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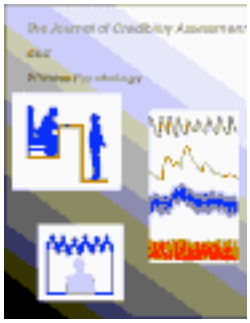

Eye Movement-Based Assessment of Concealed Knowledge

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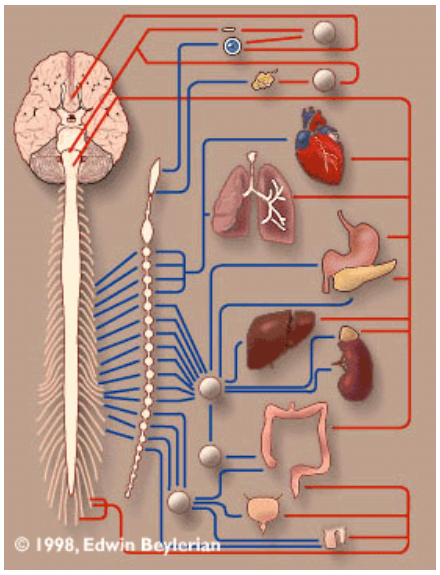
Eye Movement-Based Assessment of Concealed Knowledge

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

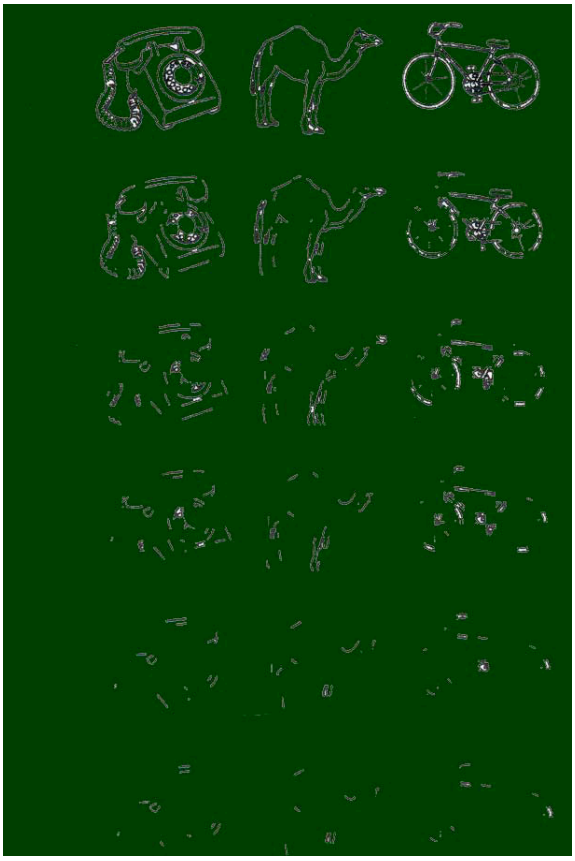
Measures of Memory – Indirect
Word Stem Completion

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

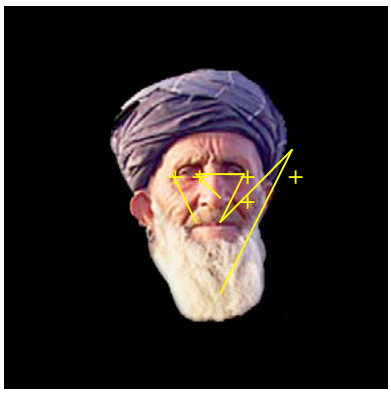
Measures of Memory – Indirect
Perceptual Identification: Images



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*

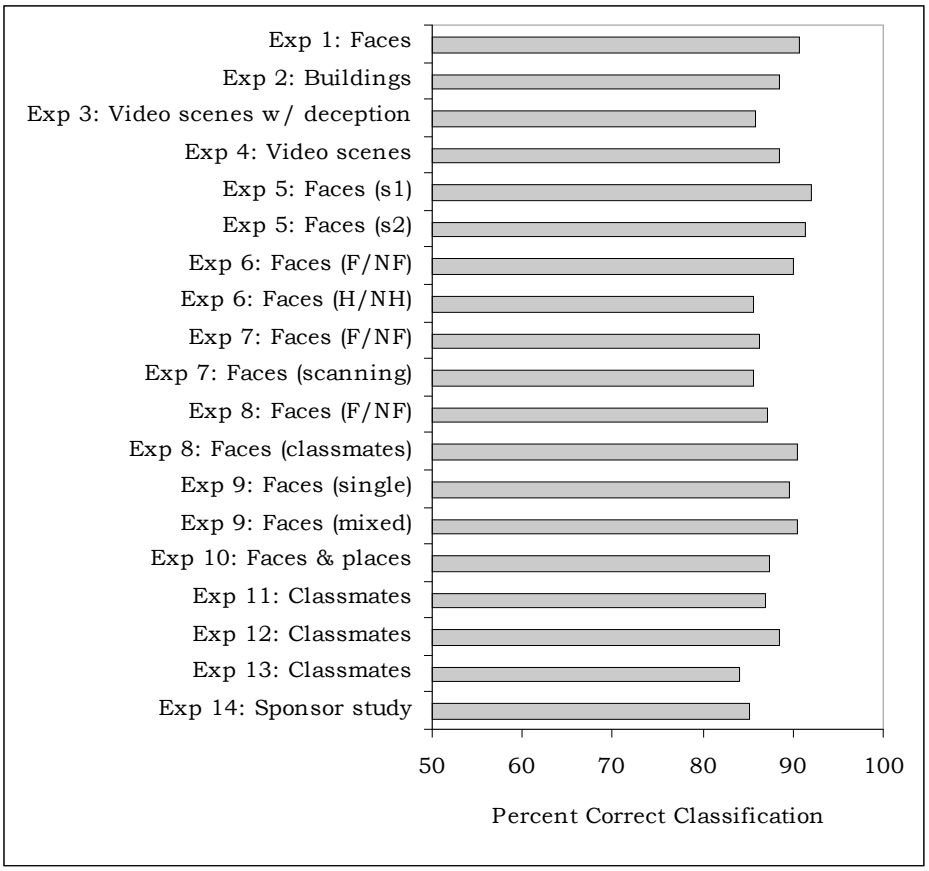
- Previously seen faces are viewed differently from novel faces
  - Fewer eye fixations
  - Fewer regions sampled
  - Less statistical constraint in sampling

* 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

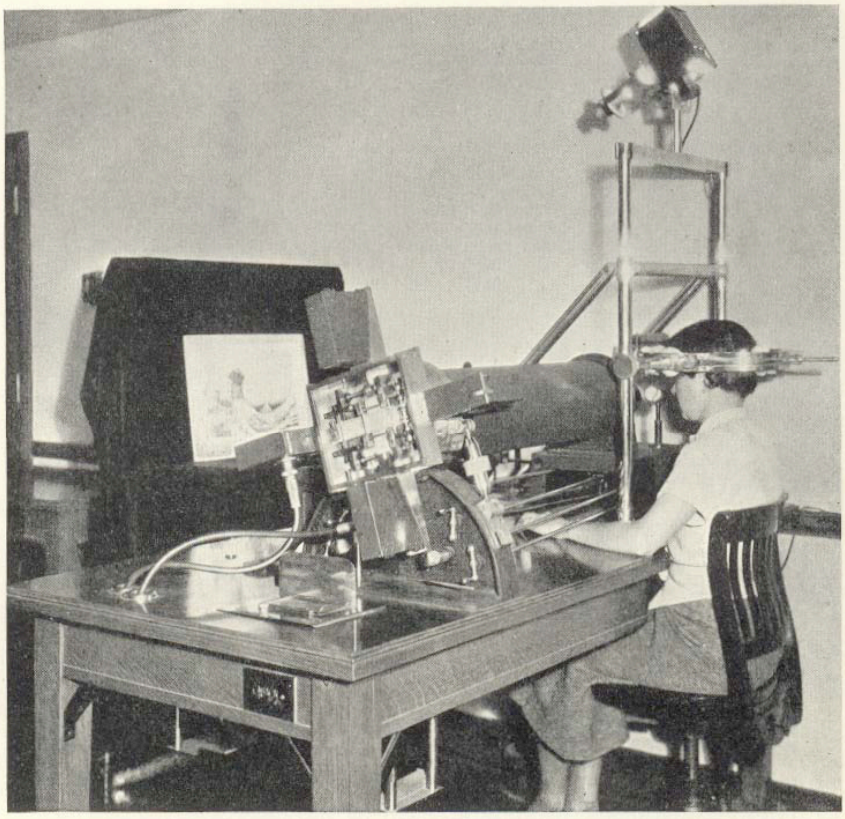
- US Government sponsor took delivery of a remote eye tracking system from the University of Illinois after six years of external research
- Internal research team formed with VRADC and personnel from Sponsor's organization to transition system from laboratory to field environment
- Effort named Project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

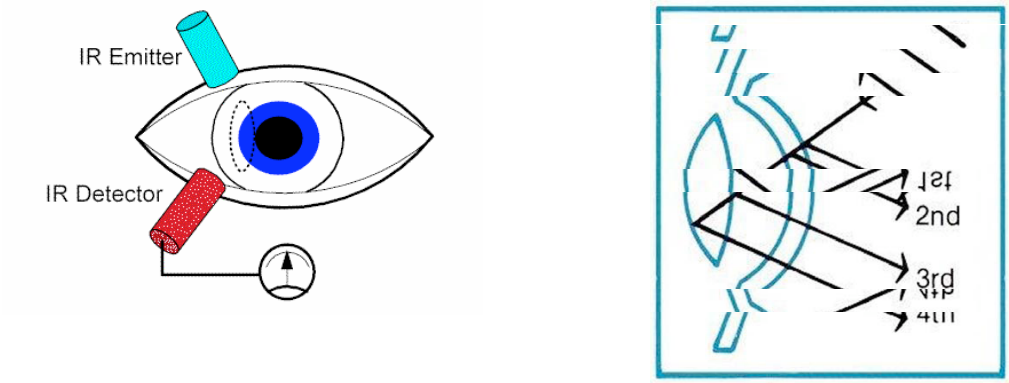
ISCAN, 1998

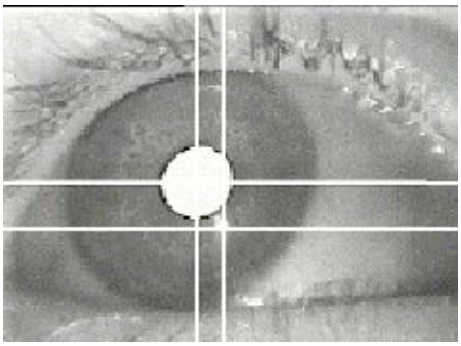
Eye Movement-based Assessment
Current Generation Eye Tracking

SMI System Configuration

Tobii System Configuration

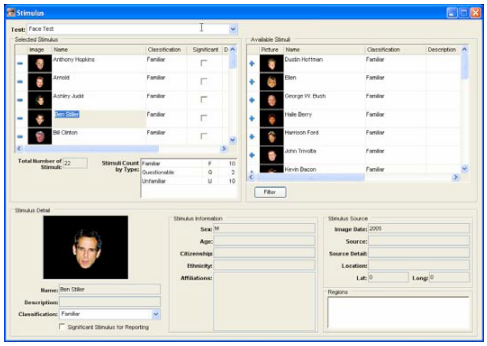
Eye Movement-based Assessment
Infrared Remote Eye Tracking





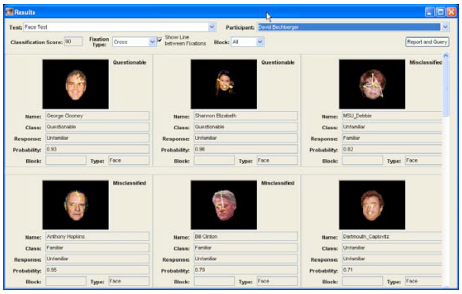
Eye Movement-based Assessment Methodology

Create Test



Integrated User Interface

Analyze Test



Conduct Test

SMI

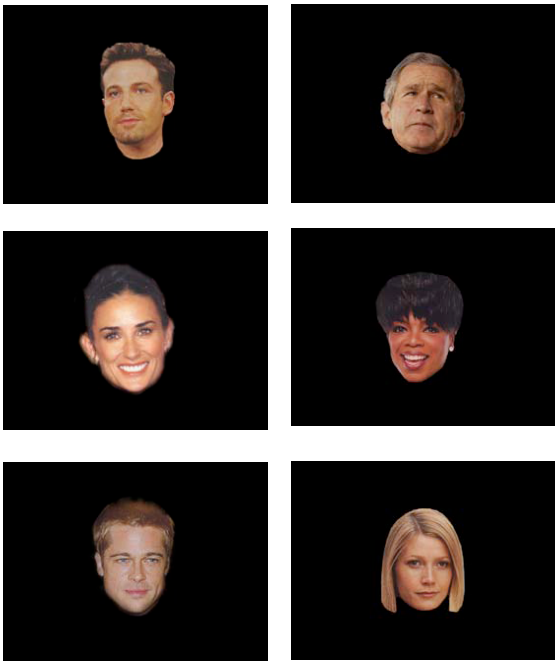
Tobii

Protocols

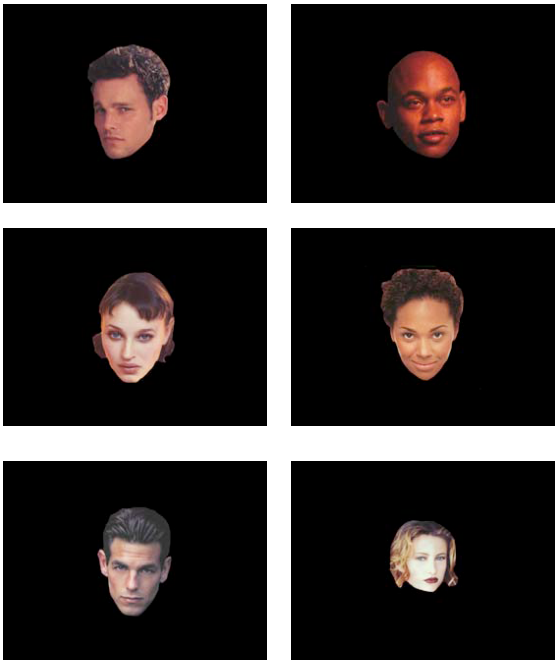
Group Membership

- Determine prior knowledge of group membership

Familiar



Unfamiliar



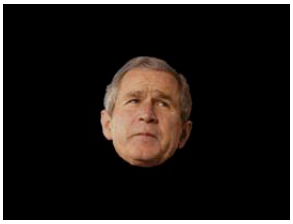
Sample Accuracy – Group Membership Protocol
Familiar/Unfamiliar

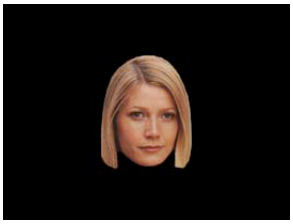
Stimulus	True Positive Rate	False Positive Rate
Faces	0.80	0.20
Objects	0.82	0.17
Scenes	0.81	0.14

Protocols
Specific Individuals

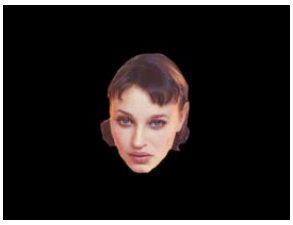
- Determine whether prior knowledge exists for a specific individual

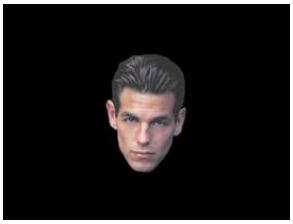
Familiar



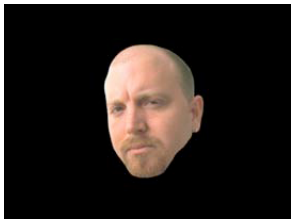


Unfamiliar



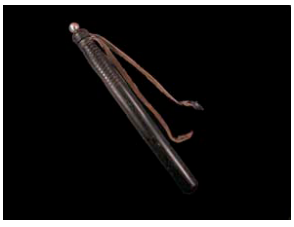


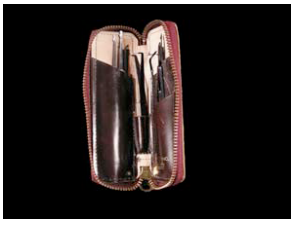
Questionable



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

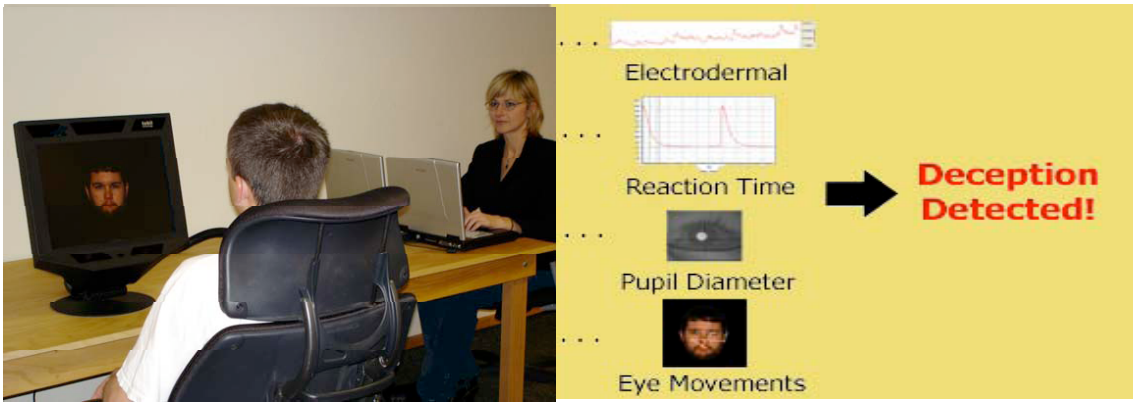
Suspect Questioning

Combatants

Border Crossing

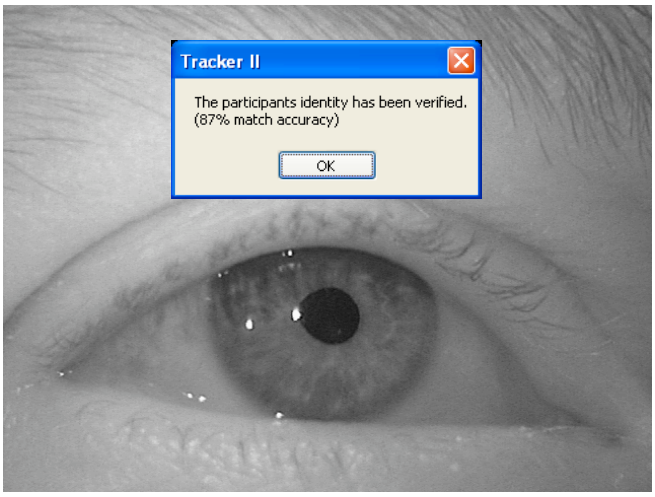
Current Research
Focused Screening

- 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

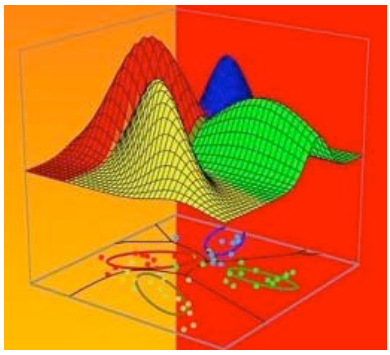


Curent Research
Determining Effect Boundaries

- 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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