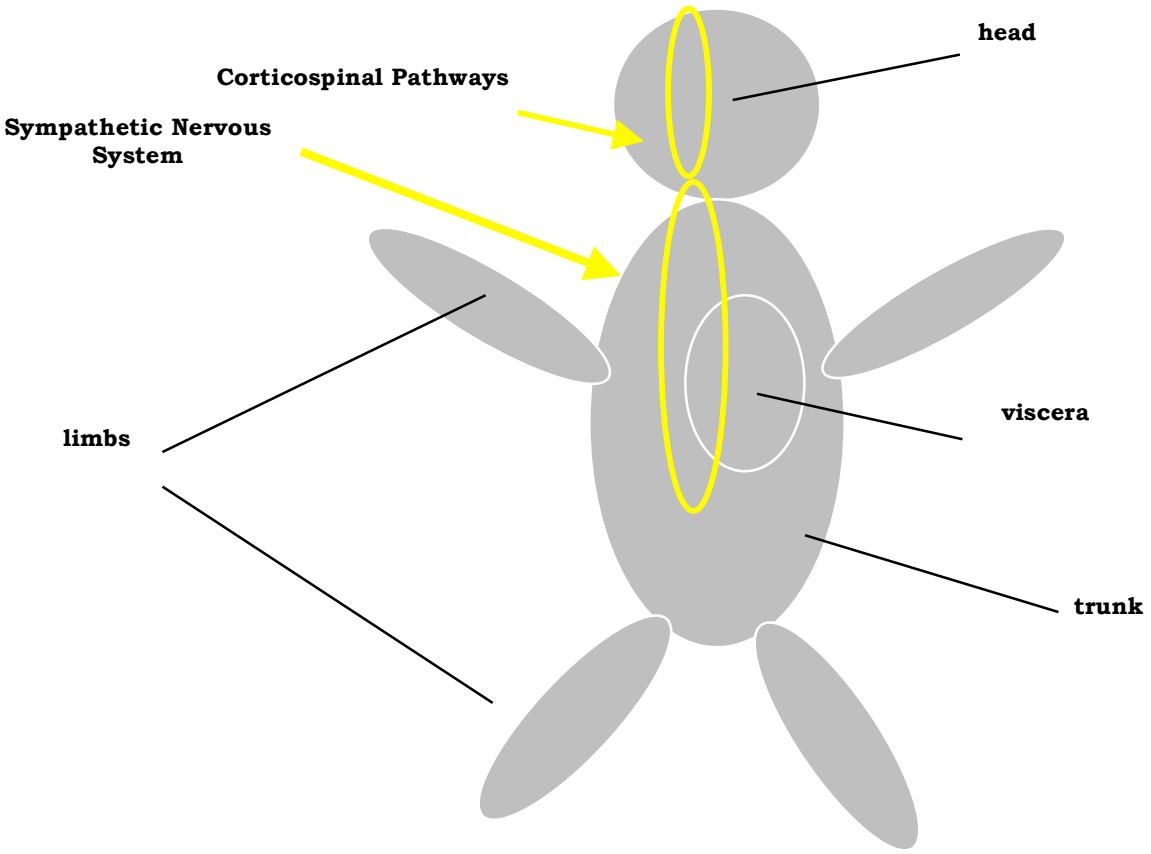
Structure	Function	VVC	SNS	DMX
Head	Communication	+		
Limbs	Mobilization		+	
Viscera	Immobilization			+

Phylogenetic Organization of the ANS: The Polyvagal Theory



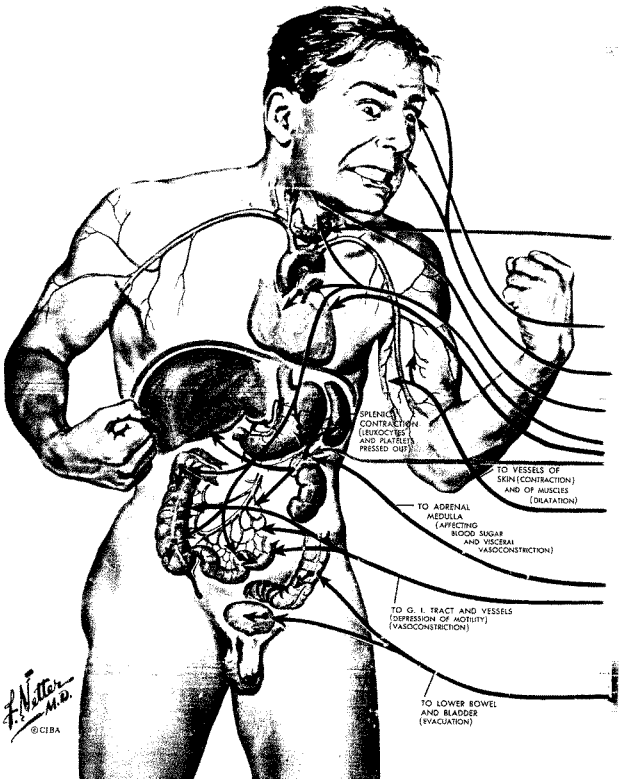
Vasovagal Syncope

Phylogenetic Organization of the ANS: The Polyvagal Theory

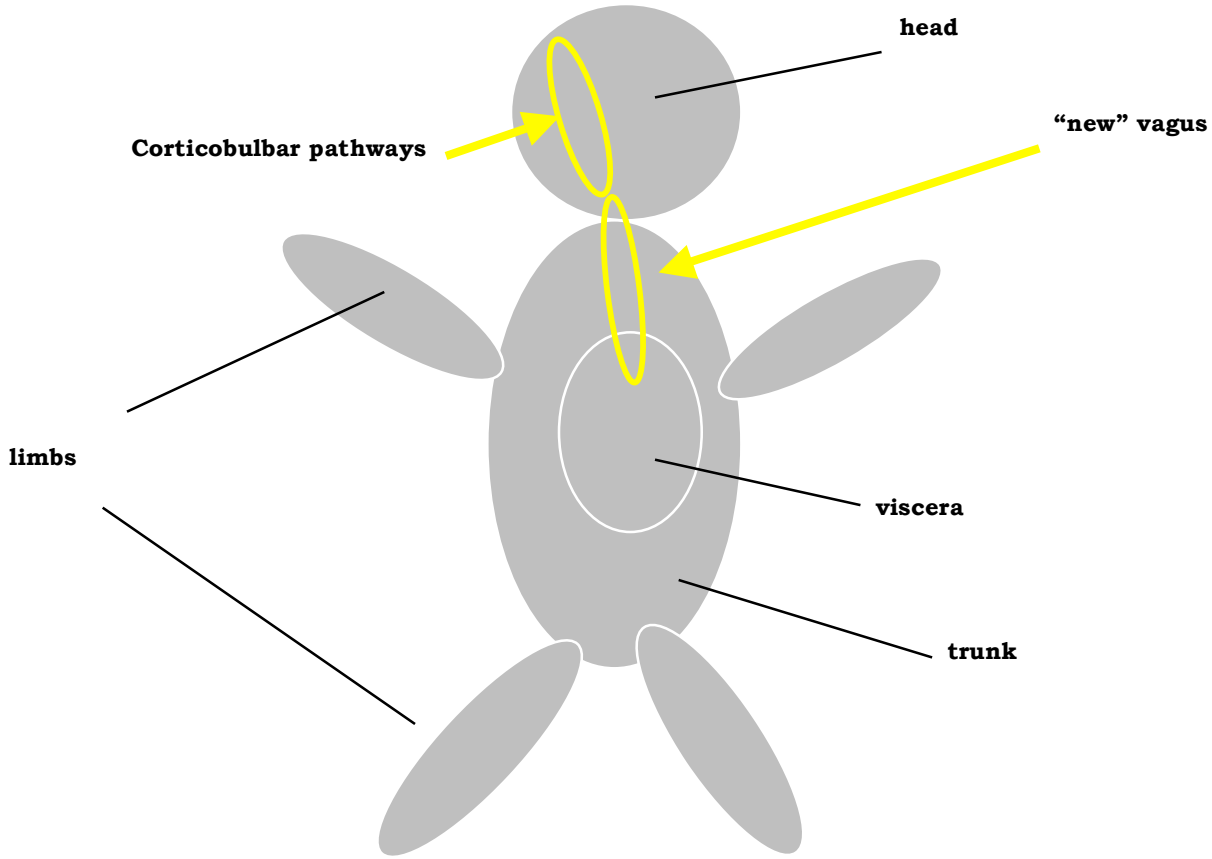


Mobilization: Flight Behaviors

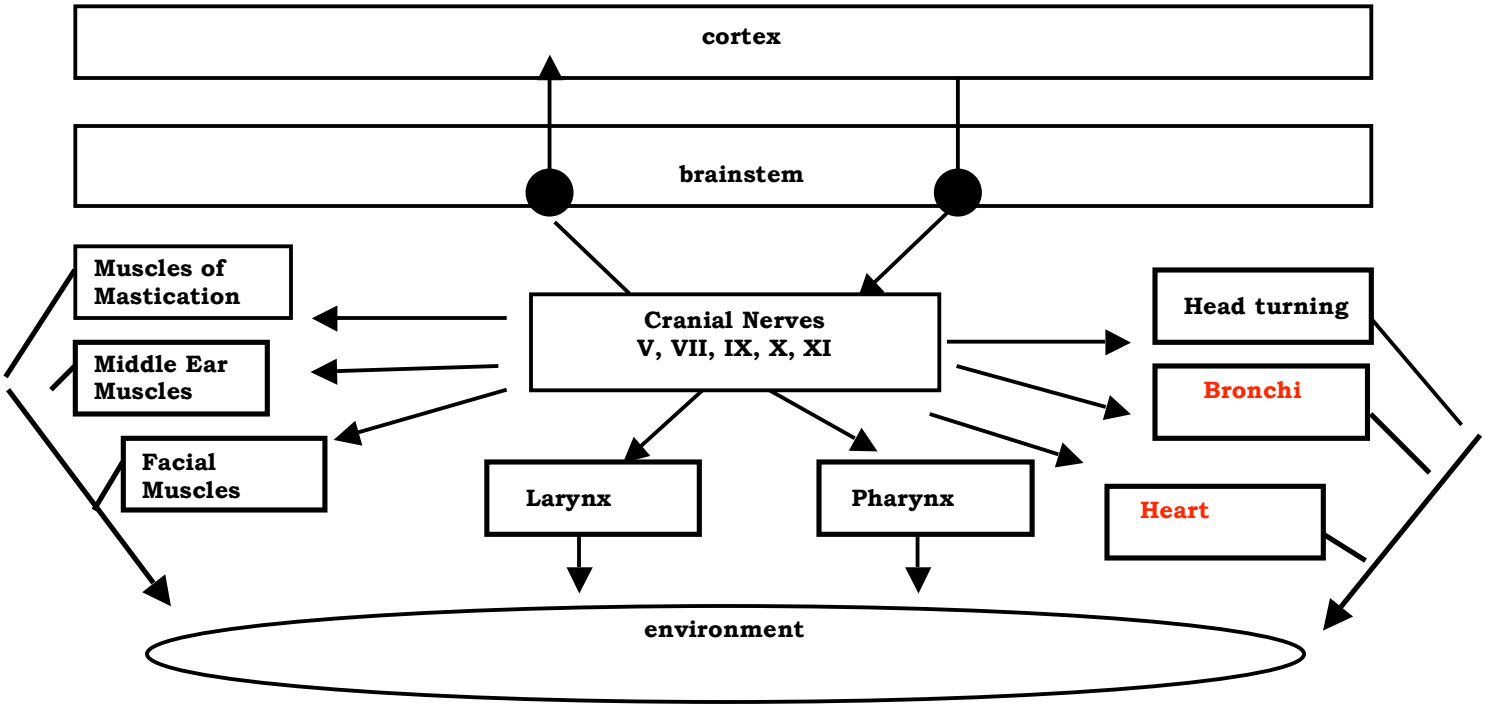
Mobilization: Fight Behaviors



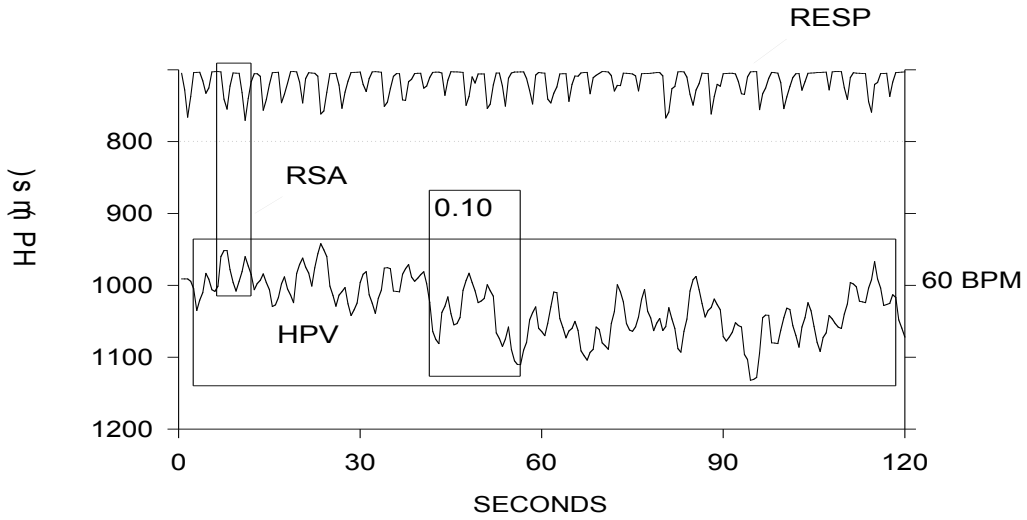
Phylogenetic Organization of the ANS: The Polyvagal Theory



Social Engagement System
Anatomical basis



Heart Rate Rhythms:
A measure of the "new" vagus

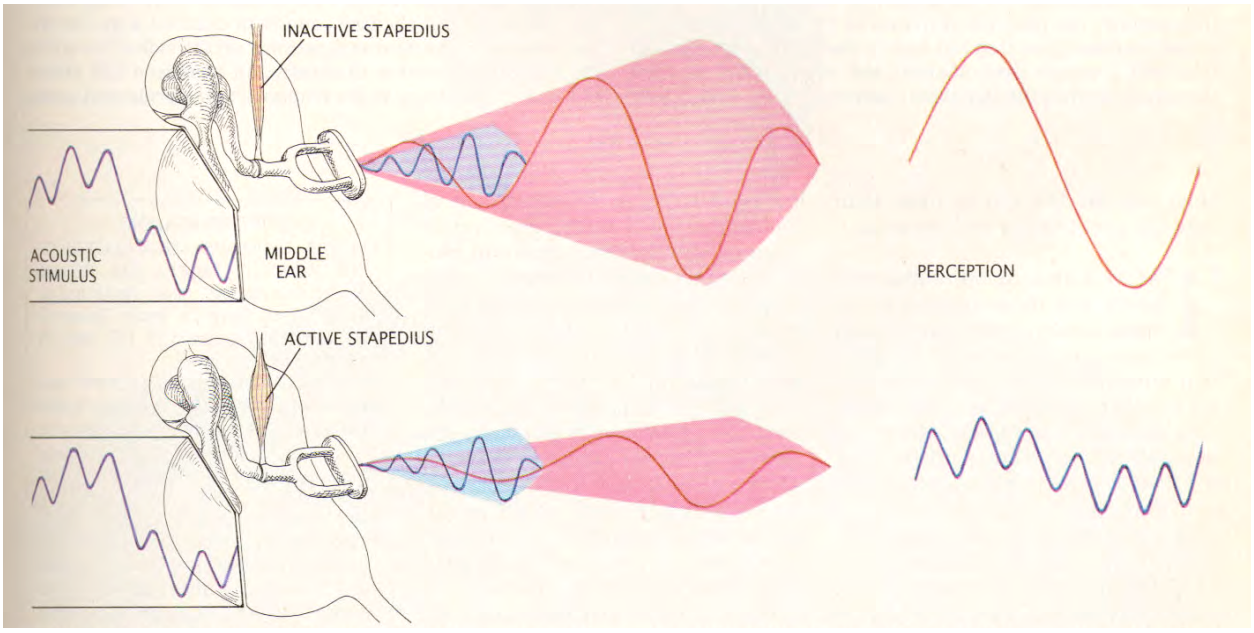


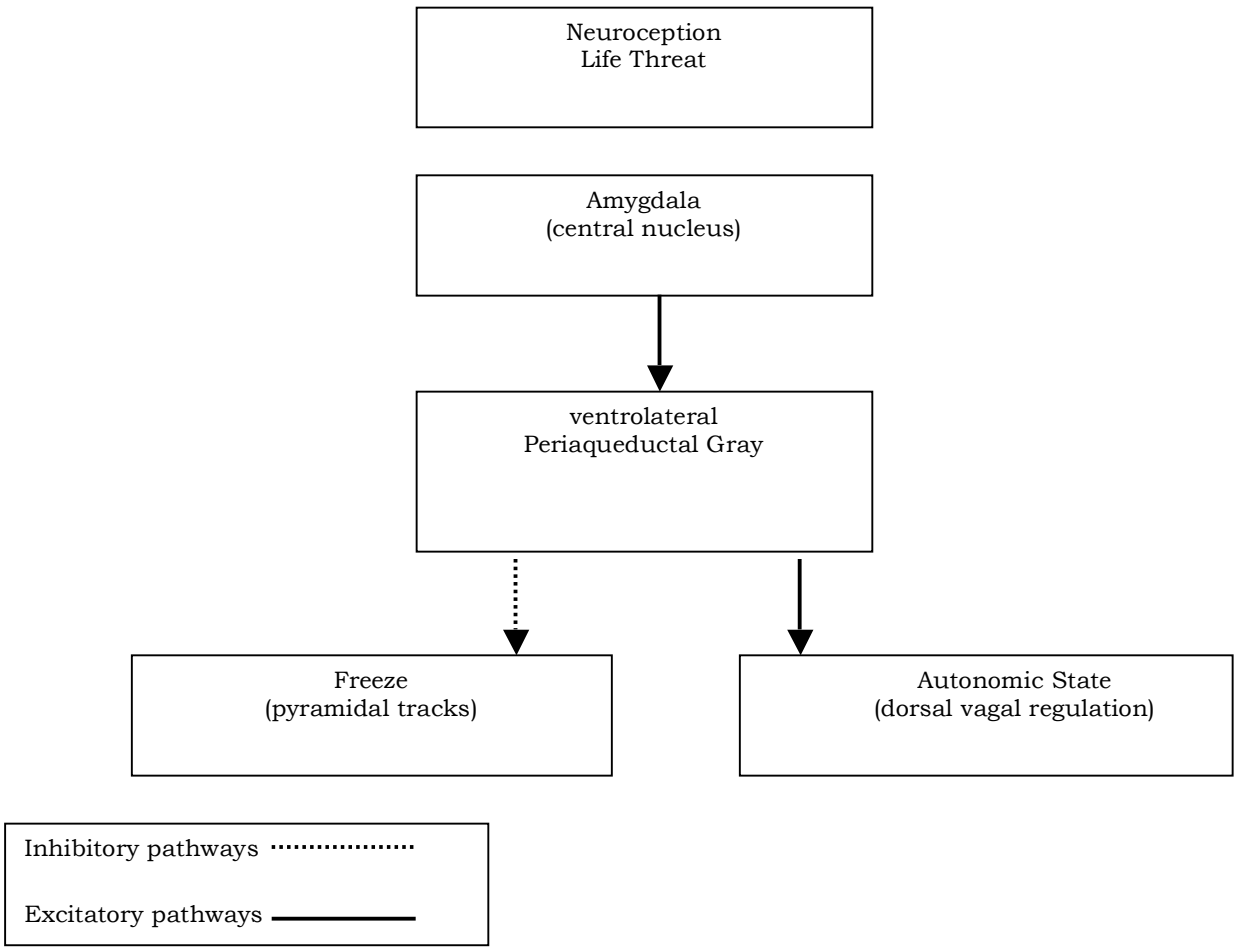
Autonomic Response Indicator System

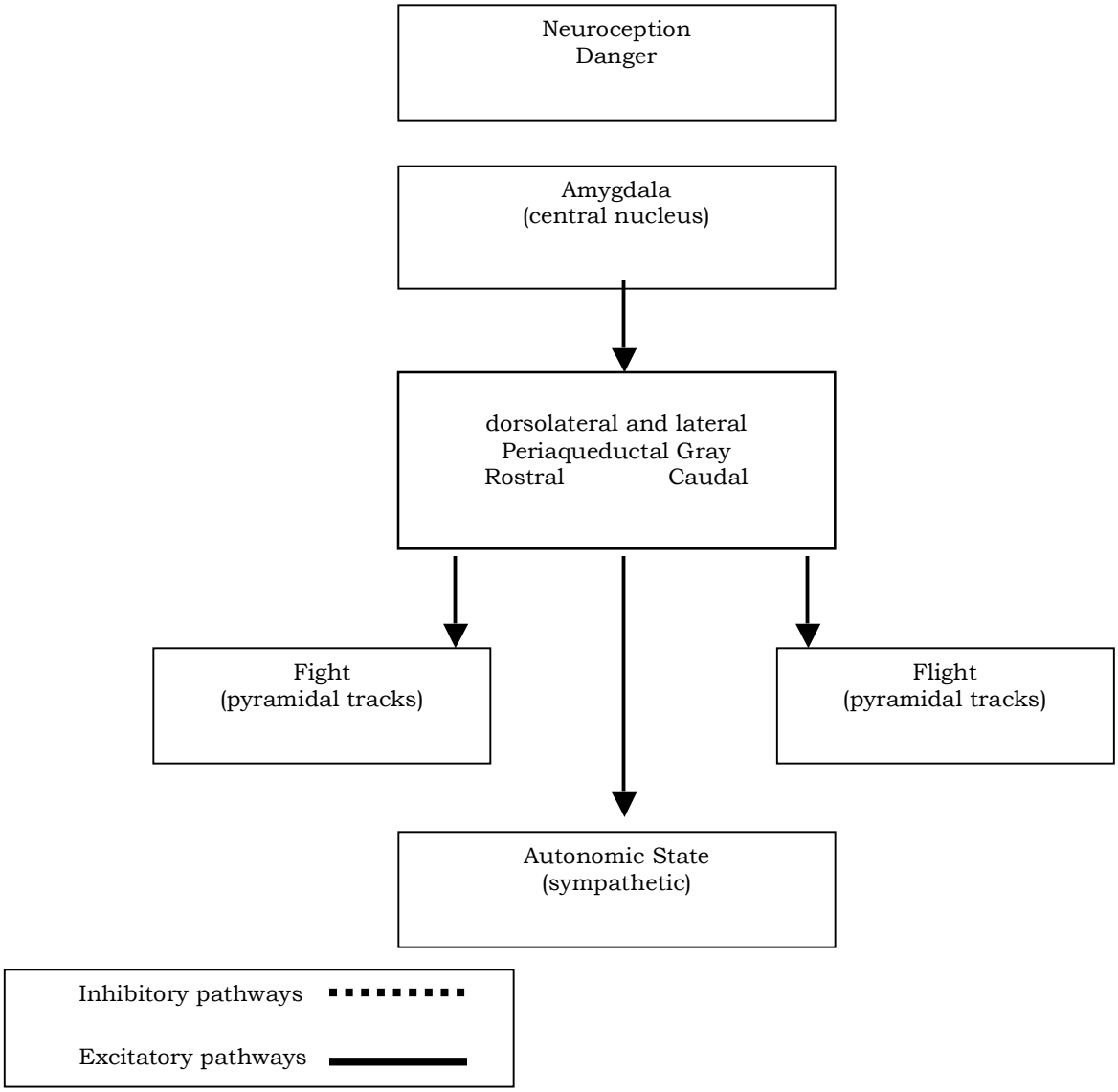
Input Signal	Derived Variable
1. ECG	HR, HRV, Q-T, RSA, CIDF, THM-A
2. Respiration	Rate, tidal volume
3. Blood pressure (finger)	Systolic, diastolic, BP variability (respiration, THM)
4. Activity (accelerometer)	Movement
5. ECG/Blood pressure	Baroreceptor sensitivity, pulse transit time

Looking and Listening: Common Neurophysiological Mechanisms

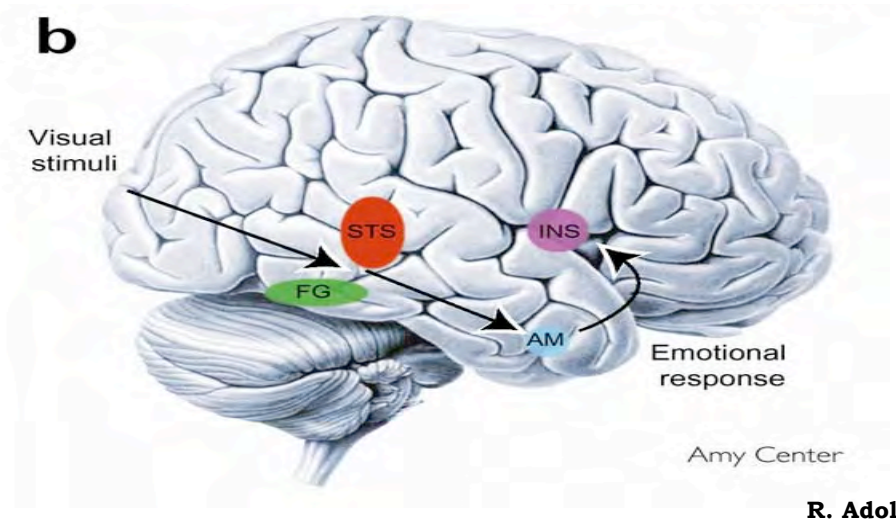
Middle Ear Muscles:
Role in Extracting Human Voice



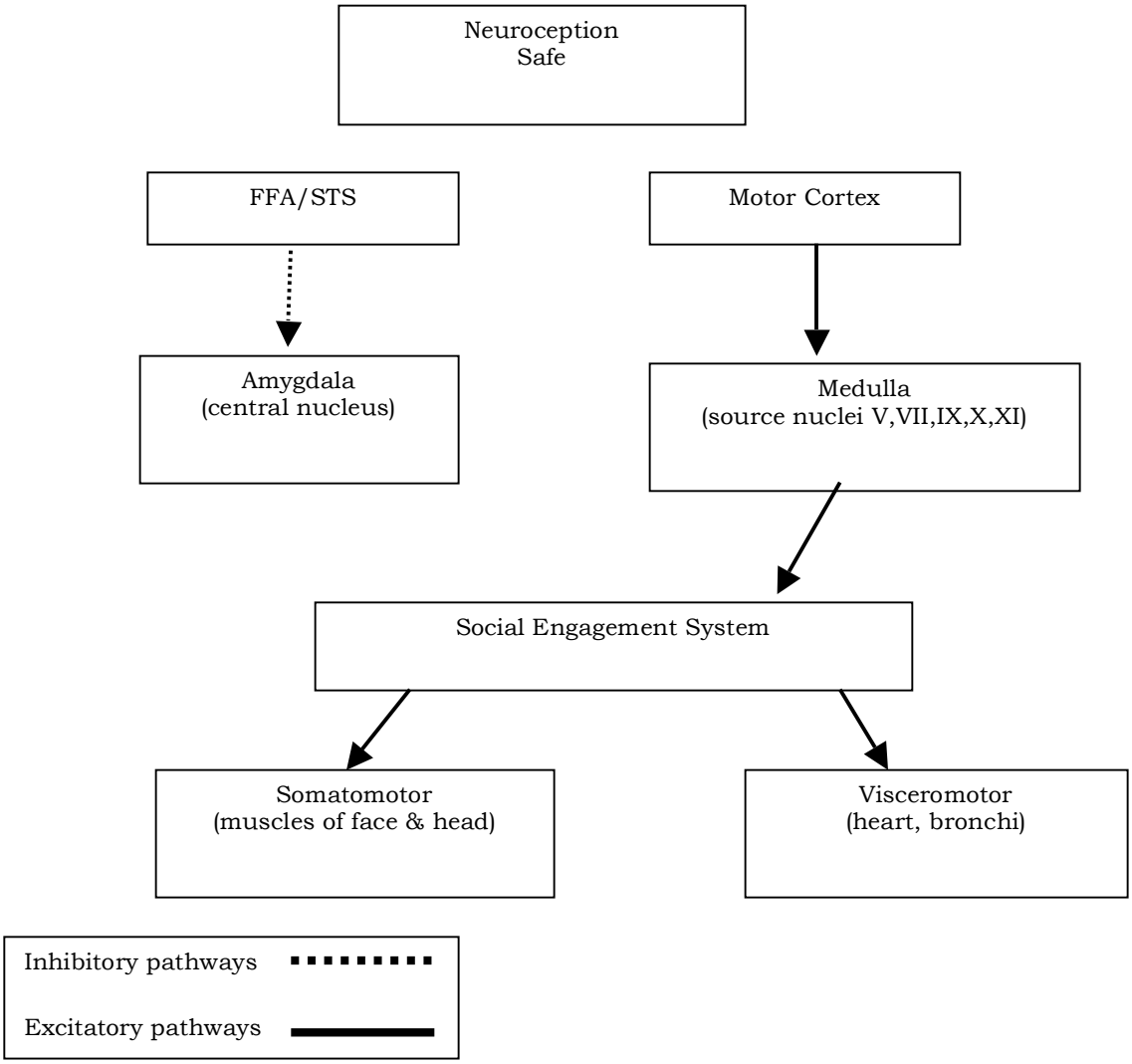




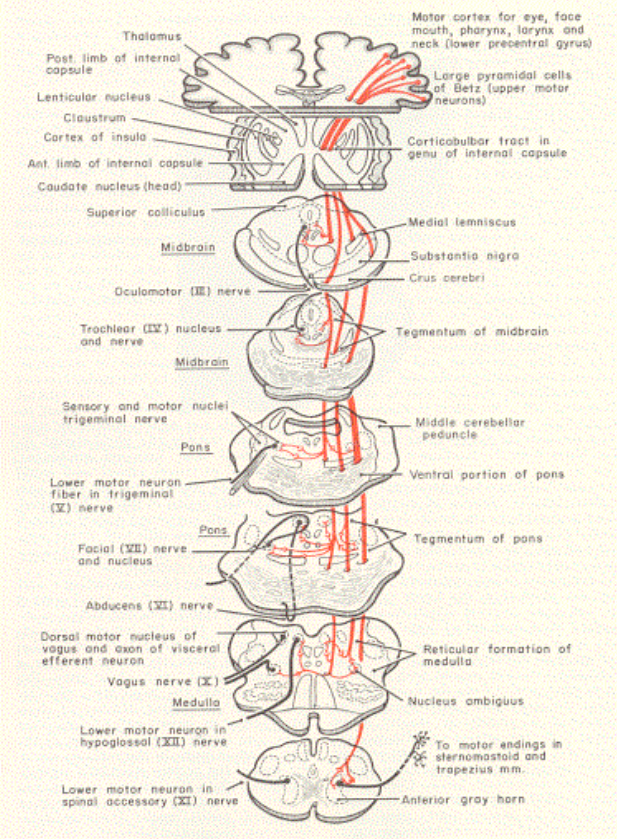
The Trustworthiness of Faces



R. Adolphs, 2002


Neuroception
Safe
FFA/STS
Motor Cortex
Amygdala
(central nucleus)
Medulla
(source nuclei V,VII,IX,X,XI)
Social Engagement System
Somatomotor
(muscles of face & head)
Visceromotor
(heart, bronchi)
Inhibitory pathways
Excitatory pathways

Corticobulbar Pathways



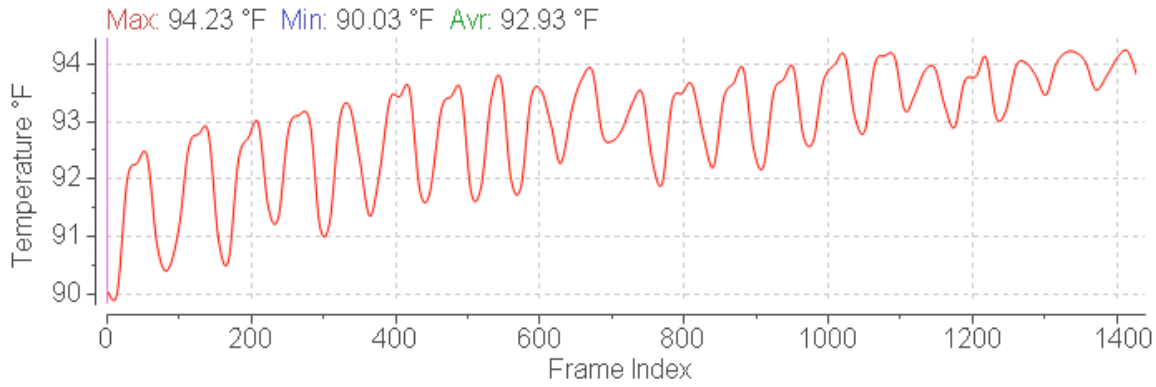
Social Engagement System:
Candidate variables for the detection of deception

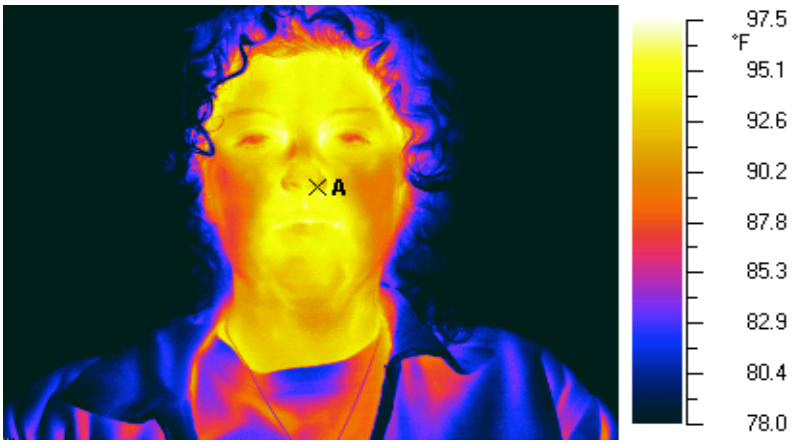
- Prosody
- Gaze
- Facial expressivity
- Autonomic measures (visceral state)
- Posture during social engagement

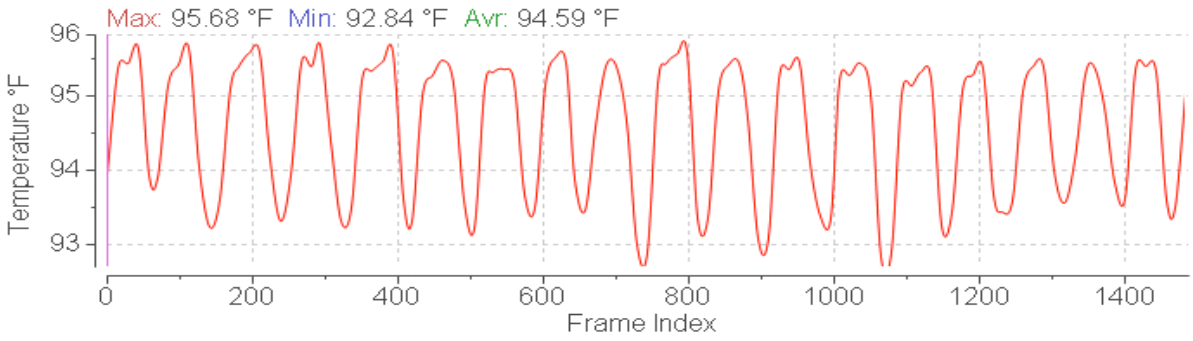
Social Engagement System
Where to look? What to measure?

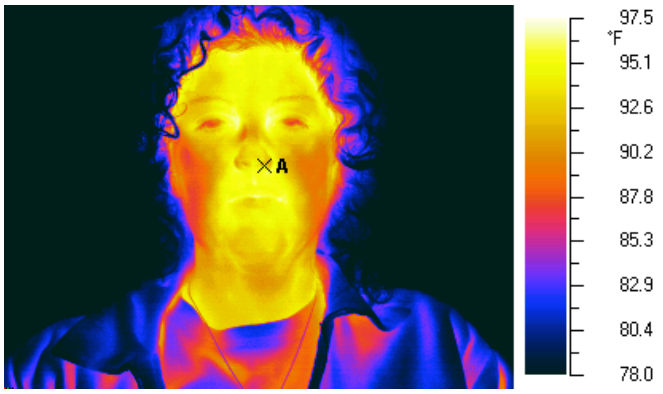
Cortex	ERP, EEG, EOP, fMRI
Autonomic	***heart rate, vagal tone (RSA),*** respiration
Middle ear muscles	impedance ***words from noise***
Facial muscles	facial EMG, thermography, video coding of faces
Laryngeal/pharyngeal muscles	acoustic properties of vocalizations, language
Gaze	***eye tracking***

The drift in temperature seen here is NOT due to actual temperature changes in respiratory flow temperatures…







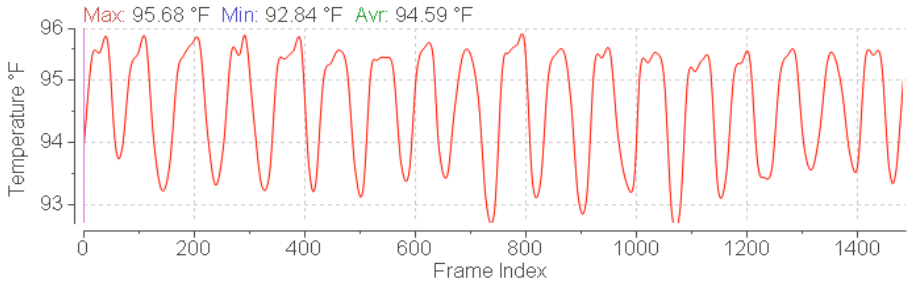


Respiration

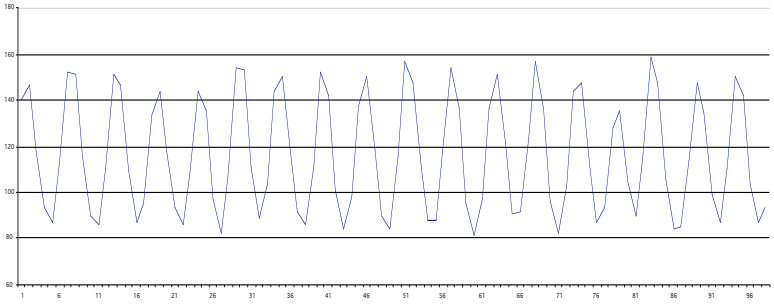
Respiration rate comparison: remote IR thermography vs. contact impedance pneumography.

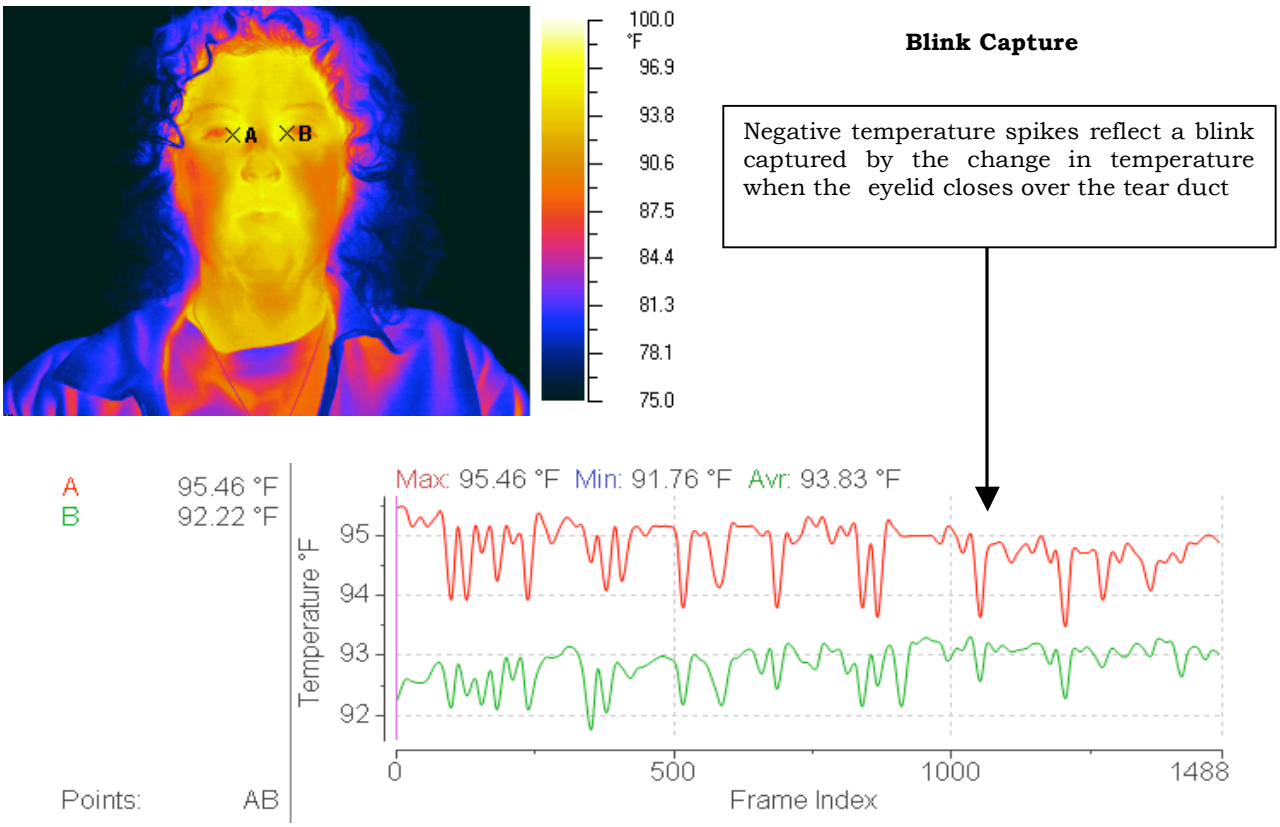
Respiration rate for each method = 21 breaths per minute

Respiration pattern via IR thermal pattern at the nasal passage

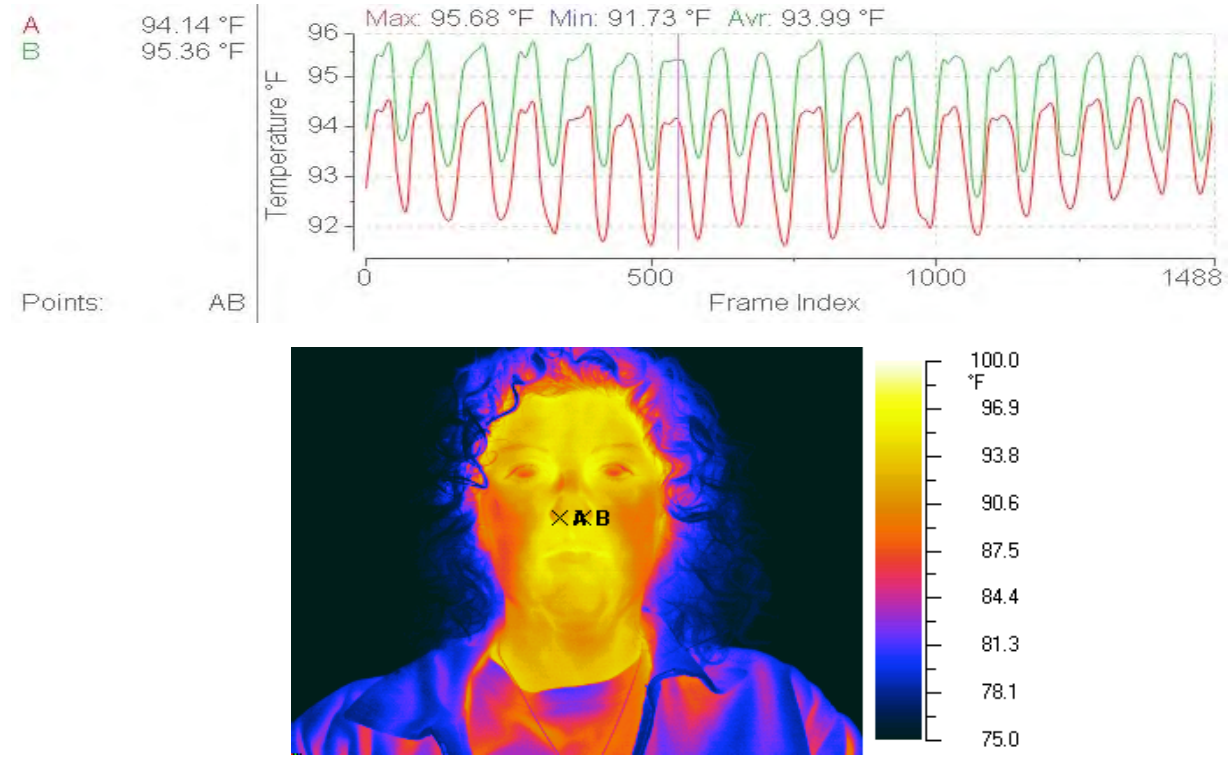


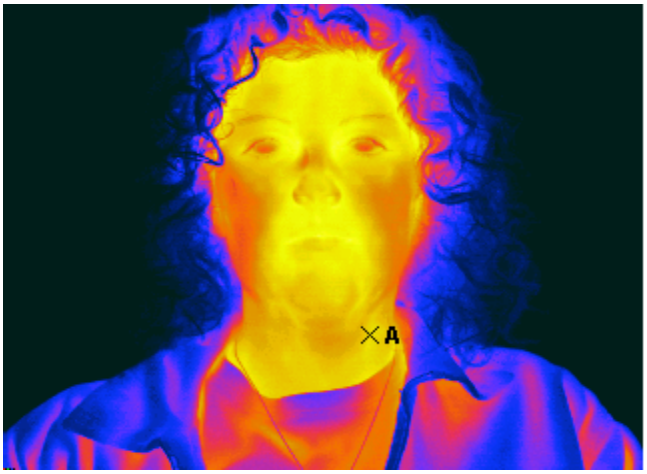
Respiration pattern via standard impedance pneumograph




100.0
°F
96.9
93.8
90.6
87.5
84.4
81.3
78.1
75.0
A
B
Blink Capture
Negative temperature spikes reflect a blink captured by the change in temperature when the eyelid closes over the tear duct
A 95.46 °F
B 92.22 °F
Max: 95.46 °F Min: 91.76 °F Avr: 93.83 °F
Temperature °F
95
94
93
92
0
500
1000
1488
Frame Index
Points: AB

Laterality

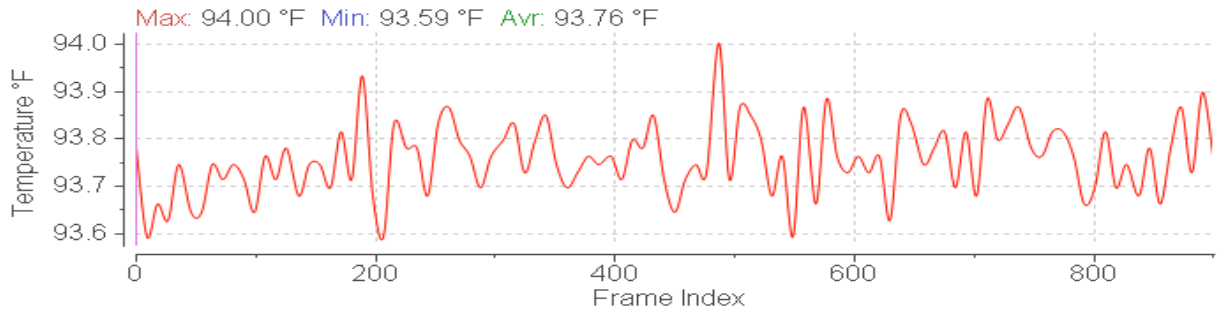

A 94.14 °F
B 95.36 °F
Max: 95.68 °F Min: 91.73 °F Avr: 93.99 °F
Temperature °F
96
95
94
93
92
0
500
1000
1488
Frame Index
Points: AB
100.0
°F
96.9
93.8
90.6
87.5
84.4
81.3
78.1
75.0
A
B

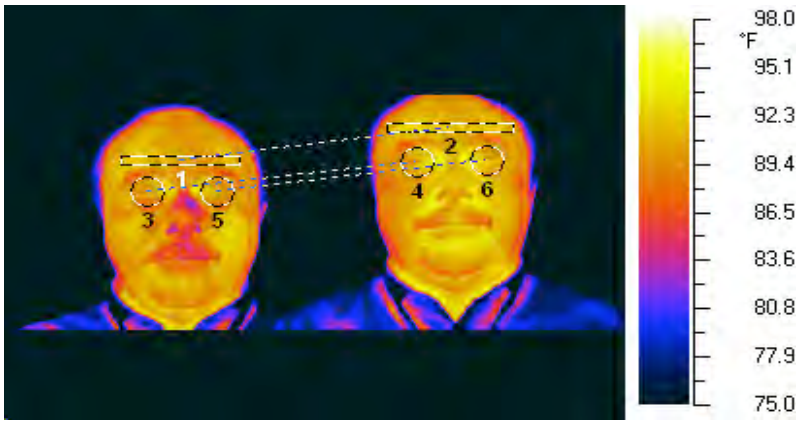


Heart Rate

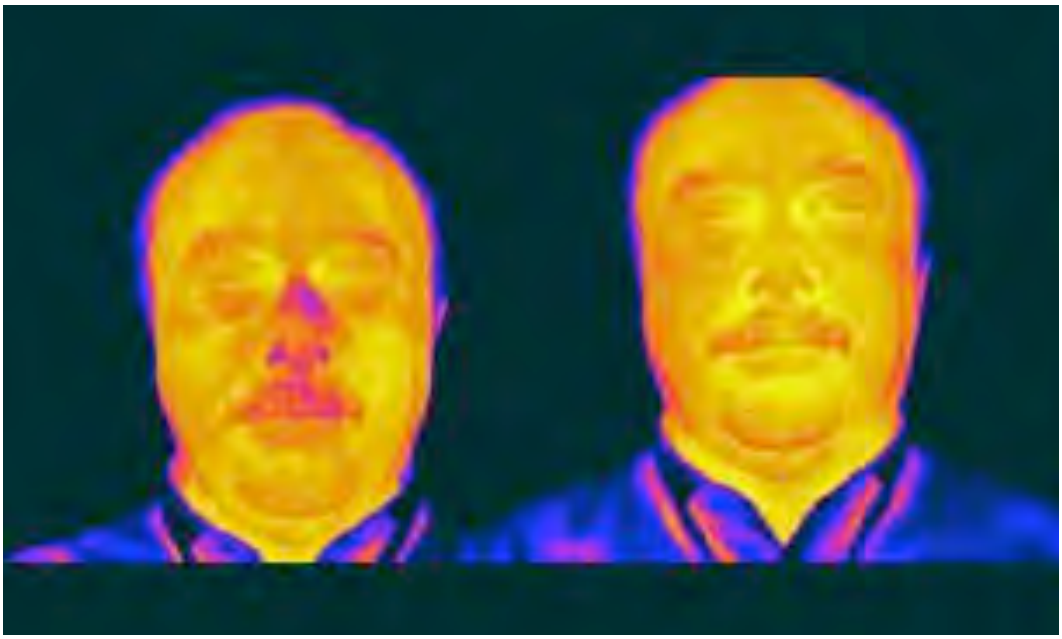
Carotid Data

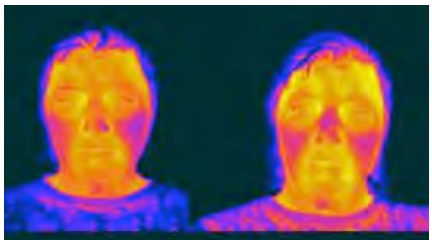
- 30 seconds (900 frames)
- ~38 spikes
- ~76 BPM

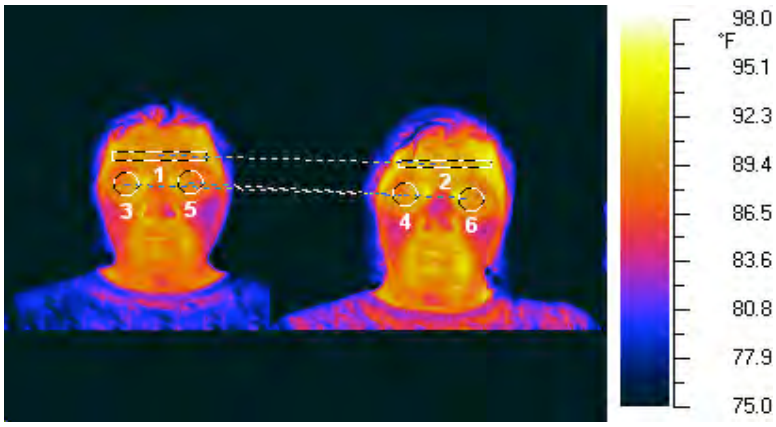




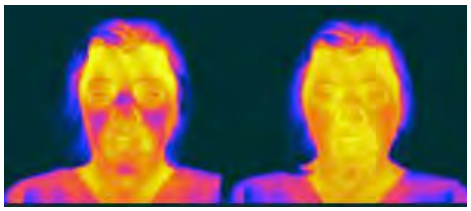
Area	Min	Max	Avg
1	89.66	92.45	90.81
2	90.19	93.29	92.07
3	87.46	92.76	90.09
4	87.96	94.33	91.17
5	87.93	92.60	90.11
6	88.72	94.14	91.27
delta 1-2	.53	.85	1.26
delta 3-4	.50	1.57	1.08
delta 5-6	.79	1.53	1.16

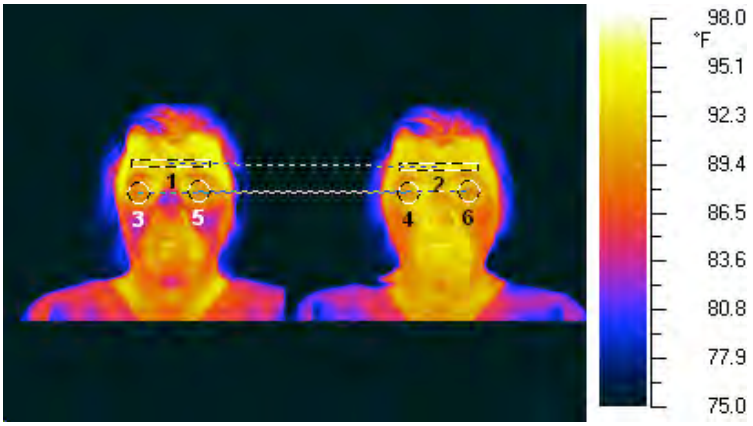






Area	Min	Max	Avg
1	88.09	91.68	89.70
2	90.13	93.68	91.52
3	86.35	92.14	89.38
4	86.85	92.33	89.83
5	85.08	90.90	88.56
6	86.67	92.60	89.77
delta 1-2	2.03	2.00	1.82
delta 3-4	.5	.19	.45
delta 5-6	1.59	1.70	1.2





Area	Min	Max	Avg
1	91.24	95.23	92.94
2	92.33	94.95	93.55
3	86.39	92.02	89.53
4	87.81	92.94	90.60
5	85.91	92.63	89.88
6	88.12	92.48	90.45
delta 1-2	1.09	.28	.62
delta 3-4	1.42	.92	1.08
delta 5-6	2.21	.15	.57

Biological Organizing Principles

- Facilitate an understanding of the neural mechanisms and contexts mediating autonomic reactivity
- Identify candidate variables for detecting deception

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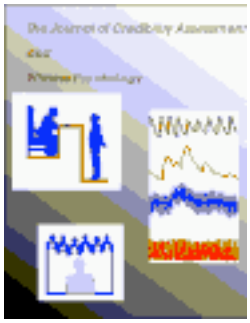
Published by Boise State University



The Use of Voice in Security Evaluations

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The Use of Voice in Security Evaluations

Introduction

- The analysis of voice and speech can lead to the identity of the speaker, explanations of the speakers behavior and, perhaps, if the speaker is lying.
  - It is 2c (stress) and 3 (deception) that are of interest here.
- But if identification of deception by voice analysis is to be attempted, one **must** first consider the effects of stress on voice. In most cases, this progression has not been properly carried out.
- While it is recognized that lying does not always result in stress (due to sociopathic conditions, stress muted by chemicals and so on), stress constitutes the substrata for deception in the great majority of instances.

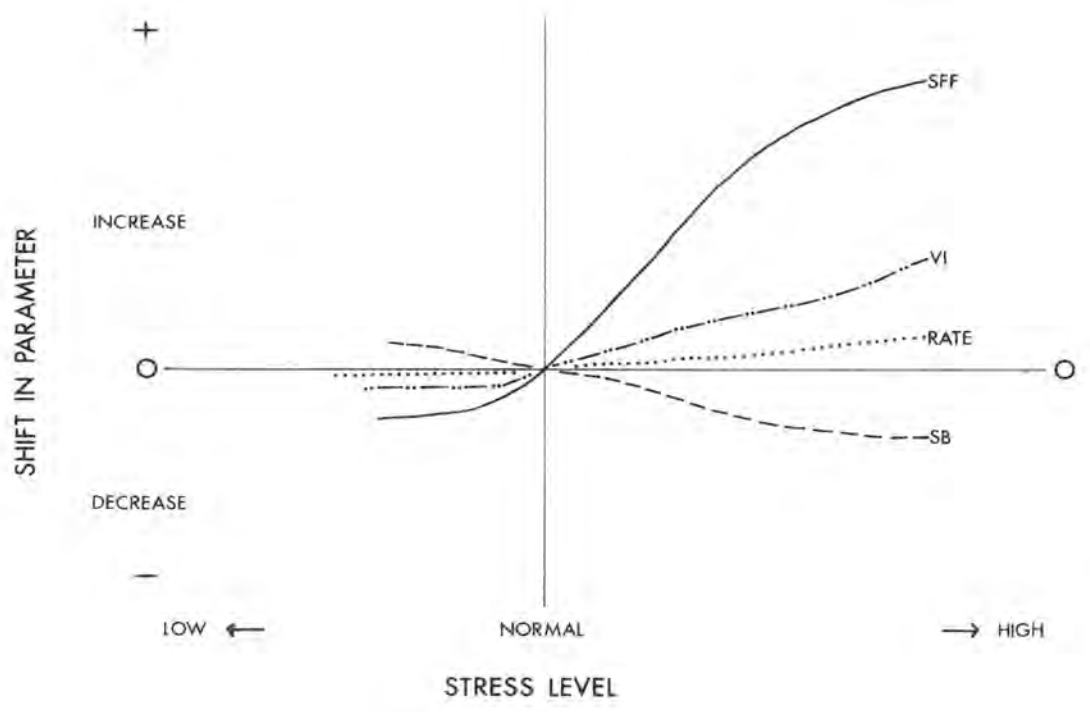
1. **Speaker Verification**
2. **Behavioral States**
   a. **Emotions**
   b. **Intoxication**
   c. **Psychological stress**
   d. **Illness, fatigue, etc.**
3. **Deception**

- It is **first** necessary to study and understand psychological stress as it is reflected in phonatory output.
- One problem to be faced is that stress is most often defined on the basis of the particular stressor involved.
- Actually, stress should be defined as a psychological response to a perceived or actual threat (as modified by coping behavior).
  - Unfortunately most research on vocal stress has been based on the former assumption -- not a useful approach.

Stress and Voice Model

- The model in Figure 1 has been gleaned from data analysis and the distillation of the available literature. Included is our own research. It involves curves of four acoustic (voice) parameters as they shift from low stress utterances through normal speech to that reflecting high stress. They are:
  - **SFF or speaking fundamental frequency:** This factor tends to rise with stress due to muscle tension and increased pulmonic airflow.
  - **Vocal intensity:** This factor tends to be reduced for low stress; quiet speech also rises -- as does speaking rate (**RATE**).
  - **Speech bursts:** The reverse trend is found for speech bursts (**SB**) and intervocalic pauses. There is an elongation, and reduction, of the number of phonatory bursts as stress rises.
  - In addition, **non-fluencies** tend to increase as a function of greater stress.

Stress and Voice Model: Figure 1



- If this model was both stable and universal, it would prove to be a boon to the study of deception as it is reflected in speech and voice.
  - Most investigators and practitioners contend that stress states provide the undergirding for the identification of deception. Unfortunately, this model is more in the nature of a hypothesis than a law.

Problems

- For example, while the data trends reported by most authors conform to the SFF and most vocal intensity curves, a few report little change or even some reversals.
- On the other hand, although the shift in speaking rate is not extensive, it appears stable.
- So do the trends for non-fluencies and speech bursts. Yet even these relationships are not universal.
- The cited across-study problems do not simply result from basing the experiments on the different types of stressors, they also appear to be created by marked differences in experimental design and variation of stressor **intensity** (i.e., the electric shock, induced anger, task complexity, threat of punishment and so on).
- Worse of all, few if any of the investigators were able (or willing) to determine the level of stress being experienced by the speakers
  - Sometimes they did not even know if their subjects were actually stressed.

A Response

- It now appears necessary to respond to all of the cited problems (particularly, the past failure to verify stress level experienced by human subjects).
- No research designs to date appear to have been robust enough to detect deception in speech samples.
- The ideal program would consist of basic research on the relationship between deception, stress and speech articulation

- Such a program should be conducted prior to testing developed products that purport to detect deception in speech.

- In the interim, we are now carrying out research which we believe will provide a reasonable and sophisticated response. We require that our stressors be powerful enough to induce a marked -- and measurable -- stress response and this **presence/level be independently verified**.

Current Study

- Specifically, we are currently conducting a study of a relatively large sample of men and women (N>40) ranging in age 20-55 years and drawn from many population subclasses.
  - These (paid) "volunteers" are carefully screened (psychiatric, hearing, speech, dialect, reading competency and so on) and for firmly held beliefs/opinions.
- The experimental conditions include speaking under high stress:
  - 1) threat of electric shock (after conditioning)
  - 2) lying with jeopardy (two conditions)
  - 3) lying with jeopardy **and** threat of shock
- Sampling procedures (see also *Speaking Conditions*)
  - Subjects are tape recorded and videotaped and told they will be heard/seen by their contemporaries -- even their friends -- espousing the lies (a proper debriefing comes later).
  - The high jeopardy lies involve intense invective and criticisms of a strongly held belief (e.g., Marines re: the Marine Corps, pro-gun activists re: the NRA, religious individuals re: their religious beliefs, etc).
  - A second type of high jeopardy lie is one that involves substantial embarrassment (e.g., men indicating they are wearing women's undergarments, women describing public menstrual accidents).
  - Also spoken/read are:
    - several repetitions of a standard passage (baseline),
    - a low stress truthful passage
    - a low stress lie
    - a truthful statement while simulating stress.
  - All passages are 25-35 seconds long and contain a long carrier (or neutral) sentence embedded within the passage.

Speaking Conditions

A. High Stress
1. Truthful passage: Stress induced by fear of electric shock
2. Lie passage: Jeopardy induced by passage content.
3. Combined high jeopardy lie with fear of shock

B. Low Stress
1. Baseline: Standard passage
2. Truthful passage
3. Lie passage
4. Truthful passage with stress simulated

Current Study (cont.)

- Stress level is being established by seven indicators:
  1. Change in heart rate
  2. Variation in galvanic skin response
  3. Oxygen usage
  4. Shifts in cortisol level (from saliva)
  5. Self reports of responses to stress (Hamilton test)
  6. Self reports of felt states (anxiety, anger, etc)
  7. Investigator observation of speaker response (sweating, flushing, trembling, etc)
- These data are being normalized and profiles developed to permit the selection of those individuals who can be used in the several studies planned.
- Preferably, we would carry out basic research in this area. However, the stated compromise at least provides (for the first time) a robustly controlled series of studies on stress and lying.

Conclusions

- Basic research in the relationship between voice, stress and deception is required in order to develop deception detection models and their ultimate security applications.
- Stress levels, both in the presence and absence of deception must be verified in both basic research and in testing existing commercial applications.

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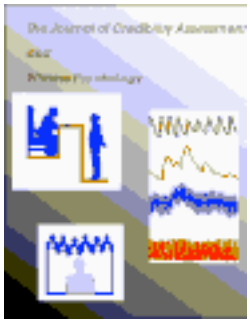
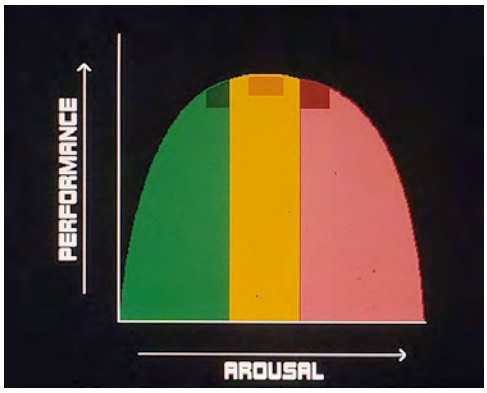


Voice Stress

James Meyerhoff

Walter Reed Army Medical Center, Washington, DC

Voice Stress



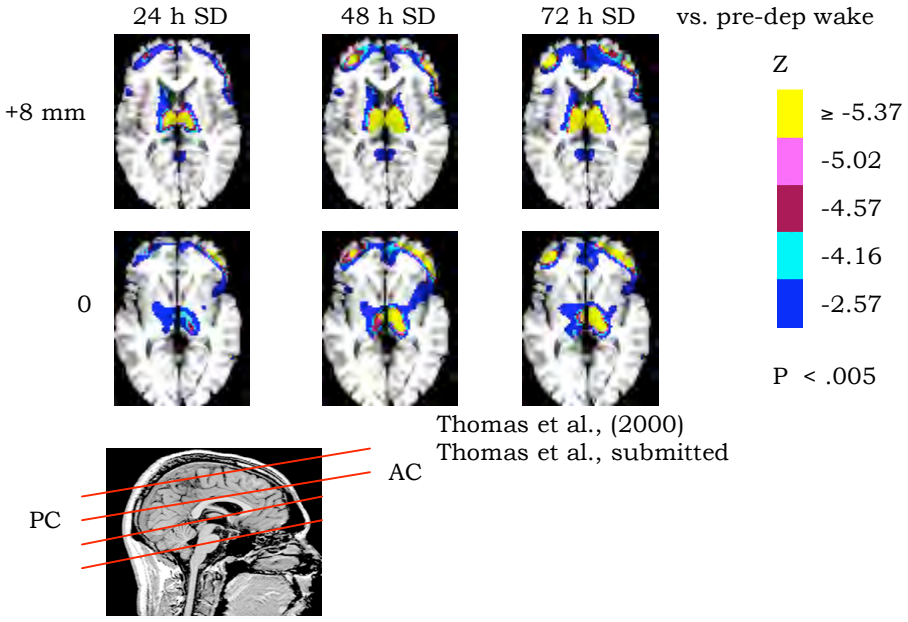
”DESCARTES ERROR” – DAMASIO

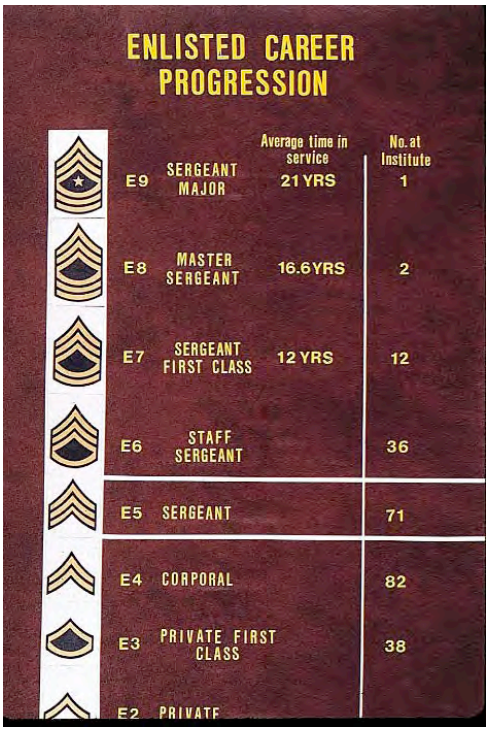
HI RISK VS LOW RISK CARD GAME

NORMALS: GSR RESPONSE TO HI RISK –AVOID HI RISK.

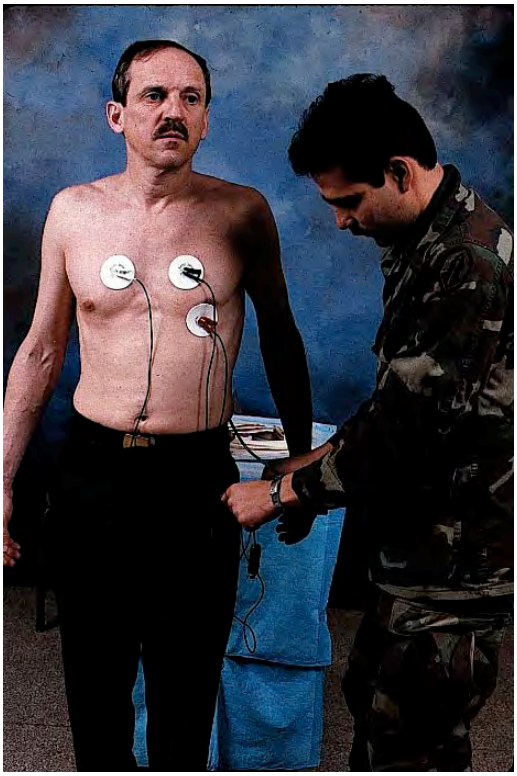
FCX DDG SUBJS: NO GSR RESPONSE –SELECT HI RISK. LOSE MONEY.UNDERSTAND STRATEGY –DON’T CARE.

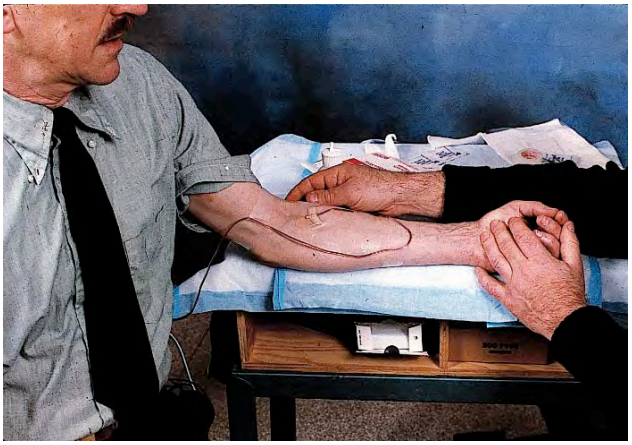
EMOTIONS ENHANCE RATIONAL DECISIONS

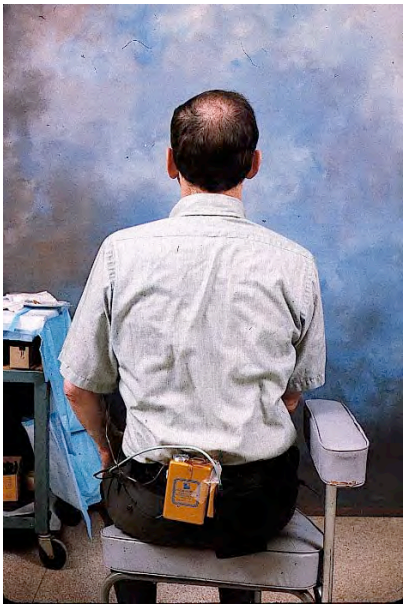


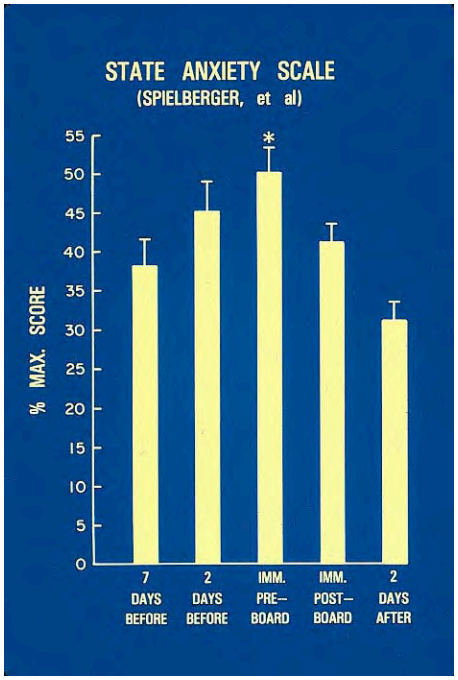

ENLISTED CAREER PROGRESSION
Average time in service
No. at Institute
E9 SERGEANT MAJOR
21 YRS
1
E8 MASTER SERGEANT
16.6YRS
2
E7 SERGEANT FIRST CLASS
12 YRS
12
E6 STAFF SERGEANT
36
E5 SERGEANT
71
E4 CORPORAL
82
E3 PRIVATE FIRST CLASS
38
E2 PRIVATE

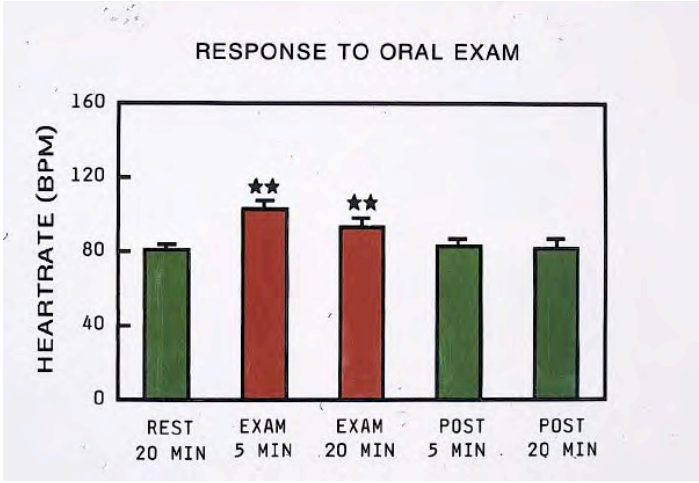

SOLDIER EXAMINATION PANEL
E6 E6 E6 E9 E7 E6 E5
CANDIDATE
E4

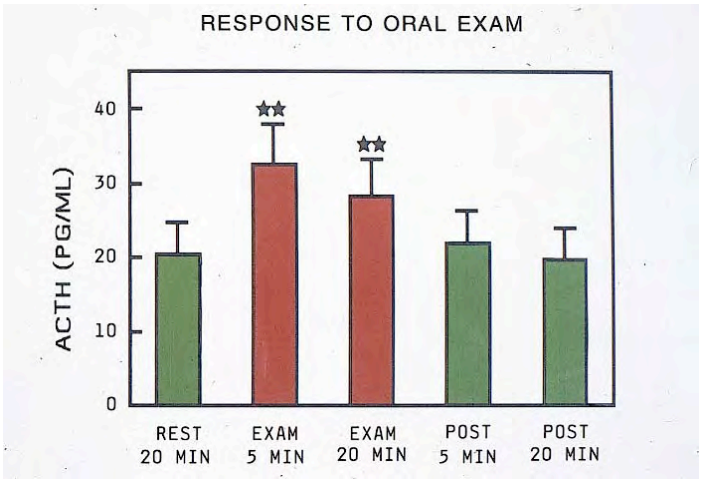


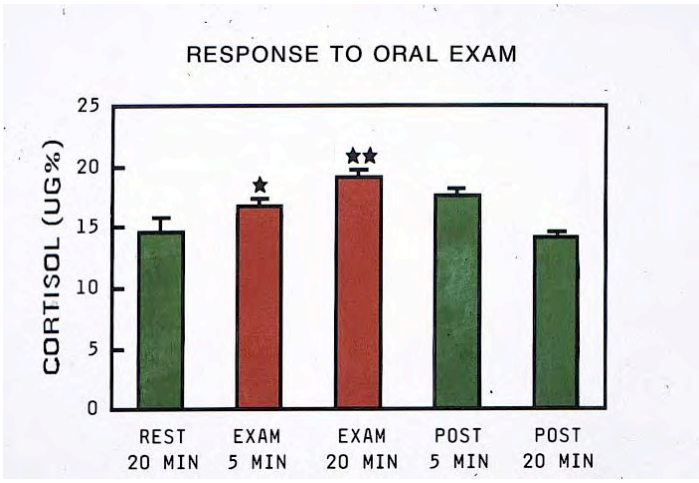


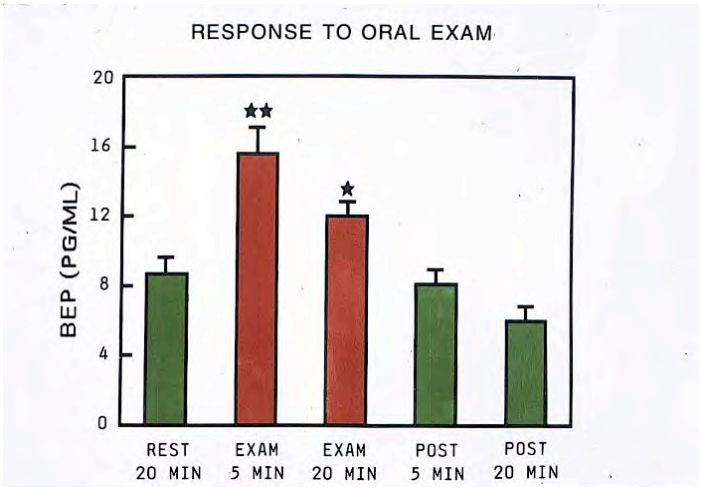


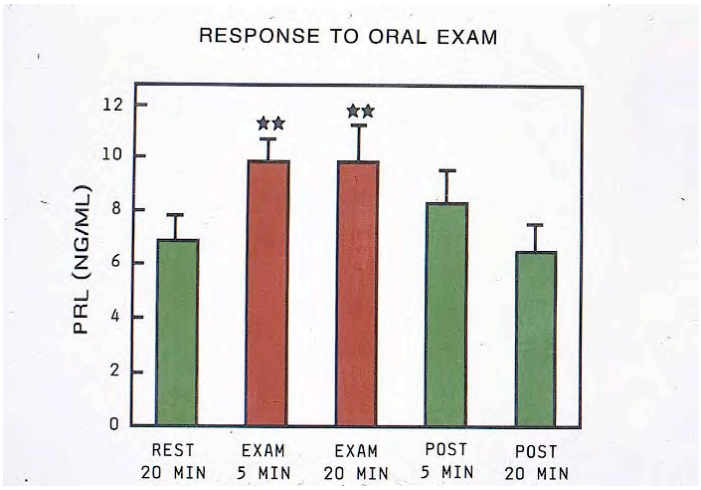

STATE ANXIETY SCALE
(SPIELBERGER, et al)
% MAX. SCORE
55
50
45
40
35
30
25
20
15
10
5
0
*
7 DAYS BEFORE
2 DAYS BEFORE
IMM. PRE–BOARD
IMM. POST–BOARD
2 DAYS AFTER

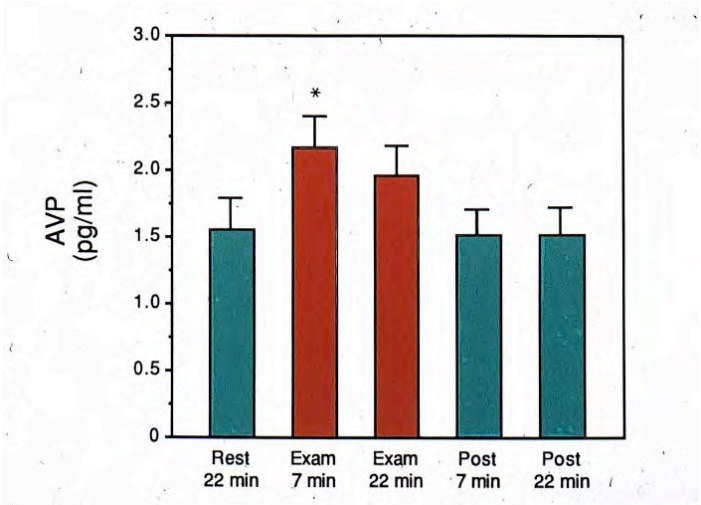

RESPONSE TO ORAL EXAM
HEARTRATE (BPM)
160
120
80
40
0
REST 20 MIN
EXAM 5 MIN
EXAM 20 MIN
POST 5 MIN
POST 20 MIN

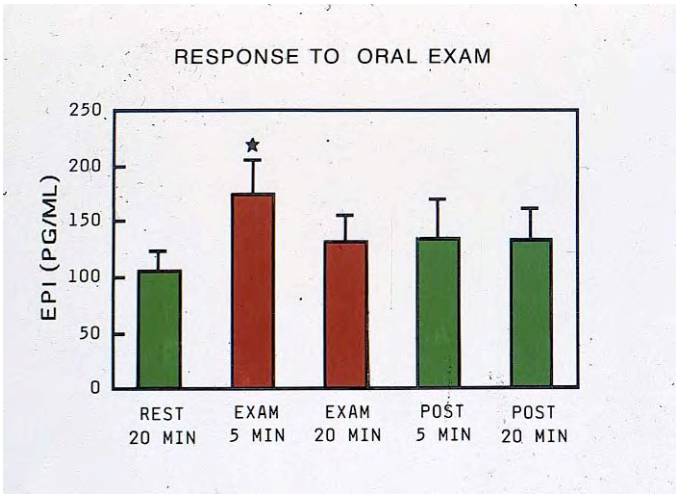

RESPONSE TO ORAL EXAM
ACTH (PG/ML)
40
30
20
10
0
REST 20 MIN
EXAM 5 MIN
EXAM 20 MIN
POST 5 MIN
POST 20 MIN

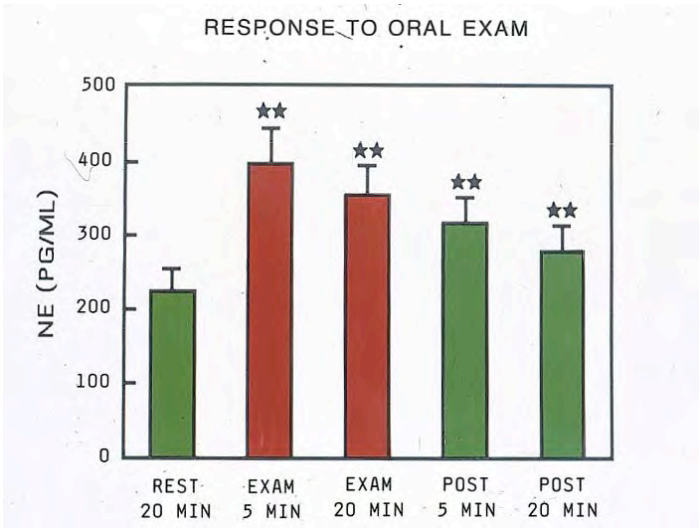

RESPONSE TO ORAL EXAM
CORTISOL (UG%)
25
20
15
10
5
0
REST 20 MIN
EXAM 5 MIN
EXAM 20 MIN
POST 5 MIN
POST 20 MIN

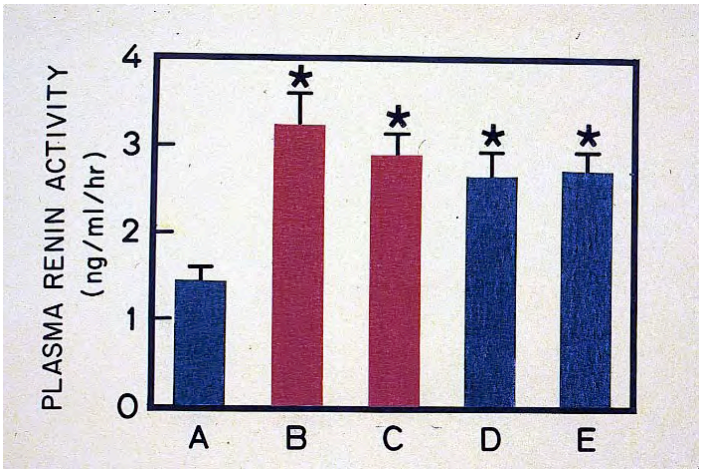

RESPONSE TO ORAL EXAM
BEP (PG/ML)
20
16
12
8
4
0
REST 20 MIN
EXAM 5 MIN
EXAM 20 MIN
POST 5 MIN
POST 20 MIN

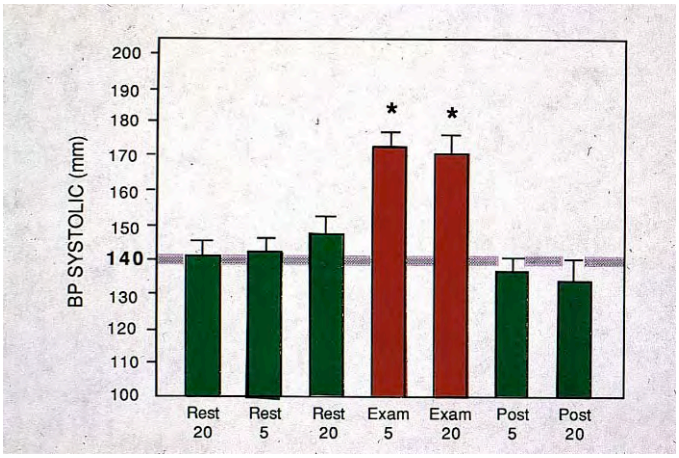

RESPONSE TO ORAL EXAM
PRL (NG/ML)
12
10
8
6
4
2
0
REST 20 MIN
EXAM 5 MIN
EXAM 20 MIN
POST 5 MIN
POST 20 MIN

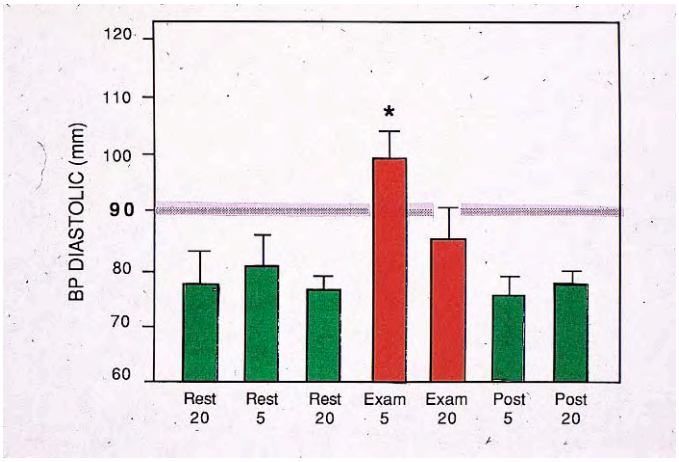

AVP (pg/ml)
3.0
2.5
2.0
1.5
1.0
0.5
0
Rest 22 min
Exam 7 min
Exam 22 min
Post 7 min
Post 22 min


RESPONSE TO ORAL EXAM
EPI (PG/ML)
250
200
150
100
50
0
*
REST 20 MIN
EXAM 5 MIN
EXAM 20 MIN
POST 5 MIN
POST 20 MIN


RESPONSE TO ORAL EXAM
NE (PG/ML)
500
400
300
200
100
0
**
REST 20 MIN
EXAM 5 MIN
EXAM 20 MIN
POST 5 MIN
POST 20 MIN

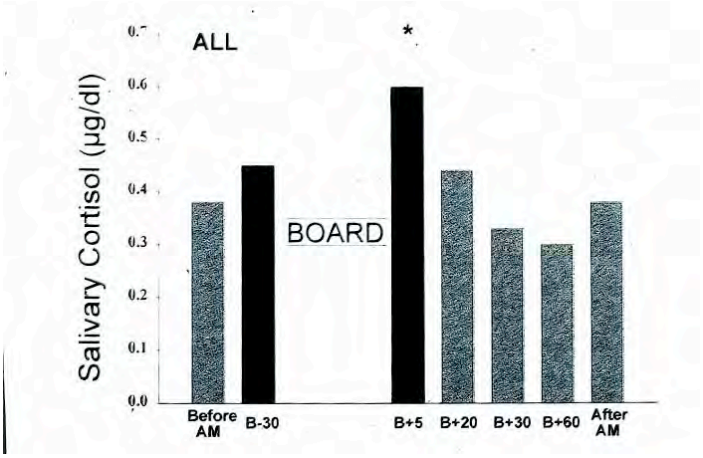

PLASMA RENIN ACTIVITY (ng/ml/hr)
4
3
2
1
0
*
A
B
C
D
E





PUBLICATIONS:
OLESHANSKY et al.,
GLASS et al.,
MEYERHOFF et al.

G. A. SAVIOLAKIS, M.D., Ph.D.
M.L. KOENIG, Ph.D.
J.L. MEYERHOFF, M.D.



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EFFECTS OF STRESS ON AUTOMATIC SPEECH RECOGNITION

J HANSEN, U. COLO.
J MEYERHOFF, WRAIR
DARPA

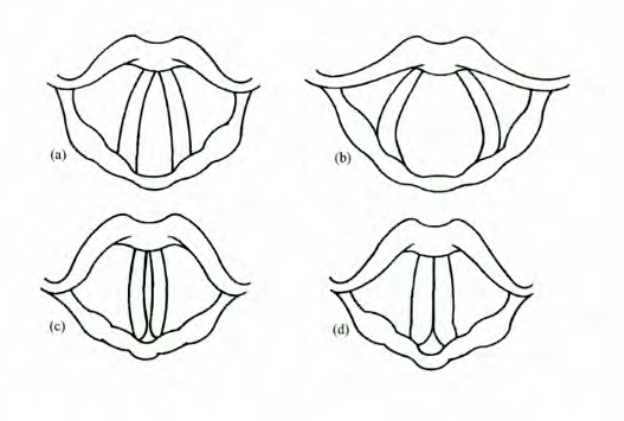
DOES STRESS AFFECT VOICE FEATURES?

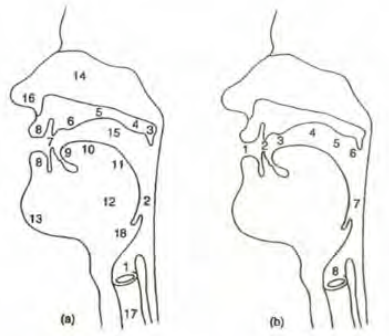
SPEECH WILL BE ABUNDANTLY AVAILABLE AND ACCESSIBLE IN THE BATTLE SPACE OF THE FUTURE.

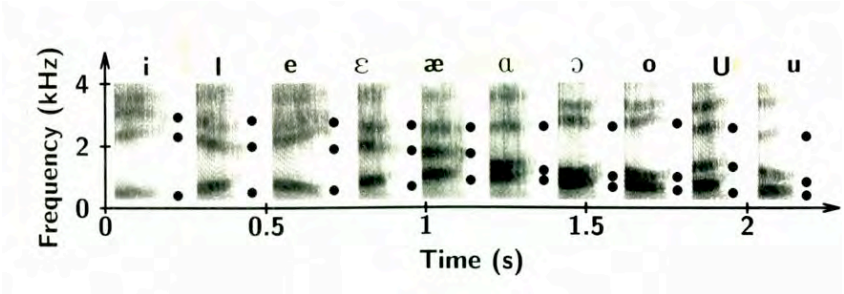
THE USE OF SPEECH TO MONITOR STRESS WOULD PROVIDE MEGABYTES OF INFORMATION WITHOUT ADDING A MICROGRAM OF WEIGHT TO THE SOLDIER'S PACK

COULD VOICE ANALYSIS DETECT STRESS AND PREDICT PERFORMANCE FAILURE?

COULD STRESS EFFECTS ON VOICE INTERFERE WITH VOICE ACTIVATED COMPUTERIZED OPERATIONS?

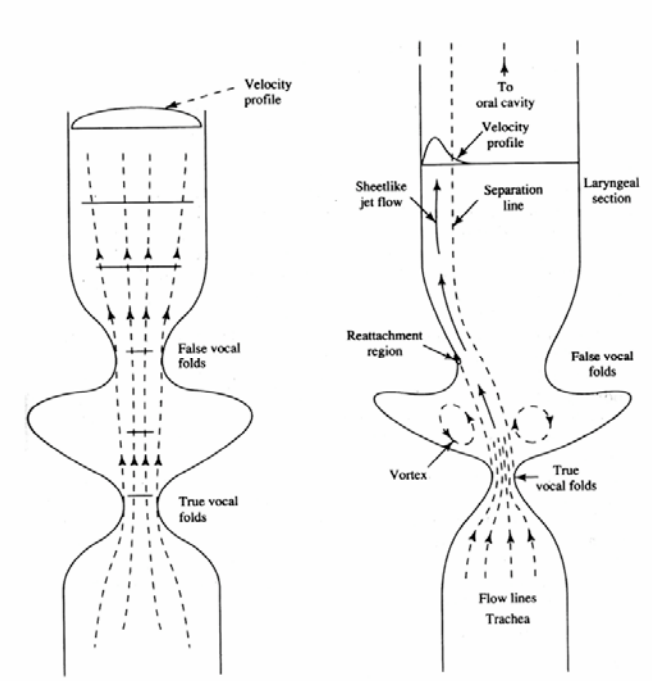






BIOMEDICAL AND PITCH CHANGE DURING STRESS

	-7 DAYS	REST	STRESS	REST
HR	70	71	93	70
SBP	118	146	178	154
DBP	78	75	90	71
F0	103	103	137	103



PUBLICATION:
Rahurkar, M.A., **Hansen, J.H.L**., Meyerhoff, J. L., Saviolakis, G., & Koenig, M.

Frequency band analysis for stress detection using a Teager Energy Operator Based Feature.

ICSLP-2002: International Conference on Spoken Language Processing. Vol 3, pp 2021-2024, 2002


AM 2:49:30

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EFFECT OF STRESS ON THREAT IDENTIFICATION, COGNITION AND PERFORMANCE IN LETHAL FORCE TRAINING

MEYERHOFF, SAVIOLAKIS, NORRIS, ATKINS, BURGE, WOLLERT, SPIELBERGER.

WRAIR, MRMC, DEPT TREASURY
FEDERAL LAW ENFORCEMENT TRAINING CENTER

Evaluating Performance of Law Enforcement Personnel During a Stresful Training Scenario

James L. Meyerhoff, William Norris, George A. Saviolakis,
Terry Wollert, Bob Burge, Valerie Atkins, Charles Spielberger

FOURTH AMENDMENT TO THE U.S.CONSTITUTION

THE RIGHT OF THE PEOPLE TO BE SECURE IN THEIR PERSONS, HOUSES, PAPERS, AND EFFECTS, AGAINST UNREASONABLE SEARCHES AND SEIZURES, SHALL NOT BE VIOLATED, AND NO WARRANTS SHALL ISSUE, BUT UPON PROBABLE CAUSE ….

DURING THE DECADE FROM 1989 THROUGH 1998, 682 POLICE OFFICERS WERE KILLED IN THE LINE OF DUTY.

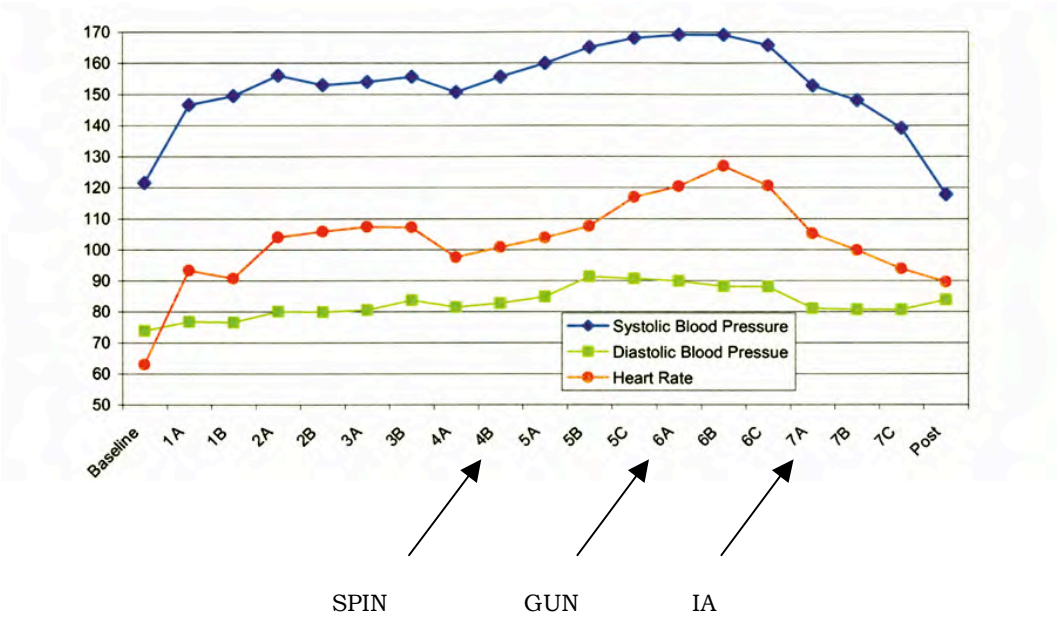
10% OF THOSE KILLED WERE MURDERED WITH THEIR OWN WEAPONS.

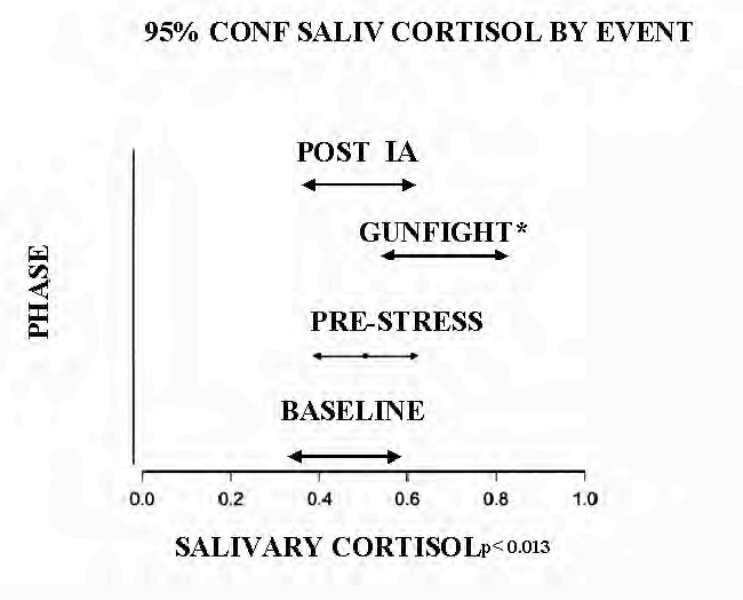
MOST SHOOTINGS OCCUR IN POORLY ILLUMINATED ENVIRONMENTS, AT CLOSE RANGE, WITH MULTIPLE PERSONS PRESENT, AND ARE OVER IN LESS THAN THREE SECONDS.

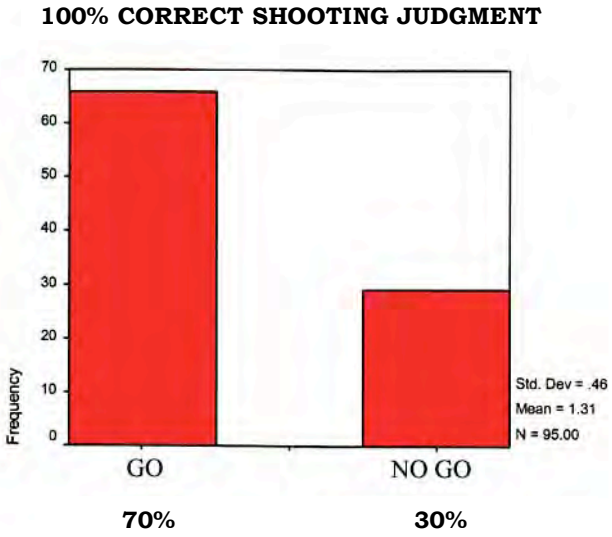
MANY DUTY SITUATIONS EXPOSE OFFICERS TO INORDINATE RISKS (DOMESTIC VIOLENCE INVESTIGATIONS, TRAFFIC STOPS, SEARCH OR ARREST WARRANTS).

FOUR PHASE POLICE SCENARIO

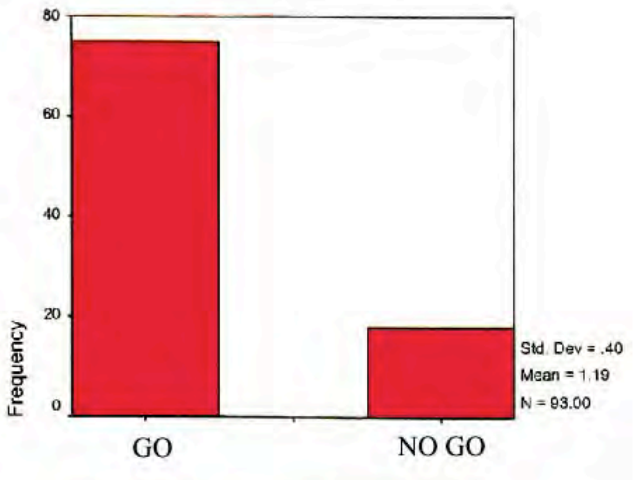
BASELINE
EVALUATION DURING A HIGH SPEED CAR CHASE
DOMESTIC DISTURBANCE: LETHAL FORCE
INTERNAL AFFAIRS INVESTIGATION
CONSTRUCTIVE DEBRIEFING


170
160
150
140
130
120
110
100
90
80
70
60
50
Systolic Blood Pressure
Diastolic Blood Pressue
Heart Rate
Baseline
1A
1B
2A
2B
3A
3B
4A
4B
5A
5B
5C
6A
6B
6C
7A
7B
7C
Post
SPIN
GUN
IA


95% CONF SALIV CORTISOL BY EVENT
POST IA
GUNFIGHT*
PRE-STRESS
BASELINE
PHASE
0.0
0.2
0.4
0.6
0.8
1.0
SALIVARY CORTISOL p< 0.013

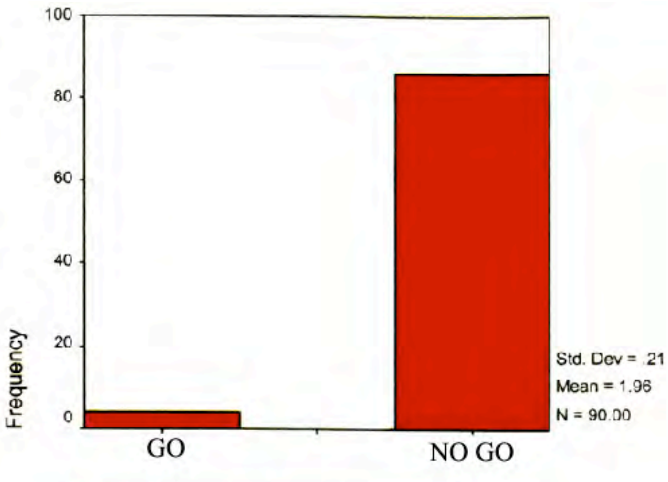

100% CORRECT SHOOTING JUDGMENT
70
60
50
40
30
20
10
0
Frequency
Std. Dev = .46
Mean = 1.31
N = 95.00
GO
NO GO
70%
30%

DID NOT SHOOT HOSTAGE

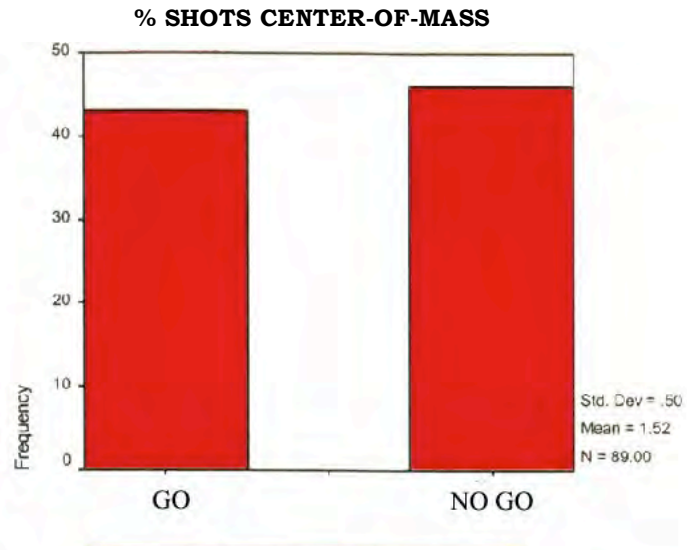


80% **20%**

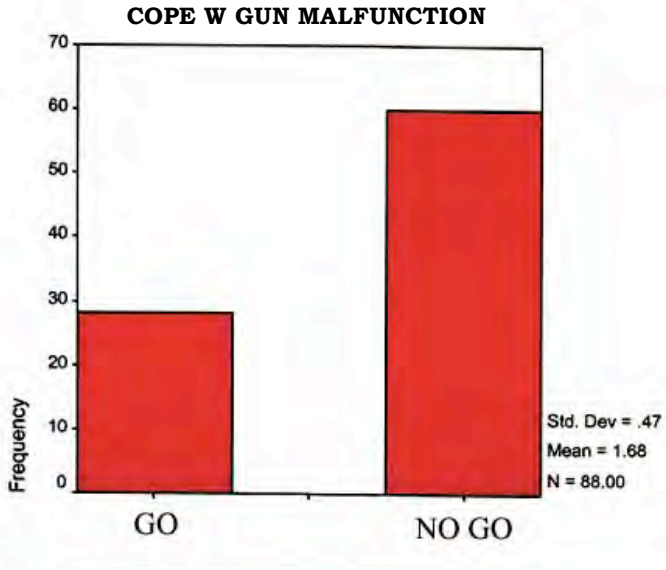
AT LEAST 70% OF SHOTS HIT SUSPECT



3% **97%**

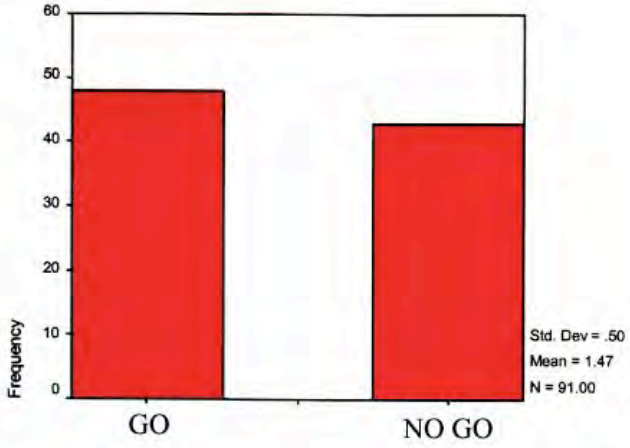

% SHOTS CENTER-OF-MASS
50
40
30
20
10
0
Frequency
Std. Dev = .50
Mean = 1.52
N = 89.00
GO
NO GO

48% **52%**


COPE W GUN MALFUNCTION
70
60
50
40
30
20
10
0
Frequency
Std. Dev = .47
Mean = 1.68
N = 88.00
GO
NO GO

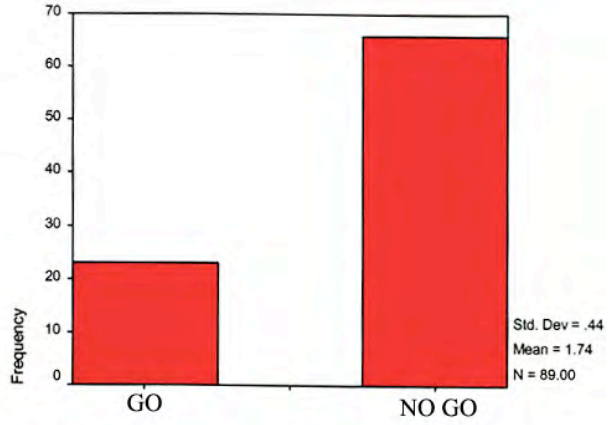
31% **69%**

CALLED FOR BACKUP



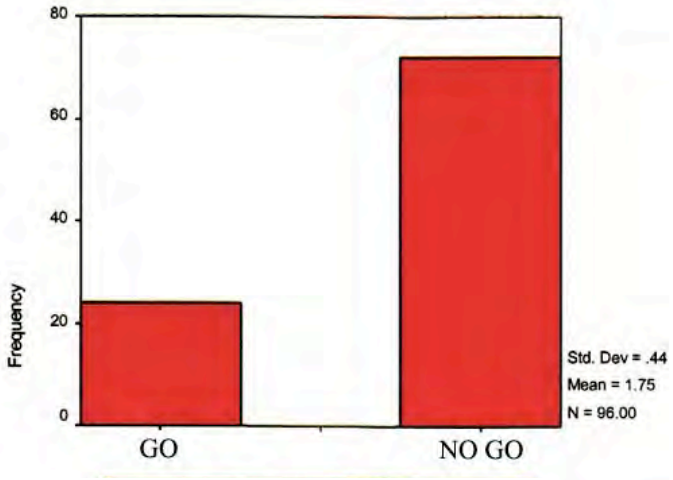
53% **47%**

PROPER WEAPONS HANDLING



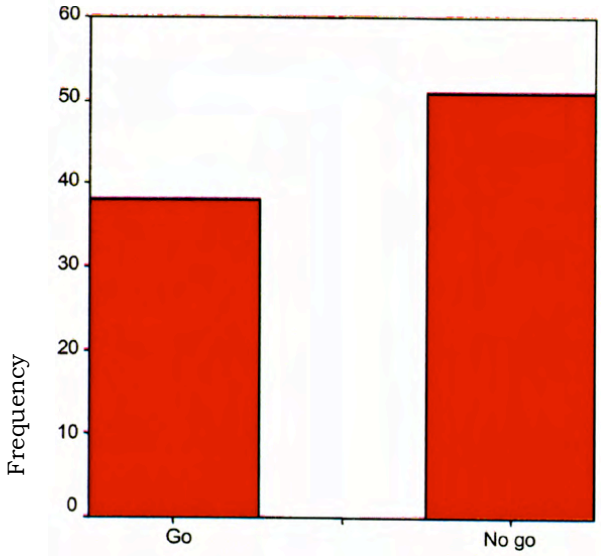
26% **74%**

COMMUNICATED WITH PARTNER ON ROLES



25% **75%**

ACCURATELY DESCRIBES SHOT PLACEMENT

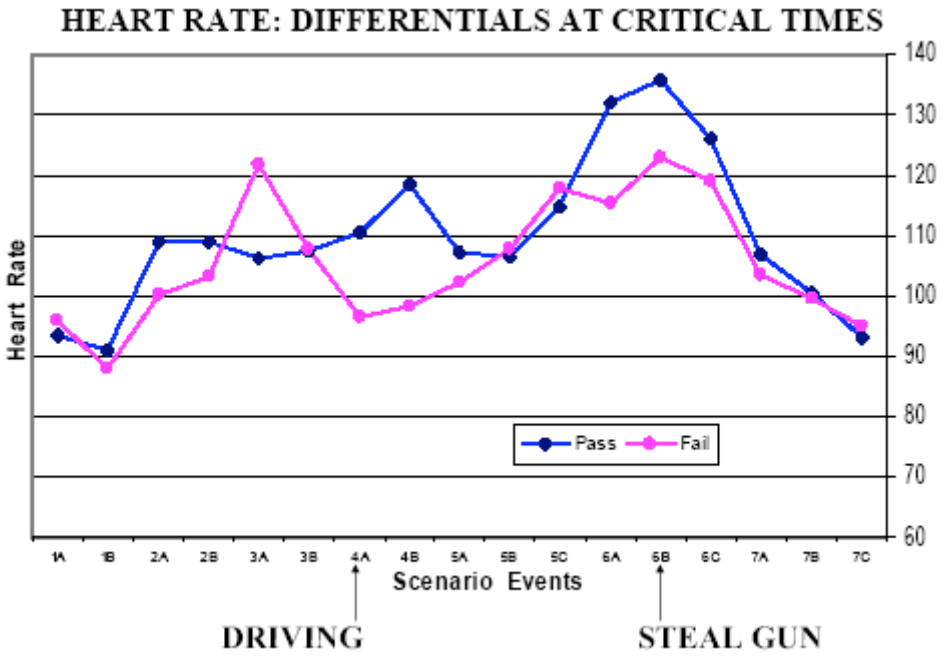


Std Dev. = .50
Mean = 1.57
N = 88.00

43% **57%**

PSYCHOMETRICS

STATE ANXIETY INCREASED
STATE ANGER INCREASED
TRAIT ANGER POSITIVELY RELATED TO PERFORMANCE



FUTURE STUDIES

ELECTRODERMAL ACTIVATION
HEART RATE VARIABILITY
RESPIRATORY RATE
PULSE TRANSIT TIME
SKIN TEMPERATURE

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2006, Vol. 7, No. 2, pp. 99-107

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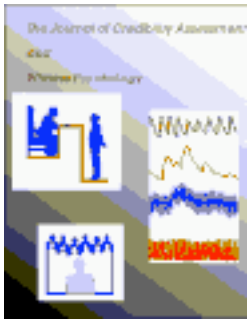


Evaluating Voice-Based Measures for Detecting Deception

Mitchell S. Sommers

Department of Psychology,
Washington University, St. Louis, Missouri

Evaluating Voice-Based Measures for Detecting Deception

Voice Stress Analysis

- Less invasive alternative to the polygraph
- Some potential applications
  - Airport security; phone-based interviews
- Most analyze 8-14 Hz frequency content of vocal signals; 'microtremors'

Product lineage for voice-based credibility assessment

- Psychological Stress evaluator (PSE) – 1970
- The Diogenes
- Computerized voice stress analyzer (CVSA)
- VSA-1000, VSA-15
- Vericator
  - Multi-layered voice analysis
  - Truster Pro
- Xandi

Selected references on voice stress analysis in credibility assessment

Author	Device	Better than chance detection of deception
Kubis (1973)	NA	**NO**
Suzuki et al. (1973)	NA	**NO**
Horvath (1978)	PSE	**NO**
Lynch & Henry (1979)	PSE	**NO**
Brenner et al. (1979)	PSE	**Marginal**
Timm (1983)	PSE	**NO**
Hollien et al. (1987)	Several	**NO**
Cestaro (1995)	CVSA	**NO**
Janniro & Cestaro (1996)	CVSA	**NO**
Meyerhoff et al.	CVSA	**NO**

Vericator

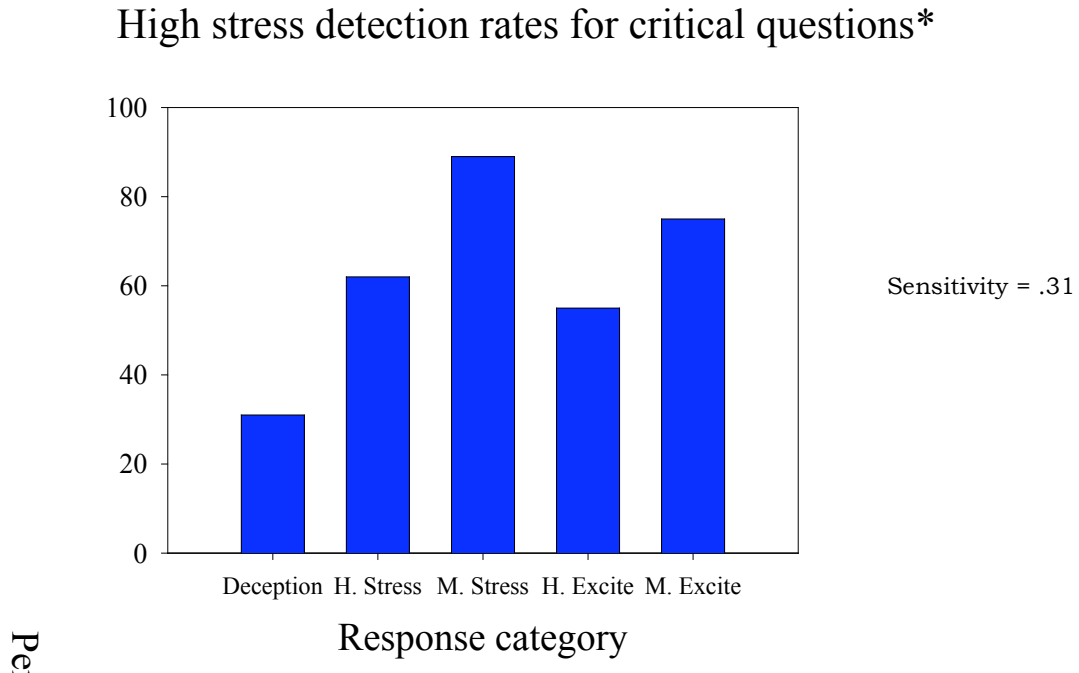
- A new product introduced in late 1990s
- Analyzes 11 parameters of vocal signal
  - Specific parameters and algorithm for combining are proprietary
- Product lineage
  - TrusterPro™ by Trustech (1998)
  - Vericator™ by Integritek Systems (2000)
  - TiPi™ by Nemesysco (2003)
- Costs
  - Approximately $10,000 for full device
  - Approximately $1,500 for training

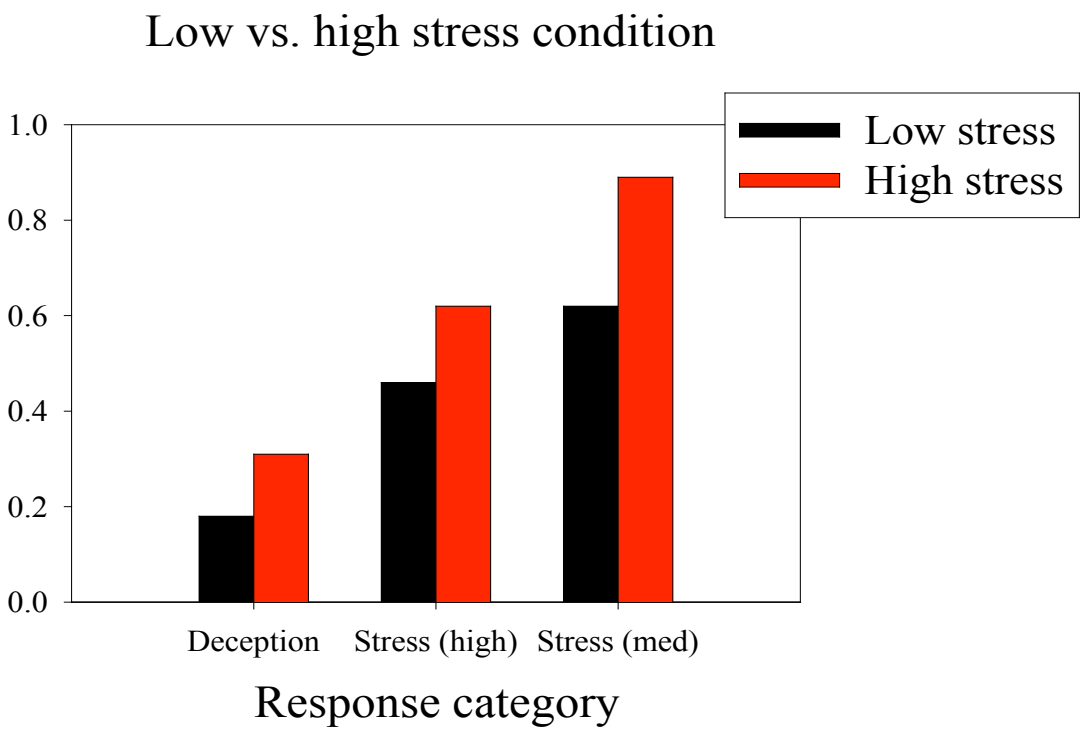
Project objectives

- Develop methodology for assessing reliability and validity of vericator
- Obtain data assessing 3 primary test attributes
  - Reliability: Test-retest
  - Sensitivity: Percentage deception detected
  - Specificity: Percentage of non-deception excluded
- Obtain data assessing relationship between overall stress levels and validity of vericator
- Compare detection rates induced by deception and other types of stress

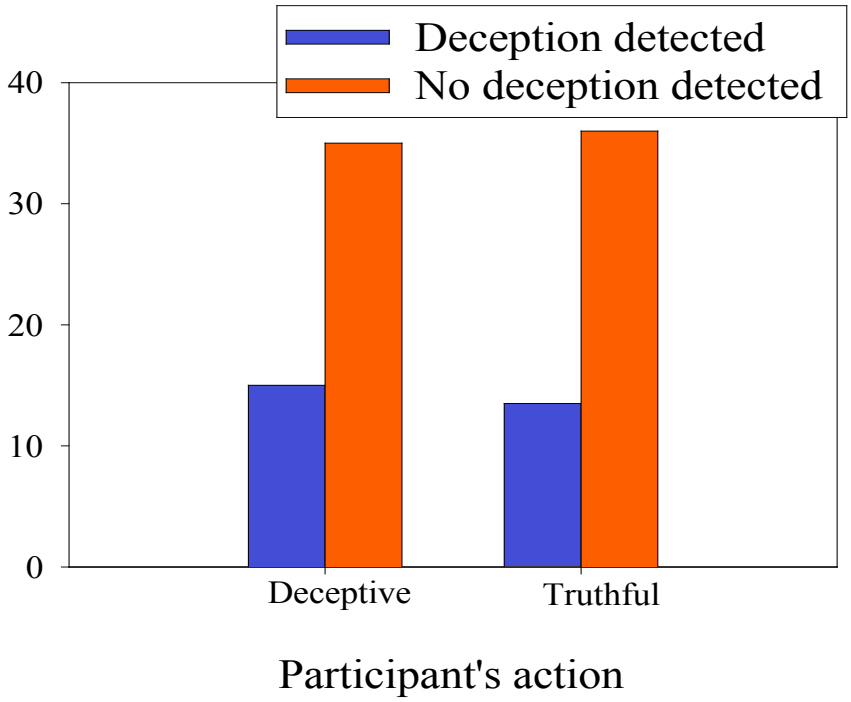
High stress condition

- Participants
  - N = 30
  - All native speakers
- Methods
  - Participant waits with confederate for "speech perception" test
  - Confederate offers to split money "found" in a box
  - Participant first asked series of calibration questions
    - "What is your major"
  - Participant questioned about events as might affect speech perception performance
    - "Did anything happen prior to the speech perception test that might have affected your performance?"





Vericator specificity = .73



DoDPI mock smuggling

- Ability of Vericator to detect smugglers at a mock security checkpoint
- More naturalistic settings
- Procedure
  - Testing took place at Strom Thurmond Federal Building & U.S. District Court complex (Columbia, SC)
    - Participants attempt to "smuggle" evidence for Federal trial through security checkpoint

Procedure continued

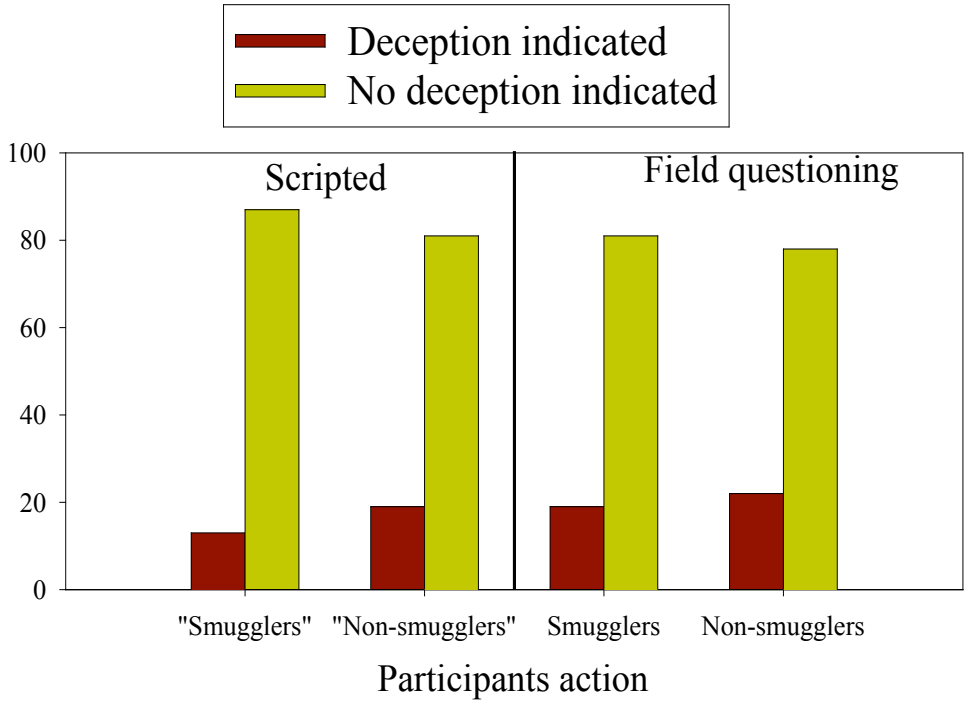
- All participants asked to go through security checkpoint

- When get to checkpoint participants are questioned by senior customs inspector
- Told that microphones are for recording responses

Two modes of questioning

- Scripted (n = 77; questioned according to set of prepared questions)
- Field-like (n = 93questioned as would do in actual interview)

Smuggler results



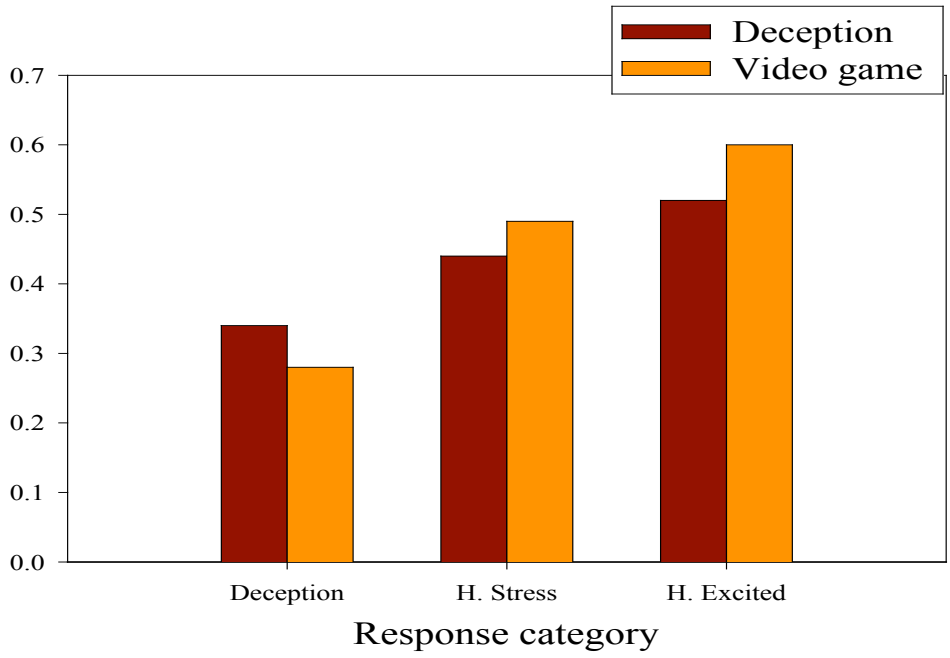
Possible explanations for poor performance

- Vericator fails to detect microtremors
  - Can indicate stress with reasonable accuracy
- Vericator detects microtremors but these are not diagnostic of deception
  - Microtremors may indicate increased levels of stress
- Can we get similar pattern of detecting deception with paradigm that induces stress but not deception?

Deception vs. other stressors

- Participants
  - N = 40
  - 20 in high-stress deception condition
  - 20 in high-stress video game
- Video game
  - Identical to deception condition except
    - Participants play demanding video game
    - Game gets progressively more difficult
    - Bonus for higher scores
  - Asked identical questions as individuals in the deception condition
    - Participant must keep playing game during questioning

Deception versus video game



Summary

- Test characteristics
  - Relatively low sensitivity and specificity
- Sensitive to overall stress levels
  - High stress gives greater detection rates than low
- Detection rates similar for actual deception and other stressors

Future directions

- Must determine vocal parameters that are diagnostic of deception
  - Example: Factor analysis of known deceptive and nondeceptive statements
- Need standardized procedures for assessing devices

Acknowledgments

- DoDPI
  - Andrew Ryan, Stuart Senter, and Troy Brown
- Washington University
  - Jennifer Dave
  - McKenzie Ballou
  - IRB

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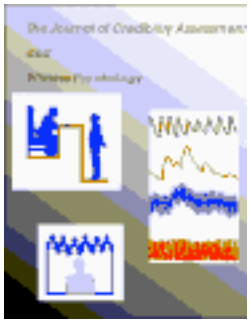

Emerging Methods and Measures for Detecting Stress and Deception: Thermal Imaging

Dean Pollina

Department of Defense Polygraph Institute, Ft. Jackson, South Carolina

Emerging Methods and Measures for Detecting Stress and Deception: Thermal Imaging

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- Data processing and algorithm development **issues** to be resolved
- Mock crime studies – Some **findings**
- Theoretical **discussion** and conclusions

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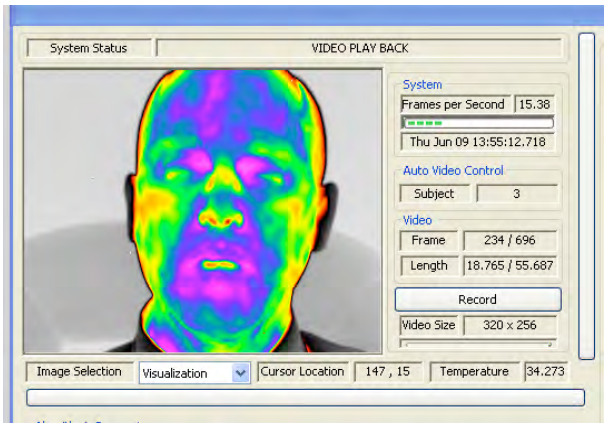

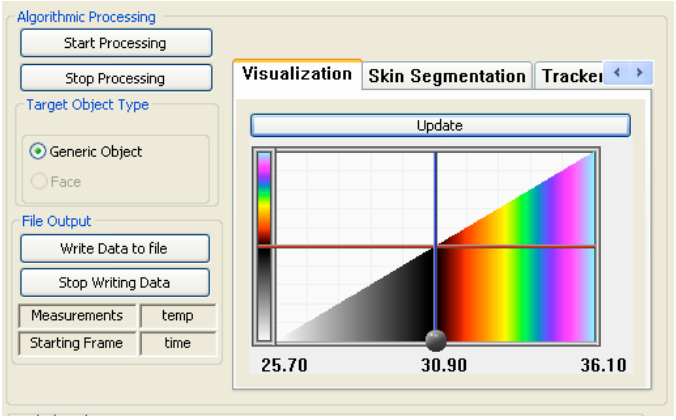

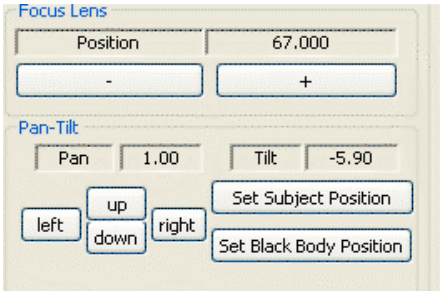

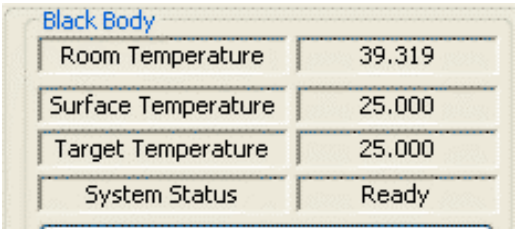

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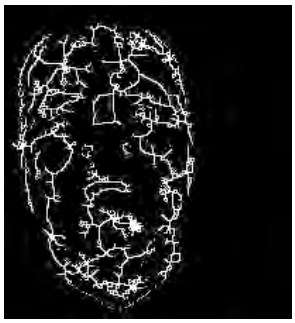

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Pattern Match Template

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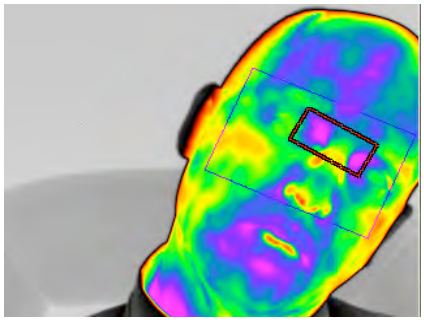

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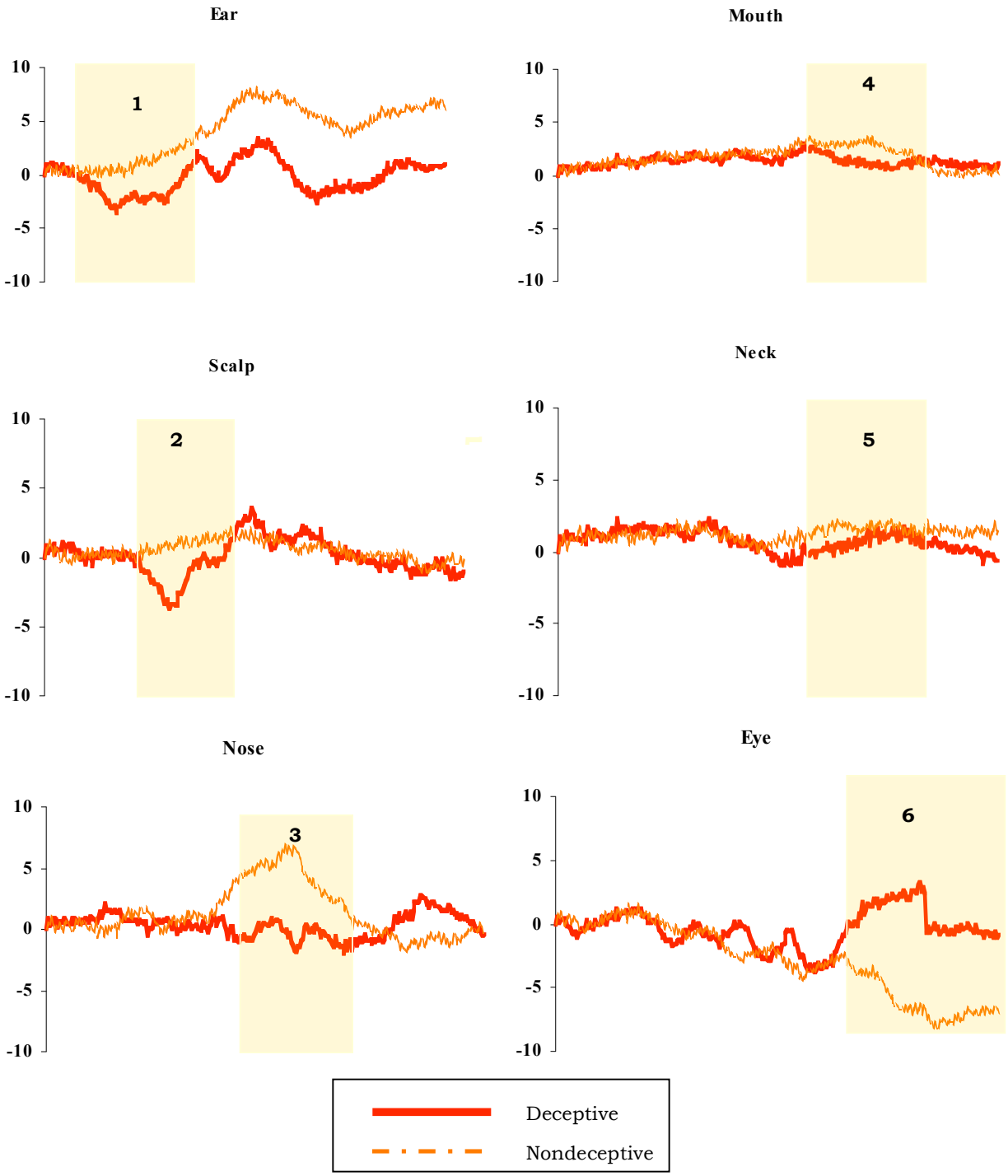

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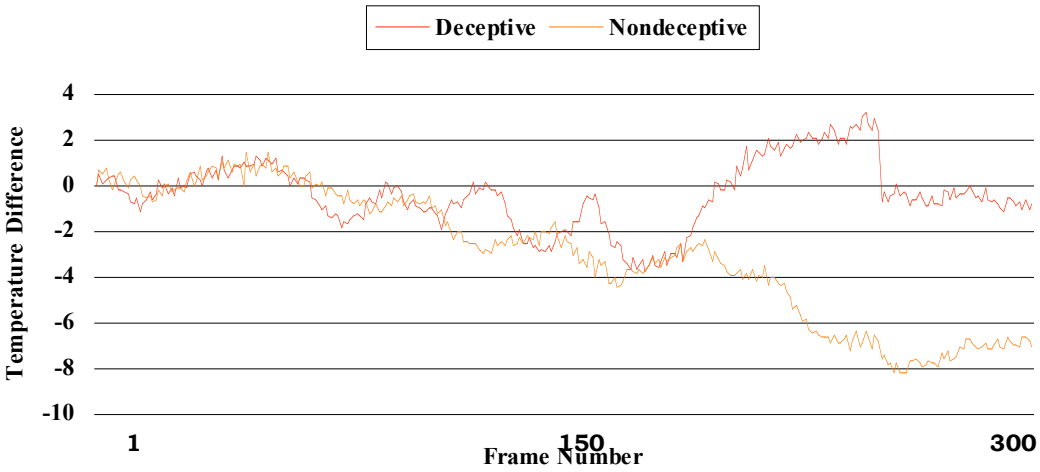

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SST Amplitude Measures	SST: Nose, Mouth, Eye, Scalp, Neck, Ear	.09	.70	.09 (N.S.)
Polygraph and SST Amplitude: Nose	BV, EDA, AR, TR, SST: Nose	.49	.90	.001
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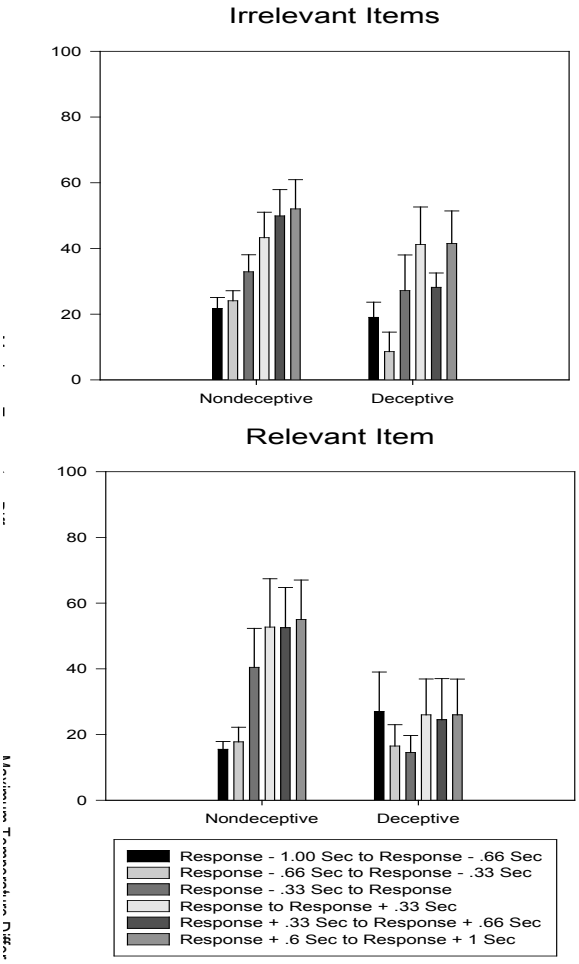

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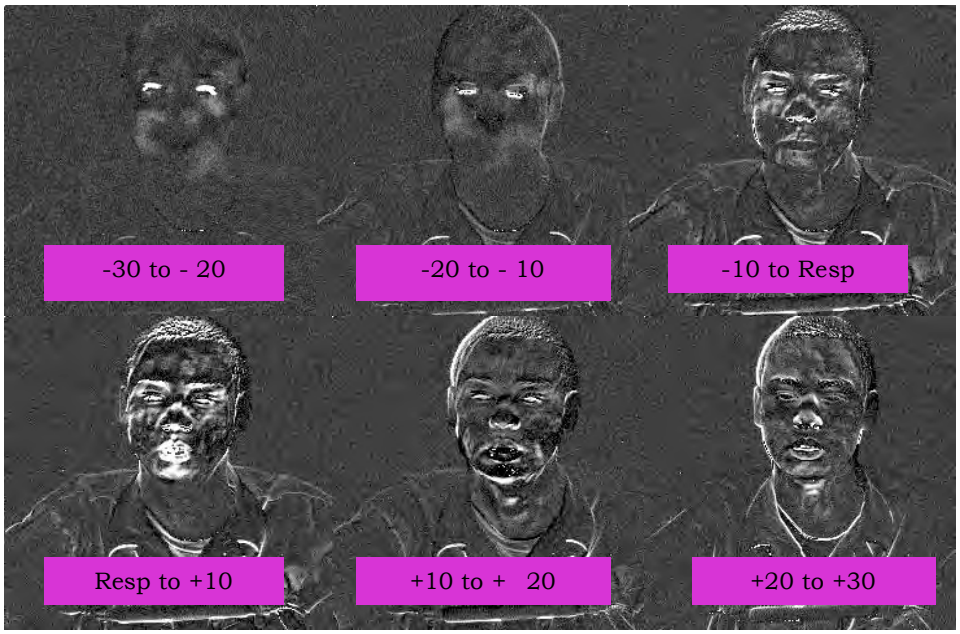

Conclusions

- Thermal imaging shows some promise, especially when combined with traditional polygraph measures.
- Questions such as optimal measurement sites, sampling rates, transformation algorithms, and combination (with polygraph) strategies need to be developed and tested.
- The long range goal is to use these measures to determine the specific emotions experienced by examinees on-line, and to use this feedback as an aid in credibility assessment.

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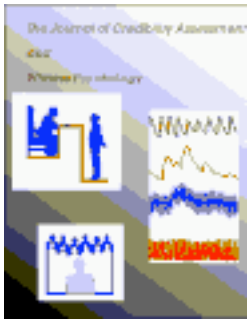

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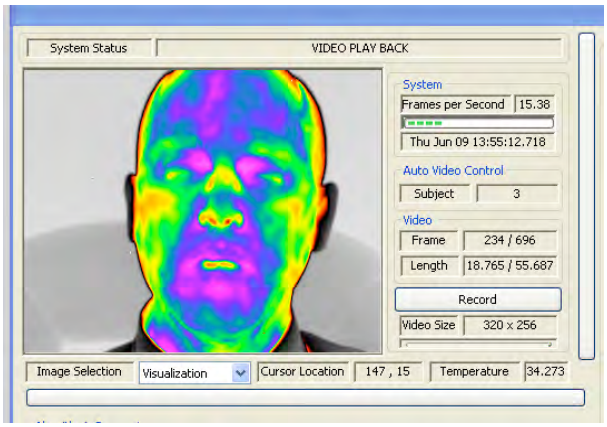

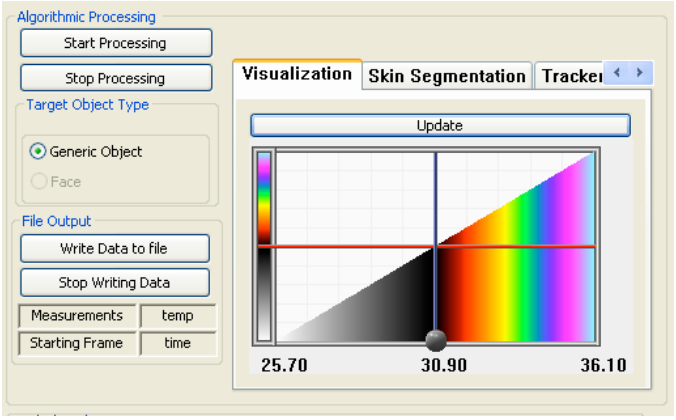

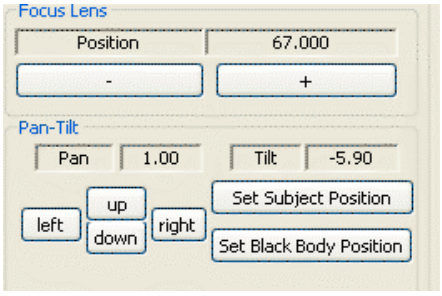

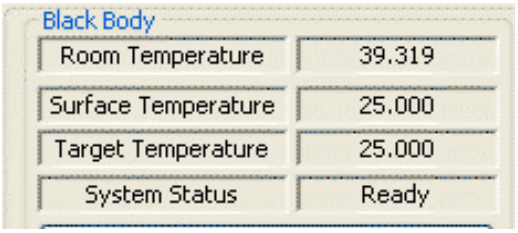

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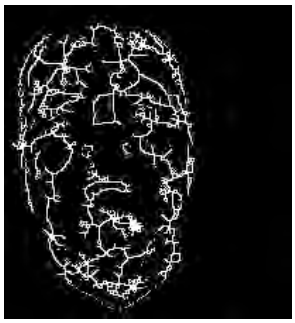

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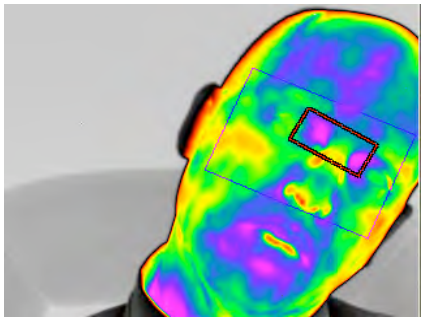

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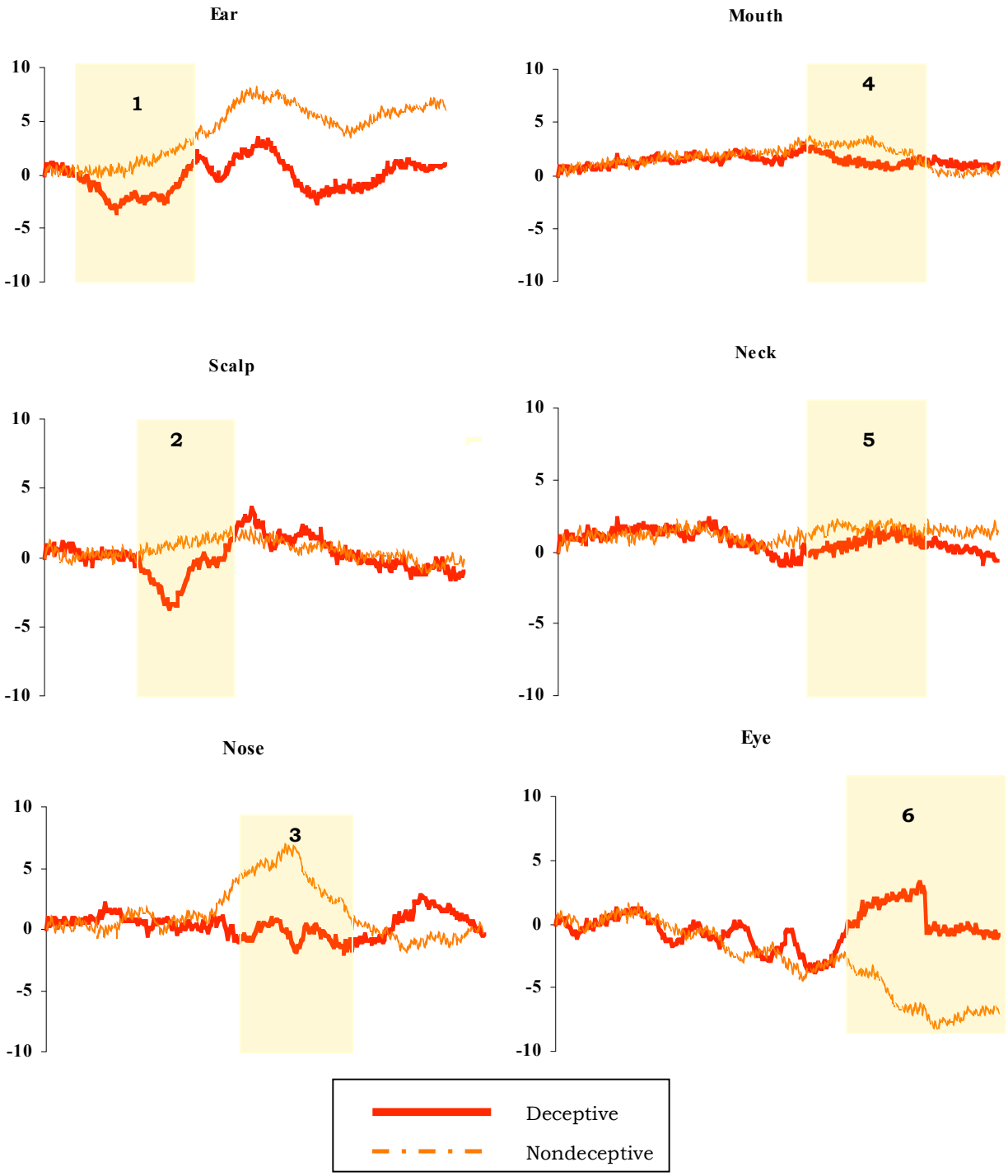

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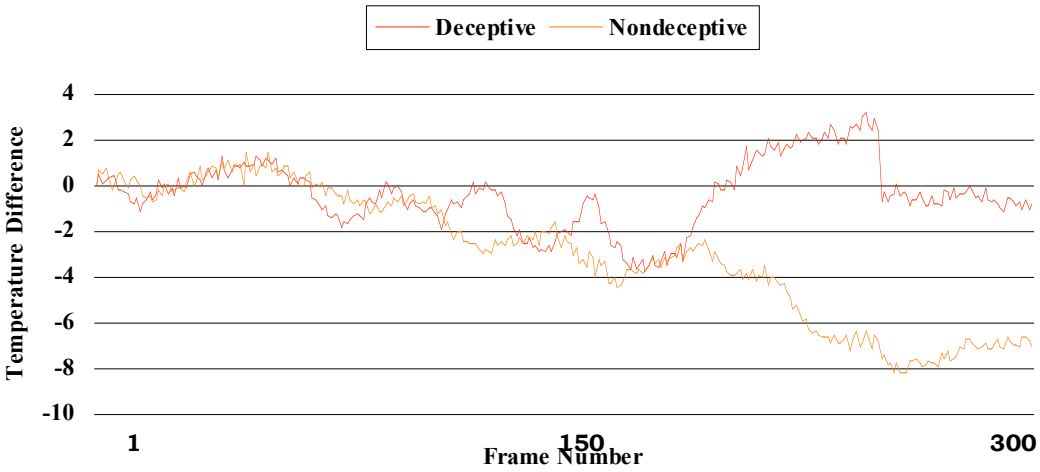

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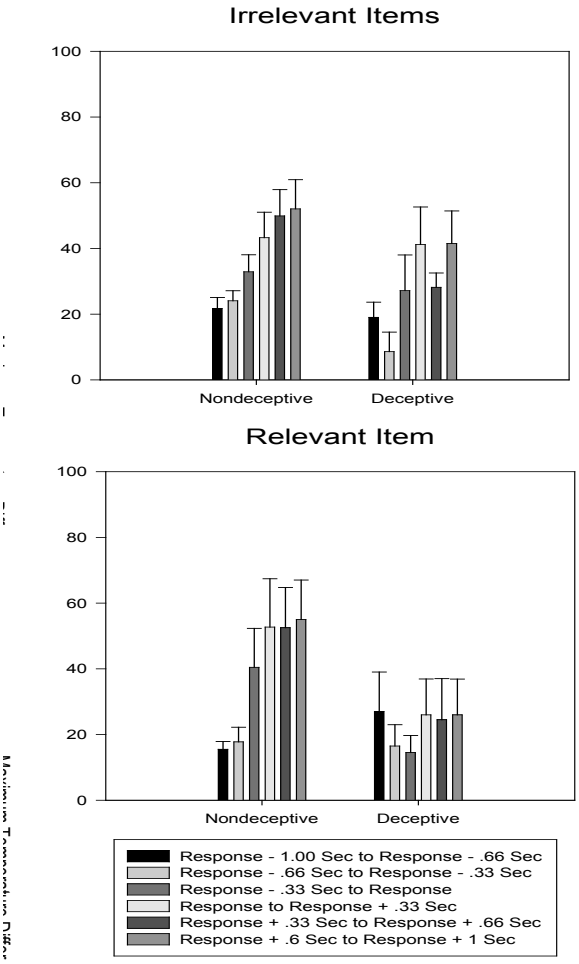

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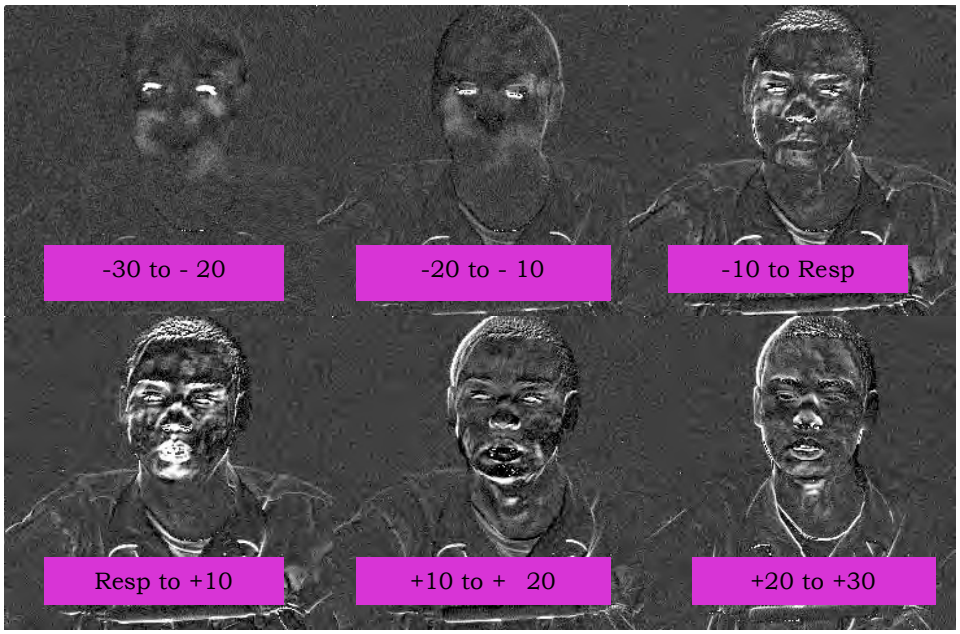
Nondeceptive Group. Gradual increase in temperature throughout the response interval. Similar for critical and non-critical items.

CIT Critical Item



Conclusions

- Thermal imaging shows some promise, especially when combined with traditional polygraph measures.
- Questions such as optimal measurement sites, sampling rates, transformation algorithms, and combination (with polygraph) strategies need to be developed and tested.
- The long range goal is to use these measures to determine the specific emotions experienced by examinees on-line, and to use this feedback as an aid in credibility assessment.

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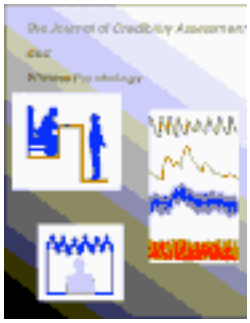


Body Odors as Biomarkers for Stress

Pamela Dalton

Monell Chemical Senses Center, Philadelphia, Pennsylvania

The Journal of Credibility Assessment and Witness Psychology 2006, Vol. 7, No. 2, 116- 126

Body Odors as Biomarkers for Stress

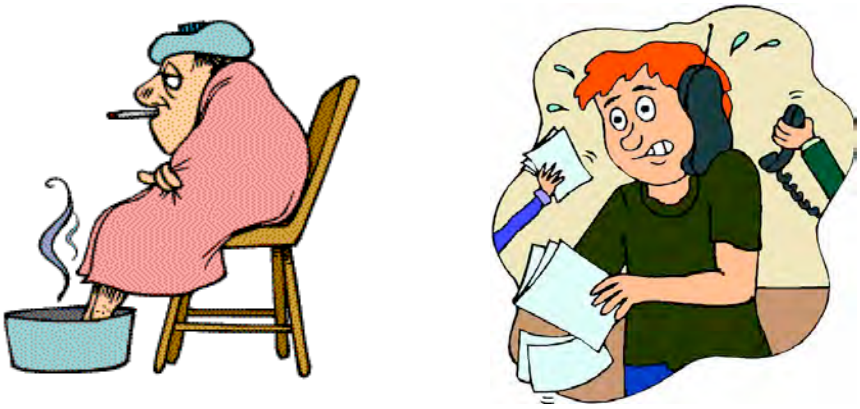
Chemical Senses & Sensors:
The Role of Chemical Communication

- Olfaction is the most ancient of the distal senses, capable of providing information from distant sources in real time
- Olfactory information is used to detect & evaluate food sources and environmental toxins as well as recognize kin and potential predators
- Many body odors evolved to be olfactory messengers to convey information between individuals

FINGERPRINTS
Every human is uniquely identified by a fingerprint, the characteristics of which are controlled in part by genes.

ODORPRINTS
Similarly, every human probably is uniquely identified by an odorprint, the characteristics of which are controlled in part by genes.

However…. Body odors can signal other types of information, such as age, health & emotional status



Chemosensory Signals of Metabolic and Emotional States

Body odor as a diagnostic indicator: Noninfectious agents

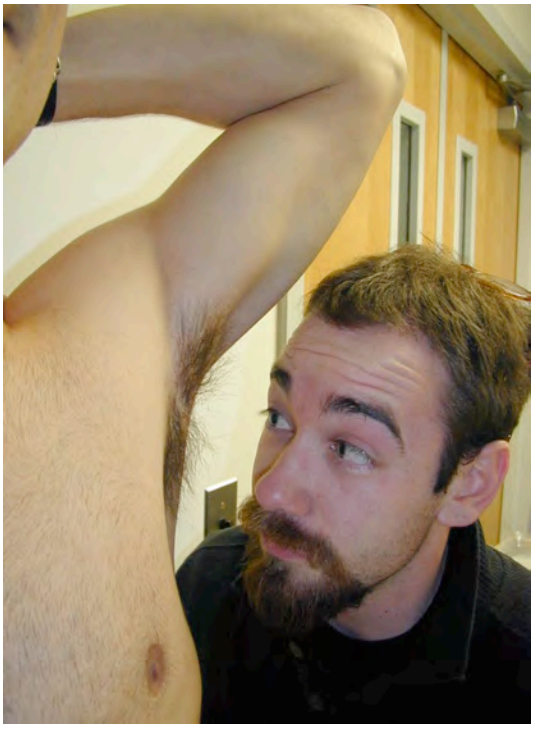
Disease	**Description of odor**
Scurvy	Sweat has putrid odor
Diabetic ketosis	Decomposing apple odor; sweet
Schizophrenia	Pungent odor
Phenylketonuria	Musty; sweaty locker-room towels
Amino acid metabolism	Maple syrup odor in body fluids
Methionine metabolism	Boiled cabbage odor in body fluids
Hyperaminoaciduria	Dried malt of hops
Trimethylaminuria	Fishy

•Penn & Potts, 1998

Body odor as a diagnostic indicator: Infectious diseases

Disease	**Description of Odor**
Smallpox	Stench
Typhoid	Fresh brown bread
Diphtheria	Sweetish
Yellow Fever	Butcher shop
Scrofula (TB)	Stale beer
Gingivitis	Significant
Syphilis	Characteristic
Gangrene	Obnoxious
Bacterial vaginosis	Malodor
Abscesses	Unpleasant

•Penn & Potts, 1998



"Professor von Neusser's acuity of smell was so pronounced that he frequently diagnosed a case on the odor of perspiration. He would walk into a ward in the general hospital in Vienna, lift a patient's arm, sniff and name the malady; then he would proceed with a thorough examination and discussion from every point of view. Rarely was his first impression proved wrong by exhaustive study." (circa 1850)

Body Odor as Messenger for Emotional Communication

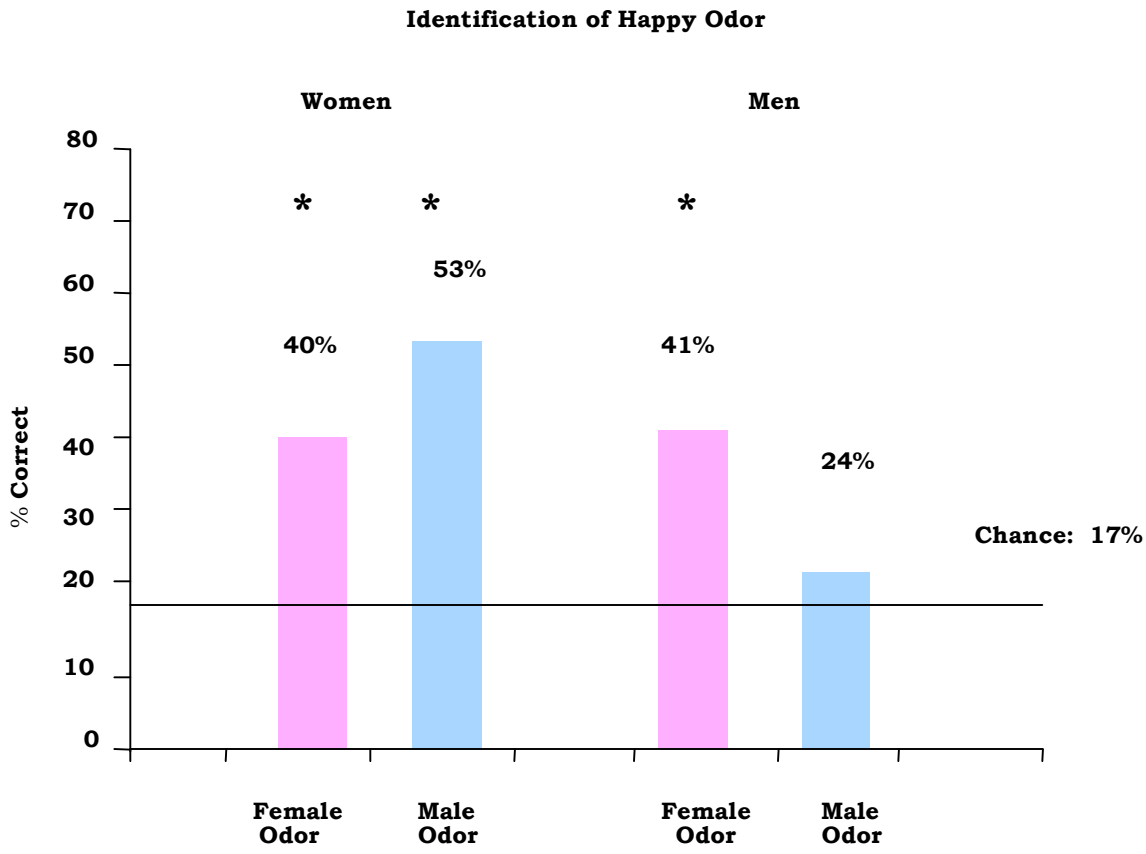
Human Emotional Communication
(Chen & Havilland-Jones, 1999)

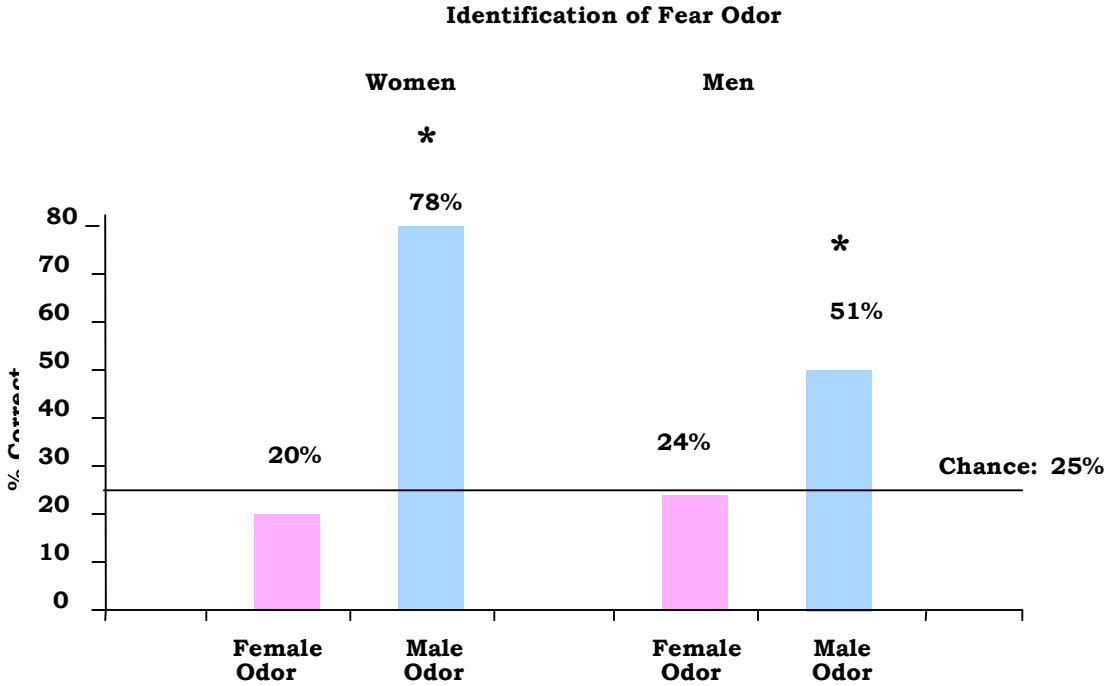
Odor collection
Axillary secretions collected on cotton pads from 11 men and 14 women on two different occasions.

Emotion manipulation
Emotional state manipulated by watching a comedy or horror movie.

Emotion Identification
77 subjects were asked to categorize following odors presented in bottles.

Happy F	Happy M	Fearful F	Fearful M	Blank	Blank


Identification of Happy Odor
Women
Men
80
70
60
50
40
30
20
10
0
% Correct
*
*
*
53%
40%
41%
24%
Chance: 17%
Female Odor
Male Odor
Female Odor
Male Odor


Identification of Fear Odor
Women
Men
*
78%
*
51%
80
70
60
50
40
30
20
10
0
20%
24%
Chance: 25%
Female Odor
Male Odor
Female Odor
Male Odor

Apocrine Secretions & Chemical Communication

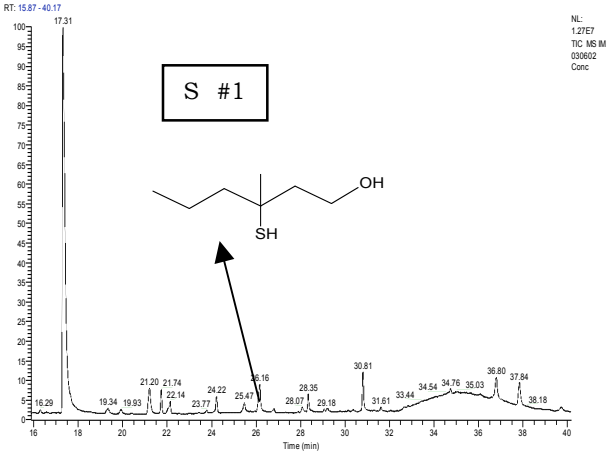
- Unlike eccrine secretions, apocrine secretions are produced by emotional situations: stress, fear and sexual arousal
- Anecdotal evidence that emotionally-elicited secretions smell different than those elicited by physical activity
- Many non-human scent glands are apocrine-like in structure
- Apocrine secretions can be stimulated by exogenous epinephrine

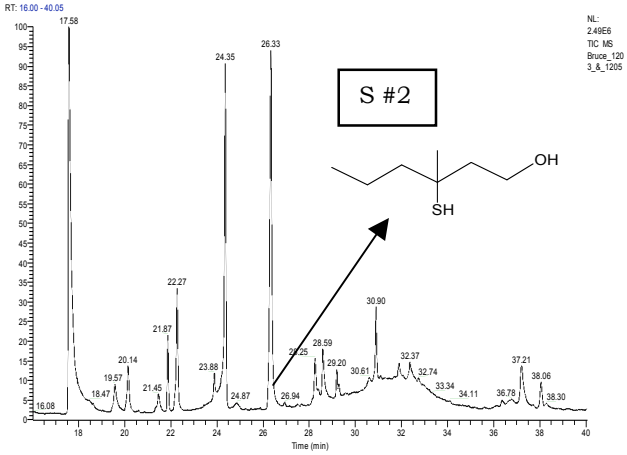
Sniff Chromatography (GC/O) of Apocrine Gland Samples

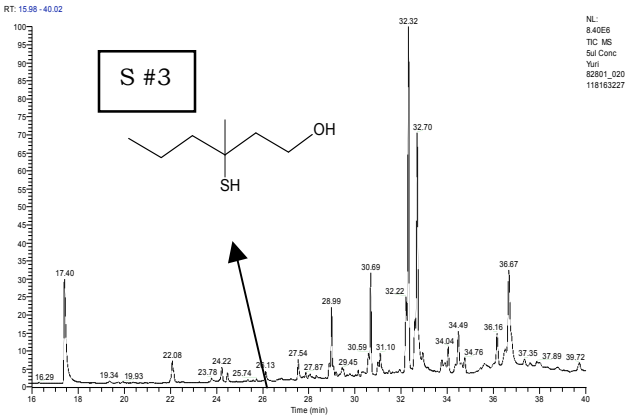
- After column separation of sample, effluent is split: one stream to detector, one to human 'sniffer'
- Human reports of odor qualities linked to chromatogram output
- Can ID odorous components of complex mixtures
- Human nose can ID presence of low-level volatiles

Organoleptic Analysis of Apocrine Gland Secretions

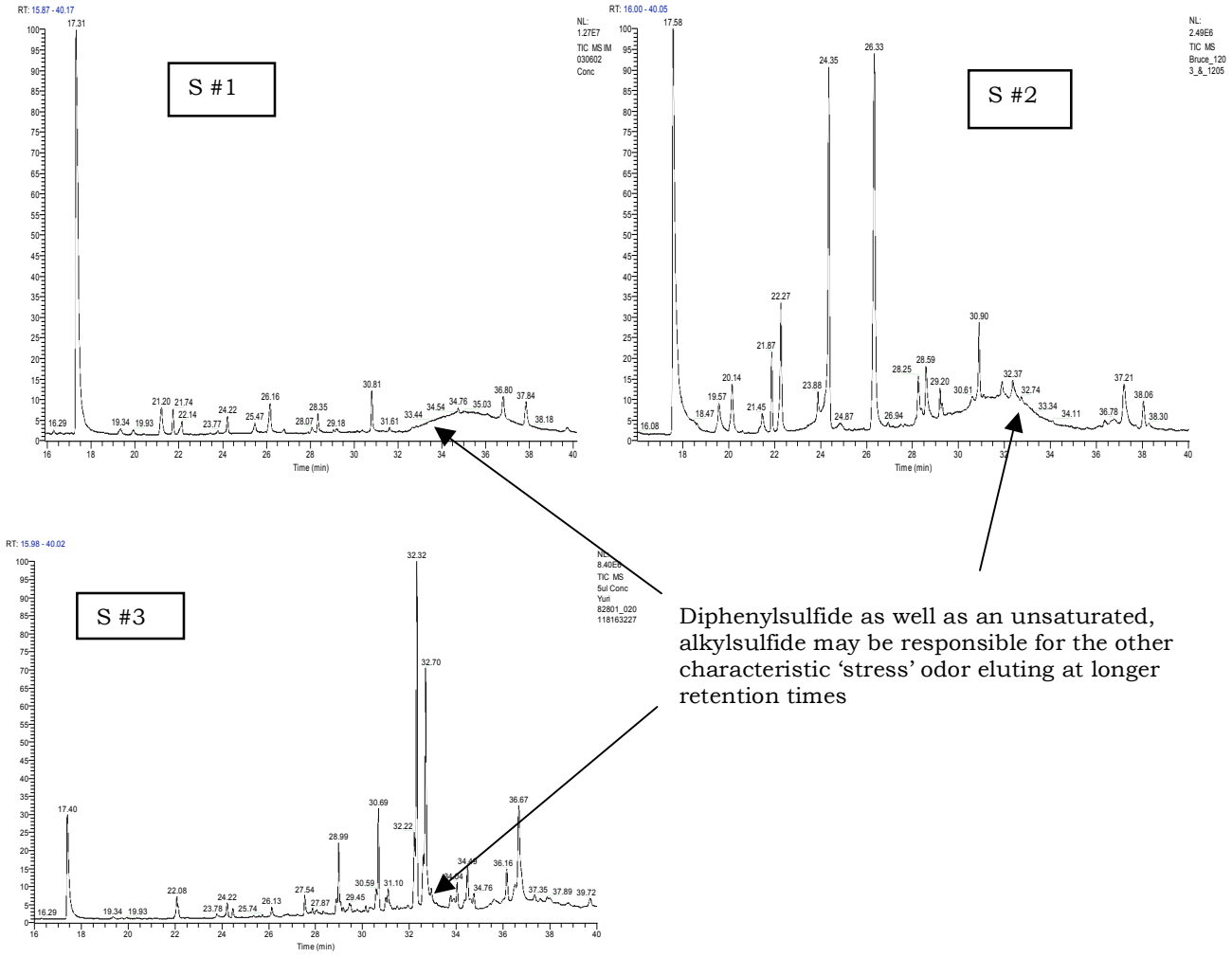
- GC/O studies compared axillary secretions collected over time, via pads, with extracts of freshly hydrolized, epinephrine-elicited secretions
- Results of 'epinephrine' challenge revealed presence of several characteristic, onion-like odors that were not found during GC/O studies of axillary extracts from pads.
- Sensory and analytic data (RT and spectra) suggest sulfur-containing compounds are involved in the characteristic odor of stress/newly hydrolyzed apocrine secretion.







Axillary extracts from 3 males with strong axillary odor and "onion" notes confirmed the presence of 3-methyl-3-mercapto-1-hexanol as the earlier eluting note

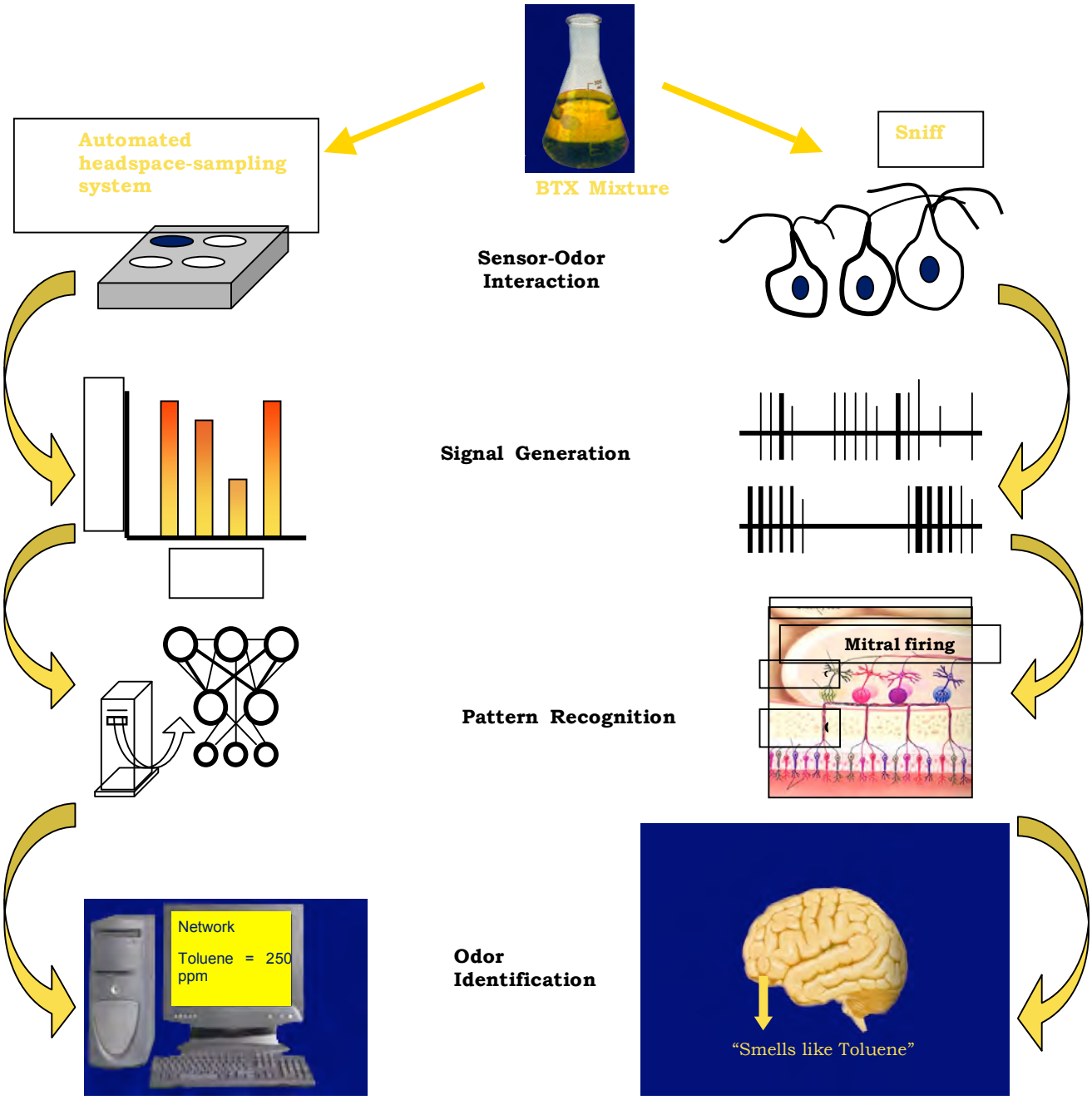


Can the characteristic 'stress' odor be experimentally elicited by a stressful, cognitive task?

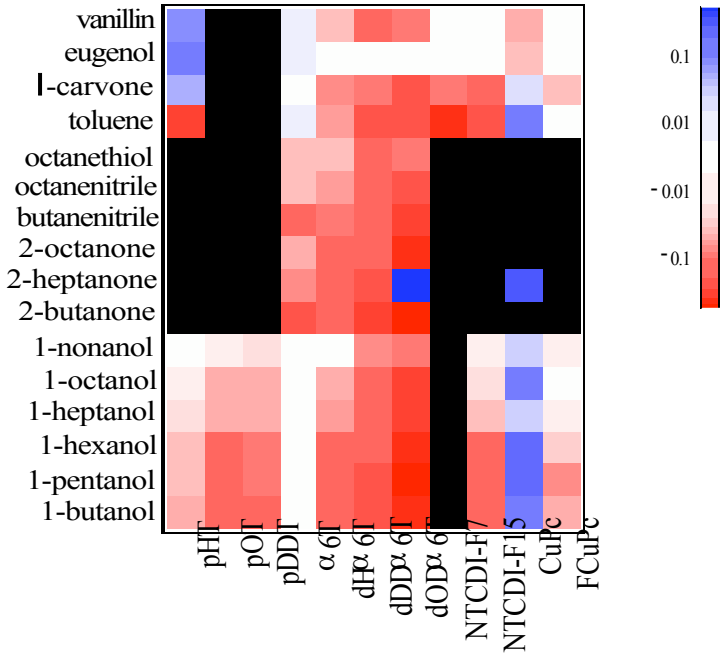
Trier Stress Test
10-min prep
5-min speech
5-min verbal math

Effects of Cognitive Stressors on Apocrine Secretions

- GCO analysis confirmed that the post-stress sample contained higher levels of 3M2H and the 'typical' odor of epinephrine-elicited axillary secretion
- At baseline and post-stress, levels of 3-methyl-3-thio-1-hexanol and 3M2H were positively correlated with:
  - self-reported stress levels
  - salivary cortisol levels
  - heart rate variability



Electronic Olfaction & Pattern Response



Blue= (+) response
Red = (-) response
Black=no data
White=no response

Conclusion

- Emotional arousal (e.g., stress, fear) appears to elicit quantitative and qualitative changes in axillary secretions
- Such changes may be a useful surrogate for monitoring physiological states which may indicate stress or deception
- Technology developed for artificial nose sensors can be implemented for covert, unobtrusive monitoring

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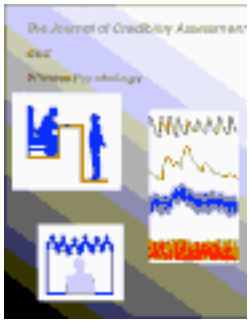


Radar Technology For Acquiring Biological Signals

Gene Greneker

RADAR Flashlight, LLC, Powder Springs, Georgia

The Journal of Credibility Assessment and Witness Psychology 2006, Vol. 7, No. 2, 127-134

Radar Technology For Acquiring Biological Signals

The Ability of Radar to Sense Biological Signals
Background of Gene Greneker

- Principal Research Scientist, Georgia Tech Research Institute 33 years
  - Radar Vital Signs Monitor (heart and respiration) Project Director
  - RADAR Flashlight Project Director
    - Through the wall detection of the human respiration radar signature
  - DARPA radar gait analysis program Project Director
    - Identification of a subject by radar sensed gait characteristics
- Retired From GTRI on 12-01-03 and started RADAR Flashlight, LLC.
- Working 49% part-time at Georgia Tech Research Institute
- Working 51% time for RADAR Flashlight, LLC on DARPA SBIR program to develop next generation RADAR Flashlight

The Ability of Radar to Sense Biological Signals

- Types of biological signals that radar can sense at present
  - Heart and respiration (vital signs)
  - Body tremor and very slight movement to maintain balance
  - Gait signature to allow identification of a subject
  - Heart signature (ballistocardiogram) of person hidden in vehicle
- Other attributes of radar sensing of biological signals
  - Detection of slight motion of the human body induced by a biological process
  - Detection of vital signs through clothes and heavy outer wear

The Ability of Radar to Sense Biological Signals
Applications of Radar Vital Signs Monitoring

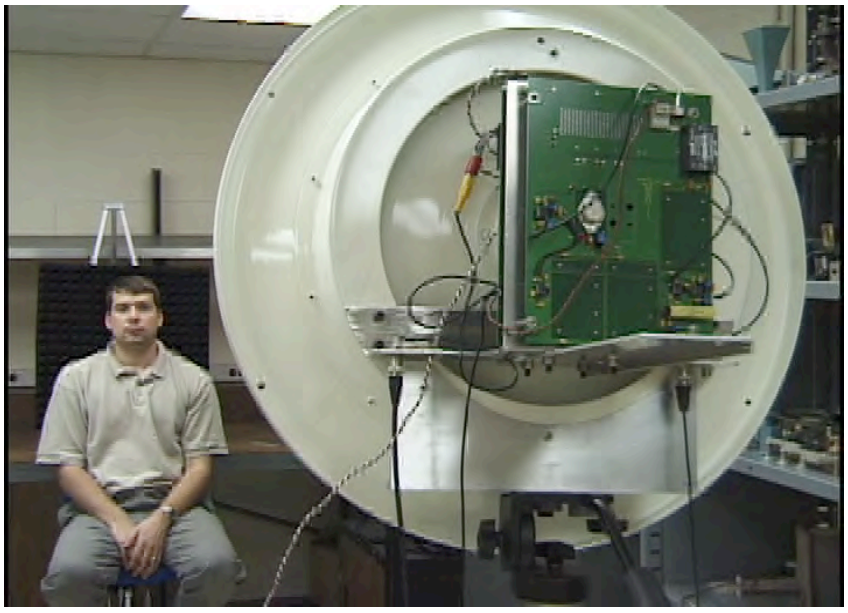
- Medical
  - Tele-medicine no connection required for heart and respiration monitoring
  - Heart disease screening
- Law Enforcement and Corrections
  - Finding persons behind walls and in closed areas
  - Suicide watch monitoring
  - Finding persons in shipping containers and border crossing inspection
  - Deception detection (heart and respiration channels of polygraph)
- Military
  - Clearing buildings in urban warfare scenario (through the wall human sensing)
  - Battlefield casualty assessment (dead or alive)
  - Vital signs monitoring through uniforms and chem/bio suits

History of Georgia Tech Research Institute's
Radar Vital Sign Monitoring Research Program

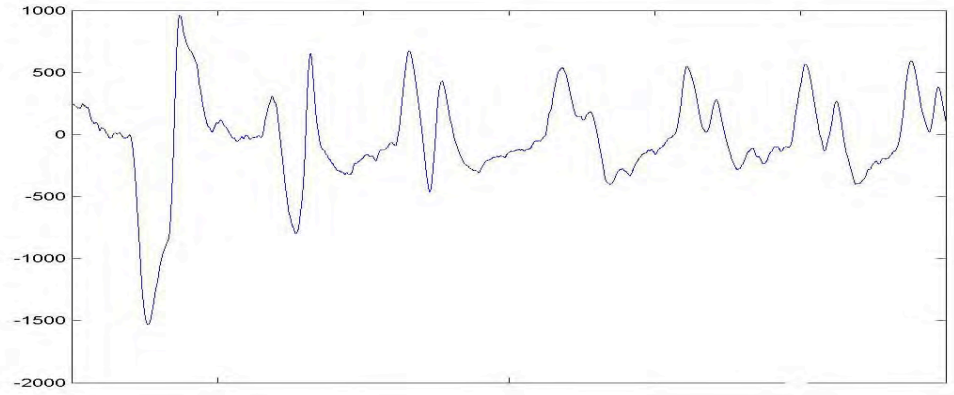
- RADAR Vital Signs Monitor developed for military applications
  - Remote evaluation of battlefield casualties from 100 meters away
  - Monitoring of vital signs (heart and respiration rate) of injured person
    - Sealed in contaminated chemical or biological suit
    - Monitor of subject without opening suit and contaminating subject
- RADAR Vital Signs Monitor developed for 1996 Olympic application
  - Monitoring of archer and rifle competitor's vital signs at a distance of 30 feet
    - Do rifle competitors shoot between heartbeats?
    - Do archery competitors shoot between heartbeats?

GTRI Olympic Athlete Monitoring System
Olympic Athlete Monitor – Front View

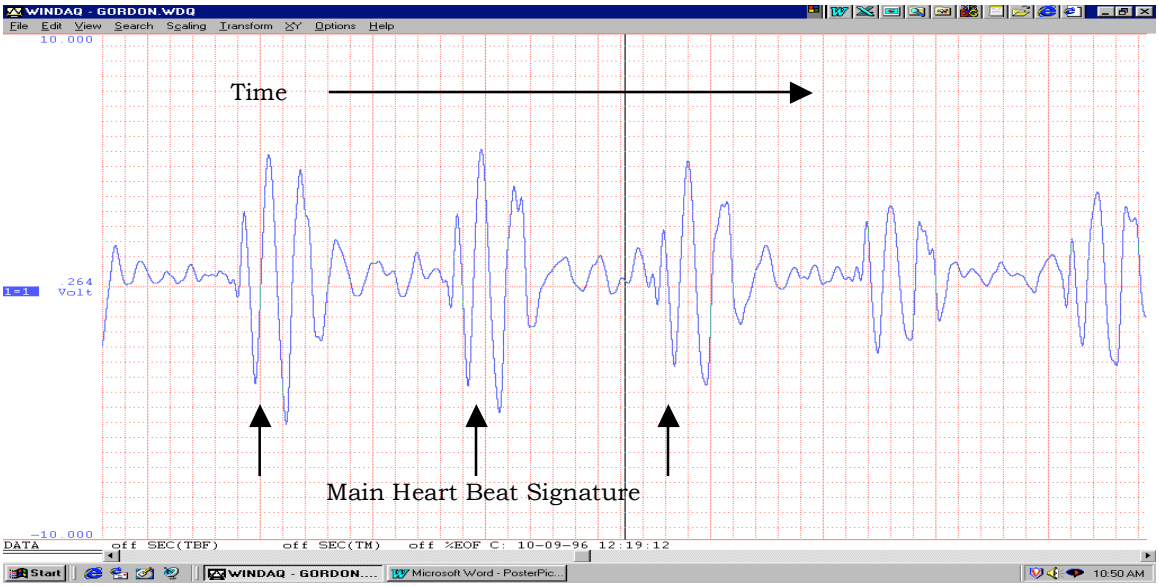
GTRI Olympic Athlete Monitoring System
Radar Vital Sign Monitor - Rear View



GTRI Olympic Athlete Monitoring System
Respiration Signature at 30 feet



GTRI Olympic Athlete Monitoring System
Radar Cardiogram Taken at 15 Feet



Thorax Aspect Range To Subject = 15 feet

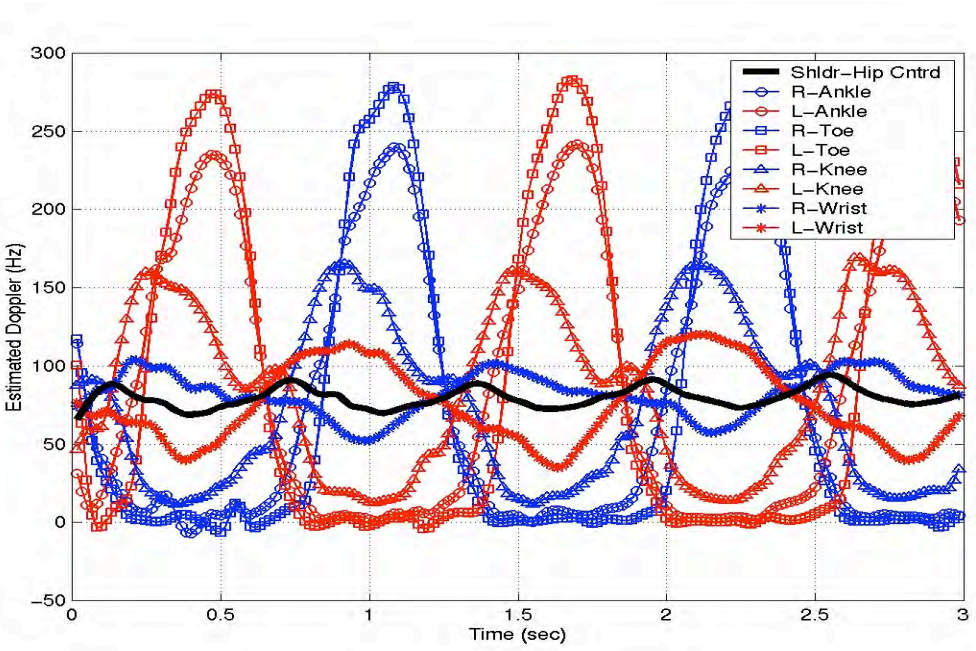
GTRI Human Gait Program
Radar Measured Gait

- Radar Measured Gait Analysis
  - Investigation of radar sensed gait to identify subjects after they have been enrolled in a 'gait' data base

- Gait research program performed for DARPA
  - Registered almost 100 subjects by having them walk toward radar
  - Took gait data 6 months later on same subjects used to build data base
  - Developed recognition algorithm to compare 'probe' to 'gallery'
  - Had 80% and higher recognition rate with low false alarm rate

GTRI Human Gait Program
Processed Human Gait Signal

- Doppler signature produced by body members (walking subject)



Radar Flashlight, LLC Clip-on Monitor
Heart and Respiration Rate Sensed Through Clothes

- RADAR Flashlight, LLC is commercializing radar vital signs instrumentation
  - Clip-on radar heart and respiration rate monitor is first product
  - Stand-off long range non-contact radar vital signs monitoring system also planned as product

Radar Flashlight, LLC Clip-on Monitor
Clip-on Sensor Specifications

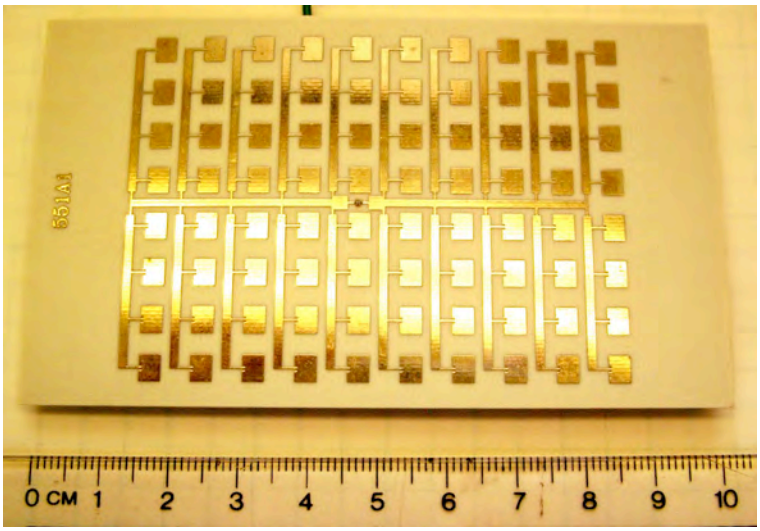
- Sensor unit is clipped on uniform over thorax area
- Battery operation
- Up to 10 patients monitored simultaneously
- Patient monitoring performed on hand held unit
- Sensors data sent to hand held unit via radio link
- Distance Between clip-on sensor and hand held monitor = 50 feet
- Loss of signal alarm
  - Radio link
  - Patient vital signs

Radar Flashlight, LLC Clip-on Monitor
Heart and Respiration Rate Sensed Through Clothes

- Applications for RADAR Flashlight, LLC Clip-on System
  - Small military units behind operating behind lines with wounded
    - Wounded stays in body armor and battle dress while system monitors
    - Victim can be moved on short notice without usual wired system mobility problems
  - Civilian heart and respiration rate monitoring applications
    - No removal of clothes required to monitor
    - Next generation system may be very inexpensive (disposable)

Radar Flashlight, LLC Clip-on Monitor
Radar System

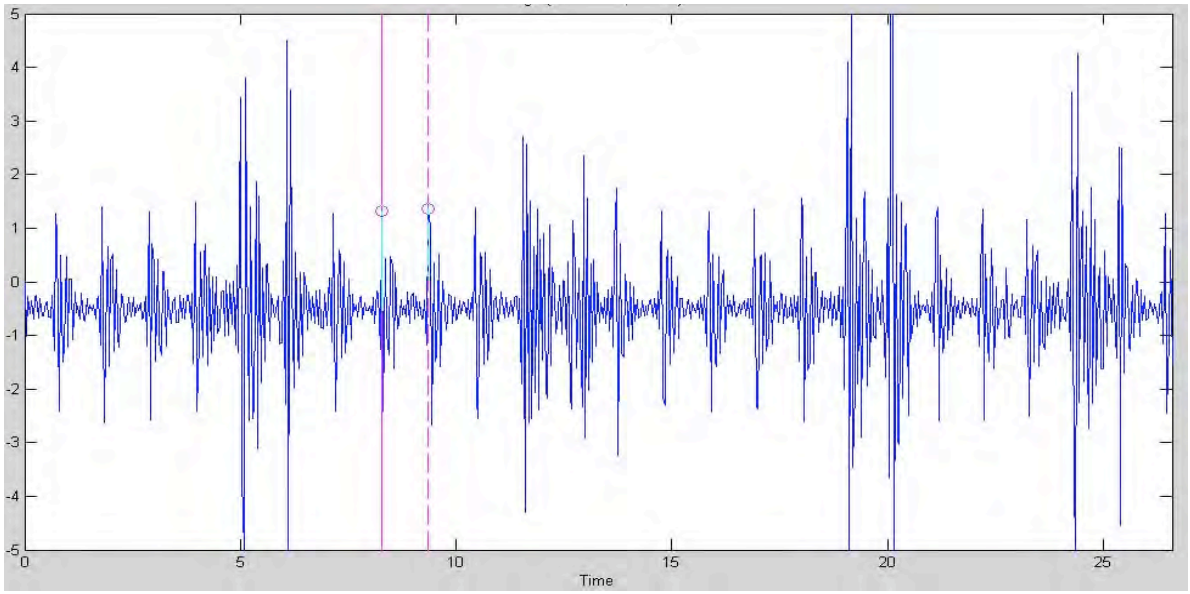
Radar System Used in Clip-on Sensor Package



Sensor weight is 2 ounces

Radar Flashlight, LLC Clip-on Monitor
Heart Signature Taken Through Clothes

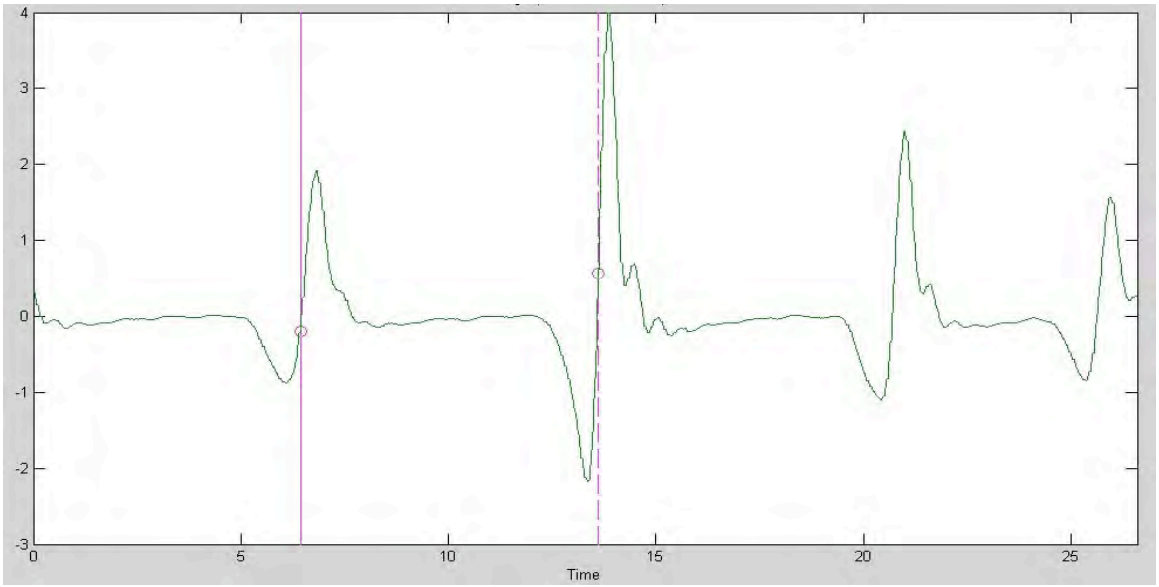
Clip-on Sensor's Heart Signal Channel Output



Time in seconds

RADAR Flashlight, LLC Clip-on Sensor
Respiration Signature Taken Through Clothes

Clip-on Sensor's Respiration Signal Channel Output



Time in seconds

Radar Technology For Acquiring Biological Signals
What Radar Can't Do (Yet)

- Monitor low level biological electrical signals in body
  - EKG
  - EEG
- Recover heart and respiration signals from all parts of the body
  - Thorax - front aspect best to monitor
  - Heart and respiration signal can be picked up from back area
  - If vessel or artery comes close to surface heart signal detectable

Radar Technology For Acquiring Biological Signals
Current Radar Vital Signs Challenges

- Any subject motion currently causes artifacts in signal from stand-off radar system
  - Moving body motion induces signal larger than small heart and respiration signal
  - Techniques to isolate heart and respiration signature from small body motion signature needs to be developed
  - Covert deception analysis on basis of heart and respiration rate at checkpoint possible if subject body motion artifact problem can be solved
- Motion artifact not same magnitude problem in clip-on system
- Recovery of radar developed heart and respiration signal from walking subject topic for future research
  - Data is in the Doppler sidebands but only as "micro-Doppler" components
  - Micro-Doppler recovery techniques should be subject of future research efforts

Radar Technology For Acquiring Biological Signals
Future Research Topics in the Area of Radar Based Deception Detection

- Heart and respiration signal recovery while subject is being questioned at Customs or Immigration counter
  - Motion artifact suppression research
  - Method to determine deception from only 2 channels of information
- Detection and recovery of heart and respiration signal when subject of interest is walking
- Techniques to isolate heart and respiration rates of subject moving in crowd

Radar Technology For Acquiring Biological Signals
Representative References

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4. Greneker, E. F., "Radar Sensing of Heartbeat and Respiration at a Distance with Applications of the Technology," Proceedings of IEE RADAR-97, Edinburgh, Scotland, October 1997, pp. 150-153
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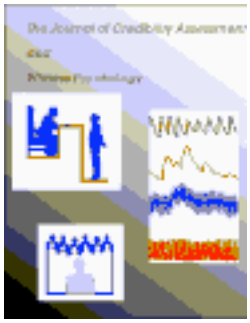


The Physiology of Threat: Remote Assessment Using Laser Doppler Vibrometry

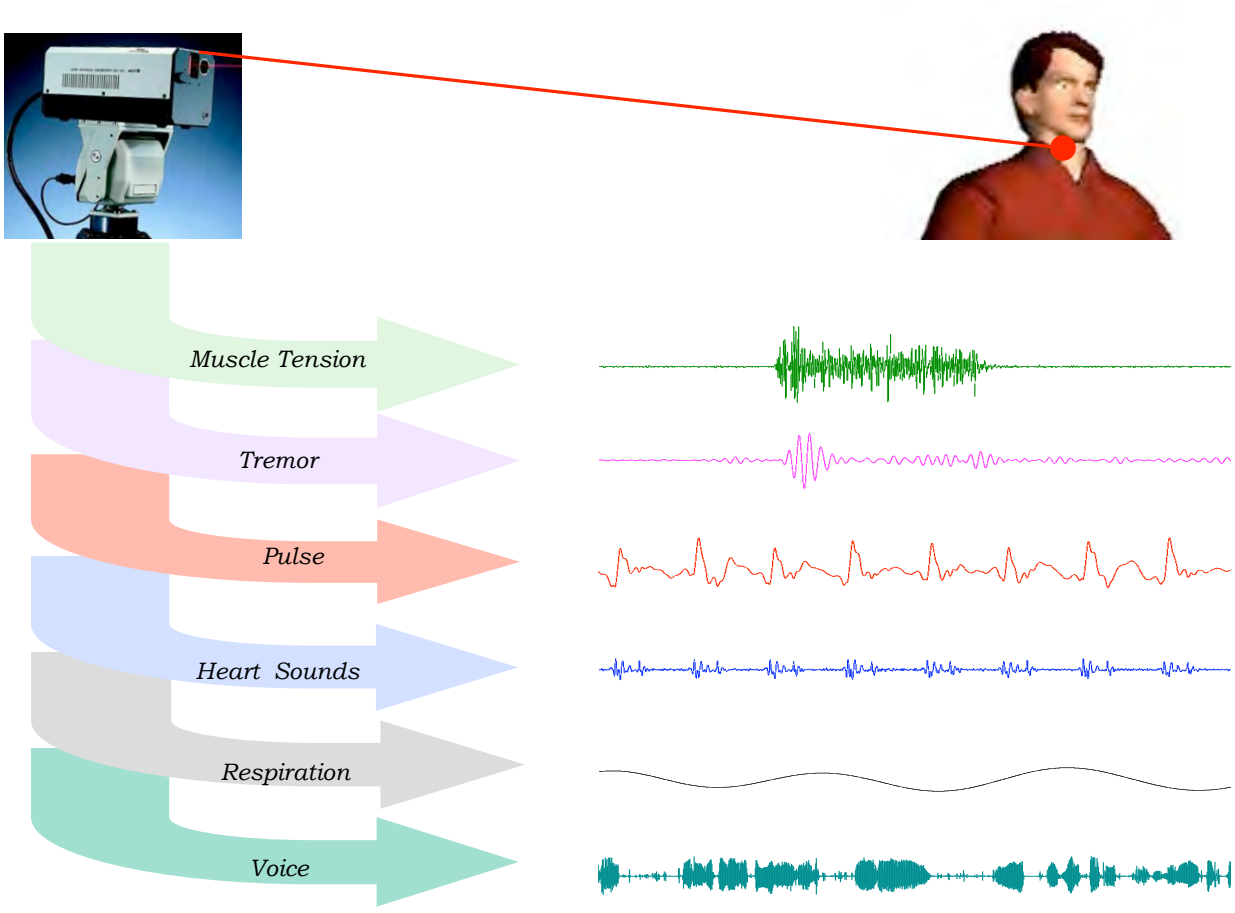
John W. Rohrbaugh*, Erik J. Sirevaag*, John A. Stern*, and Andrew H. Ryan, Jr.†

***Washington University School of Medicine, St. Louis, Missouri**
†Department of Defense Polygraph Institute, Ft. Jackson, South Carolina

The Journal of Credibility Assessment and Witness Psychology 2006, Vol. 7, No. 2, 135-145

The Physiology of Threat: Remote Assessment Using Laser Doppler Vibrometry

Laser Doppler Vibrometry:
Remote Recording of Multiple Physiological Signals



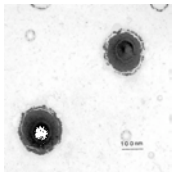
Overall Premise:

Internal physiology has mechanical components that can be detected in the form of surface (skin) vibrations.

- Provide basis for conventional methods based on accelerometry, plethysmography, etc.
- Key to clinical methods based on auscultation, palpation, and percussion of body sounds and movements.

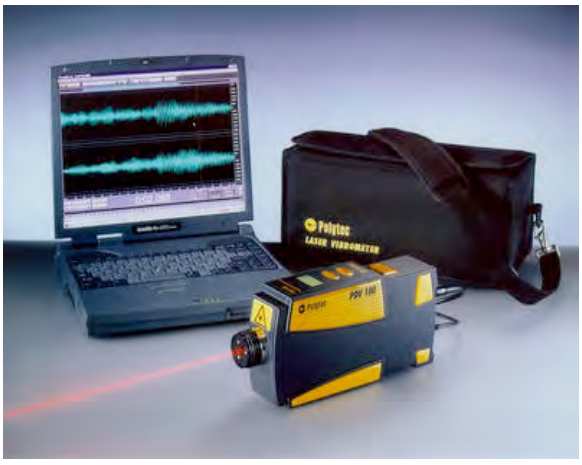
- Multiple forms of activity can be sensed, supporting differentiation among stress and emotional states.
- ***Vibrations can be sensed remotely.***

Works on Doppler principle, using phase-shifted reference beam to yield direction-encoded interference patterns.



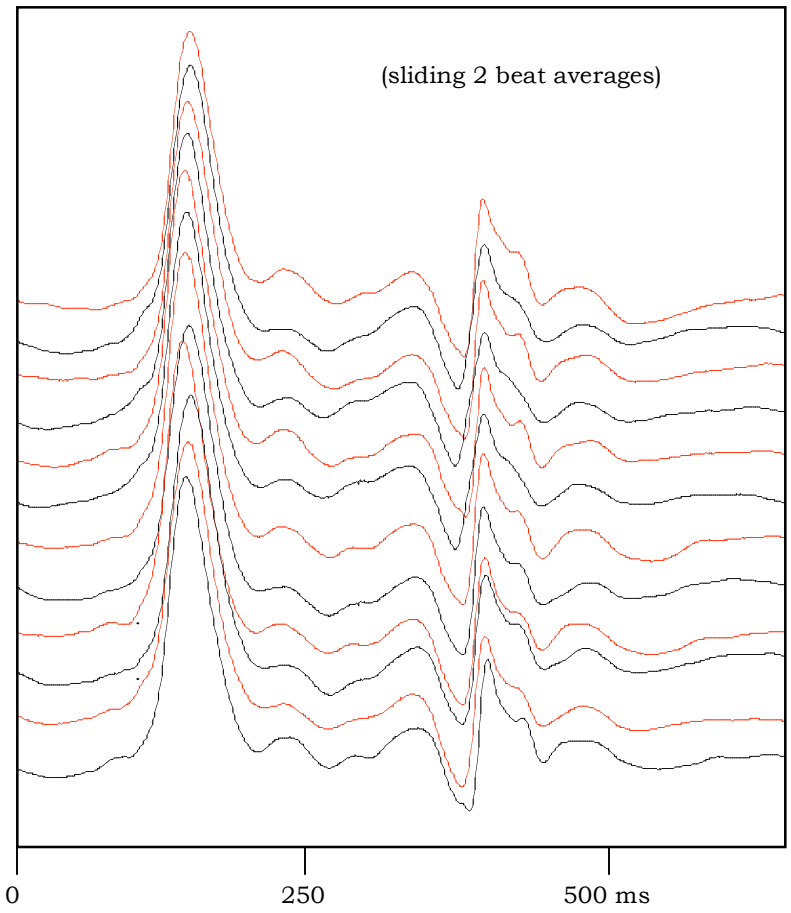
- Laser: 633 nm, 1 mW
- Range: >5 m
- Bandwidth: 0 - >20 kHz
- Sensitivity: <1 nm

Polytec PSV400 Scanning Vibrometer

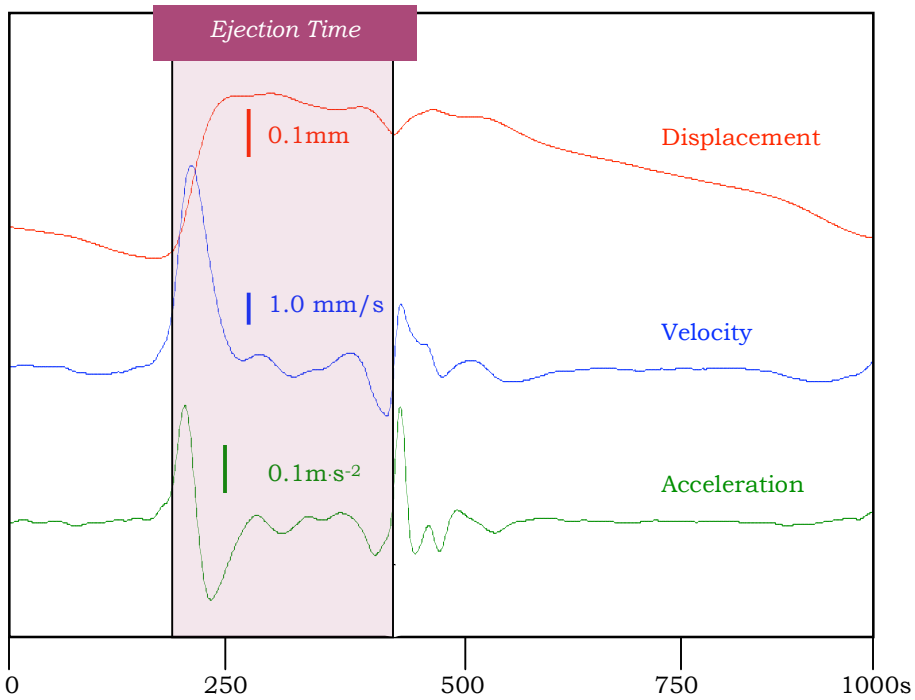


Polytec PDV100 Portable Vibrometer

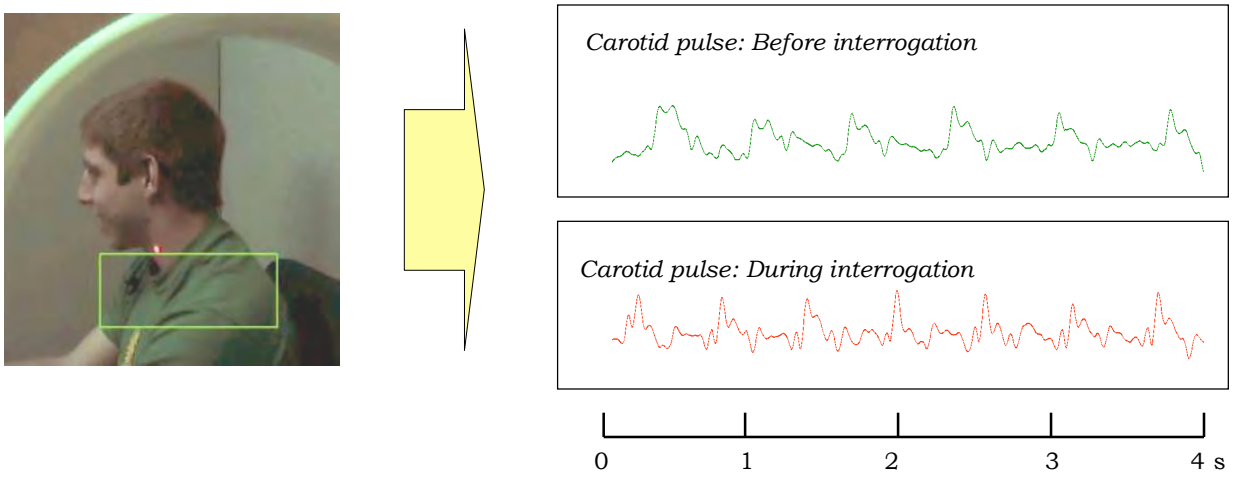
Carotid Pulse: Beat to Beat Stability



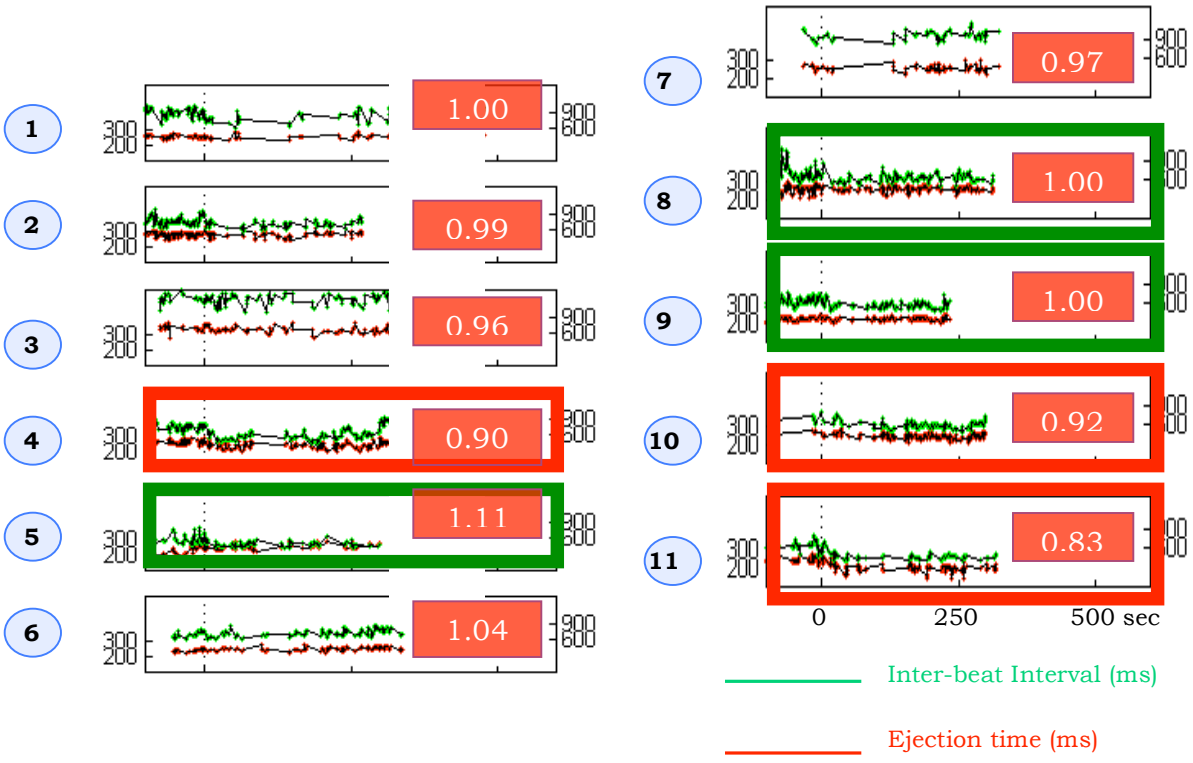
LDV Carotid Pulse Contour



Carotid Pulse During Interrogation

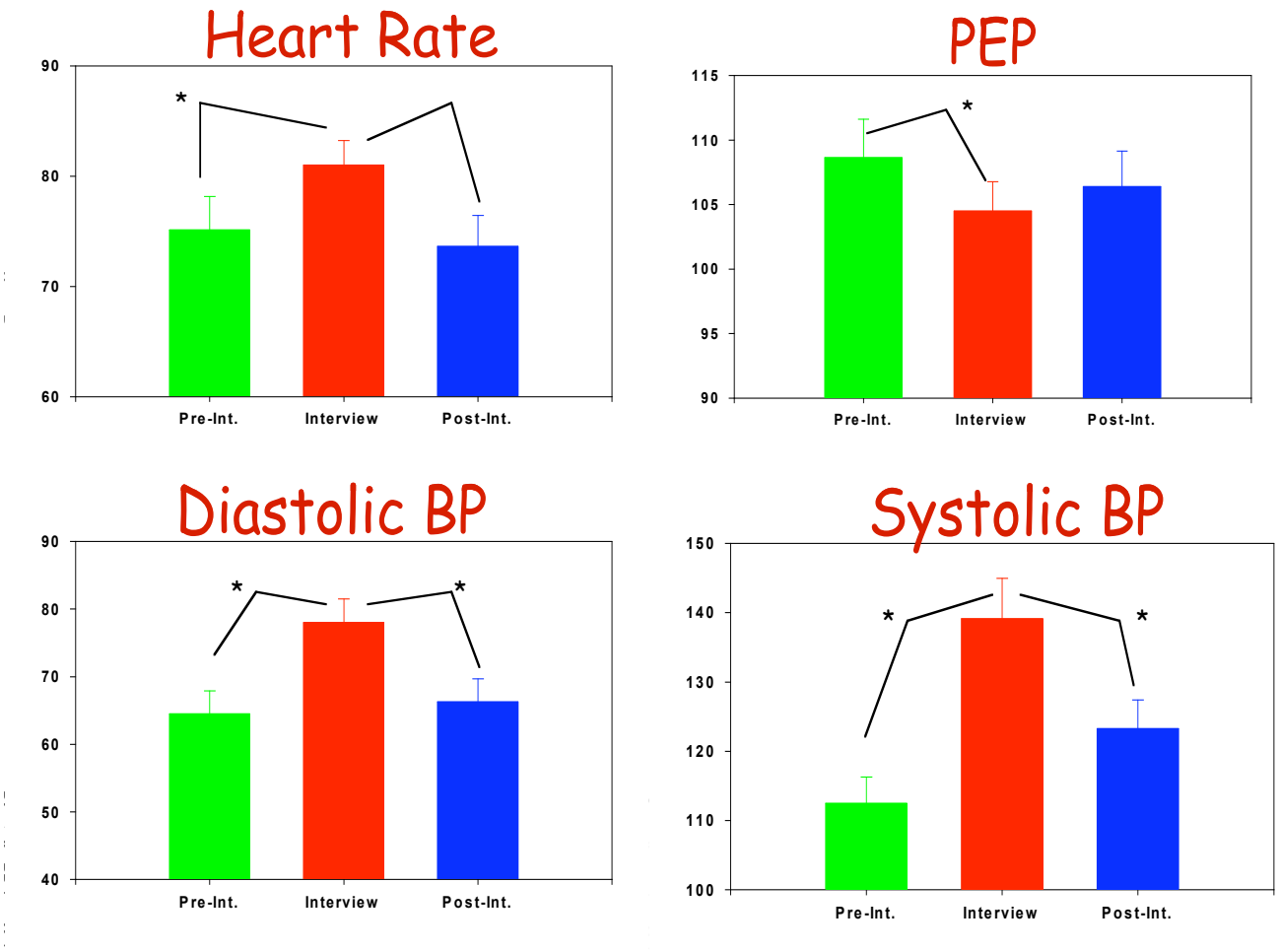


Interbeat Interval and Ejection Time During Interrogation

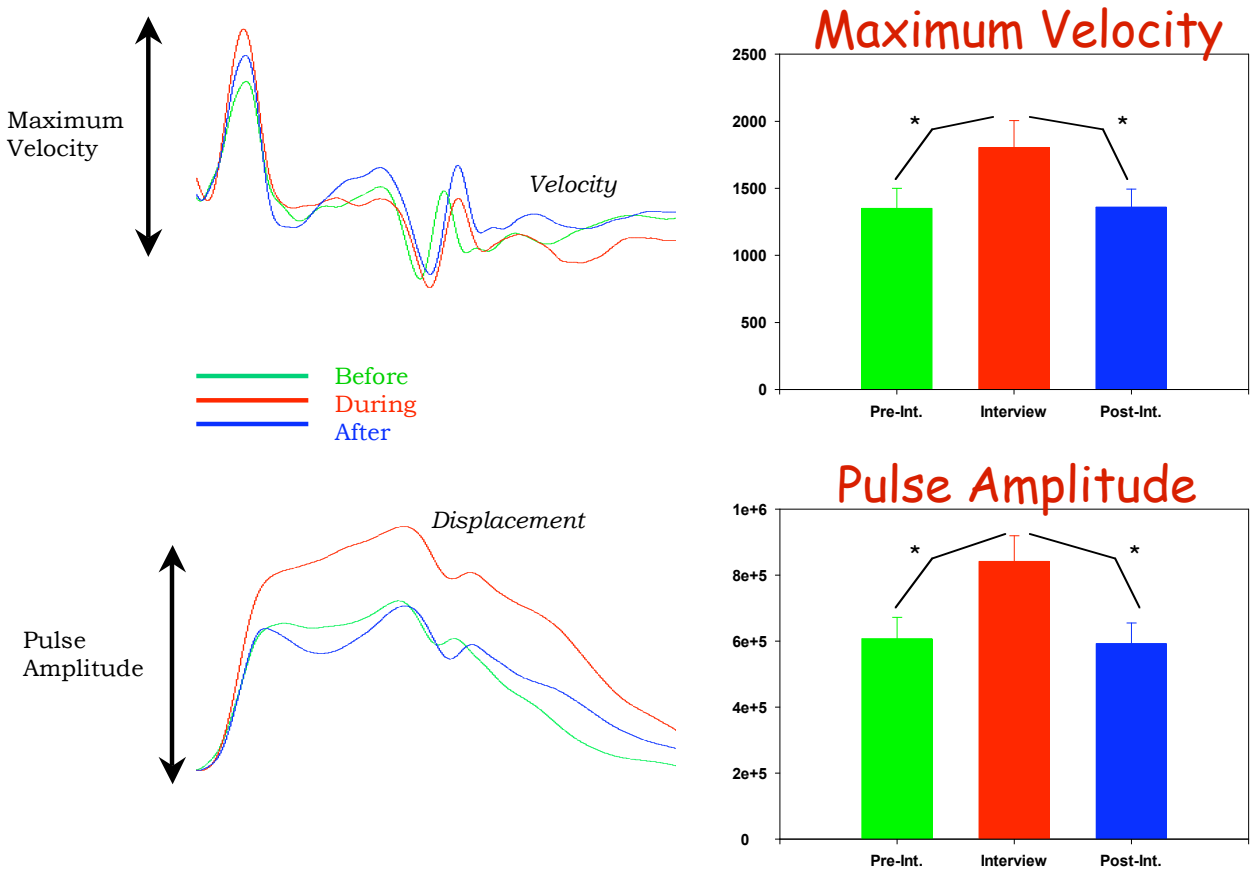


Stress Interview

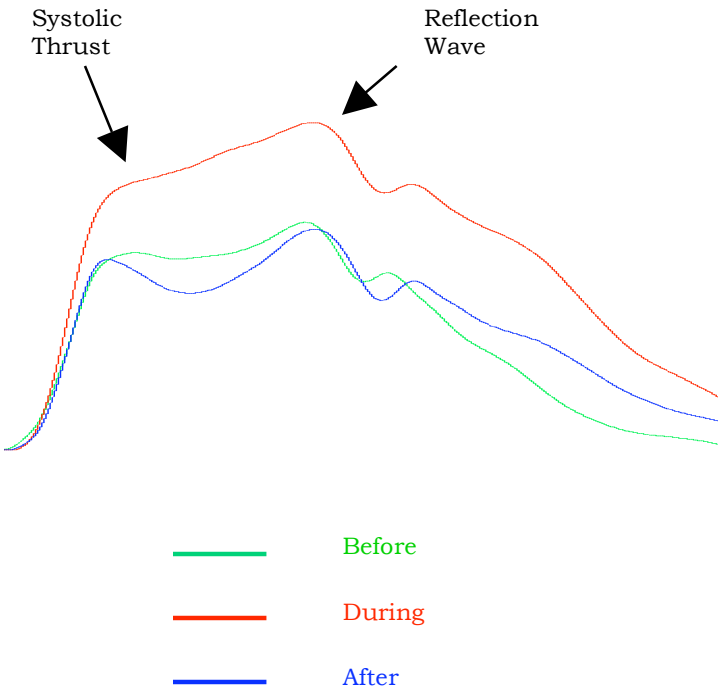
16 min semi-structured, face-to-face interview covering common life stressors (following procedures of Dimsdale et al., 1988).

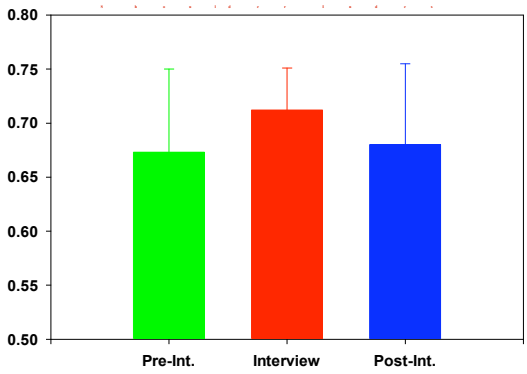


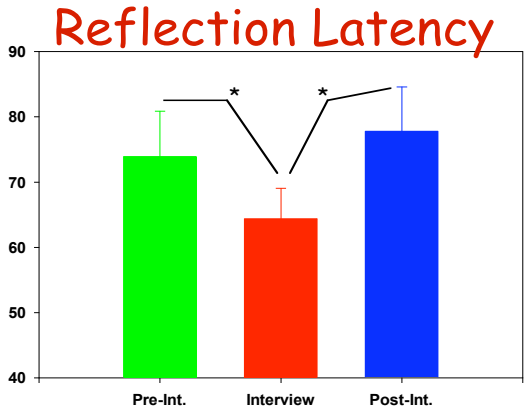
Carotid Pulse Amplitude



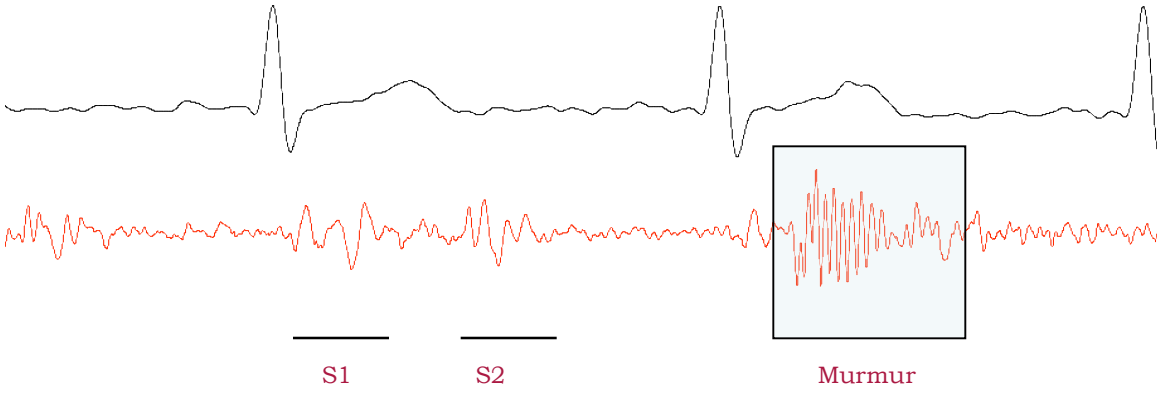
Carotid Pulse Contour







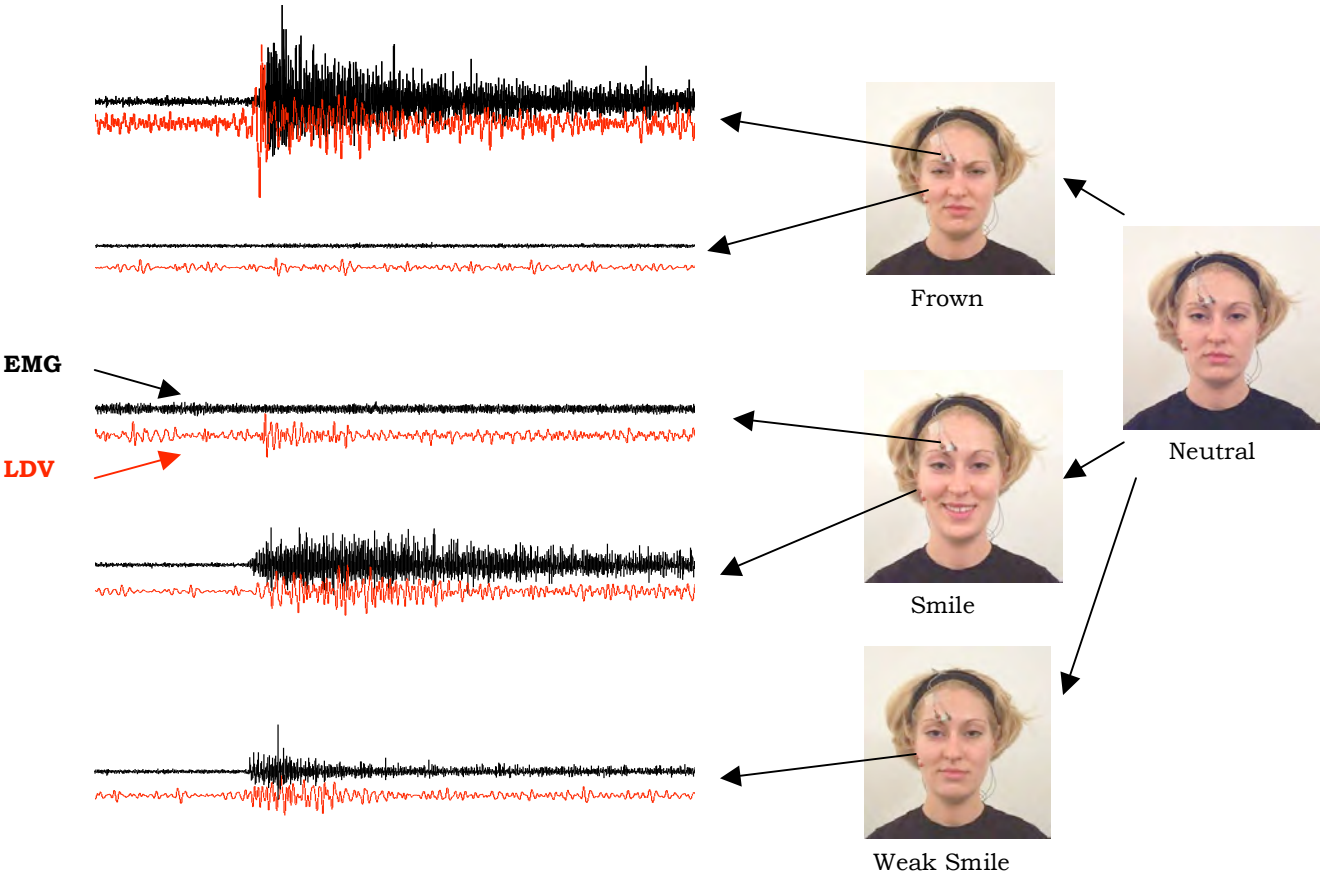
Systolic Murmur



Muscle Vibrations
(Acoustic Myogram)

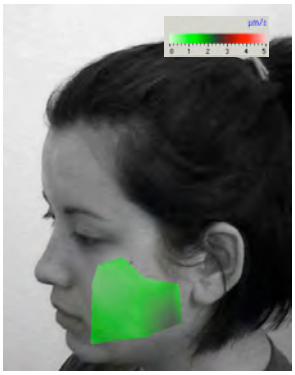
- First described by Grimaldi, 1665.
- Peak frequency *ca* 10 to 30 Hz.
- Usually recorded using microphones or accelerometers.
- Reflect lateral vibration or expansion of muscle, associated with firing of motor units.
- May be more directly related to force production than is electrical signal (EMG).

Facial Myography
(corrugator, zygomatic)



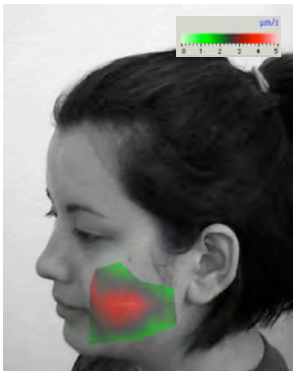
Lower Face
(RMS velocity, 16-32 Hz band)

Neutral



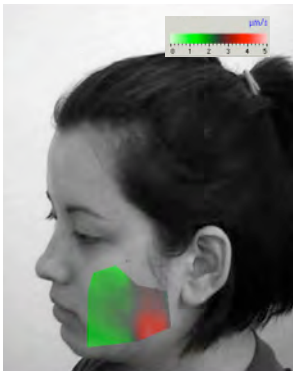
AU 20

Lip Stretcher



AU 31

Jaw Clencher



Upper Face
(RMS velocity, 16-32 Hz band)

Neutral

AU 1

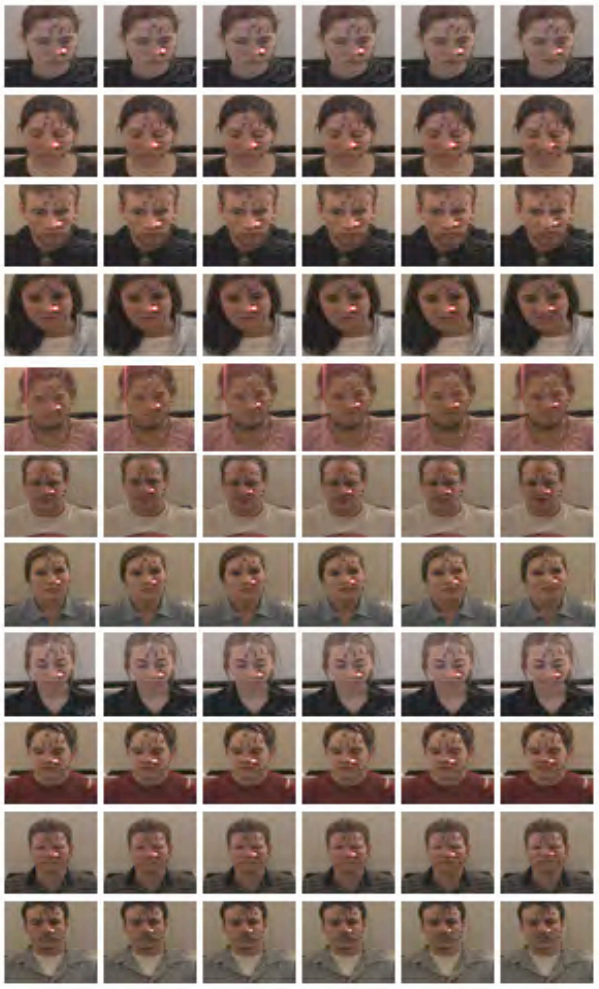
Inner Brow Raiser

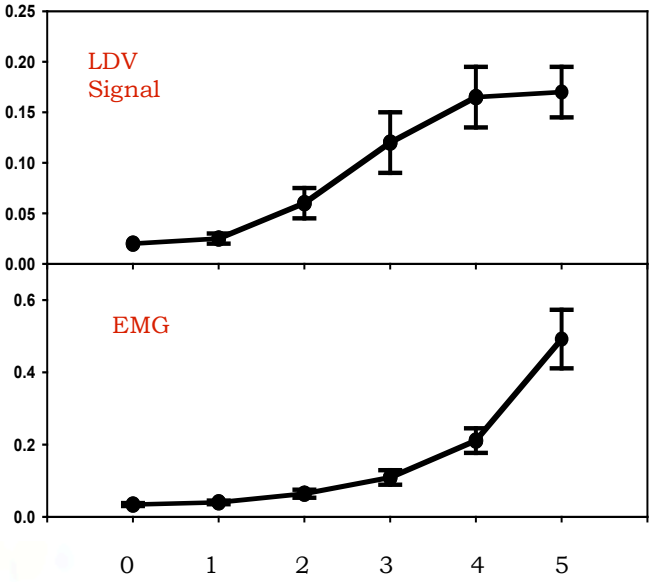
AU 2

Outer Brow Raiser

AU 4

Brow Lowerer





CONCLUSION: The LDV method can reliably assess facial muscle activity, associated with emotion and stress, at low levels—below the threshold for visible facial deformations.

Summary

Laser Doppler Vibrometry (LDV) provides advanced measures in multiple physiological systems relevant to laboratory and field assessment of stress and emotion:

- LDV ***cardiorespiratory*** recordings yield advanced measures of myocardial and vascular performance, and respiratory effort and sounds.
- LDV ***tremor*** activity compares favorably with accelerometry, and is responsive to laboratory stressors.
- LDV ***muscle*** vibratory activity can be sensed from multiple muscles, including facial muscles, and compares favorably with the EMG.

LDV signals are unaffected by environmental noise and other conditions.
LDV signals can be obtained during unconstrained interviews or interrogations.

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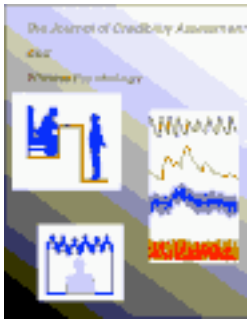

The Gaze Control System and Detection of Deception

John A. Stern

Washington University, St. Louis, Missouri

The Journal of Credibility Assessment and Witness Psychology 2006, Vol. 7, No. 2, 146-148

The Gaze Control System and Detection of Deception

- Camera based systems allow for relatively unobtrusive recording of:
- Oculomotor activity
  - Eyeball movement
  - Eyelid movement
  - Pupil diameter changes
  - Minor head movement
  - Vergence eye movements

- Which components may be useful in the detection of deception?
- I will start with the one with highest probability of pay-off.
- (my guesstimate – and I may be wrong)

1. Pupil diameter change – highest likelihood of immediate payoff:
   - Reasonable literature in support of this measure.
   - Most recent – report from Technion on guilty knowledge test (2004).
   - Innocent found innocent 90%.
   - Innocent found guilty 10%.
   - Guilty found guilty 75%.
   - Guilty found innocent 25%.
   - Question: 1. What can it contribute to current polygraph measures? 2. What can it contribute to non-polygraph based investigations?

2. Eye movements – saccades
   - Saccades move gaze to location of interest
   - Timing of saccade with respect to "information" presentation.
   - Speed with which gaze shifts to location of interest.
   - CLEM – suggestive of information processing style- does operator have to think about answer before responding?
     - Do left movers use strategies different from right movers when attempting to be deceptive?

3. Head movement – minor movements.
   - If task is "difficult" likelihood of head movements is enhanced. Is lying more difficult than truth telling?
   - Timing of head movement with respect to eye movement.

4. Eye blinks
   - Increase – with "anxiety" (and other variables)
   - Decrease – with difficulty of information processing task
   - Timing – with respect to eye and head movements,
   - Timing – with respect to aspects of information processing
   - Duration – discriminating between blink and lid closure

CONCLUSION: SPECIFIC and GENERAL

1. There is no unique oculomotor signature associated with deception
2. There is no unique "bio-behavioral signature" associated with deception
3. Deception involves both affective and cognitive components.
4. Which component is most important may be unique to the individual
5. The bio-behavioral signature may be unique to the individual but we should be able to identify parameters effective for identifying deception for a specific subject.

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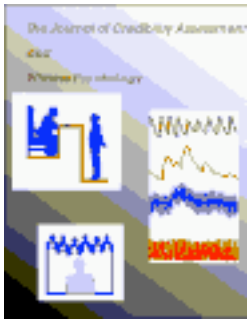


Eye Movement-Based Assessment of Concealed Knowledge

Frank M. Marchak

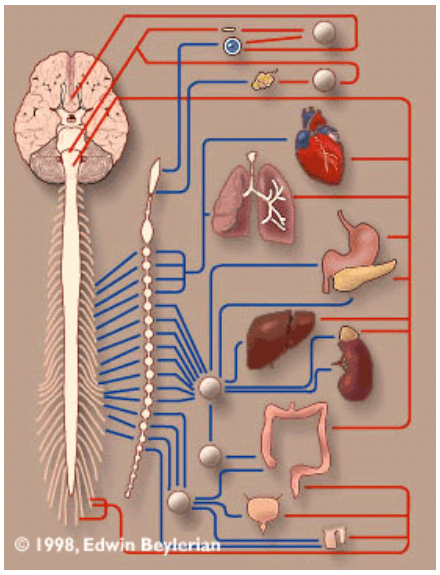
Veridical Research and Design Corporation, Bozeman, Montana

The Journal of Credibility Assessment and Witness Psychology 2006, Vol. 7, No. 2, 149-163

Eye Movement-Based Assessment of Concealed Knowledge

Theoretical Background
Traditional Deception Detection

- Polygraphy hypothesizes that individuals in deceptive situations experience an emotional response that causes arousal of the autonomic nervous system (ANS)



- Increase in arousal is detected through measurement of change in physiological functions
  - Respiration
  - Blood pressure
  - Heart rate
  - Skin conductance

Theoretical Background
Current Concept

- Change in the responses of cognitive and perceptual processes can be measured and employed in a similar manner

- Previous exposure to materials can be revealed by changes in subsequent cognitive processing
- Indirect measures of performance, such as speed and accuracy, show an increased efficacy in the processing of previously presented materials

Theoretical Background
Measures of Memory

- Direct
  - Require reference to target event in personal history
    - Free Recall
    - Cued Recall
    - Recognition
- Indirect
  - Require reference only to task at hand
    - Speed
    - Accuracy

Measures of Memory
Memorize this List

alligator	hammer
apple	house
arrow	lemon
baby	microscope
bird	ocean
book	pencil
butterfly	rock
computer	shoes
corn	table
fish	window

Measures of Memory – Direct
Free Recall

- Recall all of the words that you remember

_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Measures of Memory – Direct
Cued Recall

- Recall all of the words that were animals

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Measures of Memory – Direct
Recognition

- Which of these words were on the original list?

alligator	hammer
apple	key
banana	lemon
bag	microscope
bird	ocean
book	penguin
butterfly	radio
computer	shoes
corner	table
floor	wheel

Measures of Memory – Indirect
Word Fragment Completion

all_ga_ _r
ap_l_
a _r_w
m_ cr_ _ _ _pe
b_ _ _er_ _ _
c_ _pu_ _ _
h_ _ _ er
pe_ _ _in

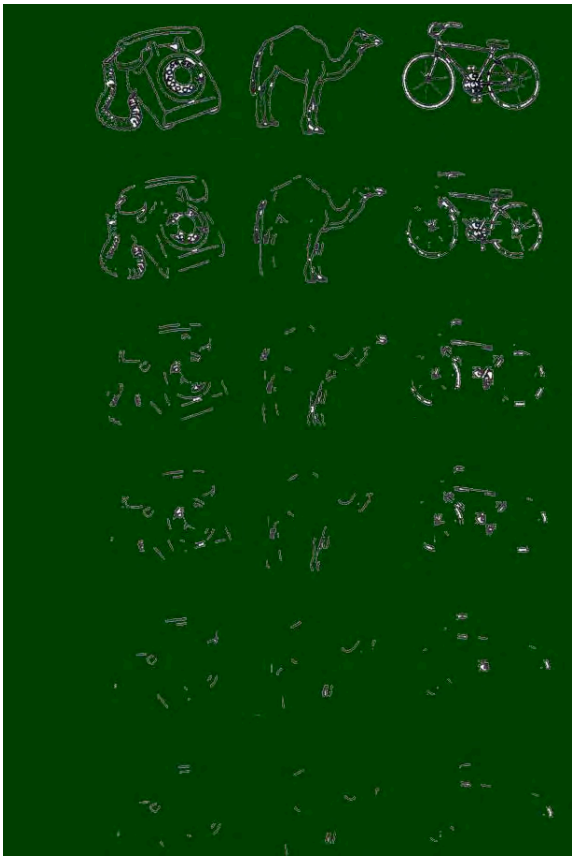
Measures of Memory – Indirect
Word Stem Completion

all_ _ _ _ _
ap_ _ _
ar_ _ _
mic_ _ _ _ _ _ _
but _ _ _ _ _ _
com _ _ _ _ _
ham _ _ _
pen _ _ _ _

Measures of Memory – Indirect
Perceptual Identification: Words

alligator
apple
banana
bag
bird
book
butterfly
computer
corner
floor

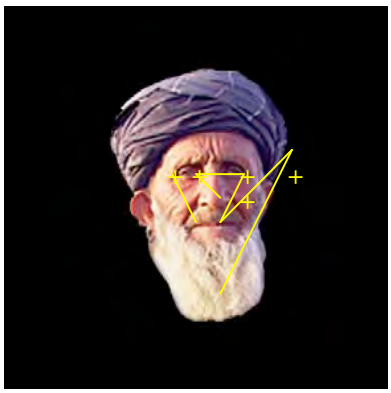
Measures of Memory – Indirect
Perceptual Identification: Images



Snodgrass & Feena, 1990

Theoretical Background
Repetition Priming

- Prior exposure to stimuli produces:
  - Enhancement in performance
  - Changes in how stimuli are processed
- Changes in eye movement patterns can serve as an indirect measure of memory and effectively indicate concealed knowledge
  - Developed by Neal Cohen at the University of Illinois –Urbana/Champaign (UIUC)



Theoretical Background
Eye Movement-Based Memory Effect*

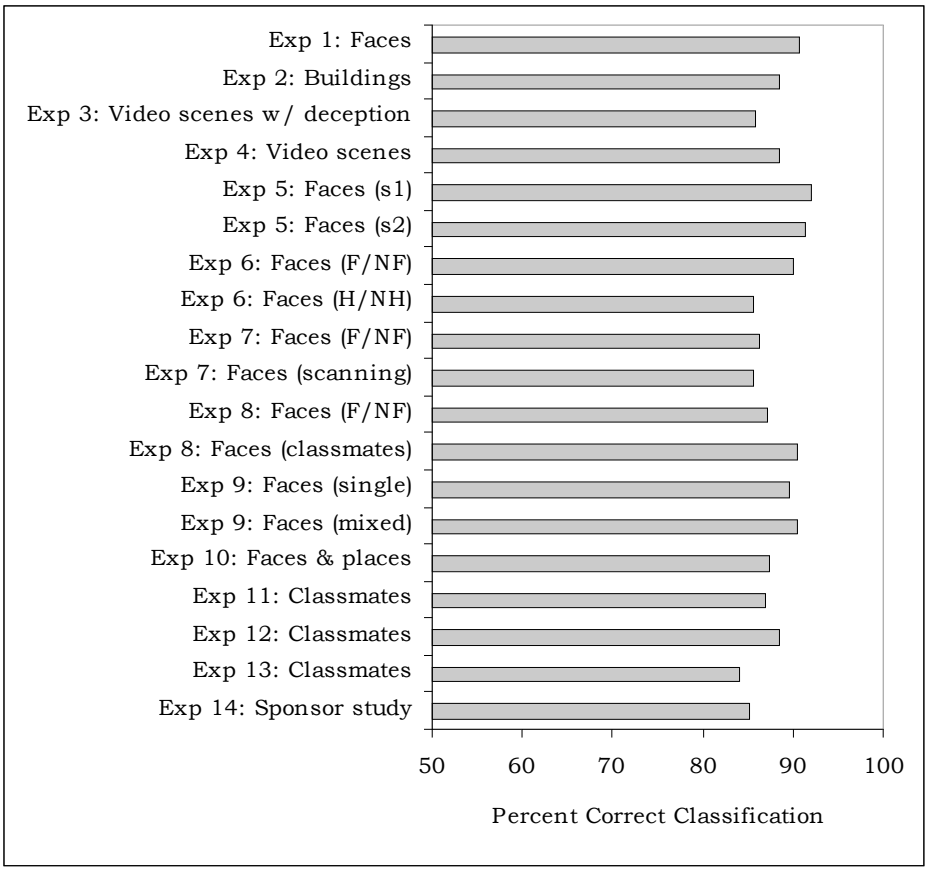
- Previously seen faces are viewed differently from novel faces
  - Fewer eye fixations
  - Fewer regions sampled
  - Less statistical constraint in sampling

* Althoff, R. R. and Cohen, N. J. (1999). Eye-movement-based memory effect: A reprocessing effect in face perception. *Journal of Experimental Psychology: Learning, Memory and Cognition, 25(4),* 997-1010.

Theoretical Background
Data Analysis

- Variables calculated from eye movements to each face image
  - Number of fixations
  - Number of regions sampled
  - First return fixation
  - Proportion of fixations to left of face
  - First-order Markov measures
  - Second-order Markov measures
- Linear Discriminant Analysis performed on variables to classify face images as familiar and unfamiliar

Theoretical Background
UIUC Experiment Results



Grand Mean = 88.1%

EMMA
Project Background

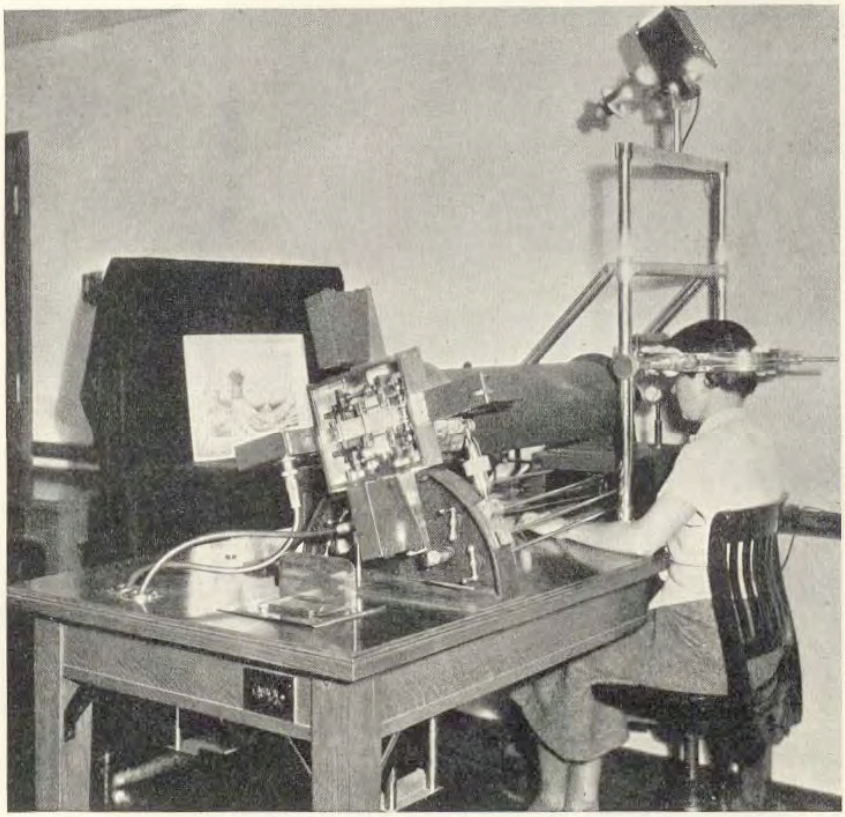
- US Government sponsor took delivery of a remote eye tracking system from the University of Illinois after six years of external research
- Internal research team formed with VRADC and personnel from Sponsor's organization to transition system from laboratory to field environment
- Effort named Project EMMA (Eye Movement-based Memory Assessment)

VRADC
TRACKER

- Turnkey Remote Assessment of Concealed Knowledge using Eye-movement Recording (TRACKER)
- Portable, easy-to-use stimulus preparation, eye tracking and analysis system
- Additional stimulus types –objects and scenes
- Creation and validation of new administration protocols
- Expansion and refinement of analysis techniques
  - Fast Adaptive Mean Shift Clustering
  - Bagging Quadratic Discriminant Analysis
  - Bootstrapping

Methodology

Eye Movement-based Assessment
First Generation Eye Tracking



Apparatus Used for Photographing Eye Movements, Front View

Buswell, 1935

Eye Movement-based Assessment
Later Generation Eye Tracking

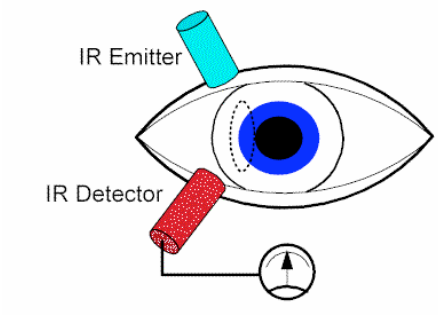
ISCAN, 1998

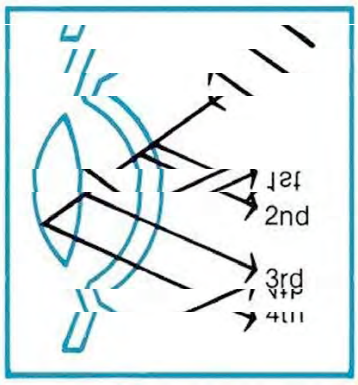
Eye Movement-based Assessment
Current Generation Eye Tracking

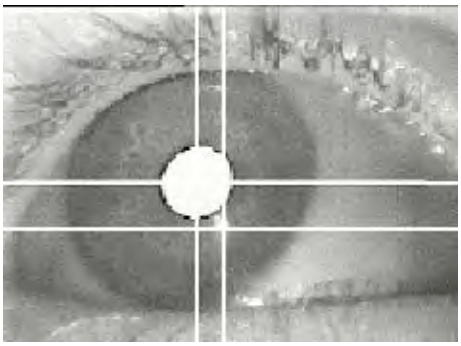
SMI System Configuration

Tobii System Configuration

Eye Movement-based Assessment
Infrared Remote Eye Tracking

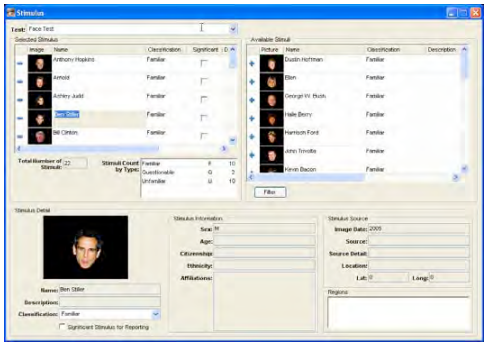






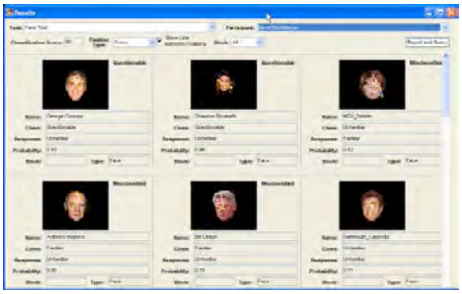
Eye Movement-based Assessment Methodology

Create Test



Integrated User Interface

Analyze Test



Conduct Test

SMI

Tobii

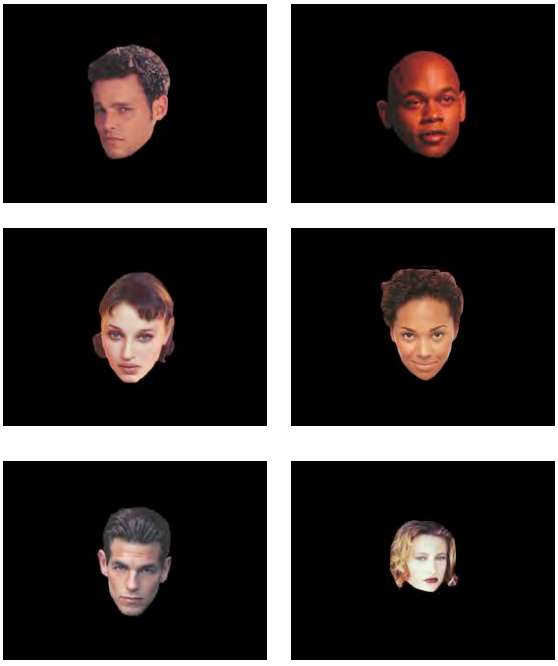
Protocols

Group Membership

- Determine prior knowledge of group membership

Familiar

Unfamiliar



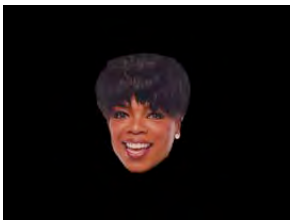
Sample Accuracy – Group Membership Protocol
Familiar/Unfamiliar

Stimulus	True Positive Rate	False Positive Rate
Faces	0.80	0.20
Objects	0.82	0.17
Scenes	0.81	0.14

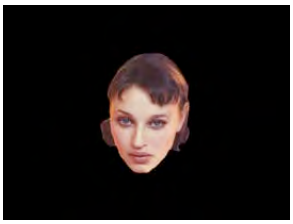
Protocols
Specific Individuals

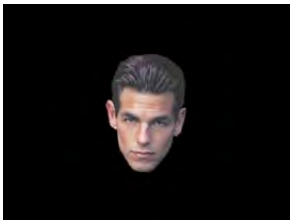
- Determine whether prior knowledge exists for a specific individual

Familiar

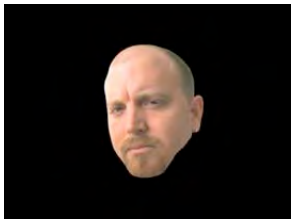


Unfamiliar



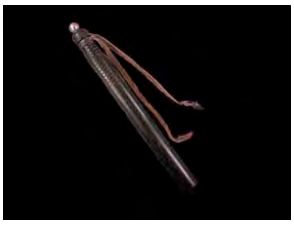


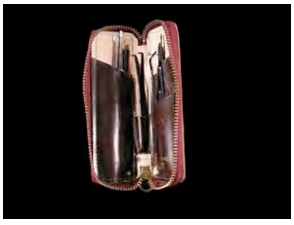
Questionable



Protocols
Object Knowledge

- Differentiate seen objects, handled objects, and unseen objects





Protocols
Scene Knowledge

- Determine prior knowledge for scene content through addition, deletion, or feature change

Original

Manipulated

Applications & Current Research

Current Applications

Concealed Information

Source Verification

Eyewitness ID

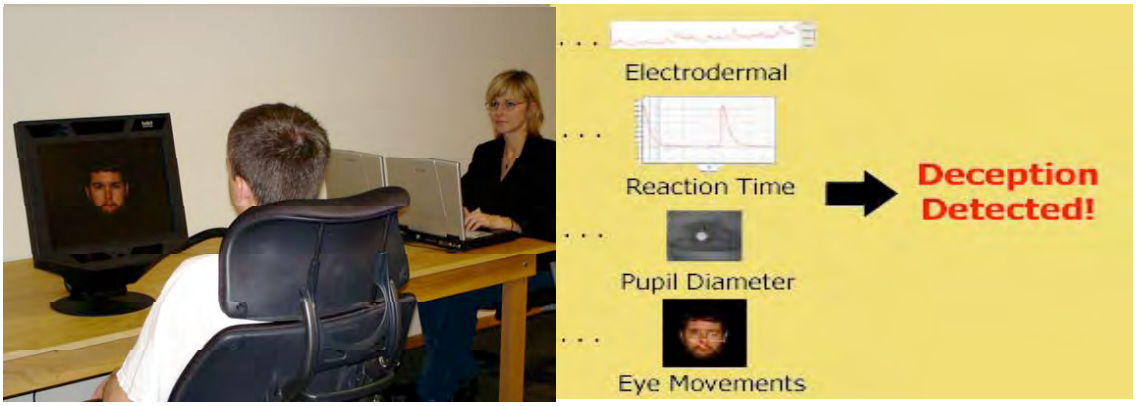
Suspect Questioning

Combatants

Border Crossing

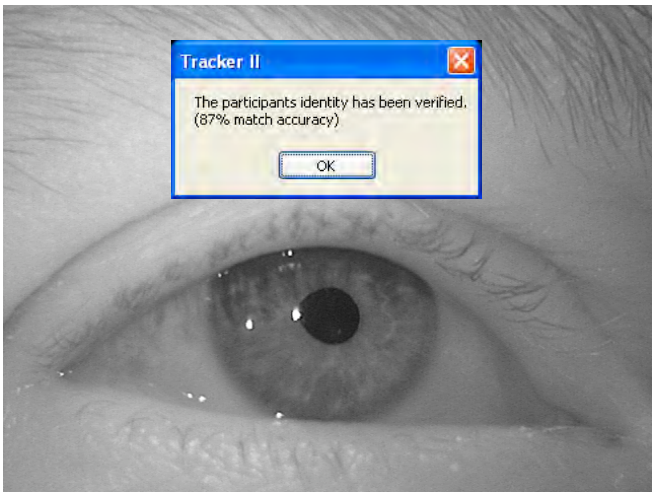
Current Research
Focused Screening

- Combine eye movement data with electrodermal, pupil diameter and reaction time data
- Develop and validate protocols



Current Research
Integrated Biometric Identfication

- Prototype Software System
- Supports enrollment & verification

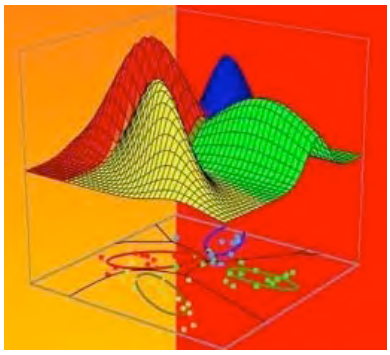


Curent Research
Determining Effect Boundaries

- Stimulus Differences
  - Photo types
  - Feature differences

- Participant Differences
  - Cultural

- Analysis Methods
  - Classification techniques
  - Eye movement variables



Eye Movement-based Assessment
Summary

- Eye Movement-Based Assessment provides an effective, non-invasive tool to determine prior knowledge
- Supports use of faces, objects and scenes as stimuli
- Application to a wide range of verification situations
  - Source verification
  - Witness corroboration
  - Perpetrator identification
  - Detection of concealed information

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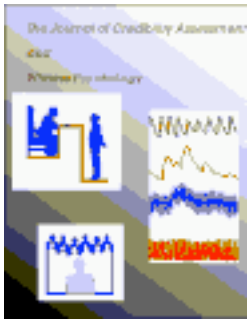


Multimethod Assessment of Deception on Personnel Tests: Reading, Writing, and Response Time Measures

Andrea K Webb, Sean D. Kristjansson, Dahvyn Osher, Anne E. Cook, John C. Kircher, Douglas J. Hacker, & Dan J. Woltz

University of Utah, Salt Lake City, Utah

The Journal of Credibility Assessment and Witness Psychology 2006, Vol. 7, No. 2, 164-168

Multimethod Assessment of Deception on Personnel Tests: Reading, Writing, and Response Time Measures

Experimental Design

	Item Presentation	
Guilt Condition	Serial	Parallel
Cash	n = 10	n = 10
Card	n = 10	n = 10
Innocent	n = 20	n = 20

Procedure

- Flyers posted around campus
- Interested students/staff called a secretary
- Preliminary instructions emailed
- Students came to a designated room
  - Signed a consent form
  - Read instructions on a computer

The Experiment

- 2 guilty conditions, 1 innocent condition
  - 2 mock-crimes
    - Cash
    - Card
- 3 types of true/false items
  - Neutral
    - "I was born prior to the year 1990."
  - Cash
    - "I was involved in the theft of the $20."
  - Card
    - "I took nothing from the student's computer."

Data Collection
Applied Sciences Laboratory Model 501
head-mounted eye tracker

Item Presentation

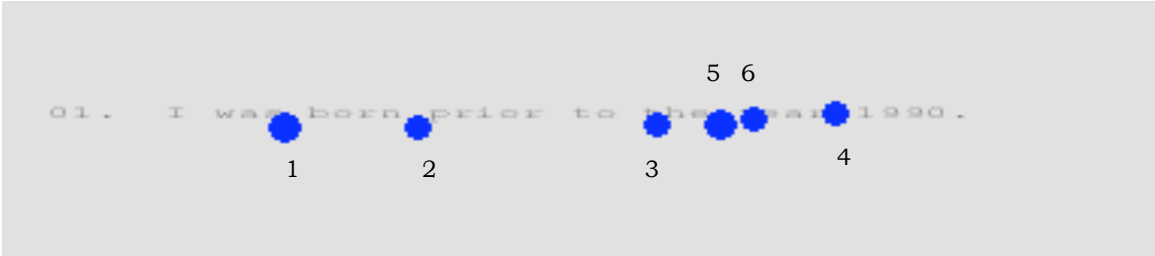
	T	F
3. I did not take the money that was in the secretary's purse.	○	○

Participants

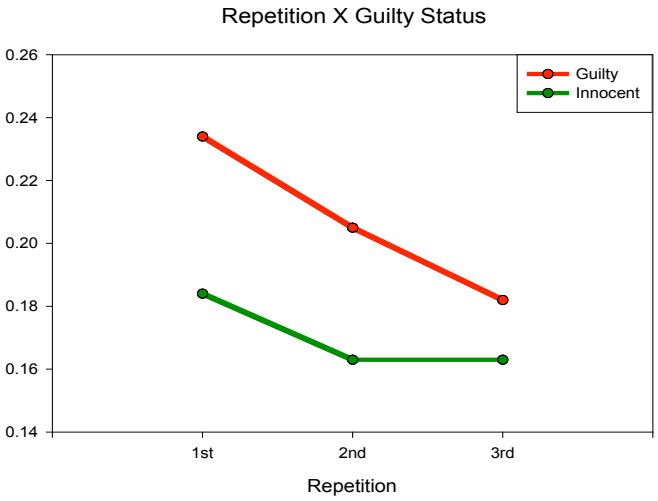
- 10 Cash, 9 Innocent
  - 8 female, 11 male
- Mean age: 22.32
- 78.9% Caucasian

Measures

- Number of fixations
- First pass duration (time reading)
- Second pass duration (time rereading)

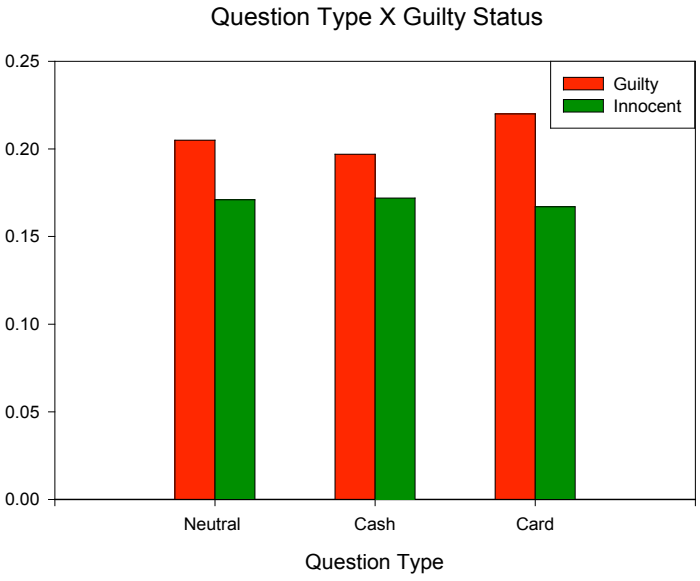


Results: Number of Fixations



- Guilty subjects make more fixations across repetitions than do innocent subjects
- Decrease in number of fixations across repetitions is predicted
  - savings in processing time

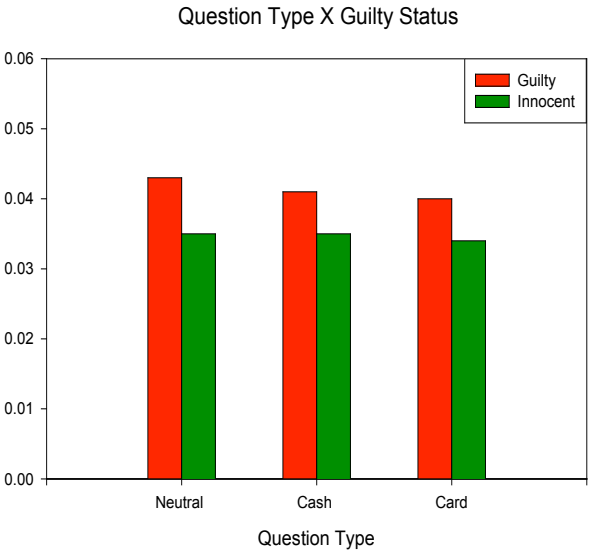
Results: Number of Fixations



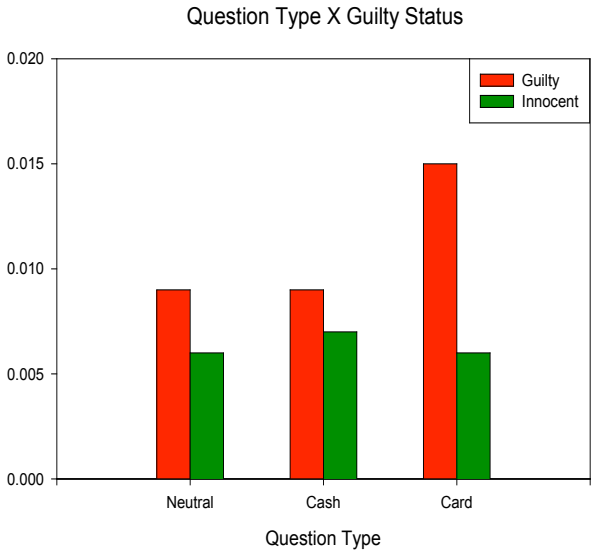
- Guilty subjects make more fixations across question types than do innocent subjects
- Guilty subjects make more fixations on the card items than on the other two types

Results: Reading and Rereading

Reading



Rereading



- Guilty subjects reread more than did innocent subjects
- Guilty subjects reread card items more than other items

Summary

- Traditional reading measures can be used to distinguish between guilty and innocent subjects
- Writing and response time measures
- Other eye movement measures
- Recruitment differences
- Motivation

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