Determining the Optimal Time on X-ray Analysis for Transportation Security Officers

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Rationale and Experimental Questions

- Transportation Security Officers will experience performance decrements
- This decrement is due to a vigilance decrement
- Current duty cycle is 30 minutes
- *What happens to performance when TSOs interrogate images for 2 hours?*
- *Are there individual differences?*

Is the TSO X-ray image analysis task a true vigilance task?

| Traditional Visual Search or Inspection tasks	Traditional Vigilance tasks
Complex scenes under the control of the searcher	Complex dynamic scene not under the control of the searcher
Multiple targets / classes of targets simultaneously	Usually has only one event at a time that is a transient target
TSA task is *self-paced* – and the scene doesn't change until the TSO advances the belt	Usually *task-paced* - targets appear and disappear as a function of task timing, the observer's decision process
Momentary lapse of attention won't result in an error	Momentary lapse of attention can result in a miss error that is not correctable
Length of signal presence is measured in seconds and is under the control of the TSO	Stimulus durations typically measured in milliseconds (e.g., in the See et al., 1995 meta-analysis, stimulus durations ranged from 2 to 1500ms)

Experimental Design

SOP/Belt (Between Ss)	Threat Type (Within Ss)	10-minute Epoch (Within Ss)
TSA Pre✓® - static	Clear	1-12
	Threat	1-12
TSA Pre✓® - continuous	Clear	1-12
	Threat	1-12
Standard - static	Clear	1-12
	Threat	1-12
Standard - continuous	Clear	1-12
	Threat	1-12

- Stimuli:
  - TSA-generated images of 1,000 carry-on items, displayed to TSOs on Sandia-created emulator
  - 99 with threats, same 99 imaged without threats
    - Called Threat and Cleared Threat bags
    - These are the bags used to calculate d prime and response bias
  - 802 clear items
  - Contents (e.g., presence of oversized LGAs) also controlled for, matched stream of commerce

Stimulus generation

- Generated either 31 or 32 image products for each of the 1,327 .rcf files TSA provided

  – Bounding box images (if generated by Rapiscan)

  – Normal view images

  – Black and white

  – Crystal clear

  – High penetration

  – Inorganic materials

  – Organic materials

  – Inverse colors

  – Variable color

  – Variable density

- 62 or 64 total image products per .rcf file (top and side view) captured for a total of **83,624** images
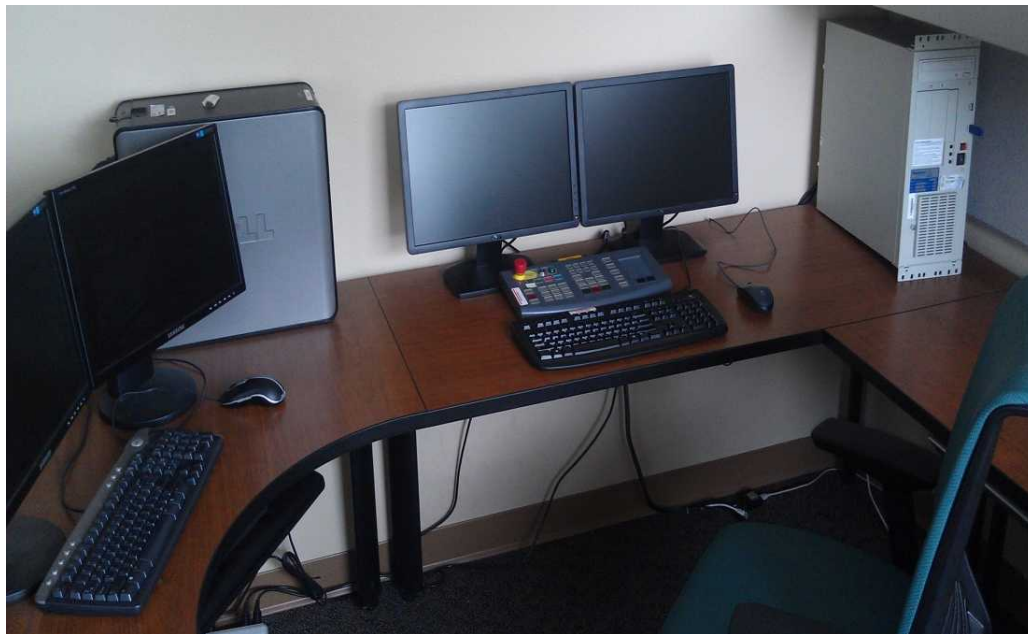
Three methods of image validation

- Filenames
  - All image products were present for all images
- Hash value
  - No two images across the 83,624 that we generated were identical
- Pixel values of .png versions of the original .rcf files compared to pixel values of normal color .png files SNL captured on emulator
  - Battelle.png file = Sandia-generated .png with the corresponding filename captured using the emulator
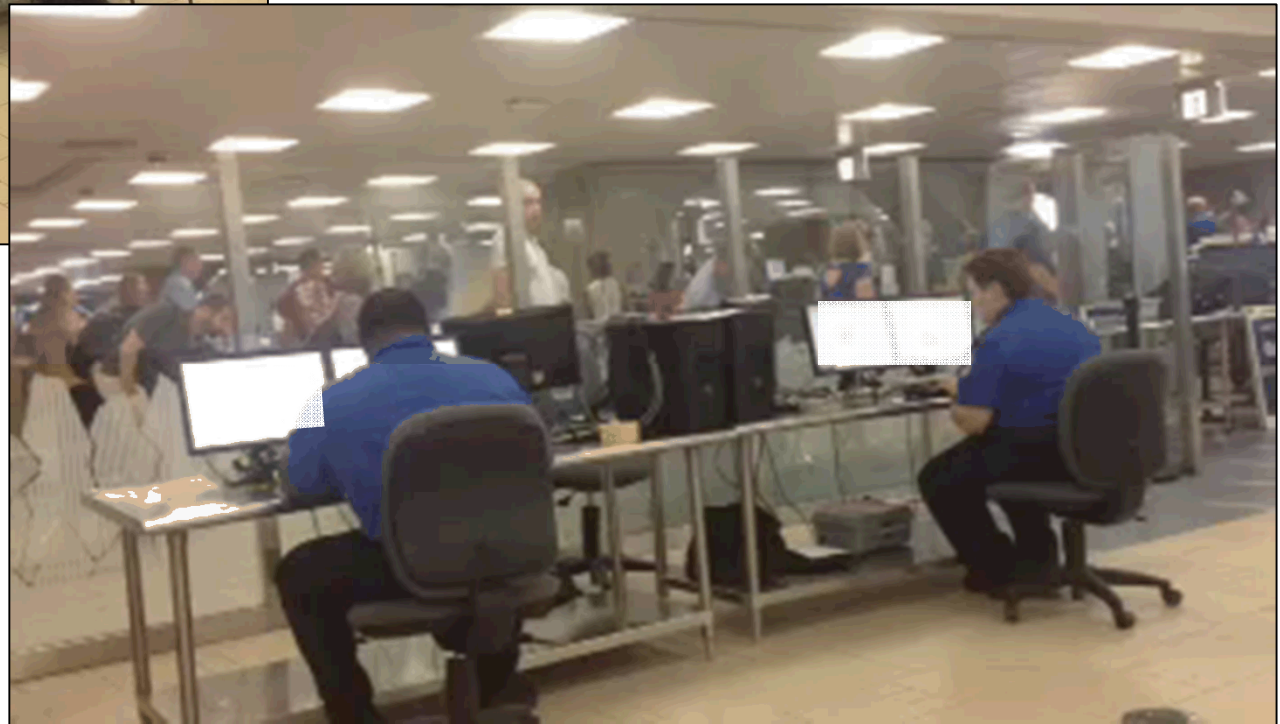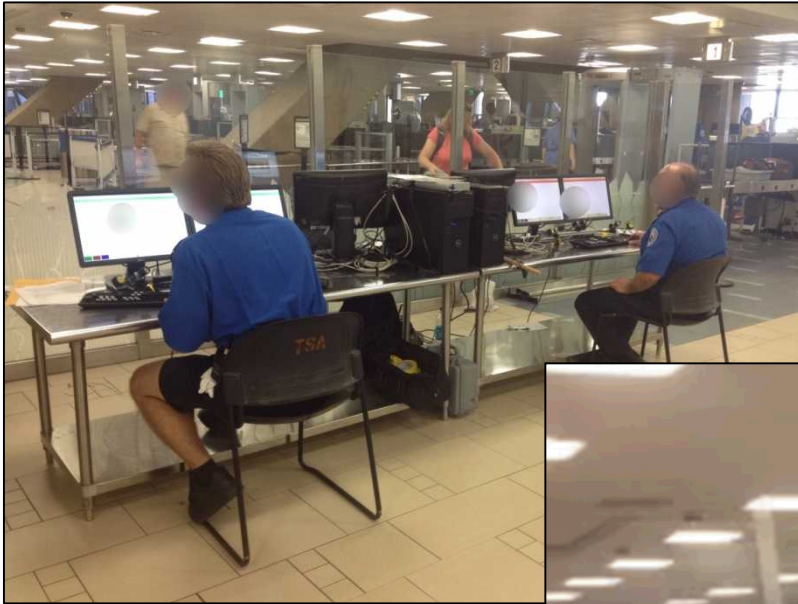
The System
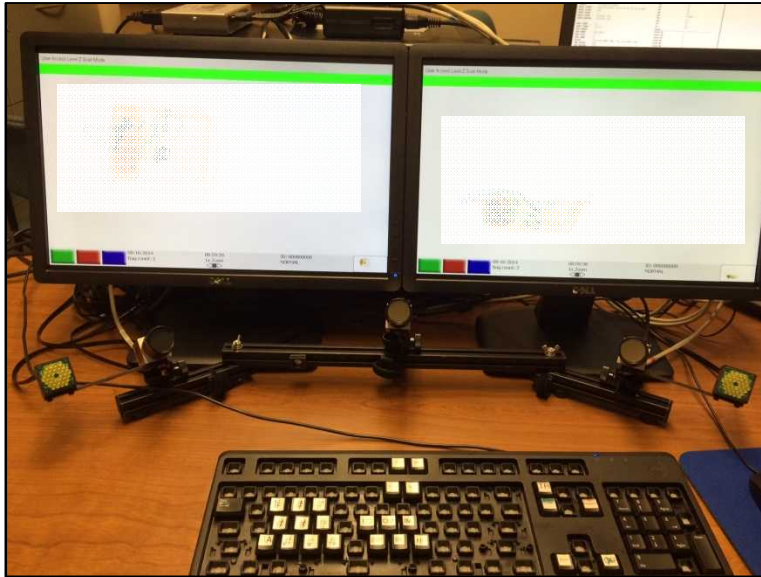
- Monitors identical to those used at checkpoint
- Three infrared eye tracking cameras from SmartEye
- MAAPS eye tracking data analysis software
- Located at the checkpoint
- Emulator captured all user interactions at nanosecond resolution
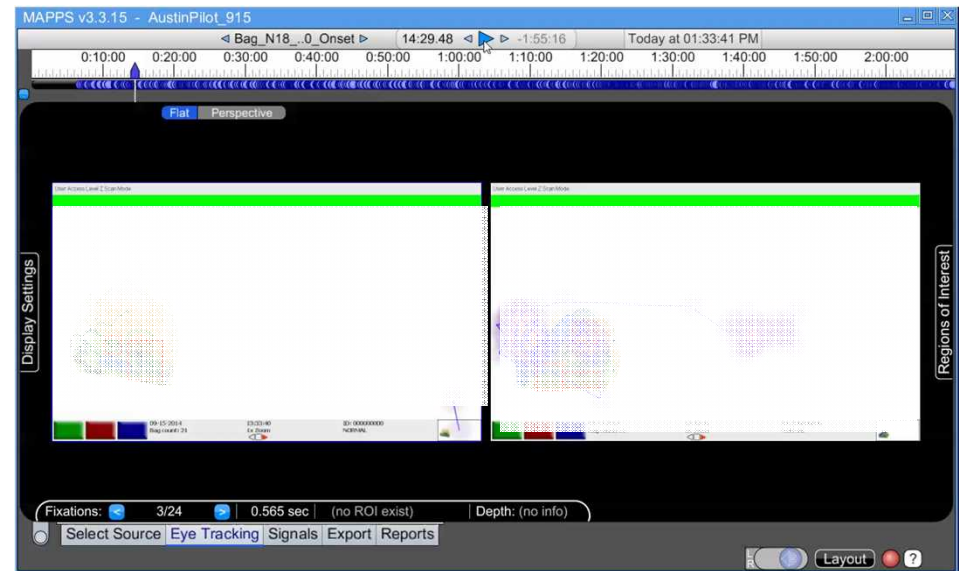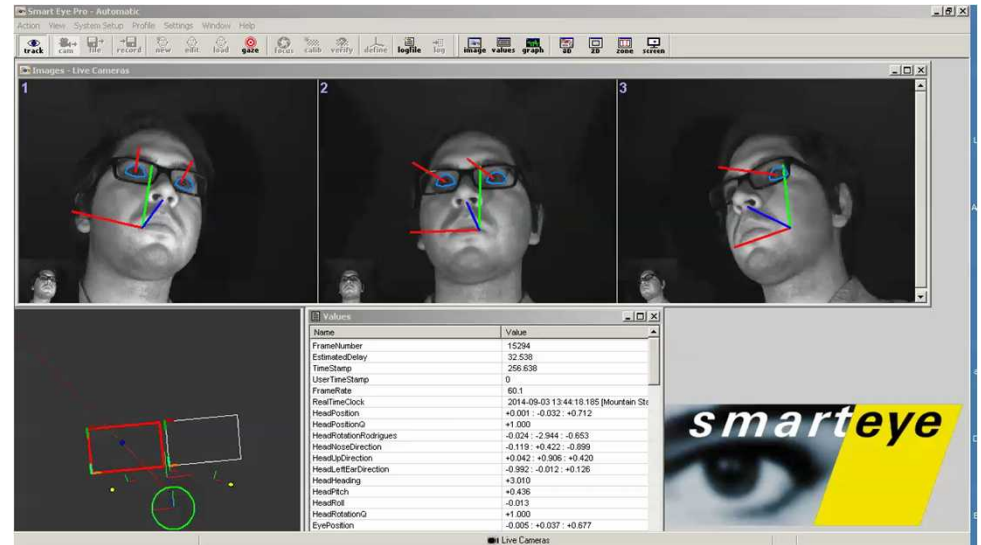
One of the setups

Dependent Variables & Procedure

- All calculated as a function of 5-minute epoch:
  - Pd, Pfa, d', response bias
  - Decision Time
  - Eye Tracking
  - Calculated variables – including d', c, search time consistency
  - Image product use (e.g., order of image manipulation tools, which tools selected, eye tracking patterns associated with each bag, etc.)
- General procedure
  - For each bag, TSO had to clear any bounding boxes, make a decision about the bag itself, indicate the number of threats and benign prohibited items they detected in each bag
  - 187 TSOs analyzed images for 2 hours with no breaks followed by a general cognitive battery

Resulting dataset

- 187 subjects across 6 airports
  - 90 female
  - Average age – 41.5
  - Average years experience as TSO – 7
- 2 hours of main baggage screening task
  - 85 to 1000 bags interrogated in 2 hours
  - Mean = 467, SD = 201.5
  - Total: 87,438 observations contributing to each behavioral DV
  - Between 5831 and 8384 observations per epoch
- 45 minutes of domain-general visual cognitive battery
  - Details in Matzen et al. (this session)
- Eye tracking (60Hz) and user interaction log
  - Over 80 million data points of eye tracking
  - Terabytes of human data

Data analysis

- Behavioral data
  - Multilevel models for each DV
  - Covariates
    - Multilevel models – each DV
    - Multiple linear regression – random slope and intercepts from primary multilevel models
- Eye tracking analysis
  - Time to first fixation
  - Types of errors
  - Scan patterns
  - Etc.
  - Relationship between eye tracking on general cognitive battery and bag search task
- Machine learning analysis
  - Details in Stracuzzi et al (this session)