White Box Study - The Performance of Latent Print Examiners as Revealed by Eye Tracking Methodologies

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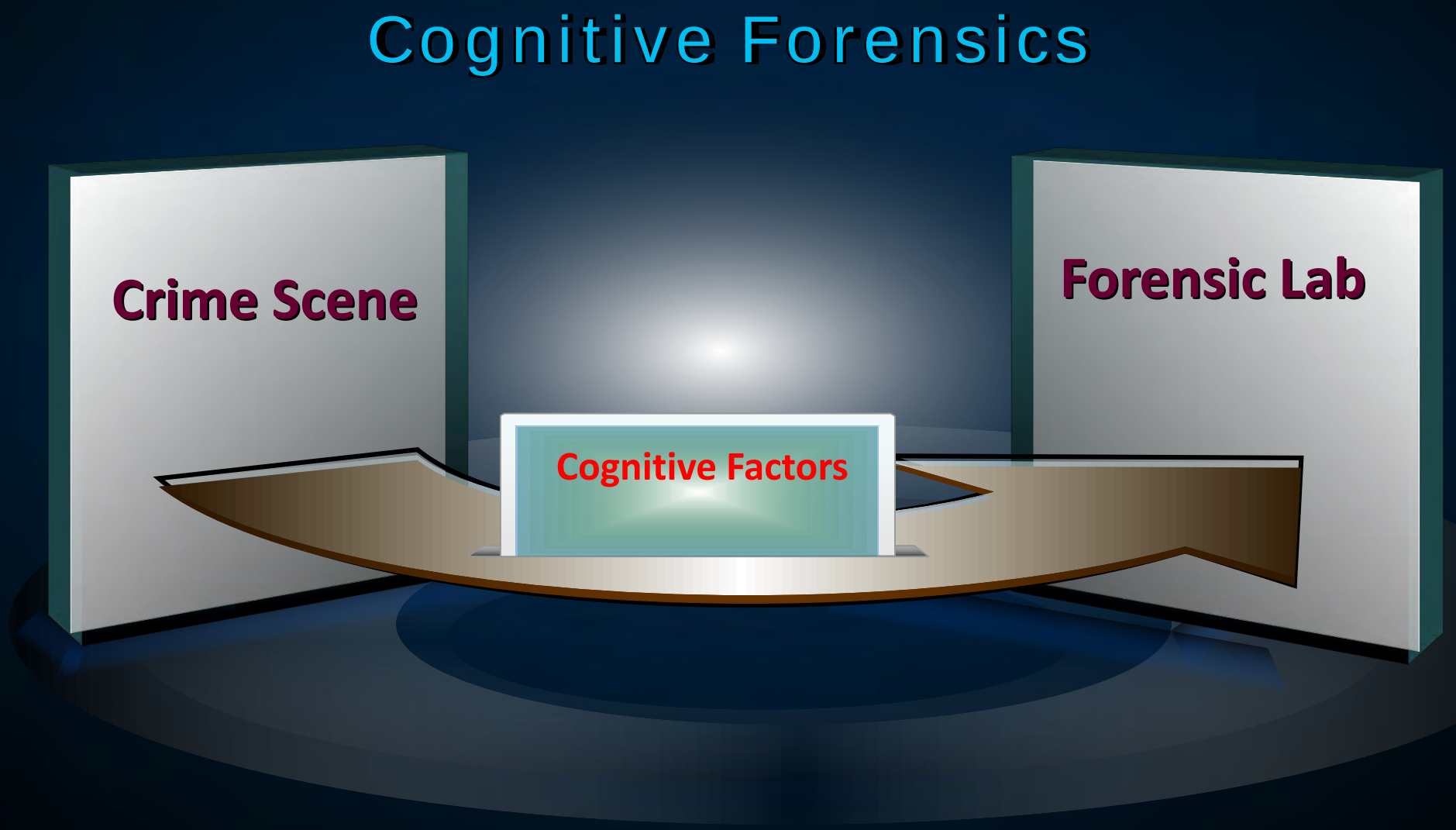
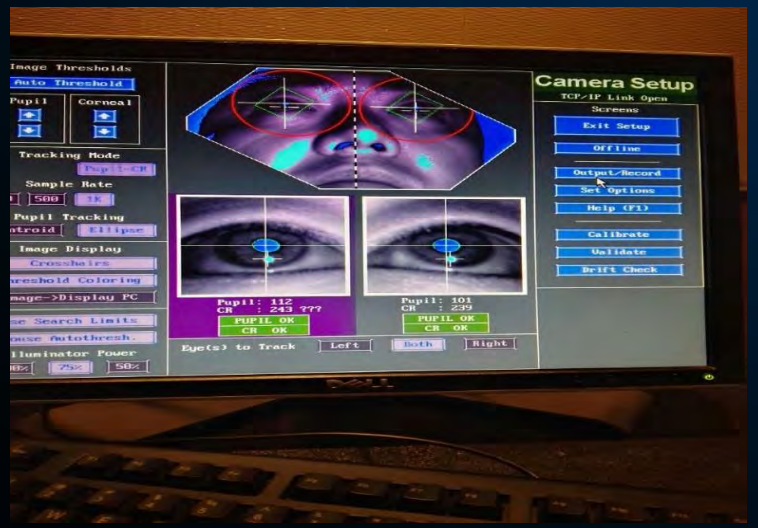


White Box Study



2016 IAI Conference

White Box Eye-Tracking Study

FBI Laboratory
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Tom Busey Indiana University

White Box Study

24th – 28th June, 2019 IFRG Conference Sheffield University, UK

ORIGINAL ARTICLE Open Access

Gaze behavior and cognitive states during fingerprint target group localization

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Abstract

Background: The comparison of fingerprints by expert latent print examiners generally involves repeating a process in which the examiner selects a small area of distinctive features in one print (a target group), and searches for it in the other print in order to isolate this key element of fingerprint comparison, we use eye-tracking data to describe the behavior of latent fingerprint examiners on a narrowly defined "find the target" task. Participants were shown a fingerprint image with a target group indicated and asked to find the corresponding area of ridge detail in a second impression of the same finger and state when they found the target location. Target groups were presented on latent and plain exemplar fingerprint images, and as small areas cropped from the plain exemplars, to assess how image quality and the lack of surrounding visual context affected task performance and eye behavior. One hundred and seventeen participants completed a total of 675 trials.

Results: The presence or absence of context notably affected the areas viewed and time spent in comparison; differences between latent and plain exemplar tasks were much less significant. In virtually all trials, examiners repeatedly looked back and forth between the images, suggesting constraints on the capacity of visual working memory. On most trials where context was provided, examiners looked immediately at the corresponding location: with context, median time to find the corresponding location was less than 0.3 s (second fixation); however, without context, median time was 1.9 s (five fixations). A few trials resulted in errors in which the examiner did not find the correct target location. Basic gaze measures of overt behaviors, such as speed, areas visited, and back-and-forth behavior, were used in conjunction with the known target area to infer the underlying cognitive state of the examiner.

Conclusions: Visual context has a significant effect on the eye behavior of latent print examiners. Localization errors suggest how errors may occur in real comparisons: examiners sometimes compare an incorrect but similar target group and do not continue to search for a better candidate target group. The analytic methods and predictive models developed here can be used to describe the more complex behavior involved in actual fingerprint comparisons.

Keywords: Eye tracking, Forensics, Latent fingerprints

Significance statement

Visual localization is a critical task within the fingerprint comparison process, in which the fingerprint examiner analyzes and memorizes a specific area of detail in one fingerprint and searches for the corresponding area in another fingerprint. This study isolates individual localization tasks, and details how eye-gaze behavior can be used to describe and analyze how fingerprint examiners perform localization.

Background

This study is the first detailed evaluation of localization in fingerprint comparison. Latent fingerprint comparison is critically important within the criminal justice system. A variety of studies have shown that the accuracy and reliability of conclusions by fingerprint examiners are imperfect (eg., Neumann, Champod, Yoo, Genessay, & Langenburg, 2013; Pacheco, Cerchiai, & Stoiloff, 2014; Ulery, Hicklin, Buscaglia, & Roberts, 2011). Such studies show that some examiners (rarely) make erroneous

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White Box Eye-Tracking Study

FBI Laboratory
JoAnn Buscaglia

2019 IFRG Conference

Research Design

Recognition and mood

Recognition and background information

Recognition and expert & layman

Recognition and time pressure

Mood and background information

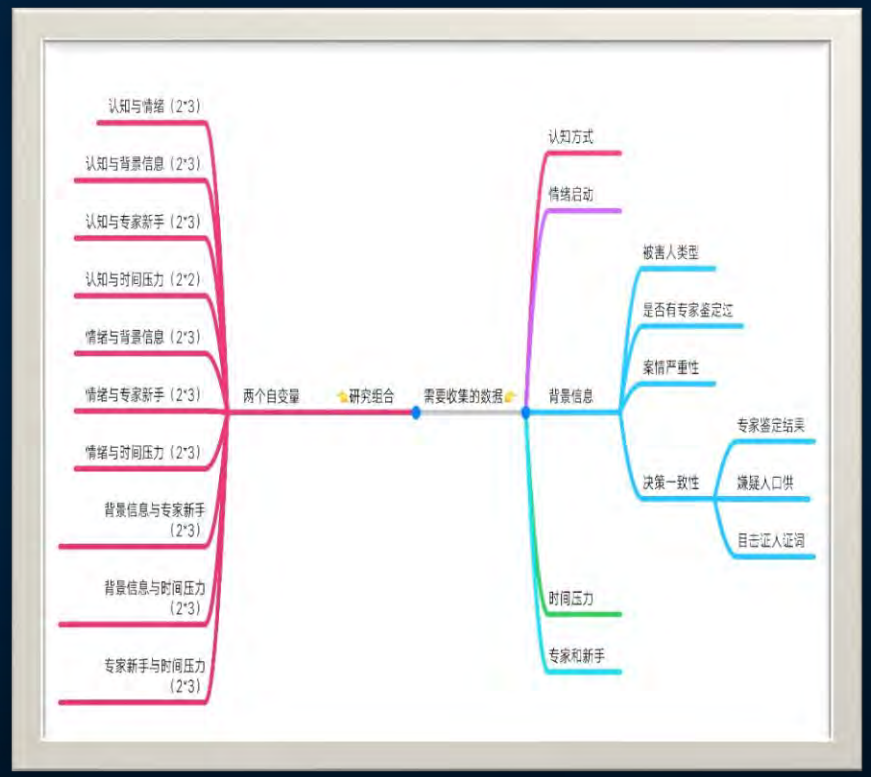
Mood and expert & layman

Mood and time pressure

Background and expert & layman

Background and time pressure

Time pressure and expert & layman



Recognition

Mood

Background information:
- types of victim
- Verification
- Case information
- Decision making

Time pressure

Expert & layman

Background

- Forensic identification is critically important within the criminal justice system.

- A variety of studies have shown accuracy and reliability of conclusions by fingerprint examiners are imperfect (e.g., Neumann, Champod & Langenburg; Pacheco, Cerchiai, & Stoiloff, 2014; Ulery, Hicklin, Buscaglia, & Roberts, 2011).

- Erroneous exclusions are much more prevalent than erroneous identifications, and examiners often are inconclusive on comparisons that resulted in identifications from other examiners.

Purpose

- This research has focused on cognitive factors in the fingerprint identification field.
- Literature and experiment results have shown that cognitive bias has influenced the reliability of fingerprint identification.
- Using eye tracking methodologies to record the performance of fingerprint examiners.

Hypothesis

- **Hypothesis 1**

  The existence of *cognitive bias* in fingerprint identification process.

- **Hypothesis 2**

  Comparison difficulty impact on *error rate* and cognitive strategy.

- **Hypothesis 3**

  Time effect can be adjusted by *difficulty of comparison*.

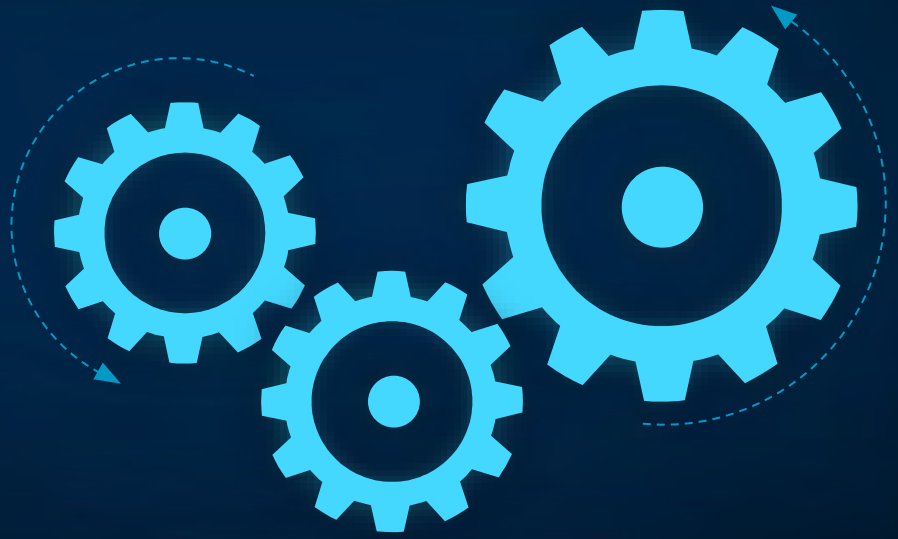
Joint Project

East China Normal University (ECNU) **Prof. Yongfang Liu**

School of Psychology and Cognitive Science

China University of Political Science and Law (CUPL)

Institute of Evidence Law and Forensic Science



Shanghai Police Department (SHPD)

Crime Lab

Experiment Design

- Experiment Fingerprint Comparison Trials: 30
- Participants: 32 police fingerprint experts
- Equipment: Tobii300 Eye Tracking Equipment
- Time pressure: Time limited and No Time Limited
- Within-subjects design

Experiment Materials

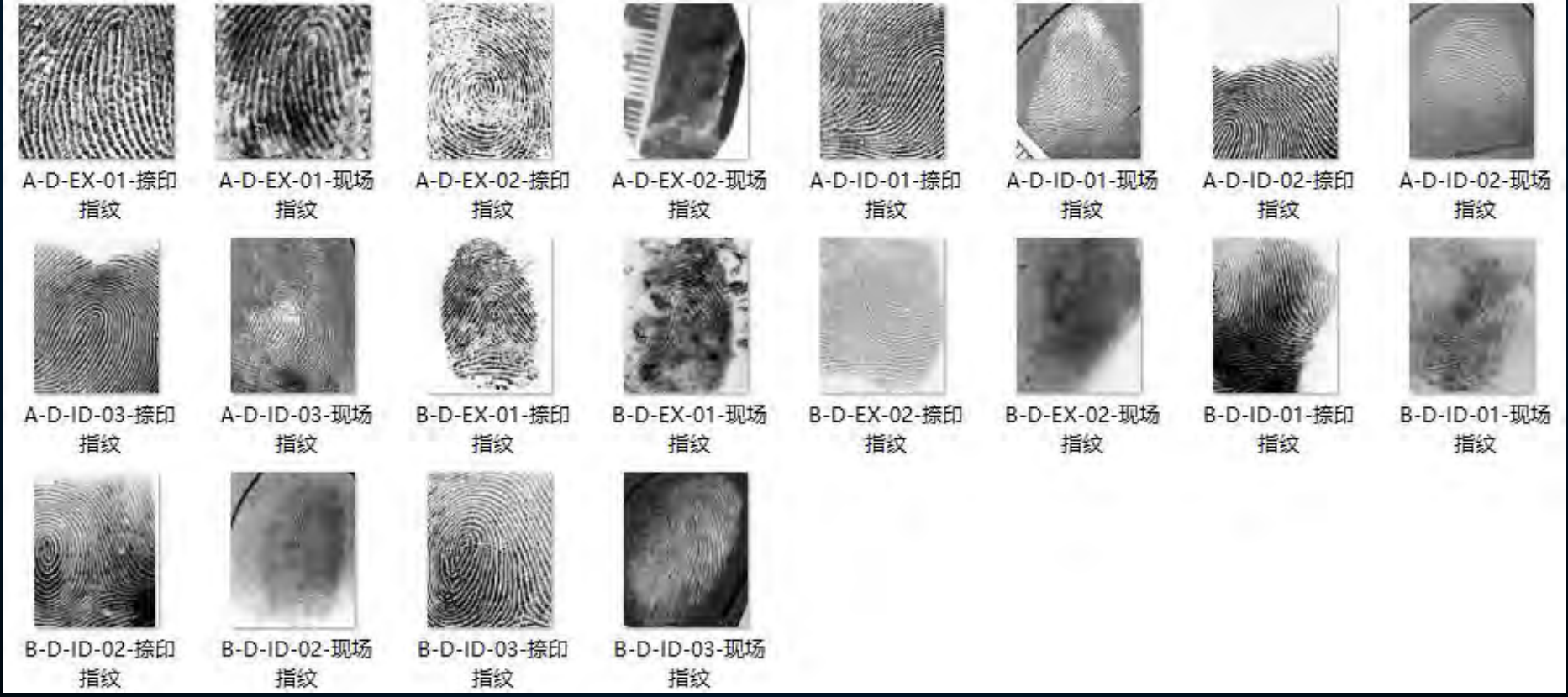
Experiment Materials

Difficulty of Comparison	
Hard	10 - 4 Exclusions & 6 IDs
Medium	10 - 4 Exclusions & 6 IDs
Easy	10 - 4 Exclusions & 6 IDs

Resolution ratio : 1024*768

Experiment Materials

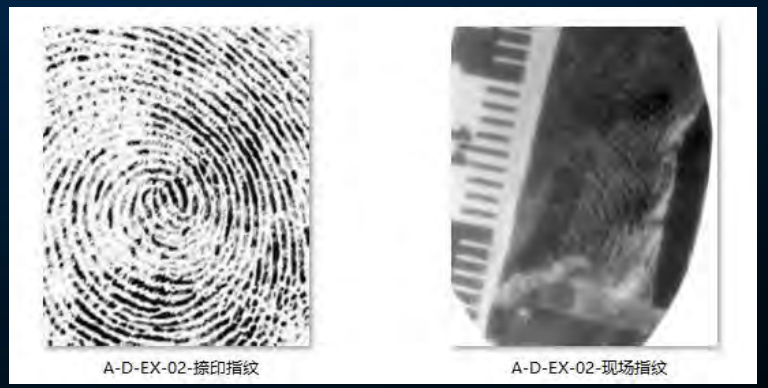
10 trials : Hard – Difficulty (4 Exclusion & 6 ID)



Experiment Materials

10 trials : Hard – Difficulty (4 Exclusions & 6 IDs)

4 Exclusions – Close Non Match

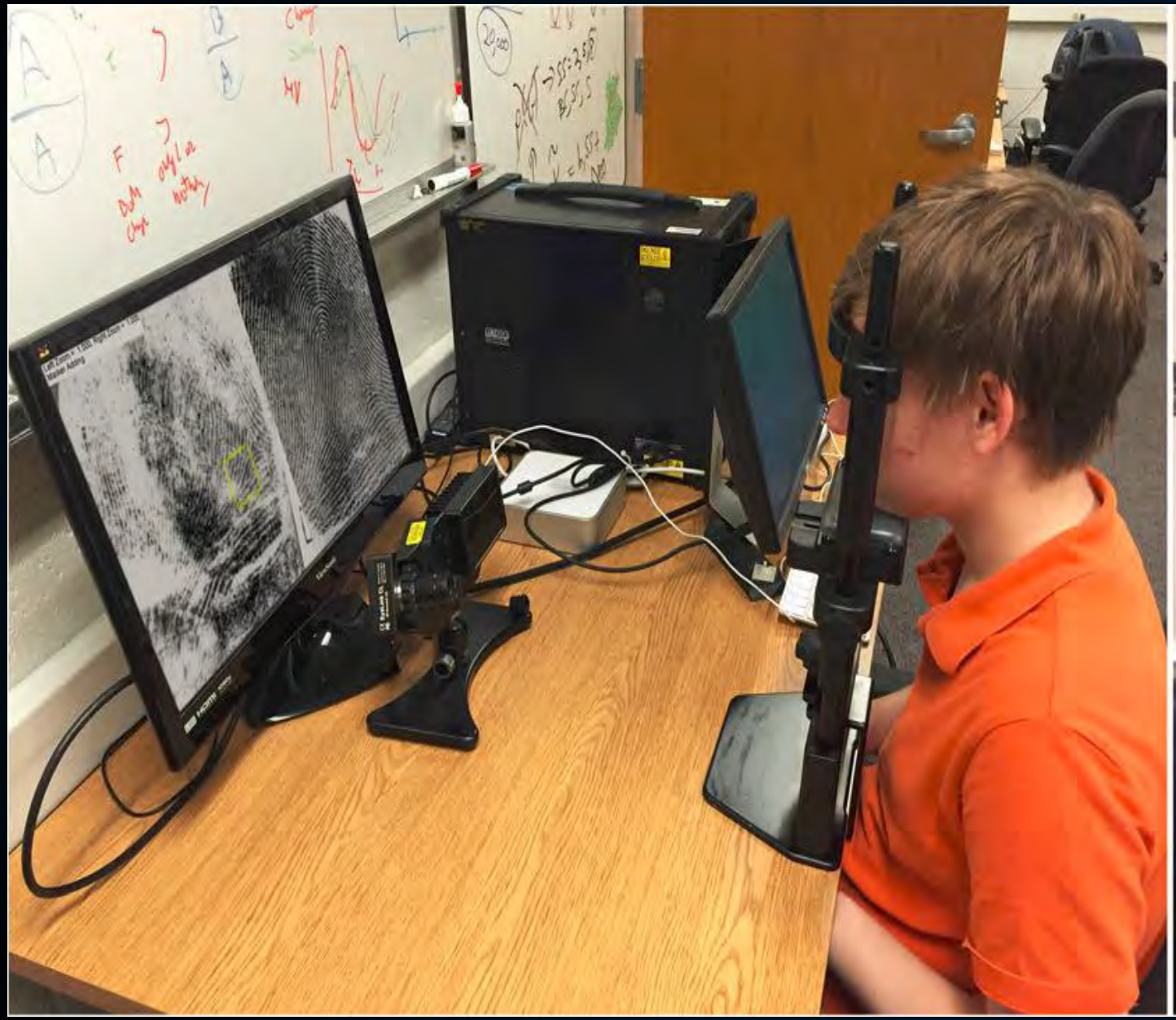


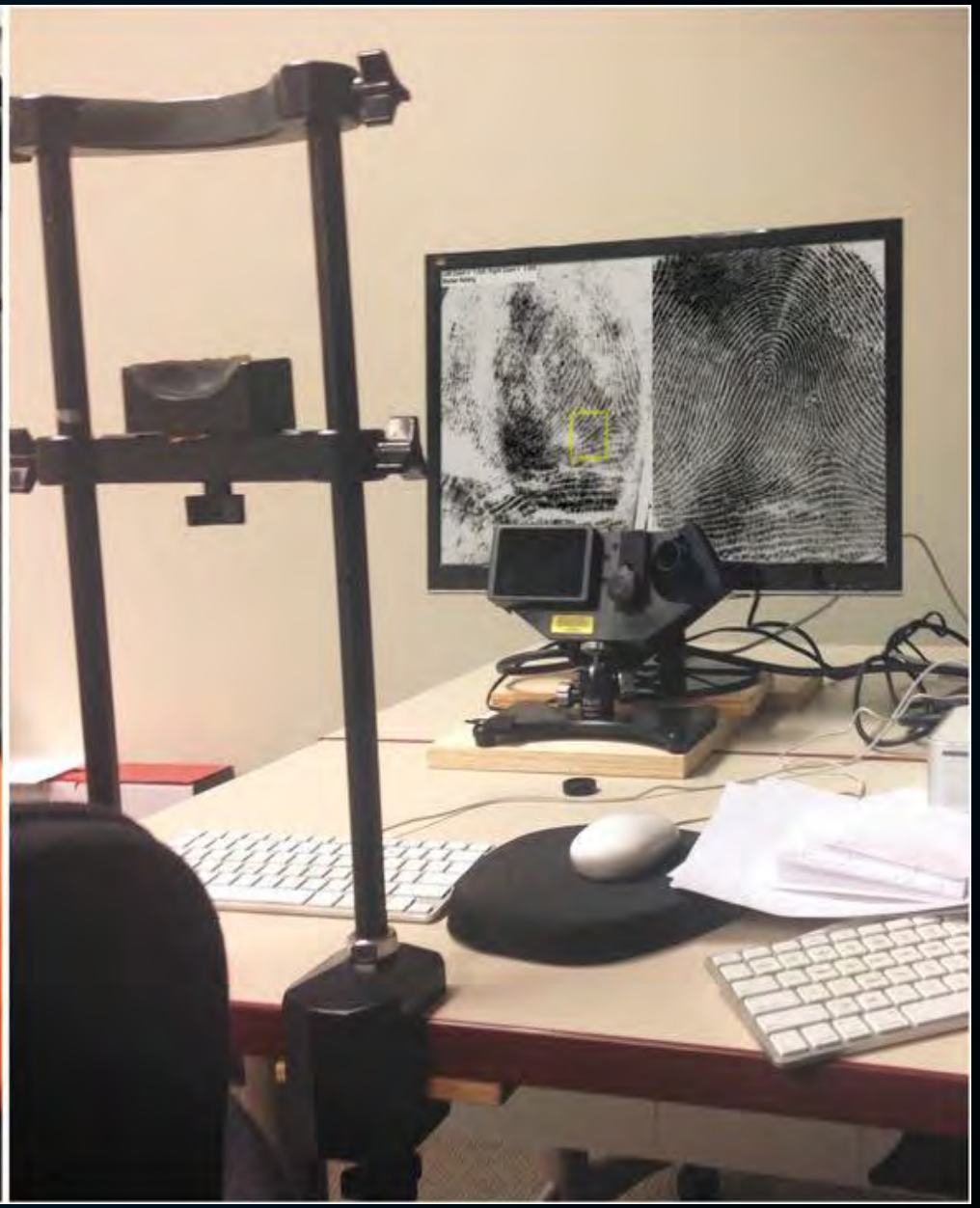
Experiment Materials

Tobii300 Eye Tracking Equipment

Sampling frequency （Two Eyes）： 300Hz
23″ liquid crystal display (LCD)
Distance from liquid crystal display (LCD): 65±10cm


tobii
tobii





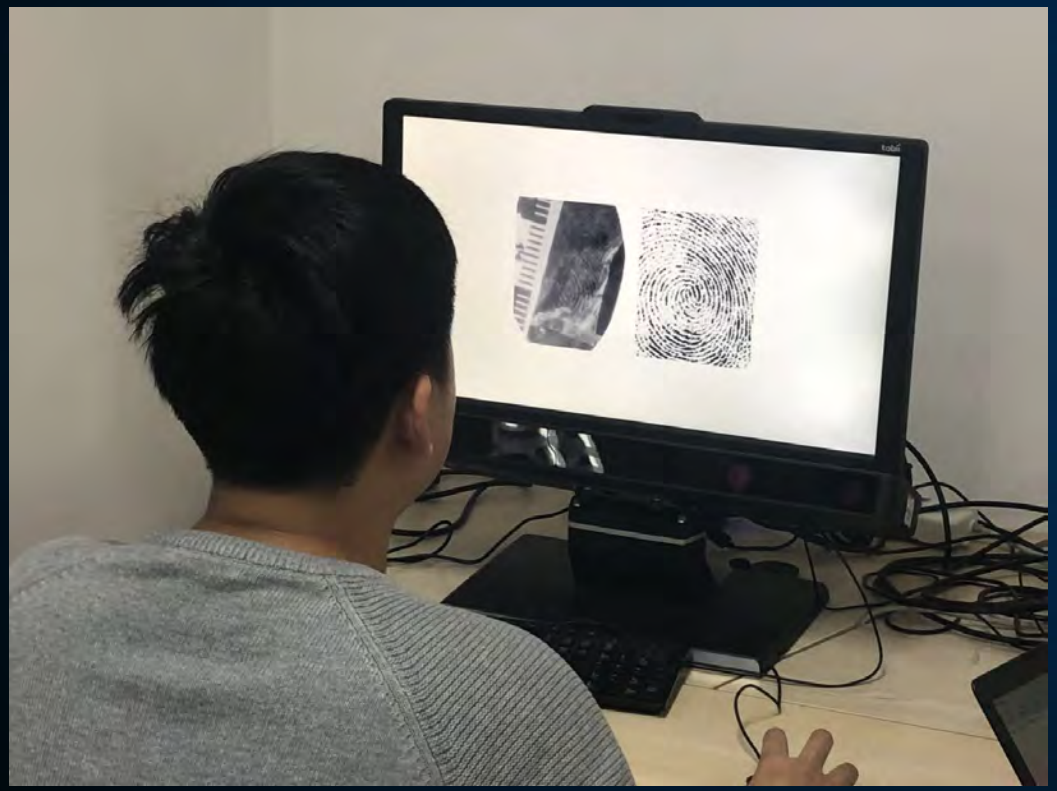
Participants

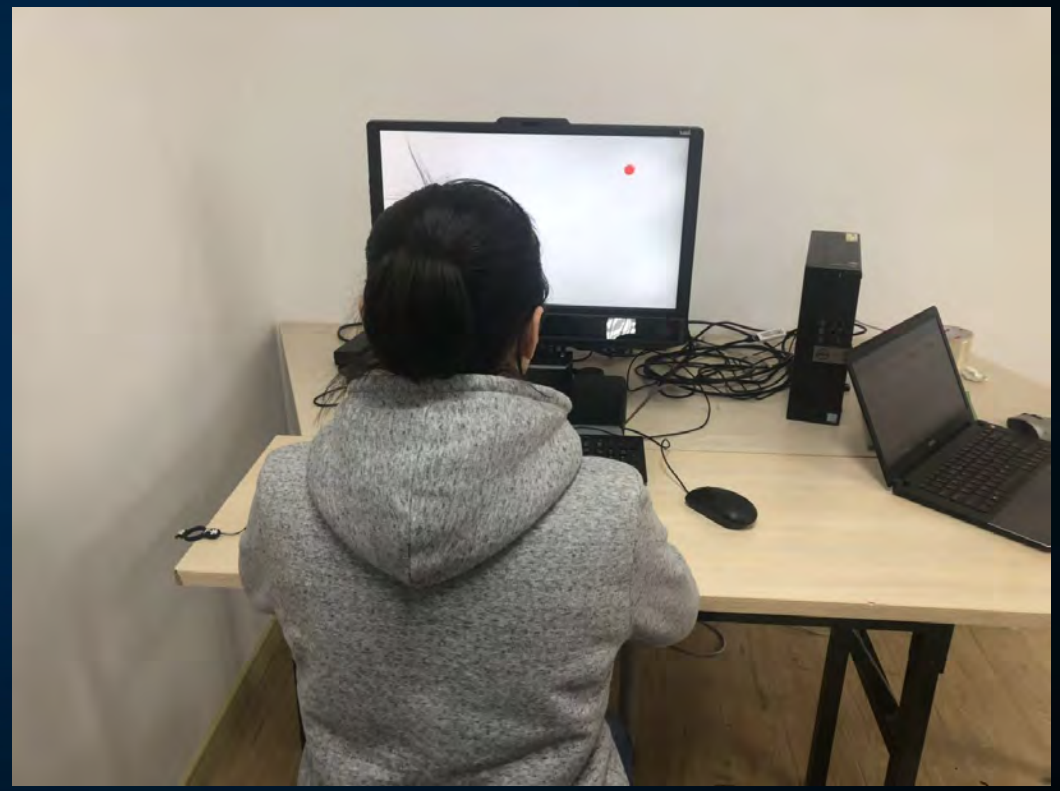
- 32 police fingerprint experts
- 1 police fingerprint expert has some issues with pupil
- 31 experts' available results

Basic information：

Age	Sex (Male: Female)	Working years	Confidence	Passion
39.1±7.5	16：15	14.3±8.4	3.8±0.7	4.1±0.8

Participants





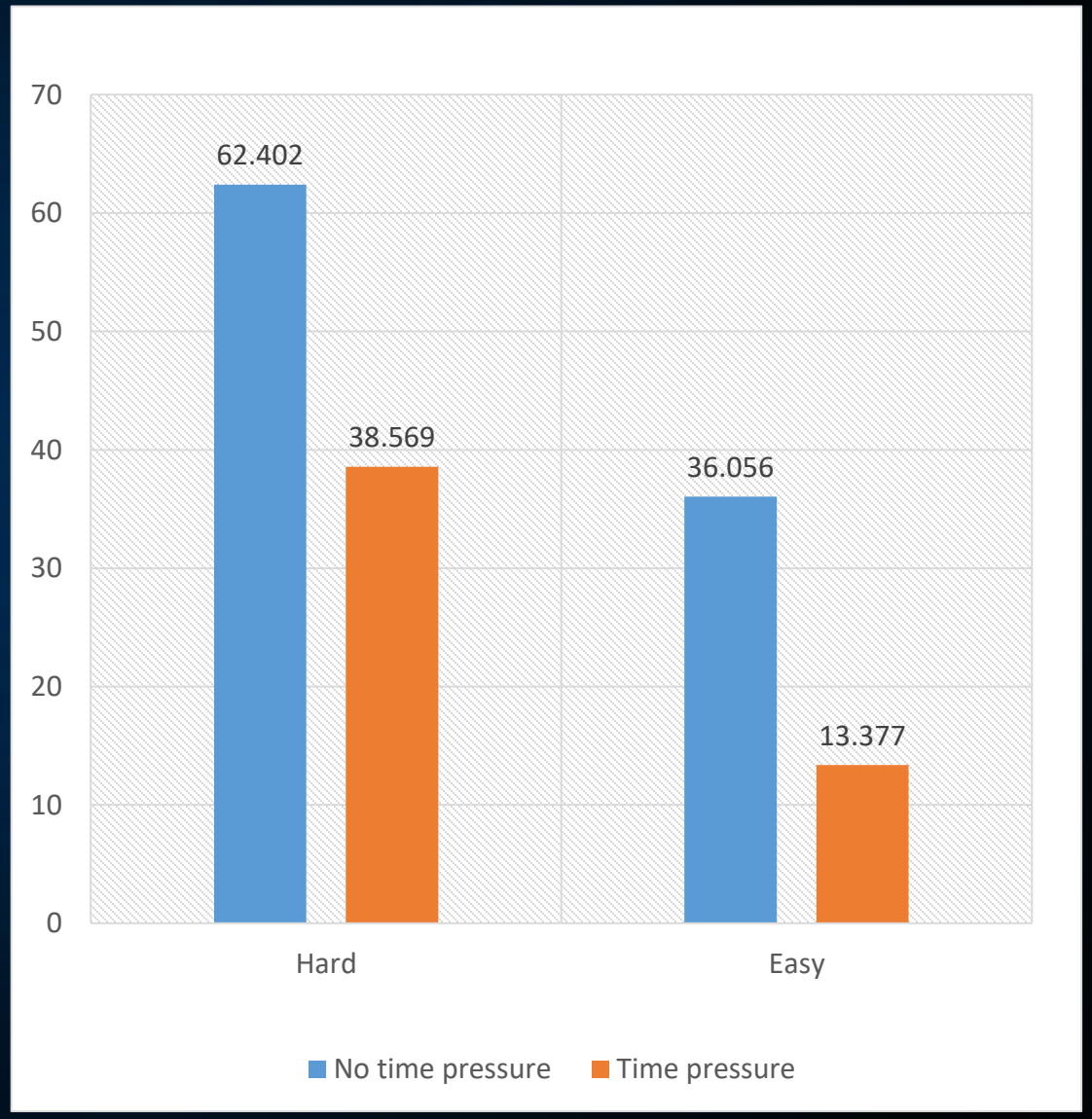
Dependent Variable

- Response time - Watching time
- Error rate - Error Number
- Fixation - Average Fixation Duration\ Fixation Counts
- Saccadic - Average Saccadic Amplitude
- Pupil - Average Pupil Diameter-left
  Average Pupil Diameter-right

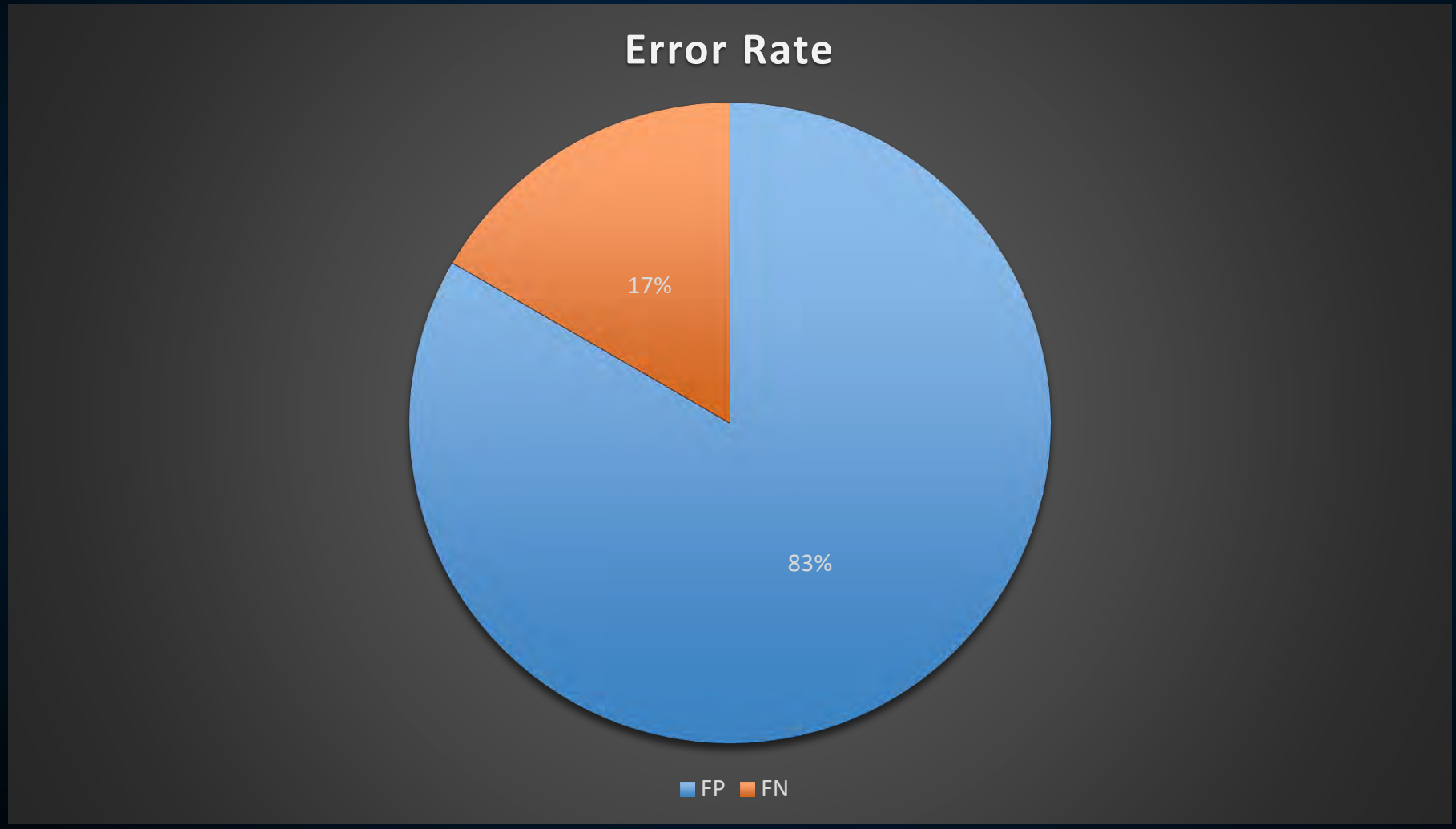
Response time

- The response time for hard comparisons was significantly longer than that for easy, and the response time with no time pressure was significantly longer than with time pressure.
- It indicates that the operation of difficulty and time pressure impact subjects' subjective control of cognitive decision-making time.

	F（1,30）
Difficulty	43.692***
Time pressure	28.929***
Difficulty*Time pressure	0.023

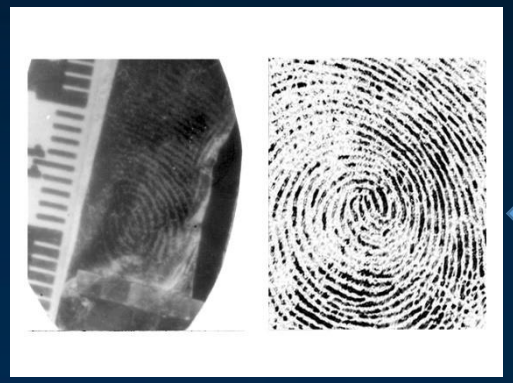


Error Rate



Error Rate

A-D-EX-01



A-D-EX-02

B-D-EX-01

B-D-EX-02

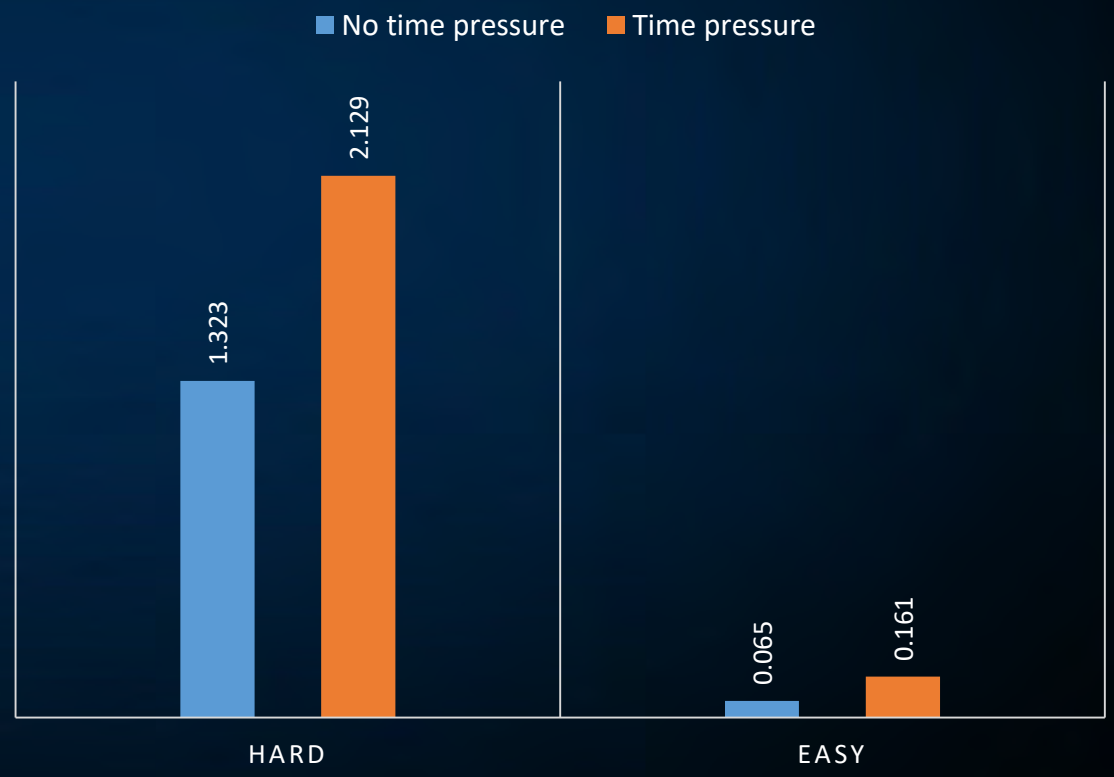
Error Rate

Effect on Error Rate with Comparison Difficulty and Time Pressure

Number of Error

	F（1,30）
Difficulty	204.082***
Time Pressure	23.195***
Difficulty * Time Pressure	13.621**

注：*代表p<0.05，**代表p<0.01，***代表p=0.00

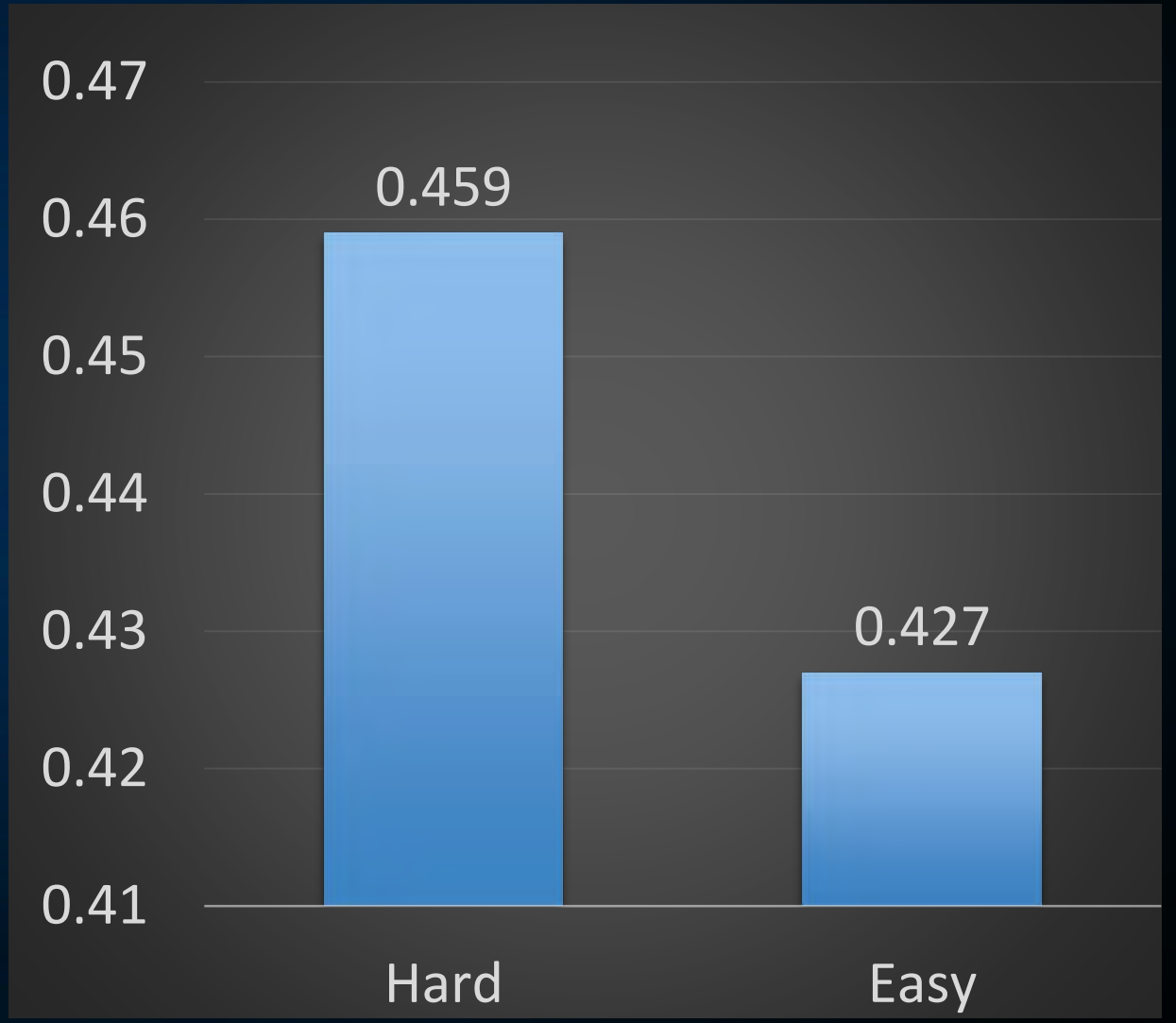


Discussion-Error Rate

- It is verified that difficulty and time pressure affect the accuracy of fingerprint identification.
- The number of errors in hard comparisons was significantly higher than in easy comparisons. The number of errors with time pressure was significantly higher than without time pressure. Moreover, the number of errors in hard comparisons was significantly higher than that in easy comparisons, regardless of time pressure or time pressure.
- Difficulty of comparison manipulation is effective, and difficulty will directly affect the accuracy of decision-making.

Average Fixation Duration

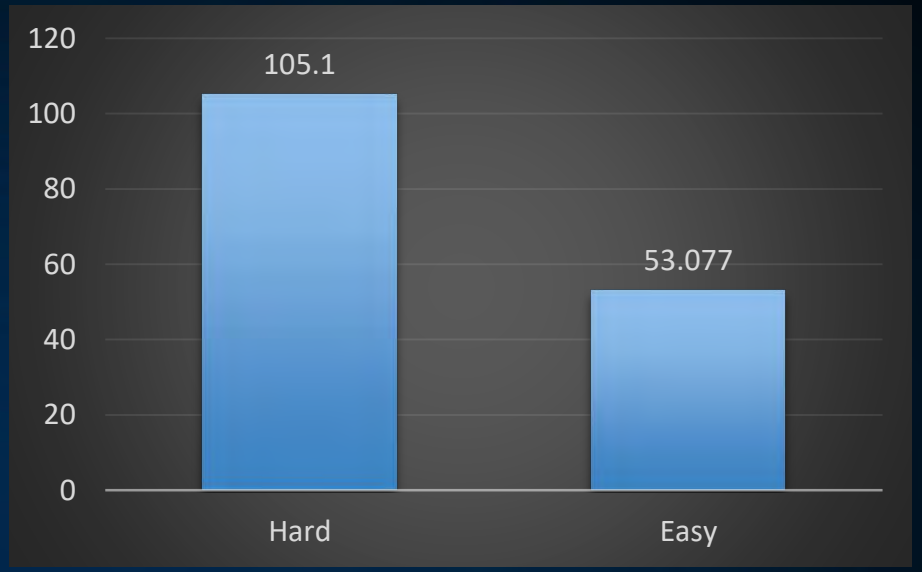
	F（1,30）
Difficulty	13.025**
Time Pressure	3.893
Difficulty * Time Pressure	0.719

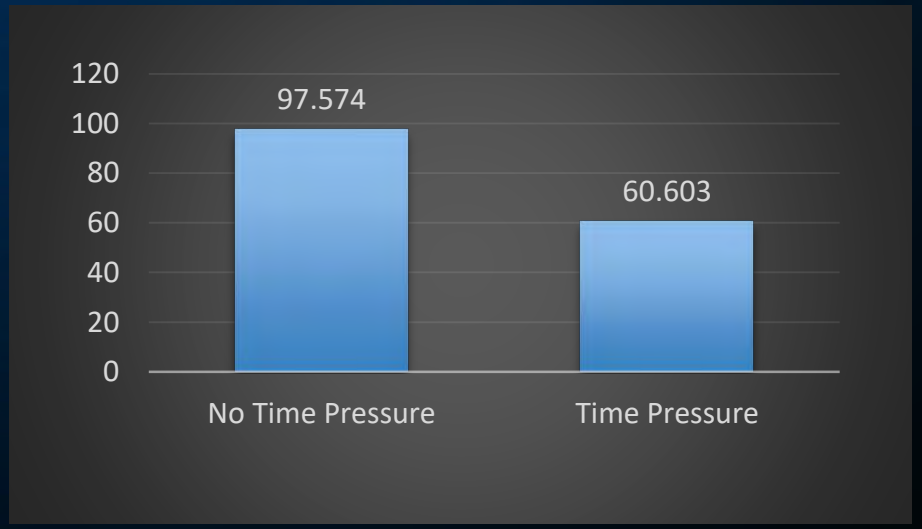


Fixation Counts

Fixation Counts

	F（1,30）
Difficulty	27.873**
Time Pressure	7.857**
Difficulty * Time Pressure	0.110

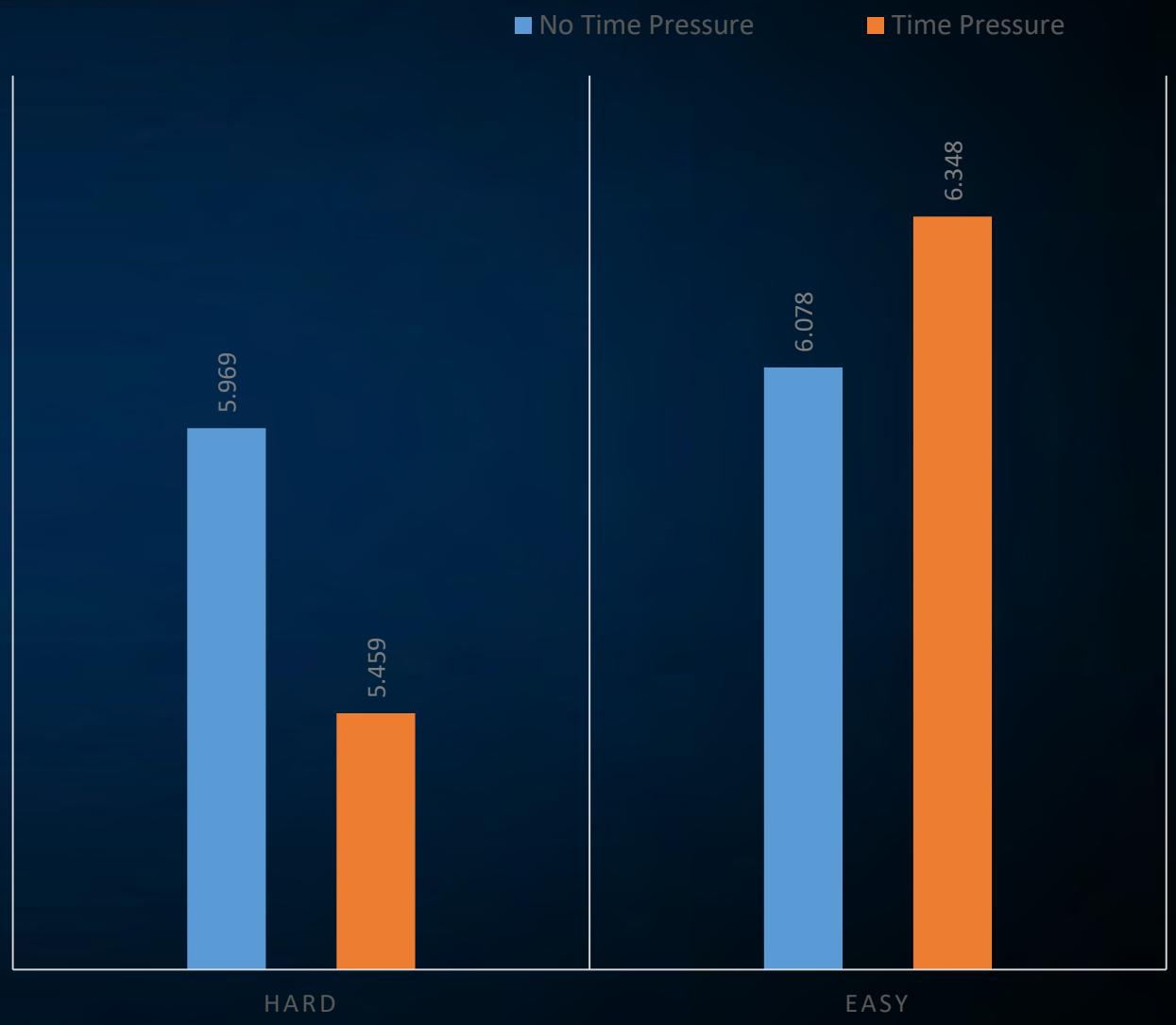




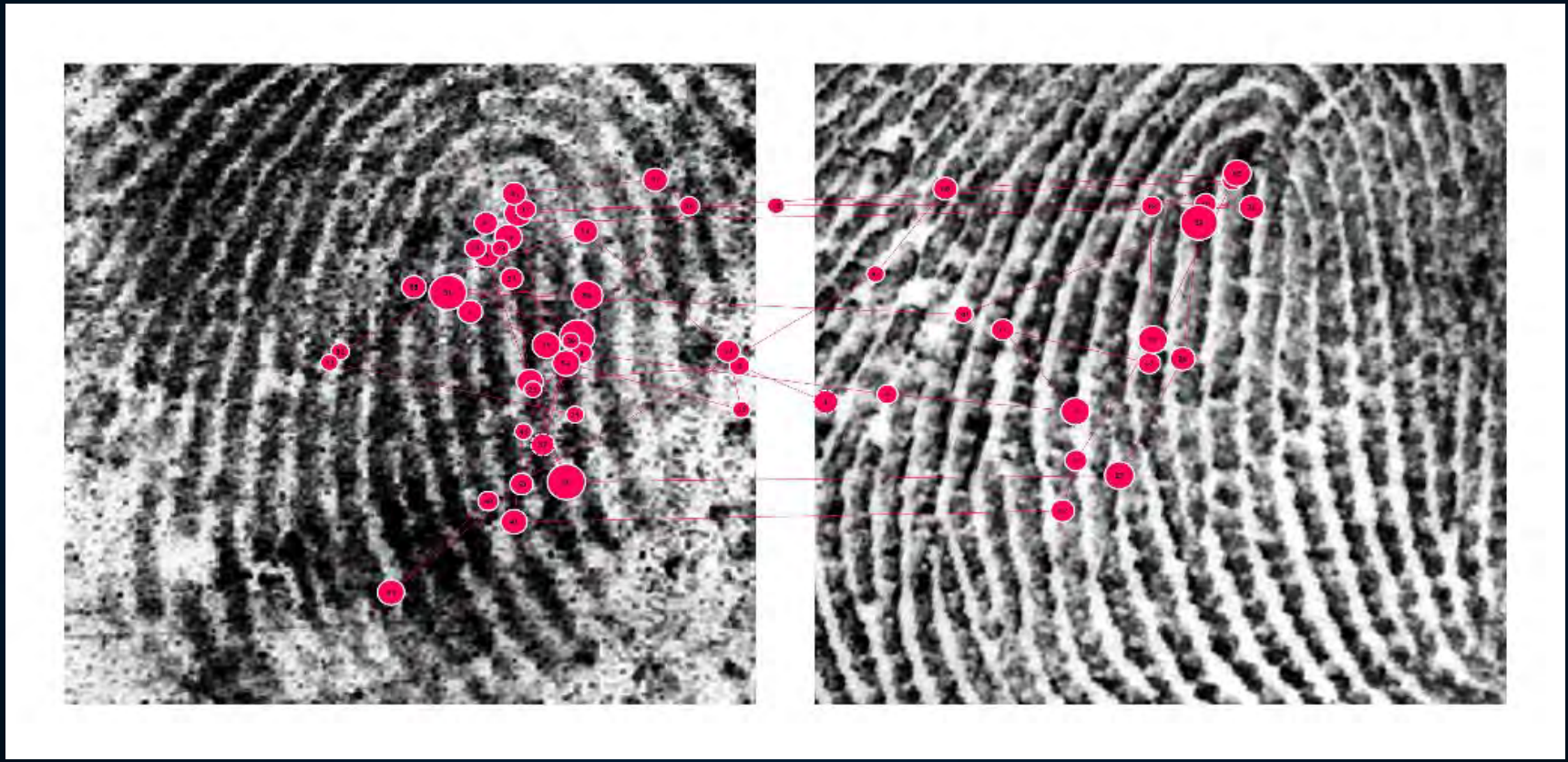
Average Saccadic Amplitude

Average Saccadic Amplitude

	F（1,30）
Difficulty	43.332***
Time Pressure	0.417
Difficulty * Time Pressure	8.218**



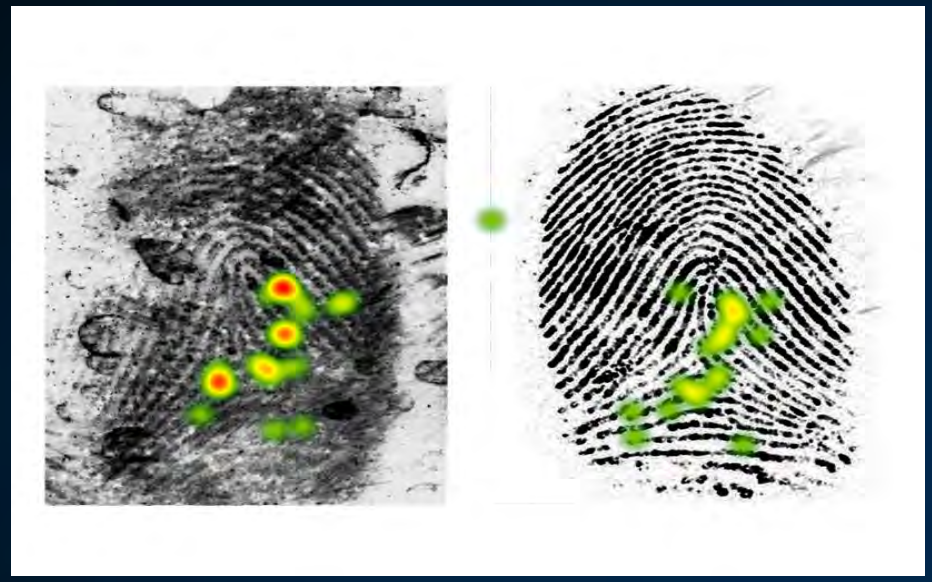
Example: Eye Movement

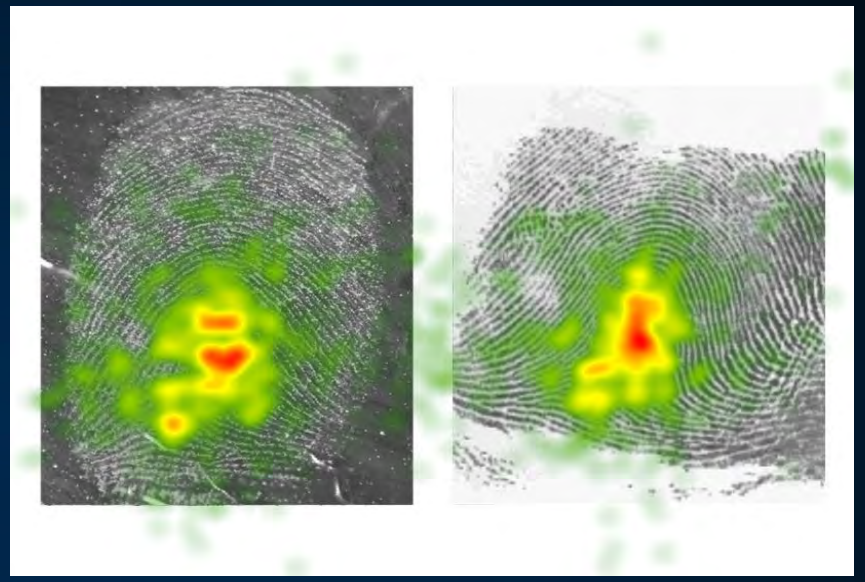


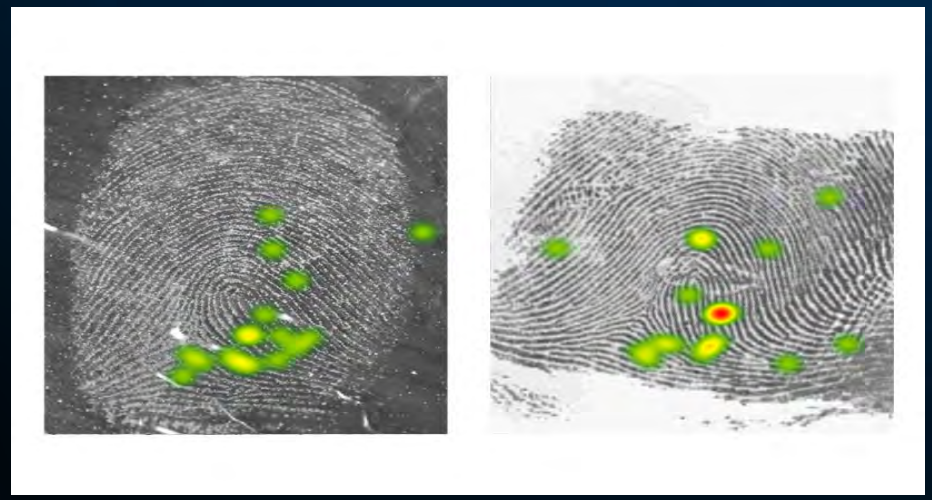
One participant's Eye Fixation Points

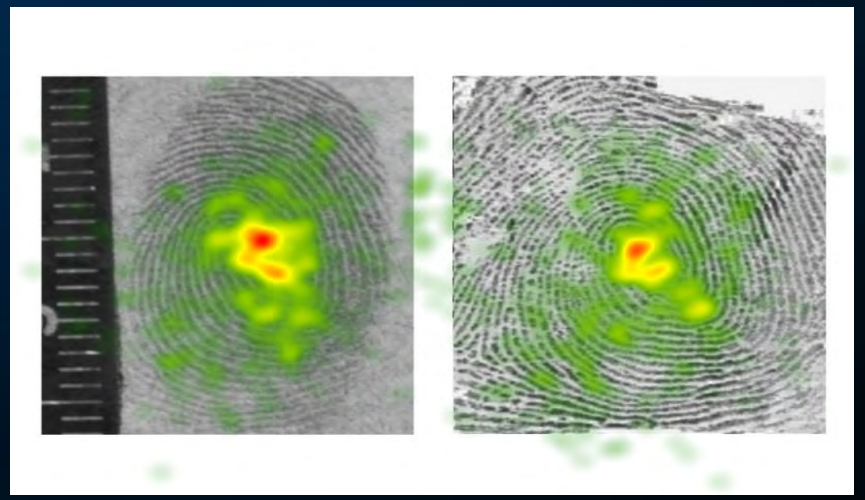
A-D-EX-01 (CNM)

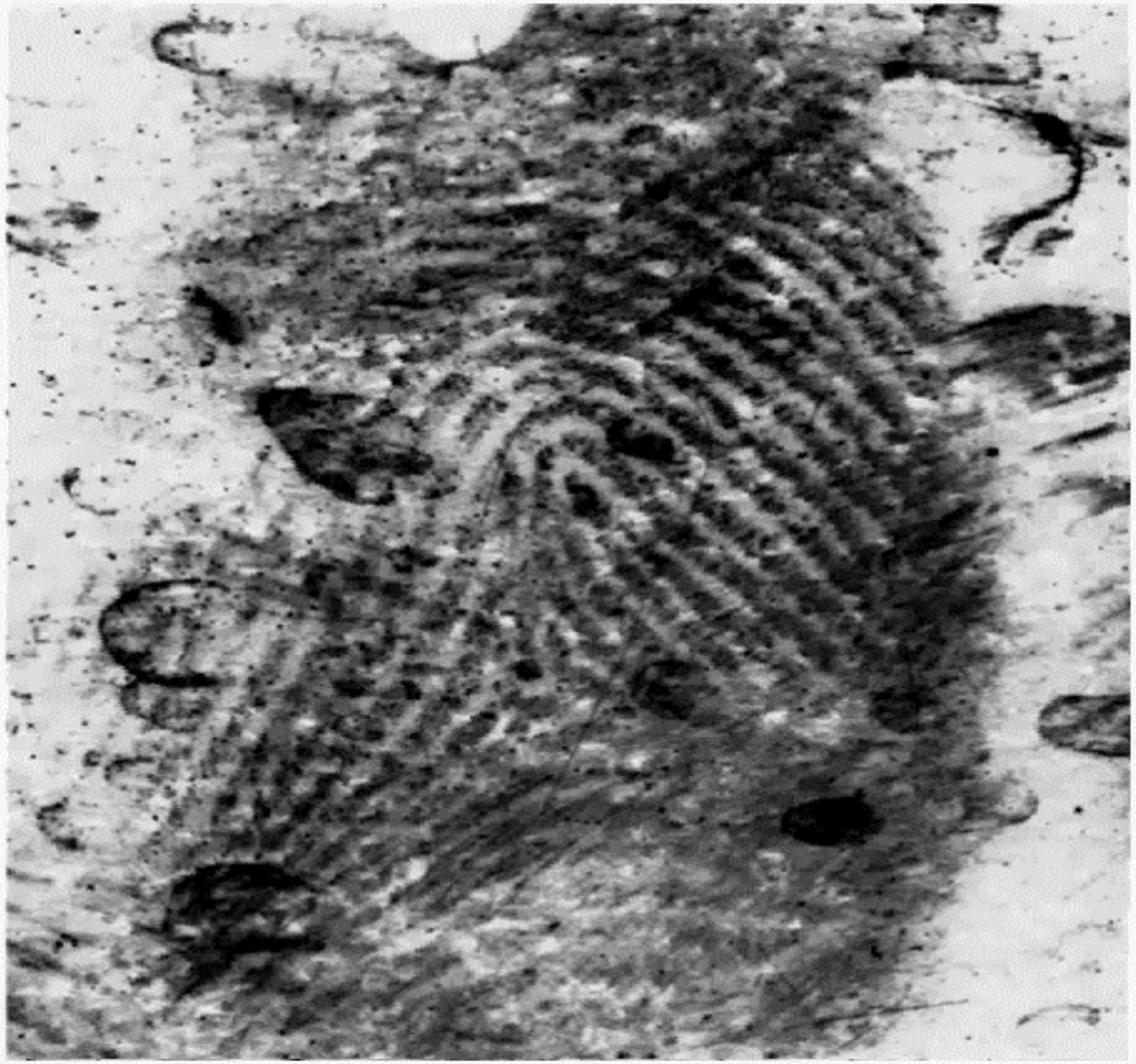
Example: Eye Movement



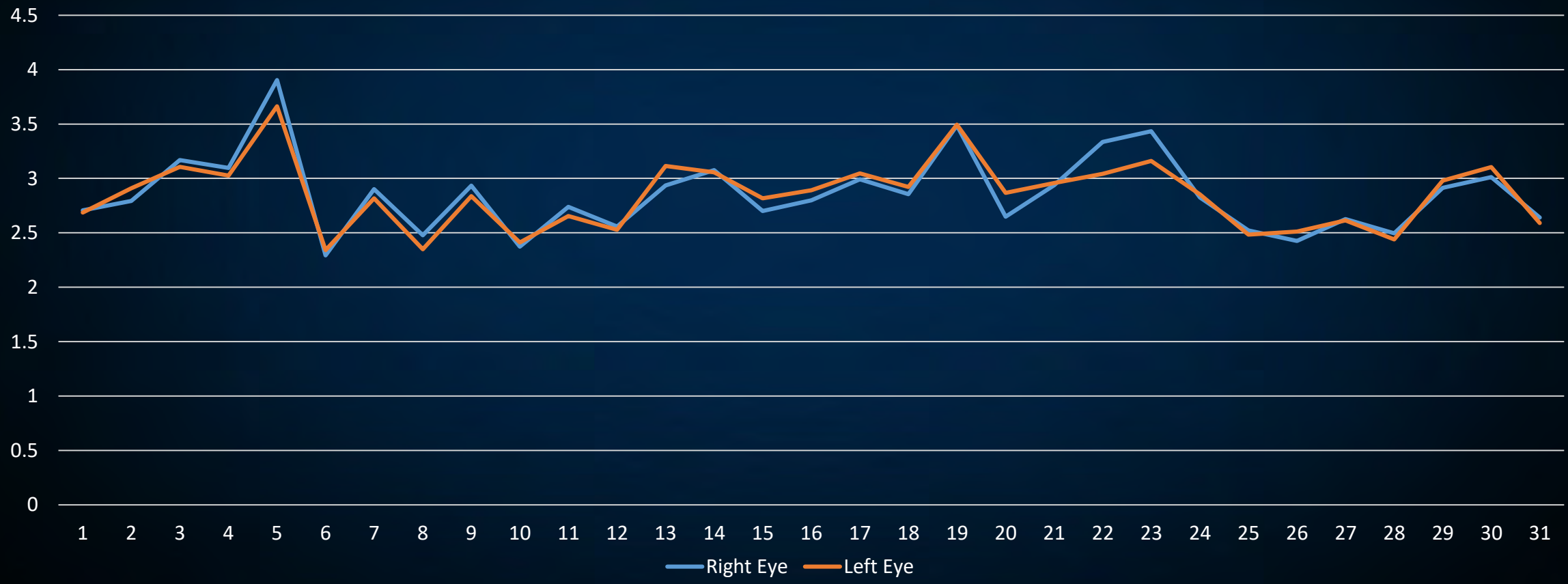








Average Pupil Diameter



Average Pupil Diameter

- Psychological significance: The size of a person's pupils is affected by how much he or she cares about and is interested in the object. The pupils dilate when you pay attention.

- The change trend of left and right pupil diameter was the same.

- The results showed that the changes of pupil diameter were all within the normal range.

Conclusions

- **Difficulty** has a moderating effect on the relationship between time pressure and errors.
- More factors will be presented to those 31 police fingerprint experts in Aug, 2019.
- Eye tracking can be used as a method to document the performance of examiners.
- The data collected is extremely large in size.
- A **Model** is needed to evaluate the performance of examiners.

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THANK YOU

Questions?

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