

# Vocal Analysis Software for Rapid Security Screening: Validity and Credibility Assessment Potential

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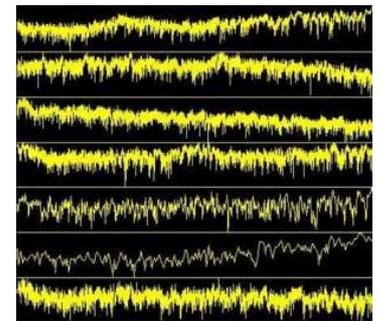
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# Introduction

- **Expanded usage of new vocal analysis software for credibility assessment**
- **A new generation of vocal analysis tools for detecting deception is available that**
  - Very few studies evaluating the vocal measures for:
    - Measurement validity and invariance
    - Measurement of stress, emotion, and cognitive effort
    - Predicting deception

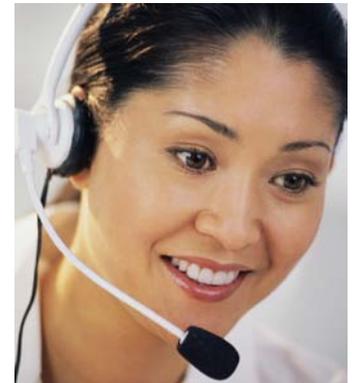


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# Vocal Risk Assessment

- **UK government investing 3 million dollars for claims assessment**
  - Housing
  - Welfare
- **Los Angeles Sherriff's department using for interrogation**
- **International airports screening passengers**



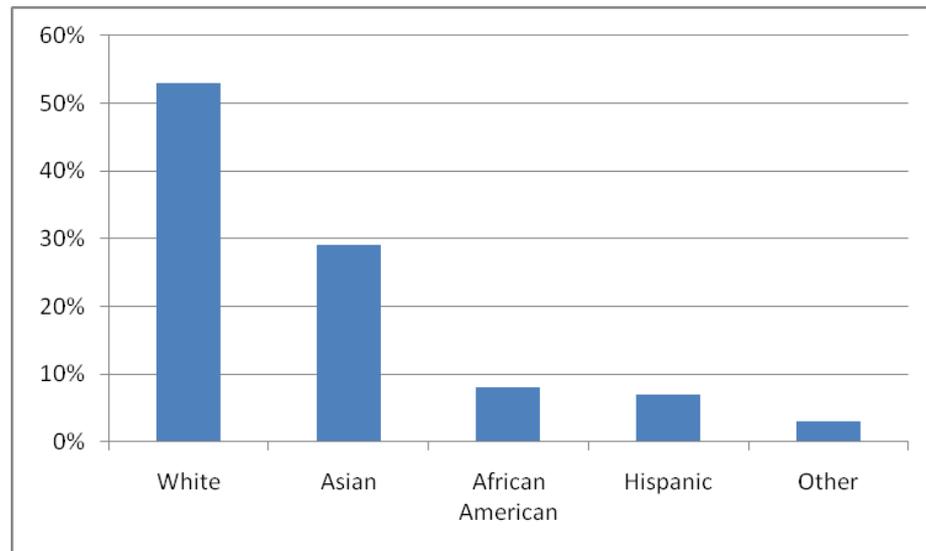
# Vocal Deception Detection

- **Time (Response Length and Latency)**
  - Deceivers speak in shorter durations
  - Deceivers have longer response latencies
- **Frequency (Pitch)**
  - Deceivers speak in increased pitch or frequency
- **Amplitude (Power or Volume)**
- **Previous Technology**
  - Vocal Stress Analysis
  - Microtremor in 10-15 Hz are contractions of muscles
  - Looks for drop in power suggesting lower blood pressure



# Description of Sample

- **220 subjects in original study**
- **96 subjects with comparable or usable audio**
  - Mean age = 26.1 (S.D. = 11.2) Range: 18 to 77
  - 55% Males and 45% Females
  - Culturally diverse



# Experimental Design

- **\$10 reward for appearing credible to professional interviewer**
- **Two Sequences:**

**First Sequence: DT DDTT TD TTDD T**

**Second Sequence: DT TTDD TD DDTT T**

- **13 Short-Answer Questions**
  - Only 8 had variation both within and between subjects
  - Two types of questions: Charged and Neutral



# 8 Short Answer Questions

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## Question

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1. Where were you born? **(N)**
  2. Did you ever take anything from a place where you worked? **(C)**
  3. Did you bring any keys with you today? **(C)**
  4. If I asked you to empty your wallet ...would anything in it embarrass you? **(C)**
  5. What city did you live in when you were 12 years old? **(N)**
  6. Did you ever do anything you didn't want your parents to know about? **(C)**
  7. Name the country stamped most often in your passport. **(N)**
  8. Did you ever tell a lie to make yourself look good? **(C)**
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Note. C are charged questions and N neutral questions.



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# Segmentation Process

- **96 Audio Files (11.025KHz, 8 bit, Mono)**
- **5 minutes of audio tagged as either noise, subject, or relevant**
- **Total of 1,181 vocal responses**
  - Sensitive to high signal-to-noise ratio
  - Low talkers
- **Generated vocal measurements for each relevant tag**
- **Vocal measures were those output by LVA**



# Nemesysco LVA 6.50

A security level voice analysis technology with online and offline modes for deception detection

**Name:**  **ID**  **Date:** 18/04/2004 **Testing ... (7)**

**Address:**   Male  Female

**Mark relevant** **Mute** **Truth** **End Test**

**Record Mode**

Show Issues | Show Graphs | Notepad | Bars Display | Segment Map

**Raw Values Bars Display**

Stress Cognitive Emotional Thinking S.O.S

**Quick Analysis : not enough samples**

**Warning Level**

**Wave Form(-)**

VT:12 VS:9

**Recalibrate**

Lie: 96 Exc: 113

Glb: 79 Cog: 98

**Lock Mixer**

**Full Graph View**

**Report Editor**

**Quit**

**Nemesysco 6.50**  
Investigation Focus Tools

LVA Voice Analysis Technology  
2003 (c) Nemesysco LTD



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# Nemesysco LVA 6.50 Layered Voice Measures

- **SPT** – Describes high frequency range (Emotional Level)
- **SPJ** – Describes low frequency range (Cognitive Level)
- **JQ** – Describes the distribution uniformity of low frequencies (Global Stress Level)
- **AVJ** – Average range of relatively low frequencies (Thinking Level)
- **SOS** – Say-Or-Stop describes changes in SPT and SPJ
- **LJ** – Measures very low frequency uniformity (Visual Memory)
- **Fmain** – Value of most significant frequency in frequency range
- **FX** – Additional significant frequencies in the spectrum (Deception)
- **FQ** – Uniformity of spectrum (Deception)
- **Fflic** – Describes frequency spectrum harmonics above 6.
- **ANT** – Evaluates expectation from highest three FRQ values



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# LVA Built-in Deception Detection Accuracy

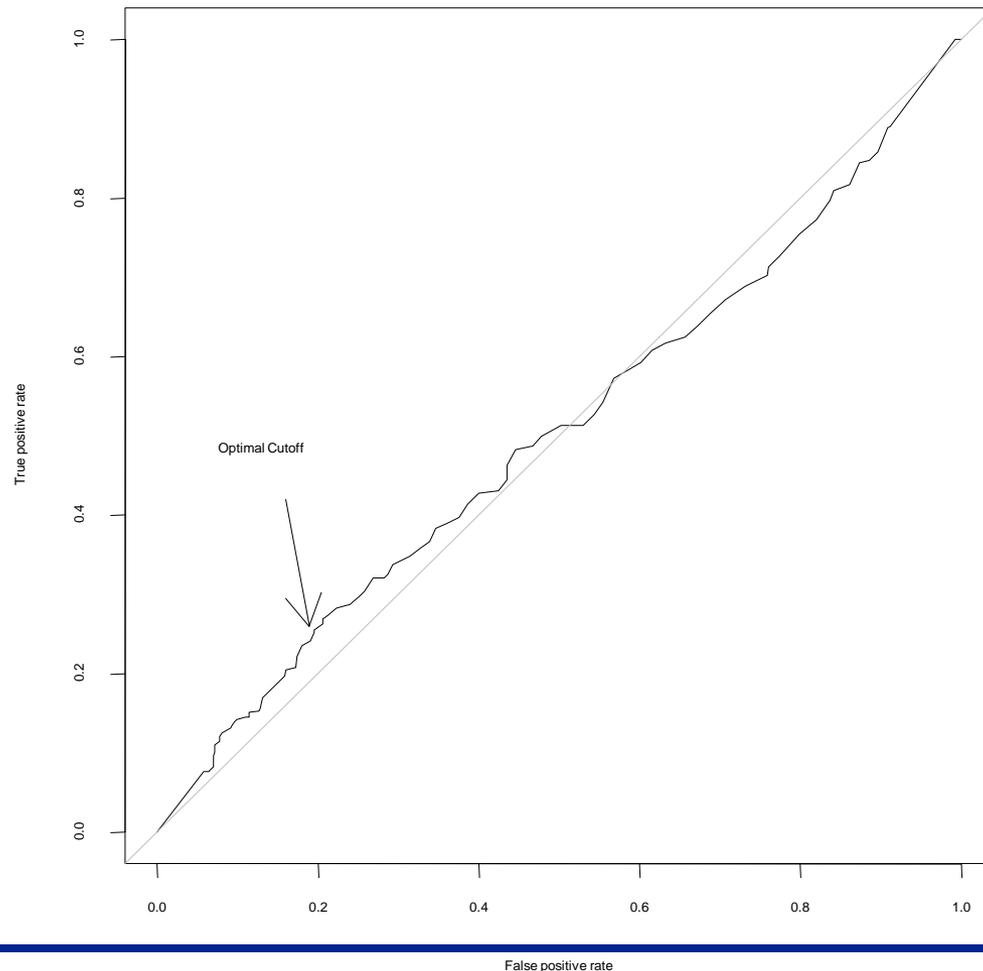
No difference in lie  
probability between liars  
or truth tellers

**F(1,735) = .59, p=.44.**

**AUC = .50**

**Total Accuracy = 52.8%**

**Optimal Cutoff: 26% TPR  
vs. 19% FPR**

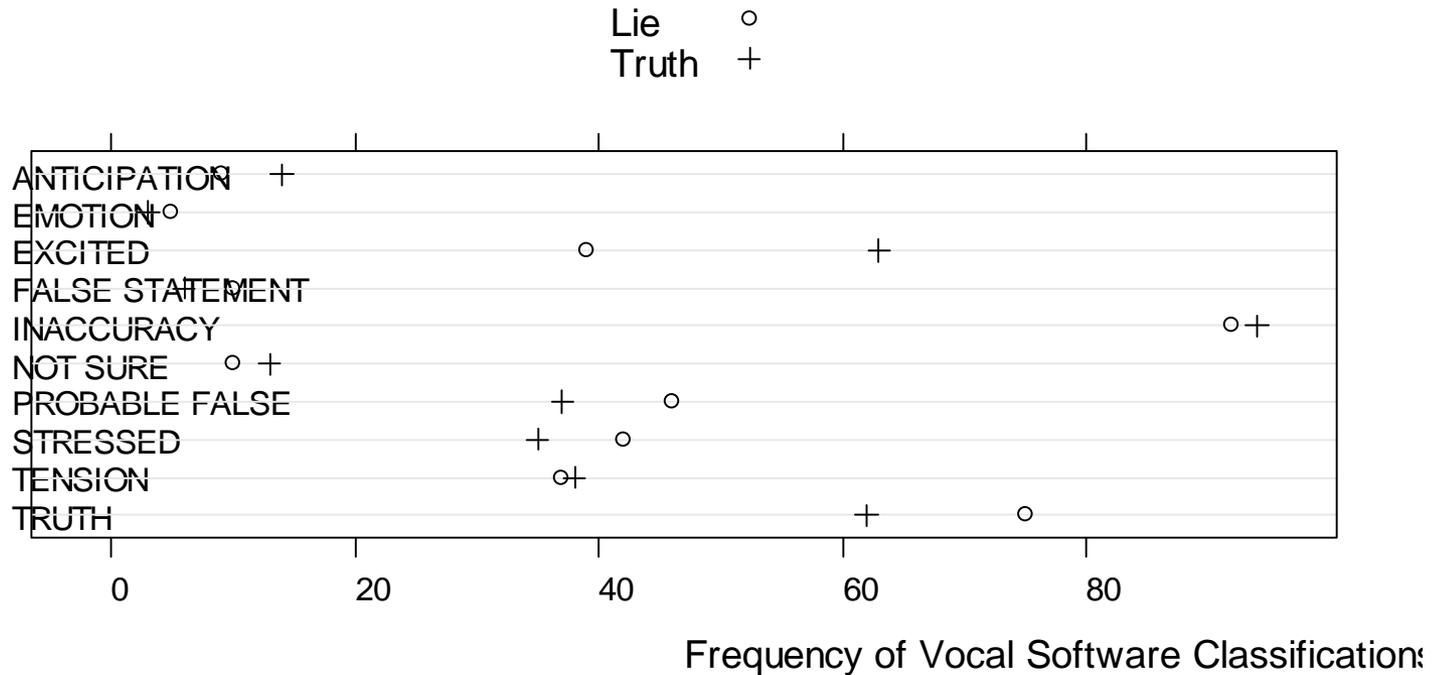


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# LVA Built-in Classifications Independent of Lie/Truth

$$\chi^2 (9, N=730) = 11.51, p = .24.$$



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# Experimental Hypotheses

- **H1: Liars differ from truthtellers vocally.**
  - Bonferroni correction ( $.05/13=.0038$ ) for familywise error correction
- **H2: Liars exhibit higher vocal indicators of cognitive effort than truth tellers.**
- **H3: Liars exhibit shorter message length.**



# Experimental Results

- **H1 and H2 Supported**
- Compared unconditional model against model with Truth/Lie Fixed Effect
- FMain (Stress)
- AVJ (Cognitive Effort)
- JQ (Stress)
- FFLIC (not significant after Bonferroni correction)

	d.f.	$\chi^2$	p
SPT	1	3.23	0.07
SPJ	1	0.32	0.57
<b>JQ</b>	<b>1</b>	<b>5.15*</b>	<b>0.02</b>
<b>AVJ</b>	<b>1</b>	<b>4.91*</b>	<b>0.03</b>
SOS	1	2.65	0.10
FJQ	1	0.03	0.85
<b>FMAIN</b>	<b>1</b>	<b>10.99*</b>	<b>&lt;.001</b>
FX	1	1.57	0.21
FQ	1	0.73	0.39
<b>FFLIC</b>	<b>1</b>	<b>4.18*</b>	<b>0.04</b>
ANTIC	1	0.03	0.87
SUBCOG	1	0.80	0.07
SUBEMO	1	0.23	0.63



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# Response Length

- H3 Not Supported, Response length for short responses not related to deception  **$F(1,734)=2.47, p>.05$** .
- Response length did differ between charged and neutral question types  **$F(1,734)=189.48, p<.001$** .



# Question Effects



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# SOS and Question Type Interaction



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# Predicting Deception

- **Methodology**
- Sample randomly split into training set (N=368) and testing set (N=368)
- Models fit and tuned against training set
- Conservative to avoid over fitting and optimistic classification
- LVA built-in lie prediction had an overall accuracy of 49% and AUC of .52 against the test data set



# Predicting Deception with Logistic Regression

- Fmain
- AVJ
- Question Type
- Question Type \* SOS Interaction
- Significant fit to training data set

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## Fixed Effects

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Intercept	1.630** (0.514)
Fmain	-0.033*** (0.009)
AVJ	-0.011~ (0.007)
CQ	1.425~ (0.812)
CQ * SOS	-0.180~ (0.094)

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~p<.10; \*p<.05; \*\*p<.01; \*\*\*p<.001

Note: Models were fit by Laplace approximation.; CQ is Charged Question



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# Lie Detection by Question

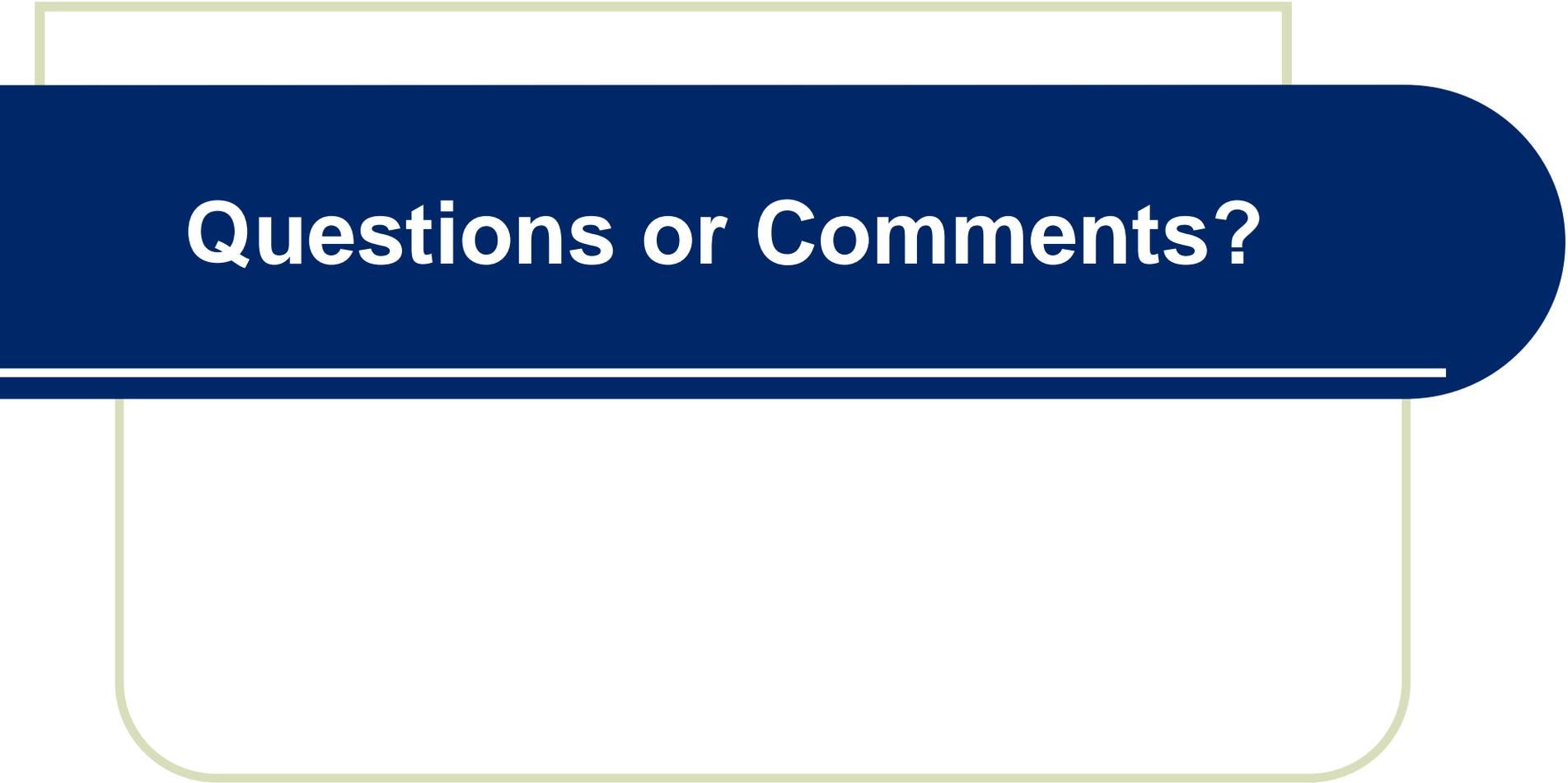
	Built-in	Logistic	Tree	SVM
1. Where were you born? (N)	51.04%	<b>53.19%</b>	42.55%	<b>53.19%</b>
2. Did you ever take anything from a place where you worked? (C)	57.30%	<b>59.52%</b>	54.76%	54.76%
3. Did you bring any keys with you today? (C)	48.86%	<b>62.50%</b>	52.50%	52.50%
4. If I asked you to empty your wallet ...would anything in it embarrass you? (C)	49.47%	47.17%	<b>50.94%</b>	<b>50.94%</b>
5. What city did you live in when you were 12 years old? (N)	52.63%	<b>59.18%</b>	55.10%	55.10%
6. Did you ever do anything you didn't want your parents to know about? (C)	49.45%	<b>62.79%</b>	51.16%	<b>62.79%</b>
7. Name the country stamped most often in your passport? (N)	<b>57.89%</b>	51.06%	38.30%	46.81%
8. Did you ever tell a lie to make yourself look good? (C)	<b>55.68%</b>	45.83%	54.17%	50.00%



# Discussion

- **No cultural moderation of deceptive behavior**
- **Built-in classification performed at chance level**
- **Vocal measures independent of system discriminated deception: FMain, AVJ, and SOS**
- **Logistic regression performed best on charged questions**
  - Higher pitch, cognitive effort, and hesitations are predictive of deception in more stressful interactions
- **The claim that the vocal analysis software measures stress, cognitive effort, or emotion cannot be completely dismissed**





**Questions or Comments?**