DECEPTION DETECTION

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Introduction

- Deception detection is based on the theory that when stressed or anxious there are certain inadvertent changes that occur in the body
- Many of the tests are related to the hypothesis that a defensive response causes a fight or flight response in the body, which increases skin conductance and changes heart rate

    - Changes that have been investigated are quite wide and varied
        - Muscles
        - Brain blood flow
        - Breathing
        - Heart rate
        - Speech
        - Body Temperature

History

- Ancient China (3)
  - It was believed that if a guilty party were stressed or anxious they would stop salivating
  - During a prosecutor's speech, the accused would hold rice in their mouth, if it was dry at the end, they were guilty

- Cesare Lombroso (1835-1909) (7/9)
  - Italian criminoligist and founder of the Italian School of Positivist Criminology
    - Had some odd theories about criminality being inherrited
      - Someone could be identified by characterisitics including large jaws, high cheekbones, large chins, hawk like noses, fleshy lips, shifty eyes, long arms,…
  - Discovered blood pressure and heart rate increase during lying and tested this using a water filled plethysmograph that recorded changes in pressure on kymograph

History – The Polygraph (3)

- The most commonly know method of deception detection is referred to as the polygraph
  - This is a general term referring to a series of physiological responses being recorded simultaneously in response to questions
  - Some commonly recorded signals
    - Blood Pressure
    - Pulse
    - Respiration
    - Skin Conductivity – Galvanic Skin Response

- Although still not admissible in court, it can often be used to aid in investigation
  - Can be used to see if suspect is worth pursuing
  - Can be used to help focus investigation

Overview – Questioning Methodology (3)

- Comparative Questions Test (CQT)
  - Compares physiological reactions to questions about the crime to reactions to irrelevant questions
  - Makes both guilty and innocent people nervous so could give false guilty

- Concealed Information Test (CIT) / Guilty Knowledge Test (GTK)
  - Subject is presented with series of multiple choice questions with a few incorrect answers and one correct for each
    - Only a subject with knowledge of the correct answer will have a reaction to it and responses to other choices can be used as a baseline

The Standard Polygraph (1)

- Experiments are still being performed on the same types of systems that have been around for decades

- An recent experiment was performed at Ghent University as a joint study between the Psychology and Applied Math and CS departments to determine the types of responses expected on a "standard polygraph" when comparing lies to concealed information

- There is currently conflicting evidence on what happens to heart rate during a lie, as it is often seen to speed up and then decelerate

- The study tries to support the theory that the initial acceleration is due to actually preparing to verbalize a yes/no answer and that in a concealed information test, only the heart rate deceleration would be seen

The Study (1)

- Participants were told they were participating in a experiment on feigned amnesia detection and were told to try to hide recognition of information about themselves

- They were offered a cash prize if they succeeded

- Skin conductance was measured using a constant .5V source and sampled at 10Hz

- Respiration was measure using a strain gauge around the thorax which was sampled at 250 Hz

- Respiration line length was measured by combining the amplitude of the breath with the rate of the breath
  - Lower line length expected on concealed information

- Heart rate was determined using a photoelectric transducer on the left index finger sampling at 500 Hz.
  - The same sensor was used to calculate finger pulse amplitude and finger pulse line length

Results (1)

- The test was done based on stating correct and incorrect biographical information about the subject based on a form they initially filled out

- The largest effect was seen on skin conductance

- Finger pulse amplitude did not show any correlation to lying

- In silent condition correct information caused a 1-5 bpm drop in heart rate 1-3 seconds after the stimulus, more significantly than for the incorrect items

Overview - Newer Tests

- Audio Analysis
  - There is still some research going into this but it is not found to be very reliable on its own

- Body Movement
  - The theory is that when someone is trying to lie, they become overly aware of their body movements

- FMRI
  - A functional magnetic resonance image of the brain shows blood flow that tends to change during deception or recognition

- FNIRS
  - Functional near-infrared spectroscopy, a cheaper alternative to FMRI

- Thermal analysis
  - Body temperature changes with mood

fMRI – Functional Magnetic Resonance Imaging (5)

- The ability to lie a complex process that requires specific areas of the brain every time it is performed

- Unlike other deception detection tests which measure the indirect effects on the body from lying, fMRI detects the brain activity that allows a person to create a lie

- Scalp recorded event-related potentials (ERPs) can measure the voltage levels accurately but it is hard to determine exactly where in the brain they came from

- BOLD – Blood Oxygen Level Dependent fMRI accurately measures the changes in blood flow through the brain

- Most studies have found lying activates the anterior cingulate and the prefrontal cortex which are responsible for inhibition and behavior modification

fMRI – The Study (2005) (5)

- Previous studies could not show results for individuals, only averages of group data due to the poor SNR of fMRI

- Experiment consisted of two parts, model building and model testing

- For model building, subjects were recruited to participate in a mock-crime by stealing either a watch or a ring and then deny performing the crime

  - They were also offered a $50 prize if they could fool the examiner to provide incentive to attempt countermeasures

- 515 images were taken of the brain, one every 1867 msec positioned to the anterior commissure-posterior commissure line

- The responses were performed using a button press for yes/no answers rather than verbal responses

fMRI – The Study (2005) (5)

Neutral

- 1.Do you like to swim?
- 2.Do you like to read?
- 3.Are you awake?
- 4.Are you asleep?
- 5.Are you under age 50?
- 6.Are you over age 18?
- 7.Do you like the beach?
- 8.Do you live in the United States?
- 9.Do you live in South Carolina?
- 10.Do you like chocolate?

- 11.Do you like to watch TV?
- 12.Do you have a dog?
- 13.Do you have a cat?
- 14.Is it 2004?
- 15.Do you like movies?
- 16.Do you speak English?
- 17.Is it October?
- 18.Are you at MUSC?
- 19.Are you in a research study?
- 20.Are you a student?

fMRI – The Study (2005) (5)

Control

1. Have you ever gossiped?
2. Have you ever done something illegal?
3. Have you ever done something immoral?
4. Have you used illegal drugs?
5. Have you ever deceived a loved one?
6. Have you ever made someone angry?
7. Have you ever committed a crime?
8. Have you ever cheated on a test?
9. Have you ever told a white lie?
10. Do you obey every traffic law?
11. Have you ever lied to your parents?

12. Have you ever cheated on your taxes?
13. Do you curse?
14. Have you ever faked an illness?
15. Are you a law-abiding citizen?
16. Have you ever forged a signature?
17. Have you ever kept the truth from someone?
18. Have you ever been arrested?
19. Do you speed?
20. Have you ever littered?

fMRI – The Study (2005) (5)

Watch

1. Did you take the watch from the drawer?
2. Is the watch in your locker?
3. Did you take the watch?
4. Did you steal the watch?
5. Was the watch stolen?
6. Did you hide the watch?
7. Do you know who took the watch?
8. Is the watch with your possessions?
9. Is there a stolen watch in your locker?
10. Did you take a watch that is not yours?
11. Did you put the watch in your locker?
12. Did you hide the watch in your locker?
13. Did you remove a watch from the drawer?
14. Did you steal a watch from the drawer?
15. Did you place the watch in your locker?
16. Did you keep the watch in the drawer?
17. Did you leave the watch in the drawer?
18. Did the watch stay in the drawer?
#19. Was the watch moved from the drawer?
20. Is the watch in the drawer?

fMRI – The Study (2005) (5)

Ring

1. Did you take the ring from the drawer?
2. Is the ring in your locker?
3. Did you take the ring?
4. Did you steal the ring?
5. Was the ring stolen?
6. Did you hide the ring?
7. Do you know who took the ring?
8. Is the ring with your possessions?
9. Is there a stolen ring in your locker?
10. Did you take a ring that is not yours?
11. Did you put the ring in your locker?
12. Did you hide the ring in your locker?
13. Did you remove a ring from the drawer?
14. Did you steal a ring from the drawer?
*15. Did you place the ring in your locker?
16. Did you keep the ring in the drawer?
17. Did you leave the ring in the drawer?
18. Did the ring stay in the drawer?
#19. Was the ring moved from the drawer?
20. Is the ring in the drawer?

fMRI – The Study (2005) (5)

- Images were passed through fMRI mapping software that corrected for head movements and differences in slice acquistion time, then normalized and smoothed to decrease the effect of errors

- The final image was created by subtracting truths from lies

- The results show significant activation in 7 clusters in the brain with 26 out of 30 subjects having significant activation in the same three clusters (and all showing some activation in these clusters)
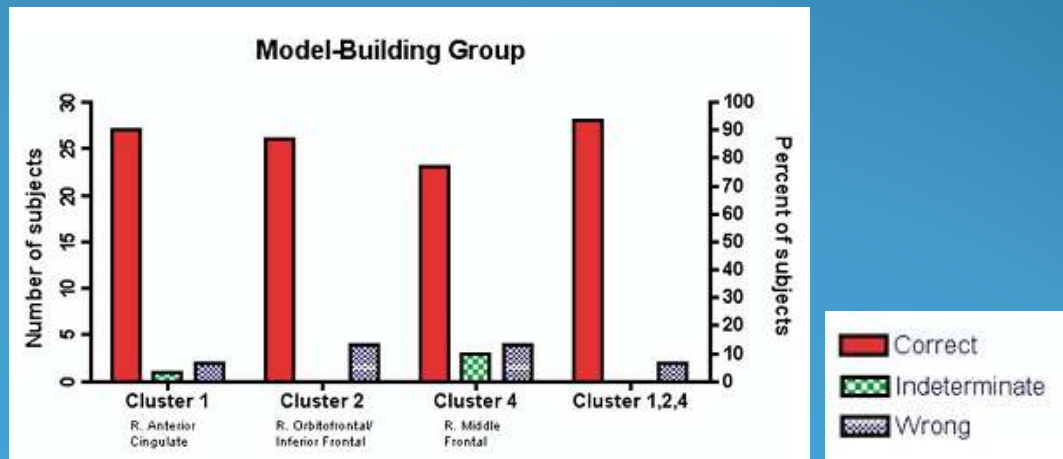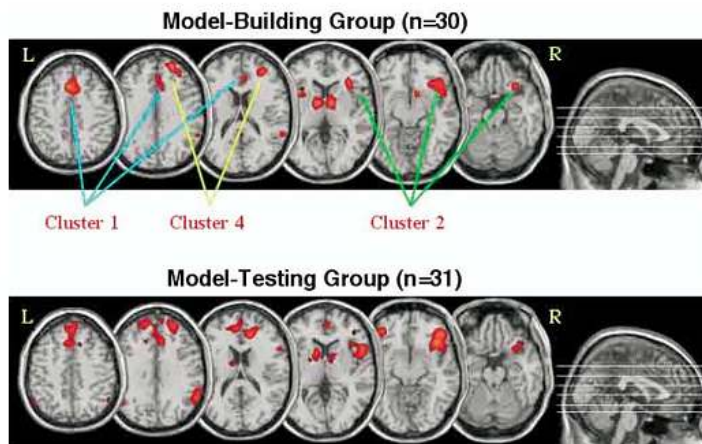
fMRI – The Results (5)

- Once the model was build, another 31 subjects were used as the model testing group
    - Using just cluster 1, deception was detected with 83% accuracy
    - Using clusters 1,2, and 4, deception was detected with 90% accuracy

- Positives Results:
    - Some subjects did say they tried to fool the machine by altering breathing or thoughts but there was no effect seen

- Concerns:
    - This test has lower risk than real world risks, not necessarily comparable
    - There was already a 50% chance of guessing correctly
    - A cooperative subject is required who will not refuse to answer questions, or will move their head

Model-Testing Group
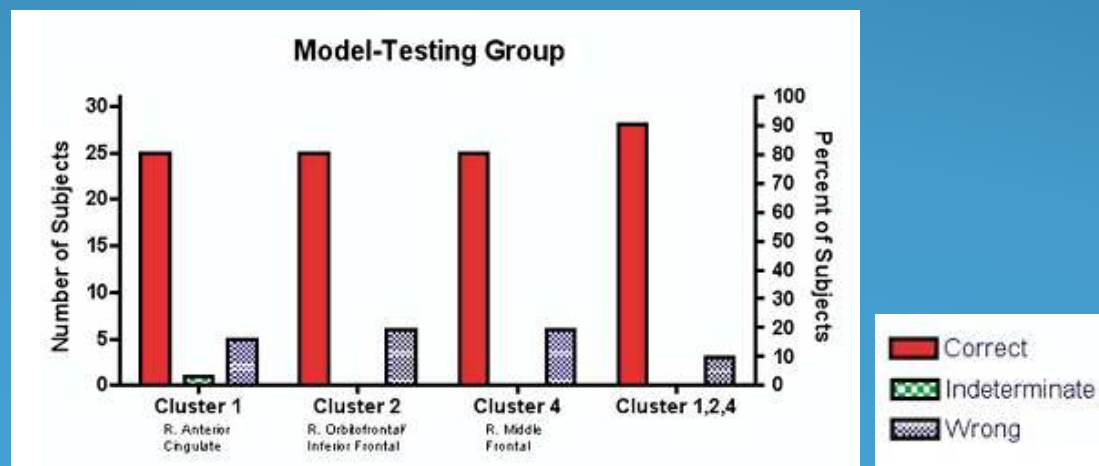
fNIRS – Functional Near-Infrared Spectroscopy (3)

- fNIRS takes advantage of the fact that infrared light can penetrate the human scalp

- It measures hemodynamic variations using near-infrared light that is absorbed oxygenated and deoxygenated hemoglobin

- Unlike fMRI, fNIRS can only detect the cortical layer of the brain but the fMRI study showed some of the clusters were located here

- It has poor spatial resolution (cm) but great temporal resolution (ms)

- 4 LEDs with 10 photodiode detectors were placed on the headand MRI was taken with test band to line up LEDs with parts of the brain
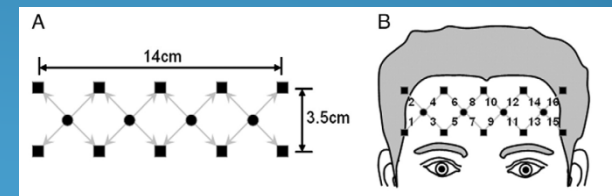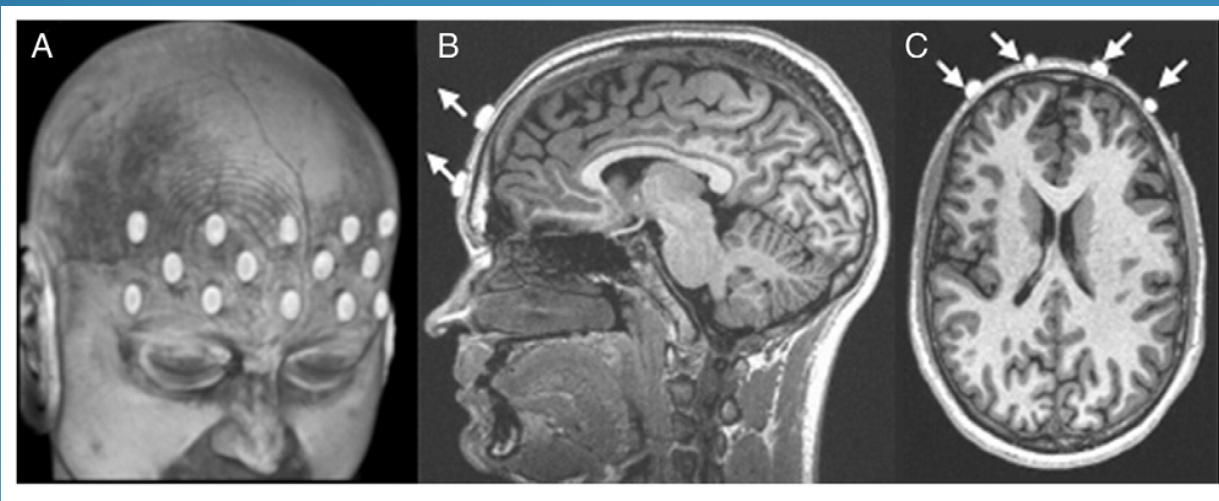
fNIRS – Functional Near-Infrared Spectroscopy (3)

$$\Delta OD(\lambda) = r \cdot DPF(\lambda) \cdot \{\varepsilon_{Hb}(\lambda) \cdot \Delta[Hb] + \varepsilon_{HbO2}(\lambda) \cdot \Delta[HbO_2]\}, \qquad (1)$$

$$\begin{aligned} \Delta[Hb] &= A \cdot \Delta OD_{\lambda 1} - B \cdot \Delta OD_{\lambda 2} \\ \Delta[HbO_2] &= - C \cdot \Delta OD_{\lambda 1} + D \cdot \Delta OD_{\lambda 2} \end{aligned} \qquad (2)$$

$$\begin{aligned} \Delta[Hb] &= 70.46 \cdot \Delta OD_{730} - 30.53 \cdot \Delta OD_{850} \\ \Delta[HbO_2] &= - 46.04 \cdot \Delta OD_{730} + 86.28 \cdot \Delta OD_{850} \end{aligned} \qquad (3)$$

- OD = incremental optical density (what the sensors measure)
- ε = molar absorption coefficient of HbO2 or Hb;
- $\Delta[HbO2]$ and $\Delta[Hb]$ are concentration changes of HbO2 and Hb
- r = distance between light source and detector
- DPF = differential path factor based on light scattering in tissue
- By using wavelengths of both 730 nm (with DPF of 6.7) and 850 nm (with DPF of 5.7) the densities can be calculated

fNIRS – Functional Near-Infrared Spectroscopy (3)

- The fNIRS samples were taken for 11 subjects at 3 Hz and passed through a high pass filter at .01 Hz and a low pass filter with cutoff at .6 Hz

- Under laboratory conditions, the system yielded 81.8% accuracy which is on level with the conventional polygraph but below that of fMRI
  - System was tested by using 10 samples as the model building cases and one as the test case and repeating this 11 times
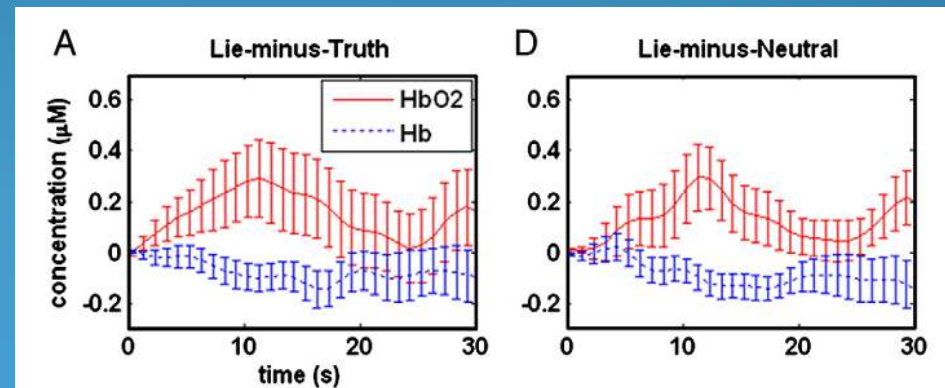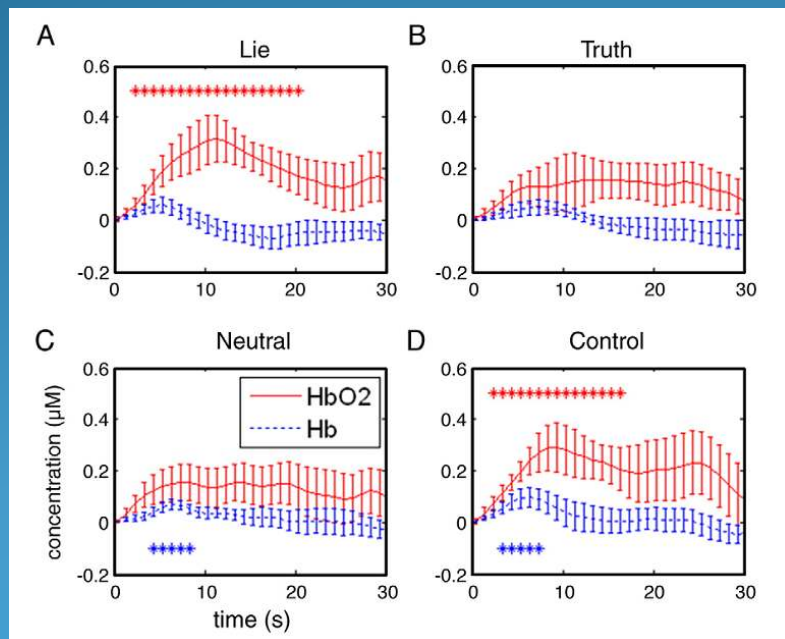
Body Movements

- Deception is often associated with involuntary body movements
- Liars may often try to avoid these movements to the point where they overcompensate, tense up, and cease all normal occasional movements
- Body movement detection does not require the subjects compliance or knowledge
- Using blob analysis based on skin color to recognize faces and hands, movement patterns can be identified
- Newer systems don't just identify lack of movement but can learn to recognize movement patters using neural network learning

Thermal Deception Detection (4)

- One type of thermal detection method is based on focusing the observations around the eyes and nose (the periorbital area)
- Anxiety in response to a question can cause a fight or flight response in a person which causes increased blood circulation to the eye to facilitate rapid eye movement
- Early papers could only determine that a blood flow increase occurred when the fight or flight response was triggered (they did this by surprising the test subject with a loud noise)
- More recent experiments have been able to quantify this using thermal cameras along with fuzzy based segmentation algorithms to track the periorbital regions from selected seed pixels
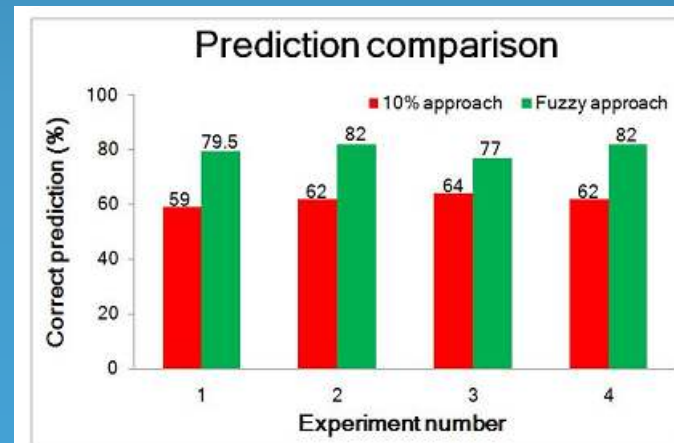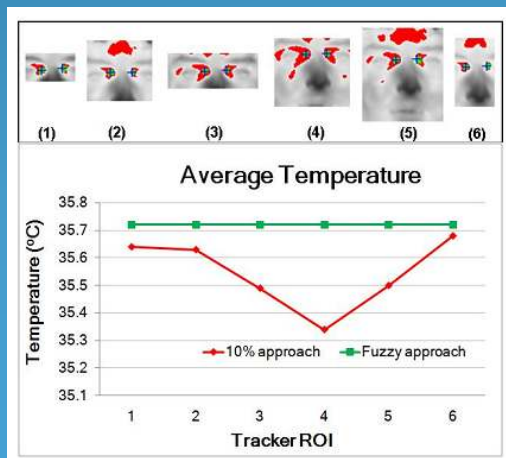
Future –

- Automated Computer Detection
- Detection Through Walls

- Ethical considerations
  - Do police need consent if it the deception detection method is non-invasive?
  - What happens to the right to remain silent if an answer is not necessary?
  - What happens if deception detection becomes so easy, it is portable, and available to the public?

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