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The Role of Test Administrator and Error

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THE ROLE OF TEST ADMINISTRATOR AND ERROR

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ABSTRACT

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This study created a framework to quantify and mitigate the amount of error that test administrators introduced to a biometric system during data collection. Prior research has focused only on the subject and the errors they make when interacting with biometric systems, while ignoring the test administrator. This study used a longitudinal data collection, focusing on demographics in government identification forms such as driver's licenses, fingerprint metadata such a moisture and skin temperature, and face image compliance to an ISO best practice standard. Error was quantified from the first visit and baseline test administrator error rates were measured. Additional training, software development, and error mitigation techniques were introduced before a second visit, in which the error rates were measured again. The new system greatly reduced the amount of test administrator error and improved the integrity of the data collected. Findings from this study show how to measure test administrator error and how to reduce it in future data collections.

CHAPTER 1. INTRODUCTION

"Biometrics is defined as the automated recognition of individuals based on their behavioral and biological characteristics" (International Organization of Standards, 2011). There are a number of factors that constitute a biometric system, some of which include the biometric characteristic itself, the sensor, the human subject, the algorithm, the environment, and the test administrator. Research in the field of biometrics has primarily focused on the sensor and the algorithm. In recent years, there has been a greater focus on the human subject with the establishment of the Human-Biometric Sensor Interaction (HBSI) model (Kukula & Proctor, 2009). This model examines the interplay between the human, the sensor, and the biometric system. In this context, the human is typically the test subject, so establishing a framework beyond the test subject is important and is the focus of this thesis. Because there are numerous "actors" in the biometric system, the actions of the test administrator will be examined to create a system that improves the accuracy of data collection.

The test administrator is a critical part of a biometric data collection system. They are responsible for following data collection procedures and supervising the test subjects (Campbell & Madden, 2009). The test administrator is also responsible for monitoring the data quality as it enters the data collection system. This includes biometric samples as

well as metadata. It is important that both types of data are correct when entered into the system.

This chapter provides an outline of the problem, the significance of the problem, the deliverables, assumptions, limitations, delimitations, and definitions of key terms.

1.1 Statement of the Problem

The goal of this study was to determine if the tools and procedures put into effect between two visits of a biometric data collection successfully mitigated test administrator error.

1.2 Significance of the Problem

This research identified potential errors that jeopardize data integrity. “Poor data quality is responsible for many or even most matching errors in biometric systems and may be the greatest weakness of some implementations” (Hicklin & Khanna, 2006, p.1). Poor data quality refers to biometric data that are captured incorrectly, causing low image quality, incorrect labeling of biometrics, or incorrect entering of metadata. Test administrators are essential to collecting data that are free of errors.

This research measured the amount of error that test administrators introduced to a biometric system. By doing so, problems were identified and mitigated through software development and training procedures. Additional testing was conducted to determine if the changes reduced the amount of test administrator error and what further improvements could be made. By measuring test administrator error, this research creates

a connection to the HBSI model, so that test administrator error can be assigned to an HBSI error metric in future work.

1.3 Deliverables

The deliverable of this research is a framework that reduces the amount of test administrator error attributed to the biometric system. To develop this framework, test administrators are surveyed over their data collection experiences. This survey used prior data collections to address administrative concerns, testing procedure challenges, and collected the opinions and recommendations of test administrators for future studies. Data from the first visit of an ongoing biometric study is used to measure the amount of test administrator error in the biometric system and how test administrators create error. Test administrator errors are measured, and changes are put into effect. Errors are measured again after the second visit to confirm that the documentation and process improvements worked. The goal of this study is to determine if the tools and procedures put into effect between *visit one* and *visit two* successfully mitigated test administrator error. After analyzing *visit two* data, a project post-mortem is conducted to further identify changes to be implemented for future studies and even further reduce test administrator error.

1.4 Assumptions

The assumptions for the research include the following:

- The test administrators answered all survey questions truthfully.
- The test administrators did not maliciously introduce errors to the biometric system.

1.5 Limitations

The limitations for the research include the following:

- The test administrators used in this research have only collected data in experiments conducted by one facility.
- This research does apply to impostor transactions.
- This research does apply to unattended systems.
- The test administrator error is not representative of all metrics in the HBSI framework.

1.6 Delimitations

The delimitations for the research include the following:

- The data were limited to the biometric data collection facilities of Purdue University.
- Demographic metadata, fingerprint metadata, and face biometric samples were the only procedures measured for test administrator error.
- The contribution of test administrator error measured does not include subject interaction errors, device errors, or test protocol errors.
- The test administrators were surveyed only on their experience in data collections between the summer of 2012 and the summer of 2013.
- This research involves only errors that occurred in the data collection activities and not errors in the payment to the subjects.
- The Graphical User Interface (GUI) was not designed with usability principles in mind.

1.7 Definitions of Key Terms

Attended system: "A system that is under the supervision of an operator" (Hicklin & Khanna, 2006, p.21).

Biometrics: "Automated recognition of individuals based on their behavioral and biological characteristics" (International Organization for Standardization, 2011, p.9).

Concealed Interaction (CI): "An incorrect presentation made to the system that is detected by the system but is not handled or classified correctly as an error" (Kukula & Elliott, 2009, p.2).

Defective Interaction (DI): "An incorrect presentation made to the system that is not detected by the system" (Kukula & Elliott, 2009, p.2).

Error: "Factors which prevent a measure from being perfectly reliable" (Sarmah & Hazarika, 2012, p.509).

False Accept Rate (FAR): "The proportion of verification transactions with wrongful claims of identity that are incorrectly confirmed" (International Organization for Standardization, 2005, p.5).

False Interaction (FI): An incorrect presentation made to the system that is detected by the system and is classified correctly as an error (Kukula & Elliott, 2009, p.3).

False Reject Rate (FRR): "The proportion of verification transactions with truthful claims of identity that are incorrect denied" (International Organization for Standardization, 2005, p.5).

Failure to Acquire (FTA): “A verification or identification attempt for which the system fails to capture or locate an image or signal of sufficient quality” (International Organization for Standardization, 2005, p.5).

Failure to Detect (FTD): “A correct presentation made to the system that is not detected by the system” (Kukula & Elliott, 2009, p.3).

Failure to Enroll (FTE): “An enrollment attempt for which the system fails to complete the enrollment process” (International Organization for Standardization, 2005, p.5).

Failure to Process (FTP): “A correct presentation made to the system that is detected by the system but fails to process due to reasons such as segmentation, feature extraction, or quality control” (Kukula & Elliott, 2009, p.4).

Genuine user: “A user attempting to match their own stored template” (Campbell & Madden, 2009, p.48).

Habituation: Familiarity a subject has with the biometric device, system and application (International Organization for Standardization, 2011, p.2).

Human-Biometric Sensor Interaction (HBSI): “Formed by the combination of components and relationships in the HBSI model. These include the human-biometric sensor, the human-biometric system, and the sensor-biometric system” (Kukula & Elliott, 2009, p.277).

Impostor user: “A user who submits his/her own biometric characteristics as if he/she were attempting successful verification against his/her own template, but the comparison is made against the template of another user” (Campbell & Madden, 2009, p.52).

Interaction: “The action(s) that take place within a presentation” (Brockly & Elliott, 2013, p.196)

Modality: “Different types of biometrics” (Hicklin & Khanna, 2006, p.76).

Operator: “Someone that uses a biometric device to obtain biometric samples from a user in an attended system” (Senjaya, 2010, p.17).

Performance: The relationship between false match rates and false non-match rates in a detection error trade-off graph (Mansfield et al., 2001, p.10).

Presentation: “Interaction of the biometric capture subject and the biometric capture subsystem to obtain a signal from a biometric characteristic” (International Organization for Standardization, 2010, p.18).

Questionnaire: “A series of questions asked to individuals to obtain statistically useful information about a given topic” (Sarmah & Hazarika, 2012, p.1).

Sample: “User’s biometric measures as output by the data collection subsystem” (International Organization for Standardization, 2005, p.1).

Successfully Processed Sample (SPS): “A correct presentation that is detected by the system and biometric features are able to be created from the sample” (Kukula & Elliott, 2009, p.4).

Test administrator: “Person responsible for operating the test harness and supervising the test subjects” (Campbell & Madden, 2009, p.47-48).

Unattended system: “A system that is not under the supervision of an operator” (Hicklin & Khanna, 2006, p.21).

CHAPTER 2. REVIEW OF THE LITERATURE

The following chapter is a review of the literature that covers the topics of this thesis. The first section shows the relationship between the test administrator and the human operator in different environments. The second section gives an overview of biometrics and data quality. The third section reviews HBSI and the roles of the subject and the test administrator. The final section discusses the design of a biometric system and the impact of human error.

2.1 Biometric System Operator

The term operator is "someone that uses a biometric device to obtain biometric samples from a user in an attended system" (Senjaya, 2010, p.17). If a biometric system error occurs, it is the operator's duty to inform the person in charge. An example of a system error includes device failure or system malfunction. Operators need to be trained to fully understand how to handle a system error or problem if it occurs (Graves et al., 2011). Human operators are an integral part of most data collection systems and commonly make the final decision regarding whether a sample is accepted or not. This decision will occur in a biometric system in which a manual check is used to determine whether a sample meets a certain level of quality. In this paper, the term operator will be used for data collection agents in operational environments, such as border control.

2.2 Test Administrator

In a biometric data collection, the role of the test administrator is similar but different from that of a human operator. Although they share many common characteristics, a test administrator is specifically used when performing biometric testing or enrollment. The test administrator's role is to collect data, but many times they also ensure that the data collection is performed properly by the subject even if it is of poor quality. Figure 2.1 outlines the different "actors" in the biometric data collection process in a testing environment. The definitions of each one of these "actors" are shown in Table 2.1. In some cases, there are different definitions for the same individual.

This research focuses on a test environment and the role of test administrators. Test administrators are critical to the biometric acquisition process. Research conducted by Theofanos et al. (2007) showed that test administrators were able to assist subjects to overcome the deficits of both video- and poster-based instructional material. In other studies, the test administrator changed the environment (Kukula, et al., 2004), tilted and operated the camera (Theofanos et al., 2008), ensured that the session proceeded properly (Kushniruk et al., 1997), and conveyed complex instructions while administering the test (International Biometric Group, 2002).

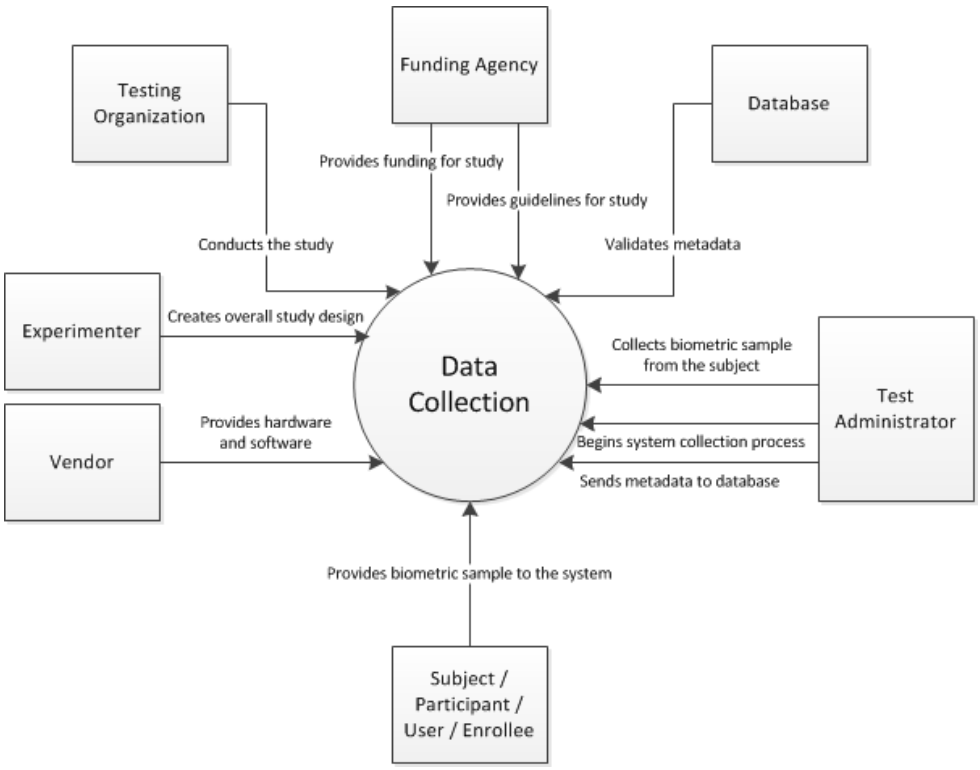

Figure 2.1 Biometric Data Collection Actors

Table 2.1 Actors and Definitions

Actor	Definition
Test administrator	• "Person performing the testing or enrollment, recording test data, and/or monitoring the crew" (Campbell & Madden, 2009, p.47-48).
Subject / Participant / User / Enrollee	• The subject is the "user whose biometric data is intended to be enrolled or compared as part of the evaluation" (International Organization for Standardization, 2005, p.3). • The user is the "person presenting biometric sample to the system" (International Organization for Standardization, 2005, p.3).
Experimenter	• "Person responsible for defining, designing, and analyzing the test" (International Organization for Standardization, 2005, p.4).
Database	• "A usually large collection of data organized especially for rapid search and retrieval (as by a computer)" (Merriam-Webster, 2013).
Funding Agency	• "Funding agencies are most of the time quasi-public organizations financed by the state to define and execute a large part of the science policy" (Braun, 1998, p.4).
Testing Organization	• "Functional entity under whose auspices the test is conducted" (International Organization for Standardization, 2005, p.4).
Vendor	• One who provides biometric solutions (Walker, 2002).

2.3 Biometric Data

In a biometric data collection scenario, it is important that the data are collected correctly. Incorrectly recorded data can come from problems within the data collection, the behavior of the subject, or the test administrator. At the operational level, poor data, regardless of the source, leads directly to customer dissatisfaction, increased cost, and lowered test administrator job satisfaction (Redman, 1998).

In addition to considering the quality of the collection of biometric data, metadata should also be acquired correctly. Metadata are important in data collections because they provide additional context to the biometric samples. Examples of metadata include age, gender, moisture of subjects' fingerprints, and documentation of any disorders that may affect the subject's ability to complete the successful presentation of a biometric sample. The task of entering and updating biometric data into a database can create metadata errors (Hicklin & Khanna, 2006). Furthermore, these data are typically entered manually in the presence of the subject. If the metadata information is incorrect, the results of the data analysis will be incorrect because subjects may become associated with erroneous data.

2.4 Biometric Performance

In 2007, Theofanos et al. addressed the need to incorporate the human subject as a component of the biometric system. Human factors and the usability of the system are important to the capture of the biometric sample and the biometric system performance. The methodology of HBSI has further established the human subject as a part of the process to quantify data collection errors. The subject can provide incorrect behaviors

that impact the performance of the biometric system. This effect will be positive or negative depending on the consistency and correctness of their interactions with the biometric device.

This framework established in this research addresses the need to add the test administrator to the HBSI model and this is necessary because he or she will influence the HBSI model. Just as the data collection human subject needs to provide a correct presentation, the test administrator also needs to conduct the test correctly and validate the entry.

The General Biometric Model is shown in Figure 2.2. This model is used to display the five subsystems that comprise a biometric system. All of these subsystems are impacted by data collection errors. This research focuses on the data capture subsystem of the model.

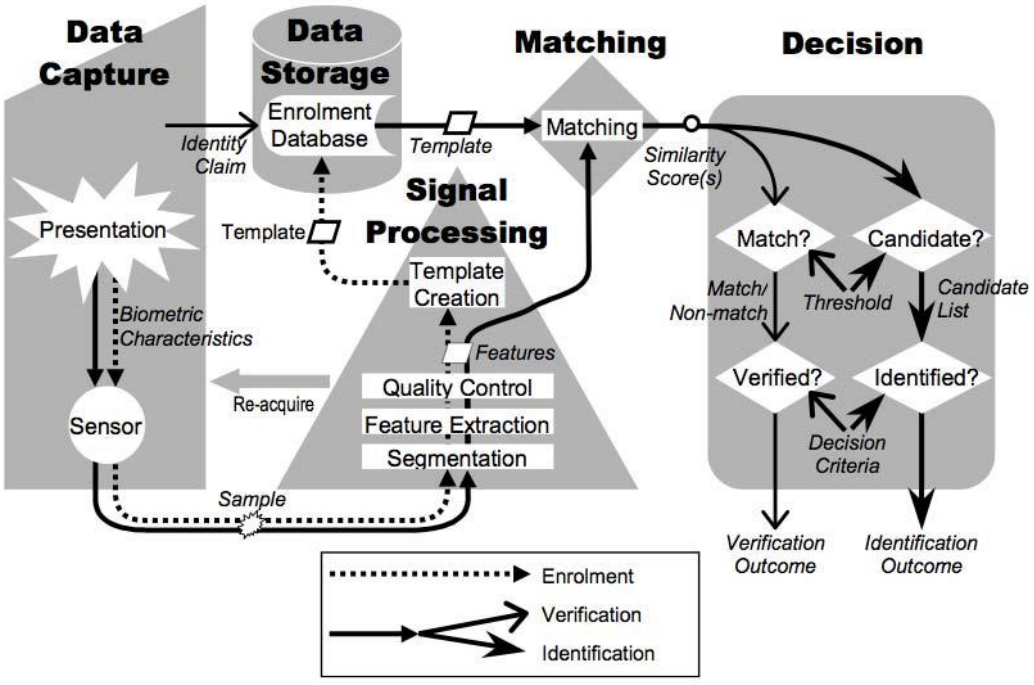

Figure 2.2 General Biometric Model (Mansfield & Wayman, 2002)

2.4.1 Human-Biometric Sensor Interaction

The HBSI model was created by the convergence of three key principles of biometric data capture. The human, the sensor, and the biometric system converge to create intersections of ergonomics, usability, and sample quality, which are shown in Figure 2.3. Ergonomics refers to the discipline concerned with the understanding of interactions among humans and other elements of a system (International Ergonomics Association, 2006). Usability is defined as the extent to which a product can be used by subjects to achieve goals with effectiveness, efficiency, and satisfaction in the context of its use (International Organization for Standardization, 2006b). Sample quality addresses the capture fidelity of the subject's physical characteristics (Hicklin & Khanna, 2006). In other words, HBSI is the link between the individual and the biometric device (Kukula & Elliott, 2006).

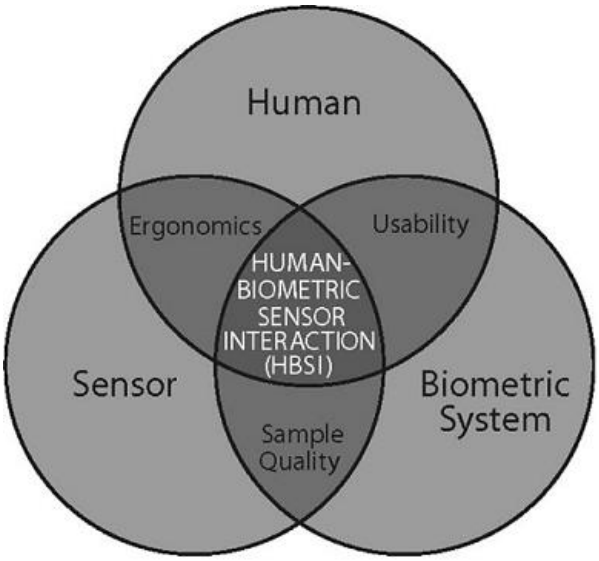

Figure 2.3 HBSI Model (Elliott et al., 2007)

The purpose of the HBSI framework is to understand the common correct and incorrect presentations that occur with biometric devices (Elliott & Kukula, 2009). Improving these presentations is part of a larger study on human factors. Human factors include the reduction of error, improving productivity, enhancing safety, and user comfort (Wickens et al., 2004). Each presentation can be either correct or incorrect. Then, the system determines whether the presentation is detected or not. If the presentation has been detected, the system will classify the sample as correct or incorrect. Depending on the detection, classification, and presentation, the system will either assign one of the error metrics or record the sample as a Successfully Process Sample (SPS). This is shown in Figure 2.4.

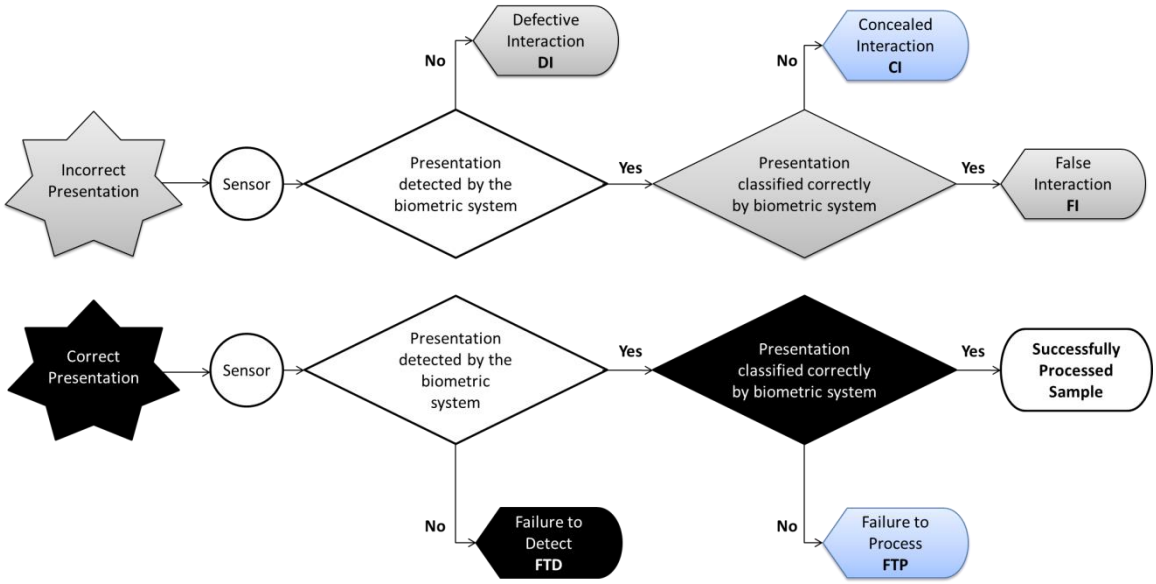

Figure 2.4 Current HBSI Framework (Elliott & Kukula, 2010)

The goal of research on the HBSI model is to address usability issues to develop the next generation of universally usable biometric systems (Kukula & Proctor, 2009). Currently, the framework only incorporates the test subject as the human. To use this

model in a testing environment, the test administrator should be considered. The test administrator not only influences the subject's likelihood of making a correct or incorrect presentation but also creates their own error. In some cases, test administrators can contribute to incorrect or correct presentations when they are taking a picture of the subject for facial recognition. If the camera is held incorrectly or used with the wrong settings, an incorrect presentation will occur. This paper provides a basis for test administrator error, which in conjunction with HBSI will create the next stage of the HBSI model.

2.4.2 Test Administrator Error

Test administrator error affects many data collection procedures. Errors include the misuse of a device, inconsistent sampling, providing incorrect instructions to subjects, and incorrect data entry. Some of these issues can be caused by a lack of training, incompetence, overwork, or unrealistic throughput expectations set by the experimenter (Hicklin & Khanna, 2006). Unrealistic throughput expectations will cause test subjects to queue up, which may create additional stress or burden on the test administrator. Hicklin and Khanna (2006) recommend including test administrator performance metrics to identify lapses in training and data collection errors. These performance metrics are necessary to fully understand the test administrator's impact on the system. They do not, however, provide further guidance on how to operationalize this.

The reliability of the test administrator is affected by the length of the test, the test administrator's abilities, the subjects' abilities, and the test conditions where the data collection occurs (Sarmah & Hazarika, 2012). The errors measured in this research are

only the errors contributed by the test administrator. The research measures the validity of the test administrator's collected data to show that it measures what it was truly meant to measure.

2.4.3 Test Administrator Training

One way to control the amount of test administrator error in a data collection environment is with training. Test administrators are given a set of minimum training topics to introduce them to the biometric technology used in the test. Some of these topics include an overview of device operations, how to install the devices, the skills needed to successfully use the device, start-up procedures, normal operating procedures, human interface procedures, shutdown procedures, and device error response activities (Transportation Security Administration, 2005). Typically, all training that takes place is supervised by another member of the facility with prior experience in the study. All training policies and procedures for training needs are also identified in the internal quality manual that adheres to ISO 17025. The goal of training is to prevent poor quality from the source (Hicklin & Khanna, 2006). It is important that the test administrator is trained on the actual system they will be using during data collection to gain experience with it.

Training may vary for each data collection. Some tests have the test administrator assist the subject to complete the study. Other times, test administrators are instructed not to assist in the case of a Failure to Acquire (FTA) but instead should allow a subject to continue trying. This will help the study to demonstrate real life usability and image

quality problems based on the subjects' behaviors. Regardless the setup, test administrators must be trained on what to do when errors arise.

2.4.4 Qualities of the Test Administrator

A good test administrator needs to possess many different qualities to function well with complex systems and subjects simultaneously. Complex systems include computerized record systems (Kushniruk et al., 2007) as well as biometric data (Hicklin & Khanna, 2006). At the beginning of the data collection, the test administrator needs to serve as a host for the subjects. Some of these responsibilities include making the subject feel welcome and making the experience pleasant (Dumas & Loring, 2008). These responsibilities can be highly dependent on the personality of the test administrator. If a study requires many interactions between the test administrator and the subject, an extroverted test administrator may be better. Some studies do not allow the test administrators to talk to the subject at all, and in these cases, an introverted test administrator would be a better choice.

It is the job of the test administrator to know every aspect of the process and convey any and all necessary instruction to the subjects. An example of this process includes the test administrator giving correct instructions to the subjects for every visit. Dumas & Loring (2008) recommended that test administrator duties include greeting subjects, making eye contact, smiling, being relaxed, listening attentively, speaking slowly, and adapting to interaction style. On the other hand, activities test administrators are advised against include acting distracted, using a flat tone of voice, exhibiting nervousness, rushing subjects, showing annoyance, touching the subjects, and using

extraneous technology such as checking email, using a cell phone, or going on social media. Test administrators will be surveyed on their use of these activities (see 3.1.2).

2.4.5 Workload and Automation

The workload for a test administrator needs to be balanced so that there is enough work to do without causing the test administrator to be overwhelmed by it. The test administrator workload should be monitored so that it does not become a source of quality problems (Hicklin & Khanna, 2006). The Transportation Security Administration's (2005) Plan for Biometric Qualified Product List (QPL) suggests that test administrators should verify test crew demographics and the device installations, conduct system audits, provide the biometric device during the test conduct, review documentation of daily activities, ensure compliance with test procedures, and validate all collected data.

If the workload is too intense, a certain level of automation will need to be added. Automation aims to provide a system with more capabilities during complex scenarios to take error out of the hands of the test administrator (Graves et al., 2011). Automation should primarily be used to eliminate unwanted workload steps such as human data entry which may prove to be error prone. Unwanted workload includes mental calculations, estimations, comparisons, and unnecessary thinking (Murata & Iwase, 1998). Automating these steps will simplify the process for the test administrator, allowing them to focus their resources on the important tasks at hand. Although automation can be a useful procedure, it needs to be implemented correctly.

2.4.6 Fatigue and Stress

It is reported that fatigue, stress, and distraction are key factors that impact human test administrator performance. With these factors in mind, a person's ability to maintain vigilance and attention reduces over time (Graves et al., 2011). Systems should be designed to anticipate test administrator fatigue. Data collection can be a repetitive process, and fatigue will play a role in data collection. Shift workers are even more susceptible to fatigue than are task-based workers. Test administrators are commonly scheduled as shift workers, so fatigue needs to be avoided when possible.

There may be a link between error frequency and test administrator demand that increases subject waiting times (Ernst et al., 2004). Additional errors and quality problems can increase with test administrator workload and stress (Hicklin & Khanna, 2006). Many factors will impact the stress levels of a test administrator and may result in an increase in errors or slower throughput times. Ruthruff (1996) reported that subjects under a time deadline tend to make more errors in difficult conditions than in easy experimental conditions. The same effect may be observed for test administrators dealing with complex information.

Test administrators are commonly put in situations with time constraints or when they perceive a time constraint. The need to process subjects through the data collection is crucial and there is usually a specific time from in which to do so that is determined by throughput and budget. If this time constraint passes, additional subjects may start to line up, causing the test administrator to work at an even faster pace so that subjects are not delayed. If multiple subjects come in at the same time, a queue may cause an increase in

stress and distraction. The level of stress and distraction will have a negative impact on decision making by the test administrator.

2.5 Designing the Data Collection

A common challenge is designing systems that provide functionality but are also easy to learn and use (Kushniruk et al., 2007). Some factors that affect the usability of the system include the ergonomic design of the work area, the work station, the Graphical User Interface (GUI), and the user manual. With the test scenario, a GUI should be easy to use and should be created from the test administrator's perspective. If designed properly, the GUI will help to create a system that is free of confusion. A well-made GUI will allow test administrators to spend less time searching and thinking and more time collecting data.

Another important principle is to include only the information needed by the test administrator at a given time (Murata & Iwase, 1998). Extraneous information should be excluded so that the test administrator can focus on the subject and the data collection. Complex systems used in biometric data collections rely on a certain level of test administrator proficiency. Test administrators need to know how to handle the system in the event of a failure.

2.5.1 Continuous Improvement

Qualitative evaluations are used to highlight common errors that occur when the test administrator interacts with a system (Graves et al., 2011). These evaluations will measure test administrator error rates to improve the system design. Surveys can also be

used to learn what problems the system might have from the test administrator's point of view. This will help to identify deficiencies in the data collection. Focus groups will also be used to discover test administrator viewpoints. Focus groups are best used to obtain answers to open-ended questions and acquire as much information as possible from a descriptive answer (Graves et al., 2011).

2.6 Impact on the System

Test administrators will affect the data collection procedures. Policy and administration are two key elements of systems management. By implementing best practice policies early on, the biometric system can be designed with cognitive engineering principles in mind. These principles refer to a system that is designed to support the human that is using it (Norman, 1986). An experiment by Murata and Iwase (1998) showed that reaction time when using cognitively engineered interfaces was faster than the reaction time using an interface that was not created by using cognitive engineering principles.

The largest problem from an experimenter's perspective is the costs associated with having a system that allows errors. Labor costs are associated with paying the test administrators to work more hours, building costs are associated with keeping the facility open and functional for the additional time, subject costs come from paying the subjects to come back for an extra visit if recollection is needed, and late charges occur if the funding source charges for receiving data later than expected. The other problem is poor data quality. A system that is not cognitively engineered may not include logic tests to confirm that data are being captured correctly. Incorrect procedures, samples, or metadata

will affect the results and data analysis. With errors and no improvements to the system, the test will be jeopardized. Too much poor-quality data will affect the outcome and may render it unusable. Through the use of best practices, the system can be designed appropriately, keeping the test administrator in mind, to reduce errors and optimize the data collection process.

CHAPTER 3. METHODOLOGY

The following sections discuss the steps used in the methodology, the identification and measurement of variables, and the calculation of test administrator error.

3.1 Steps Taken

This research began after the conclusion of the first visit of an ongoing biometric data collection. 111 subjects went through the data collection and each subject was collected by one of eight different test administrators. Upon completion of *visit one*, this research involved the following steps:

- The data from *visit one* was analyzed for the contribution of error by the test administrators.
- A survey was issued to test administrators on their experiences in *visit one* and other past data collections since the summer of 2012.
- The test administrator GUI was designed and created based on the literature reviewed and *visit one* errors.
- A focus group was held so that test administrators could see the GUI and recommend further changes.
- The GUI was improved to address test administrator recommendations.

- Test administrators were required to read the laboratory's internal quality manual, pass a quiz with a minimum score of 80%, and be trained in the data collection before the start of *visit two*.
- Test administrators collected eighty-one returning subjects for *visit two* of the data collection.
- The data was again analyzed for test administrator error.
- A post-mortem session was held with test administrators from *visit two*.

3.1.1 *Visit One* Error Measurement

Biometric samples and metadata collected by the eight test administrators were examined from the first visit to identify collection errors. Test administrator error from *visit one* was limited to the areas of subject demographic metadata, subject fingerprint metadata, and face sample acquisition. Some fields in the database contained erroneous data. This was data that was either not collected by test administrators, or recorded incorrectly into the database. *Visit one* did not mandate that test administrators validated demographic or fingerprint metadata at the time of collection although it was assumed that this would be the case. Fingerprint metadata was temporarily stored on paper before being entered into the database, resulting in missing data for some subjects. Incorrect face samples used for face recognition were also a result of test administrator error. Face samples were processed through Aware PreFace to determine compliance to the ISO Frontal Best Practice face standard. When samples were not compliant with the standard, it was determined to be a test administrator error.

3.1.2 Test Administrator Survey

After the analysis of *visit one,* a survey was issued to every test administrator who had worked in a data collection at the facility since the summer of 2012. Seven test administrators in total completed the thirty-eight question survey. These questions are shown in Appendix C. Questions included in the survey came from internal audit checklists and the literature discussed in Chapter 2. The survey contained multiple Likert questions for use as quantitative data. These questions involved degrees of satisfaction with devices, studies, and administrative conditions. The survey also included open response questions for test administrators to write opinions and suggestions. These suggestions were requested for the specific data collections that test administrators were involved in. The results of this survey were used to improve the GUI and procedures for *visit two* and create an effective training strategy.

3.1.3 GUI and Focus Group

Prior to creating the GUI, documentation on data collection procedures was reviewed. Methodologies from other studies were compared to detect potential flaws in the system for *visit two*. Recommendations from other researchers such as automating processes (Graves et al., 2011) and reducing mental calculations (Murata & Iwase, 1998) were also integrated to the biometric system.

To promote continuous improvement, Corrective Action Request (CAR) forms were implemented in the GUI. These electronic forms were completed by test administrators to recommend process changes after an error had occurred. Preventive Action Request (PAR) forms were also implemented. PARs were completed by the test

administrators to recommend a process change before an error occurred. These forms included a unique identification number, the source of the problem, the urgency, a description of the problem, proposed actions to fix the problem, who assigned the problem, the assignee, and whether the problem had been corrected or not. PARs and CARs were built into the test administrator GUI for easy submission during data collection procedures. Upon submission, the CAR or PAR was stored as a database record and a copy was emailed to the test administrator to whom it was assigned.

Based on the ongoing data collection, preventive measures for test administrator errors were built into the database. Immediate validation of demographic and fingerprint metadata fields turned empty or incorrect fields "red", and did not allow test administrators to continue until the issue was corrected. These database field validations were discussed with a focus group of seven current test administrators to make sure that all their concerns from the survey were addressed. During the focus group session, the proposed data collection GUI was presented to the test administrators so they could see the functionality and request any further changes. The focus group also showed potential gaps in training that needed to be addressed through corrective action.

3.1.4 Test Administrator Training

Test administrators were required to read the laboratory's internal quality manual prior to *visit two* of the data collection. The quality manual outlined ISO 17025 (general requirements for the competence of testing and calibration laboratories) and ISO 9001 (quality management systems) to ensure that test administrators comply with internal policies and procedures. After reading the quality manual, test administrators were tested

on their knowledge of it. All potential test administrators were required to score at least an 80% (16/20) on the quiz to be considered as a candidate for training. Questions for the test administrator quiz are shown in Appendix E. The quiz resulted in either a pass or fail for each test administrator and a minimum score of 80% was based on the typical minimum grade of "B".

Upon completion of the quiz, test administrators completed a consent form, which allowed video to be recorded and their actions to be logged in the database. With the completion of the quiz and the consent form, test administrators went through a formal training session to become eligible to data collect in *visit two*. This training session was performed as a group session. Test administrators were shown one station at a time and were trained on all practices and procedures. At the end of each station, test administrators were allowed to ask any questions before moving onto the next station. After the training session, test administrators were required to observe one live data collection performed by one of the two quality leaders. The quality leaders were test administrators who were already experienced in the process and were leading the training session. New test administrators were also shadowed by the quality leaders for a minimum of two data collections to ensure that all processes were correctly understood.

3.1.5 *Visit Two* Error Measurement

The test environment, which is where the data collection occurred, is displayed in Figure 3.1. The arrows show the path that the test subject followed while the test administrator operated the various stations.

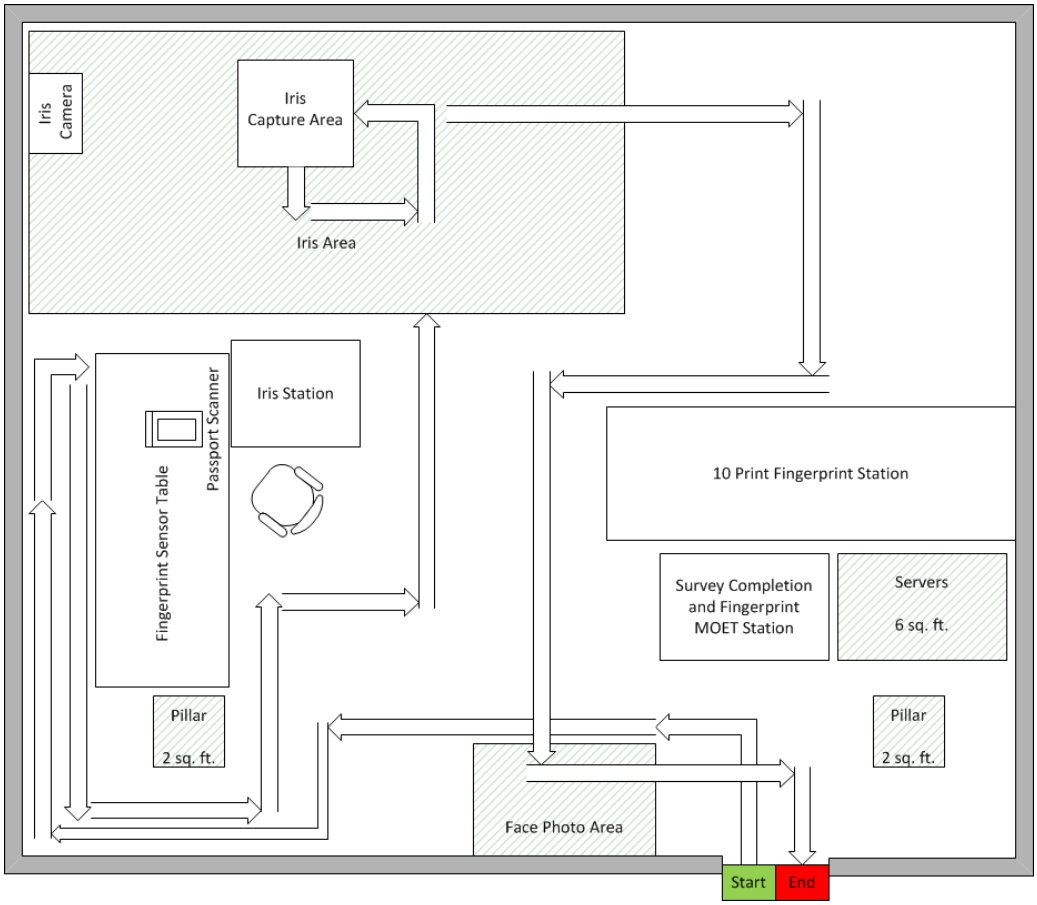

Figure 3.1 Test Environment

Eighty-one subjects had their data collected from one of seven different test administrators. The testing procedures were as follows:

- The subject filled out a consent form. The test administrator helped the subject to understand the form and ensured that it was signed and dated.
- The test administrator used the subject's driver's license or passport to validate their demographic data. This information was validated for correctness against data previously recorded in the database. If the picture or signature were missing, the test administrator scanned the identification to obtain the data.

- The test administrator used a sensor to capture fingerprint temperature, skin texture, pigmentation, sebum (oiliness), moisture, elasticity, skin color, and keratin off of the subject's right index finger. The test administrator ensured that all data were entered into the database.
- The test administrator collected six fingerprint samples from the right index, right middle, left index, and left middle fingers on each of four different fingerprint sensors from the subject. The subject was allowed eighteen attempts to submit the six samples.
- The test administrator collected twenty iris samples from the subject, allowing the subject up to twenty-five attempts. The test administrator asked the subject to follow the lines on the ground so that they disengaged from the system between each capture.
- The test administrator collected three transactions of fingerprints from the ten-print sensor from the subject. A transaction is made up of a series of presentations that include the four right hand fingers, the four left hand fingers, and both thumbs.
- The test administrator collected three face samples from the subject using a digital camera. These samples are validated and transferred from the camera to the database.
- Upon completion, the subject signed a payment form. The test administrator compensated the subject and checked that the form had been signed and dated. During this time, test administrators also scheduled the subject for a third visit. The data collection procedure lasted approximately forty minutes for each subject.

Changes addressed in 3.1.3 were incorporated into *visit two* to mitigate the test administrator error reported in *visit one*. The amount of error reduction was measured for the seven test administrators in *visit two* to demonstrate if the new procedures were effective. This study focused on variables that the test administrators had a direct role in collecting. Although most data were validated automatically by the database, face samples were validated by manual inspection.

3.1.6 Post-Mortem

After the second visit, a post-mortem session was conducted with the test administrators. The post-mortem gauged test administrators' satisfaction with recent changes. Questions about what test administrators liked and disliked helped to aid the continuous improvement process of the facility. Based on suggestions from the post-mortem, further improvements were made to the database and GUI.

3.2 Calculation Methodology

This section explains how the metrics were calculated to illustrate test administrator error. The test administrators collected data from 111 subjects in *visit one* and 81 subjects in *visit two*. Test administrators collected data from subjects based on random assignment based on test administrator availability.

Errors in the demographic government identification capture were apparent through database reports. These reports were generated through a database script that gave exported fields into Microsoft Excel sheets for calculations. Missing or incorrectly formatted metadata fields were recorded as test administrator errors. In *visit one*, all

metadata for each subject was uploaded to the database after capture. The fields that were missing or entered in an incorrect format were corrected when subjects returned for *visit two*. Data collection errors and lack of validation were shown by the number of erroneous fields divided by the number of total fields.

Test administrator errors in fingerprint metadata were also captured through database reports. All fingerprint metadata fields were collected in both visits to measure the amount of blank or incorrectly formatted fields. Data collection error and lack of validation were determined by the number of erroneous fields divided by the number of total fields.

Errors in face recognition were quantified by processing the captured samples through Aware PreFace software. These samples were tested for adherence to the ISO Frontal Best Practice standard. If the image was not compliant, a specific compliance metric violation was reported in the output. It was the job of the test administrator to capture the sample correctly. A violation in compliance demonstrated an incorrect capture on behalf of the test administrator. The data collection error was shown by the number of non-compliant samples divided by the number of total samples.

3.3 Threats to Internal Validity

Internal validity refers to the extent to which an experimenter can be confident that his or her findings result from experimental manipulation (Druckman et al., 2011). There were seven threats to internal validity including history, maturation, testing, instrumentation effects and human error, statistical regression, selection, and mortality (Sekaran, 2003).

Instrumentation effects were the biggest concerns for this research. Faulty equipment or software errors could have created false test administrator error. To mitigate this, the database was backed up daily and CARs were used to report any equipment malfunction. Test administrators also followed procedures to start-up and test equipment at the start of each day to ensure that there were no problems.

Selection was a threat because *visit two* did not have the same test administrators in the study as *visit one*. Test administrators did not work every study, and because most of them were full-time students, their participation was dependent on their class schedule. The subjects that test administrators collected data from were chosen through random selection.

Similarly to selection, experimental mortality was a risk, three test administrators graduated during the course of the study. Graduating caused them to leave the study and drop out of future data collections. For this reason, new test administrators were recruited to fill their roles and not all test administrators in the focus group returned to data collect in *visit two*.

Maturation, referring to an effect due to the passage of time, was also a threat. This study took place over two visits, so changes in experience occurred during this time. There was an eight month span between the two visits. Maturation may have affected both the test administrators and the human subjects.

History was also a threat to the internal validity of this research. History involves an event that can occur during the life of the research that will alter the results. History could have been a threat due to the large focus on quality in *visit two* due to the use of an improved database that was not used in *visit one*. Test administrators in *visit two* were

also trained under the philosophy of continuous improvement in processes and procedures, rather than just the correct way to collect data.

3.4 Threats to External Validity

External validity is related to the generalizability of the findings to other settings (Sekaran, 2003). The findings of this research may only be generalizable for a specific group of people, places or times. The first threat involves people. The test administrators used in this study were representative of college students aged 19 to 25. Places were a threat because results from test administrators are representative of one facility and may not be generalizable to other data collection facilities. The threat of places also creates the distinction between a test administrator and a biometric operator. This research took place in a biometric data collection environment and does not apply to operational environments. The final threat is time. This research took place during a certain time period and may not be repeatable in a future study. Although this research aims to create a system that will improve future studies, the changes may not achieve the same results.

CHAPTER 4. RESULTS

This chapter covers the results of the test administrator survey, the test administrator competency quiz, the test administrator error results of each data collection station, and the post-mortem session results.

4.1 Test Administrator Survey Results

The test administrator survey provided many areas for improvement before the start of *visit two*. The full results of the test administrator survey are shown in Appendix D. Seven test administrators completed the survey and most improvements were in the category of administrative changes. Eighty-six percent of test administrators reported that they preferred a consistent schedule between weeks, instead of one that varied week-to-week. For each study, test administrators reported different members of the organization in charge. It was important to assign one quality manager for each project that helps to train and give test administrators their instructions. A quality manager will also provide test administrators with a central point of contact for help and to relay time-sensitive information. Test administrators also reported that they were not always trained in the same way. For each data collection test administrators were surveyed about, all but one test administrator reported that updated instructions were at some point passed between other test administrators, rather than through a central point of contact. This exchange of

information resulted in each test administrator having different training of the procedures for the data collection. This issue was resolved for *visit two* by having a formal training session where every test administrator was given the same instructions. Although it did not occur in *visit two*, additional training sessions can be held if updated instructions are necessary. Test administrators admitted that they had many roles within the same data collection. In one study, test administrators reported they had multiple roles including being a data collector, participant scheduler, test administrator scheduler, error reporter, data manager, and system designer. These results support the multiple roles of the test administrator discussed in 2.2.

It was also noted that there should be a standardized way to handle subject comments and questions. Every test administrator reported that they "allow the participant to speak and record feedback", but in *visit one* there was no interface to allow the reporting of subject feedback. For the training session, it was determined that test administrators should not engage in conversation with a subject during data collection unless it was to answer a question. Finally, test administrators admitted they made errors when handling cameras in the past. It was reported that test administrators were not certain of device configurations and had a challenge with determining the distance to hold the device from the subject's face. This information was used as motivation to standardize the camera settings and to create a template for quickly aligning the device. All seven test administrators also reported that they questioned their own judgment and occasionally forgot what stage of the data collection they were on. This provided motivation to create a tab-based GUI so that test administrators could step through the data collection process.

4.2 Test Administrator Quiz Results

After completing the competency quiz, each test administrator was given their score along with the justification for each incorrect answer in private. The most commonly missed question involved when improvements could be implemented to the data collection. Four of the seven test administrators thought changes could not be made during the data collection because changes could jeopardize the results. Test administrators were reminded of the importance of continuous improvement and that changes could be made during the data collection as long as they did not affect the integrity of the data. All test administrators passed the quiz and the individual results are shown in Table 4.1.

Table 4.1 Training Quiz Results

Test Administrator	**% Correct**
1	90%
2	80%
3	95%
4	80%
5	80%
6	95%
7	100%

4.3 Software Fixes

The following subsections identify the improvements to the GUI and the amounts of test administrator error mitigation.

4.3.1 Test Administrator Login

Prior to starting their data collection work shift, the test administrator logged into the database with unique credentials that were created during training. If a previous test

administrator did not log out of the database, a “Switch User” button allowed them to change to their account. The primary function of the database GUI was to remind the test administrator of common operations that must be completed at the start of the day and before each new subject. This is shown in Figure 4.1.

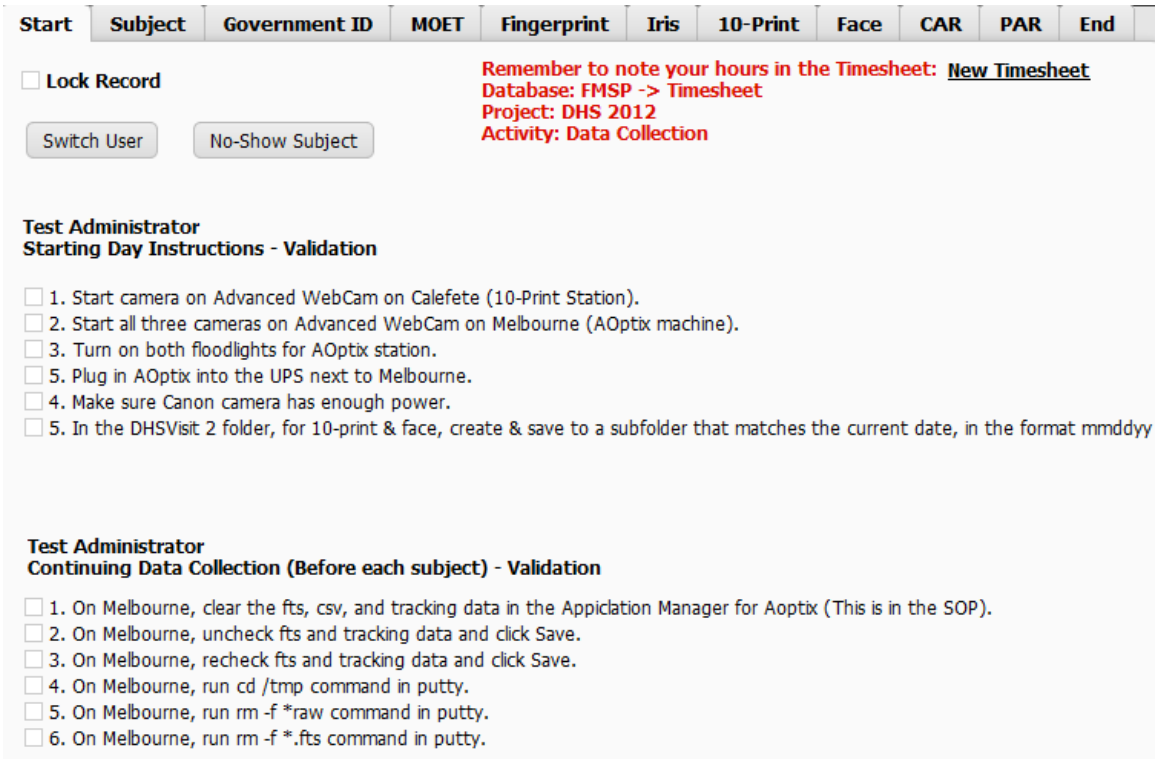

Figure 4.1 Test Administrator Login

Checkboxes were used to ensure that operations such as clearing system log files, turning on additional lighting for the iris recognition station, and starting video recordings were all completed. Items noted in the checkboxes were operations that were commonly forgotten during *visit one*. The implementation of checkboxes was a new feature added for *visit two*. The test administrator login screen and checkboxes are shown in Figure 4.1. After verifying that the operations were completed, the test administrator navigated to the “Subject” tab to check in the subject. In the event of a subject missing

their appointment, the “No-Show Subject” button was selected to create a report of this event in the database.

The checkboxes used to validate that housekeeping activates were performed by test administrators were not always used. Although the first set of checkboxes were only performed at the start of the day, test administrators needed to validate that all six of the activities listed under “Test Administrator Continuing Data Collection (Before each subject) – Validation” were completed before each new subject arrived. Although it was likely that these activities were still completed, test administrators did not use these checkboxes for ten of the 81 subjects. In the post-mortem session conducted after the study, test administrators reported that they either forgot to check the boxes despite doing the activities or did not realize that they forgot to check the boxes. Future iterations of the GUI should make these boxes red, similarly to blank fields, until they are checked.

4.3.2 Station 1: Subject Check-in

Upon selecting the “Subject” tab, test administrators were presented with a screen to look up a past subject or to add a new subject to the database. The database can be searched for returning subjects by selecting the magnifying glass icon next to the First Name field shown in Figure 4.2. The First Name, Last Name, Study Name, or any combination of these fields could be searched for each subject. Upon selecting a subject from the search, First Name, Last Name, IRB #, Subject ID, Highest Visit Completed, Visit Number, and Study Name were automatically populated. All subjects in this study had returned from the first visit or a prior study and were already in the database, allowing them to be found in a search. If a subject from the incorrect study was selected,

the Study Name field remained red. Blank demographic fields that needed to be completed before beginning the data collection were also shown to the test administrator in red.

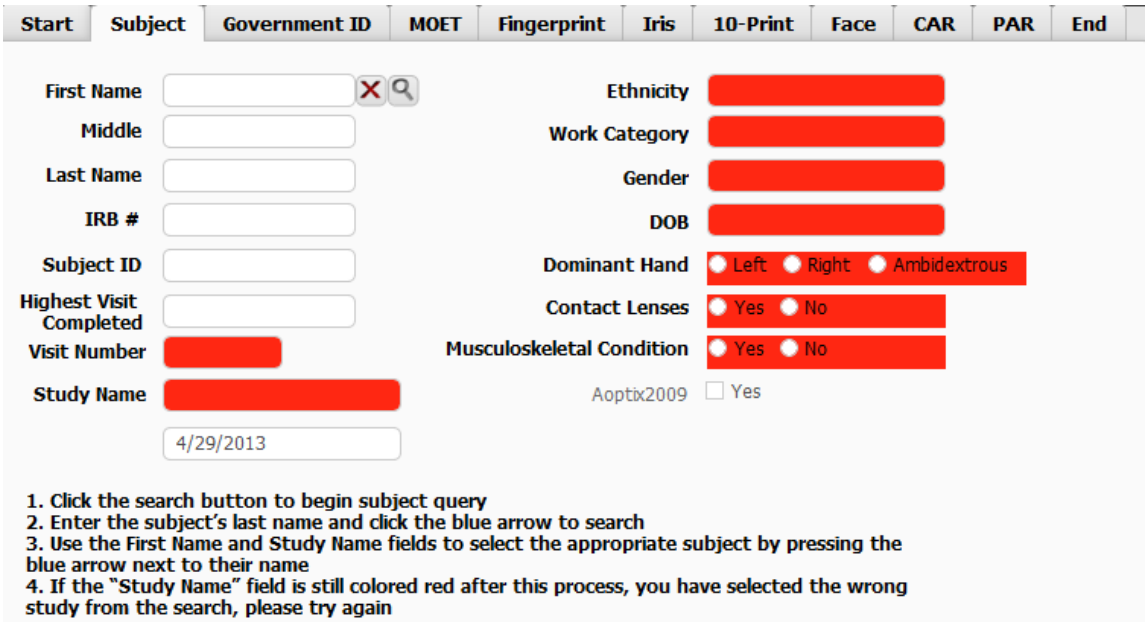

Figure 4.2 Blank Subject Check-in Screen

Any demographic information previously collected for the subject would automatically populate the red fields shown after a search for a subject. This information was intended to be collected during *visit one* of the study but was missing for some subjects. These fields were validated, and any missing data were collected from the subject and entered into the database by the test administrator in *visit two*. Fields turn white as they are populated, and a completed demographic screen is shown in Figure 4.3. The First Name, Last Name, IRB #, Subject ID, and Date of Birth are blacked out for confidentiality and subject privacy.

Test administrators successfully completed all demographic fields for every subject who returned for *visit two*. A total of zero blank fields were reported, demonstrating that the database logic used in station one was a success.

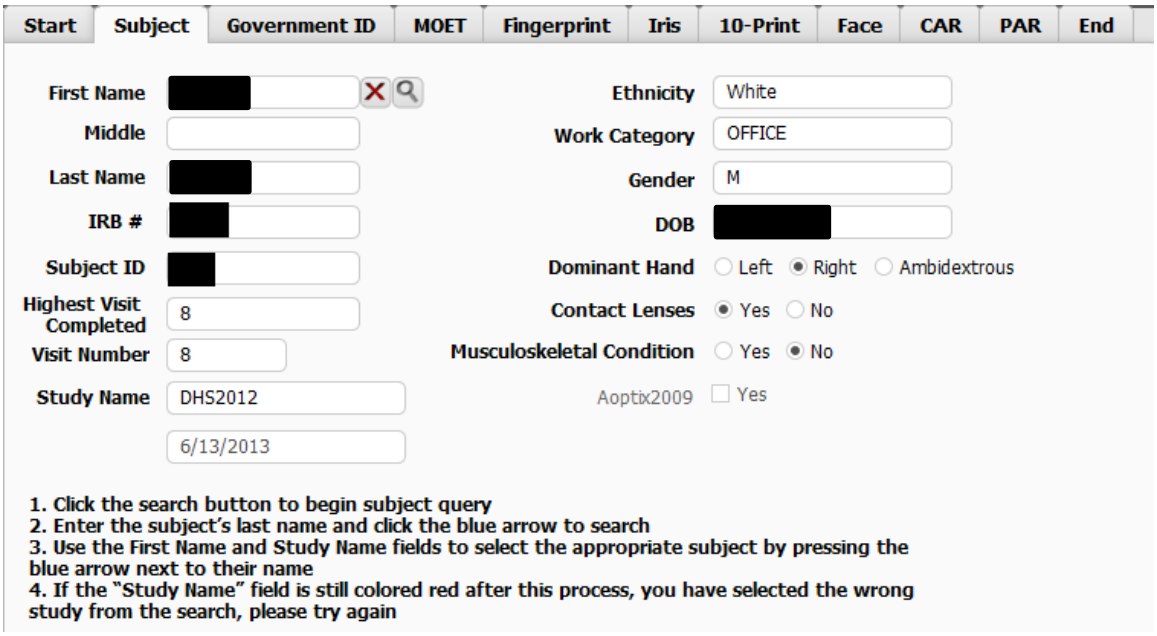

Figure 4.3 Completed Subject ID Screen

Along with the red field warnings for missing data, standard operating procedures (SOP) were also listed on each tab of the data collection GUI. Before this study, SOPs were only available in binders and took additional time to access. Step-by-step instructions were built into each station tab on the GUI and served as reminders to test administrators. The SOP for this tab instructs test administrators how to search for the subject who has arrived. This is shown at the bottom of Figure 4.3.

4.3.3 Station 2: Government Identification Metadata

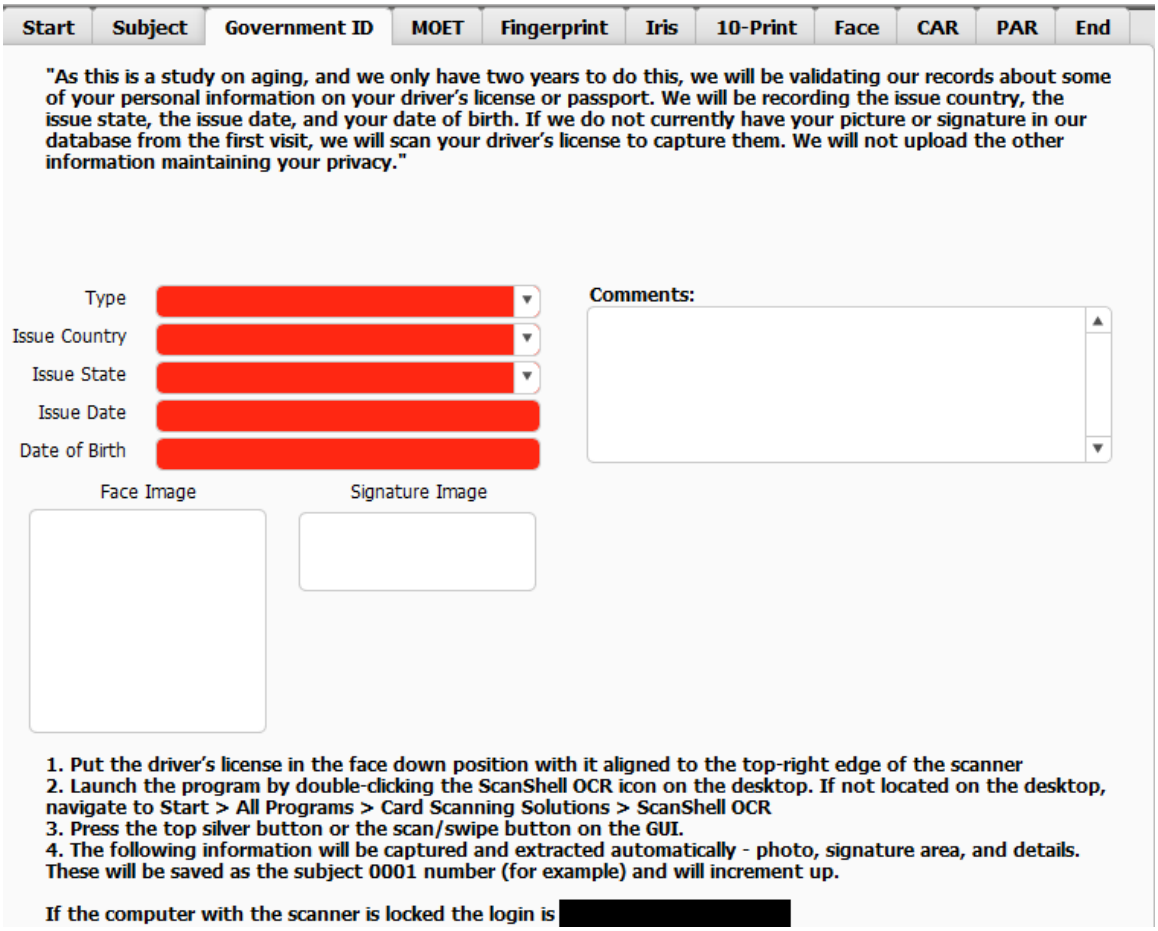

Figure 4.4 Government ID Collection Screen

The logic for blank fields was incorporated in the other GUI tabs for data collection. As the government identification information was scanned by using the passport and driver's license reader, images of the subject's face and signature were saved to a folder, and the demographic details were entered directly into the database. The majority of these data were previously collected during *visit one*, but test administrators were instructed to validate and correct any missing or incorrect data. The data collection screen used to collect this is shown in Figure 4.4. Any fields that were

blank or incorrectly formatted appeared in red until corrected by the test administrator. If fields remained blank or were incorrectly formatted, the database generated an error message such as the one shown in Figure 4.5. Unlike the textual information that was typed into the database, the face photograph and signature fields did not generate error messages because these were not validated. The image data were uploaded after the subject completed the study.

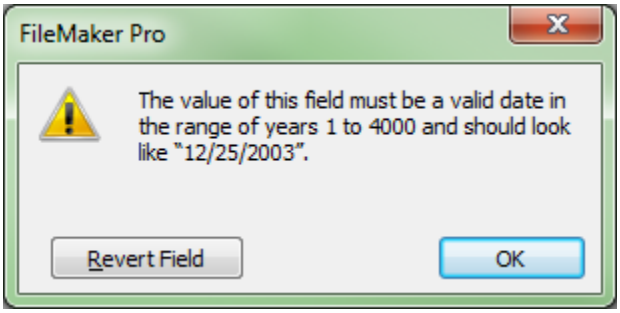

Figure 4.5 Date of Birth Error Dialog

Table 4.2 Government Identification Metadata Between Visits

Metric	Visit One	Visit Two
Missing Subjects (All Fields Blank)	25	3
Date of Birth (Blank)	27	1
Date of Birth (Incorrect Format)	1	0
Issue Country (Blank)	1	1
Issue Date (Blank)	8	1
Issue Date (Erroneous Entry)	5	0
Issue State (Blank)	1	1
Issue State (Incorrect Format)	0	1
ID Type (Blank)	0	1
Signature Image (Blank)	3	2
Face Image (Blank)	0	2
Total Erroneous Fields	**221**	**31**
Percent Erroneous Fields	**28.44%**	**5.47%**

After formal training, improvements to database logic and continuous data monitoring, there was a reduction in the amount of erroneous database fields from *visit one* to *visit two*. Test administrators remembered to collect and validate the data more often, and if a subject did not have a form of identification, it was noted in the data collection comments. One subject only had his/her signature image and face image collected, causing one blank across all other metrics. Test administrators were also required to correct "Issue State" to a standard format when validating the data. One subject was not corrected to the standard format. The entire government identification station was skipped for three of the eighty-one subjects in total. The total proportion of erroneous fields was reduced from 28.44% in *visit one* to 5.47% in *visit two*. Although this result an improvement from *visit one*, there should have been further database logic that would not have allowed any error to occur. Further improvements will be discussed in Chapter 5.

4.3.4 Fingerprint Metadata

Fingerprint metadata fields were collected by the test administrator and manually entered into the database as they were displayed on the device's screen. The Raytek infrared temperature device was used by the test administrator on the subject's right index finger to acquire skin temperature. Test administrators also used the Moritex MSA Pro device on the subject's right index finger to capture skin texture, pigmentation, sebum, moisture, elasticity, skin color, and keratin. Figure 4.6 displays the "MOET" tab that test administrators used to enter this information into the database. A SOP was

provided on how to collect each of the fingerprint metadata and was displayed on the bottom of the data collection screen.

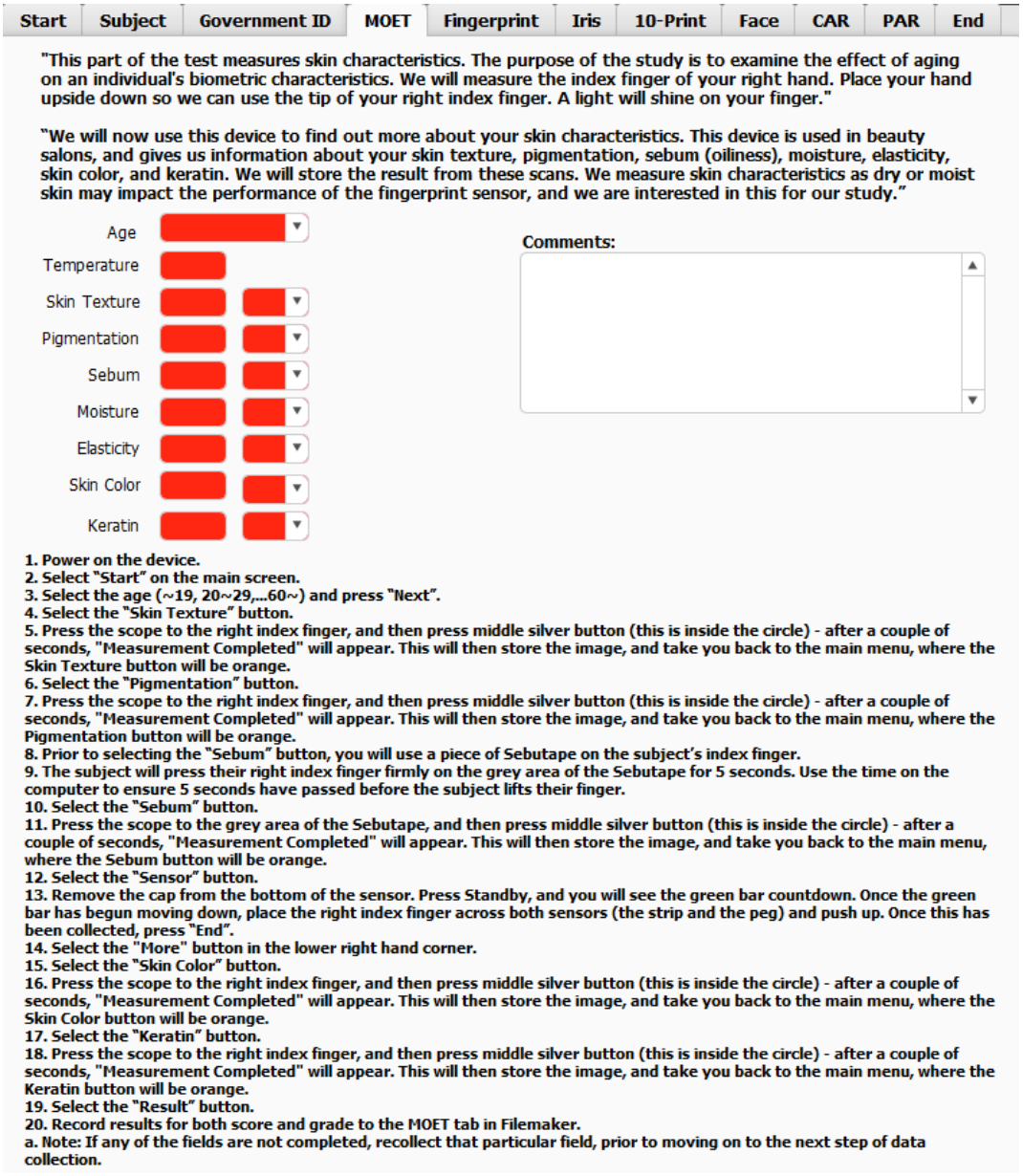

Figure 4.6 Blank Fingerprint Metadata Fields

As these data were collected, test administrators read the results off of the device's screen and entered them into the fields. The device displayed a numerical value

as well as a letter grade for each metric. As the fields were filled out, they switched from red to white indicating that no errors had occurred. The fingerprint metadata fields were restricted to values of 0-99 (with the exception of skin temperature) and drop-down boxes were provided so that test administrators could efficiently select the grade achieved. If a value was entered outside of the acceptable boundaries, an error dialog such as the one shown in Figure 4.8 was displayed.

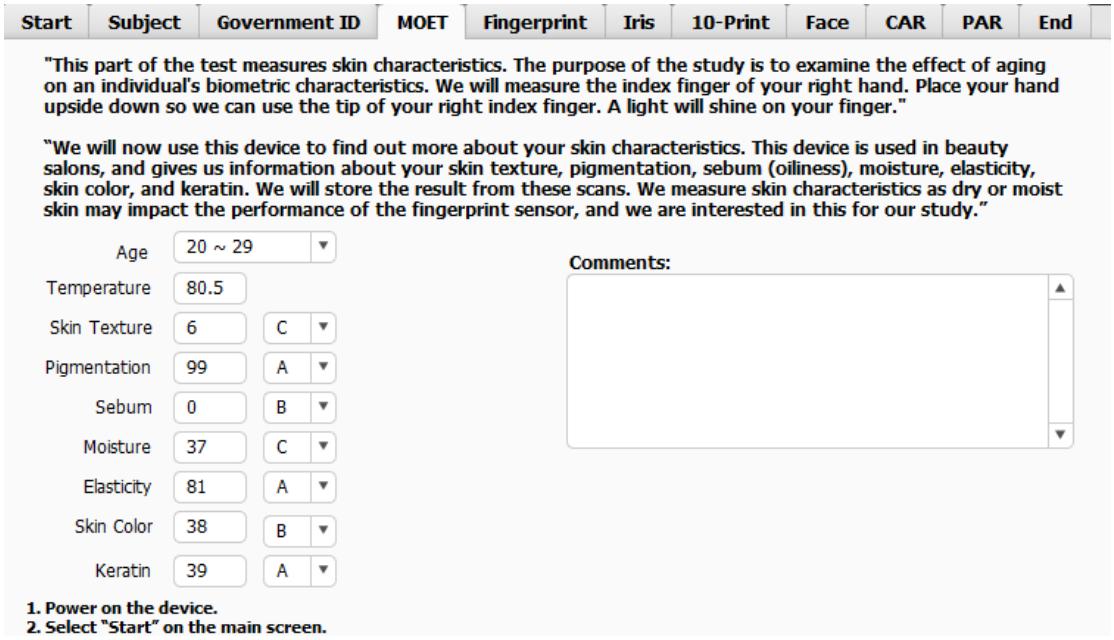

Figure 4.7 Completed Fingerprint Metadata Fields

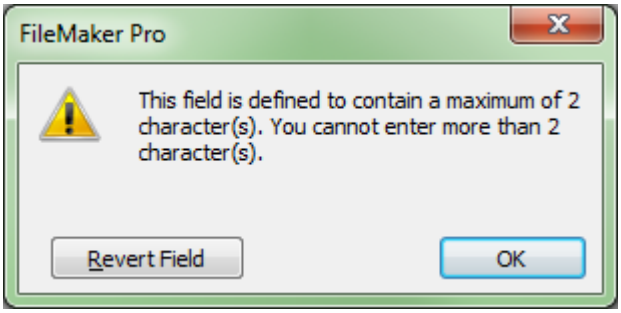

Figure 4.8 Fingerprint Metadata Error Dialog

Table 4.3 Fingerprint Metadata Between Visits

Metric	Visit One	Visit Two
Missing Subjects (All Fields Blank)	12	0
Temperature (Blank)	0	0
Skin Texture (Blank)	0	0
Pigmentation (Blank)	0	0
Sebum (Measured Incorrectly)	99	0
Moisture (Blank)	0	0
Elasticity (Blank)	0	0
Skin Color (Blank)	0	0
Keratin (Blank)	0	0
Total Erroneous Fields	**195**	**0**
Percent Erroneous Fields	**21.96%**	**00.00%**

The implementation of the database helped test administrators to collect fingerprint metadata from subjects. In *visit one,* twelve subjects were completely skipped and had no data collected. In *visit two,* test administrators were able to follow the tabs at the top of the data collection suite and never skipped this station. *Visit one* fingerprint metadata were also collected on paper, allowing the data to be lost. Because these data are now entered directly into the database, data can no longer become lost. There was also a correction to the process for collecting sebum. In *visit one,* test administrators used the device directly on the subject's skin. To correctly capture these readings, the subject needed to place their finger on a piece of Sebutape and then have the measurement conducted on that instead. This was corrected for *visit two* and test administrators collected using Sebutape. With these improvements, all eighty-one subjects had their data collected, and there were no blank or incorrect fields.

4.3.5 Face Image Compliance

Test administrators were trained on how to properly capture the face photographs for *visit two*. ISO Frontal Best Practice compliancy was used for this study. Compliant distances were determined by following face capture best practices and testing sample images through compliance software. A locator grid was added to the camera that served as a guide, allowing test administrators to line up symbols over the subjects' eyes. This helped the test administrators to achieve the standard compliance distance away from the subject's face. Face images were tested for compliance using Aware PreFace v5.3.6.

Table 4.4 Face Image Compliancy Between Visits

	% Compliant	
Metric	**Visit One**	**Visit Two**
Eye Separation	95.34%	97.21%
Eye Axis Angle	97.21%	99.20%
Eye Axis Location Ratio	87.58%	97.61%
Centerline Location Ratio	0%	0%
Height to Width Ratio	50.93%	100%
Head Height to Image Height Ratio	97.52%	97.61%
Image Width to Head Width Ratio	69.26%	37.85%
Eye Contrast	100%	100%
Brightness Score	100%	100%
Facial Dynamic Range	100%	100%
Percent Facial Brightness	100%	100%
Percent Facial Saturation	100%	100%
Degree of Blur	60.56%	68.13%
Image Format	100%	100%

Table 4.4 shows the percent of images that were compliant to the ISO Frontal Best Practice standard. Each metric was improved in *visit two* with the exception of "Image Width to Head Width Ratio". The biggest improvement was in the image "Height to Width" ratio, improving the percent compliance from 50.93% to 100%. It is important

to note that “Centerline Location Ratio” was not improved and remained at 0%. According to the NIST best practices document for the capture of mug shots

> “The width of the subject’s head shall occupy approximately 50% of the width of the captured image. This width shall be the horizontal distance between the mid-points of two imaginary vertical lines. Each imaginary line shall be drawn between the upper and lower lobes of each ear and shall be positioned where the external ear connects to the head” (McCabe, 1997, p.2).

For images to have a compliant “Centerline Location Ratio”, they must have a ratio of exactly 0.50. Hales notes that because “Centerline Location Ratio” does not allow for a range of possible values, “It is very difficult for any image, even taken under perfect conditions in a laboratory environment, to be compliant to the exact ratio of 0.5” (Hales, 2010, p.38).

4.3.6 Test Administrator Responsibility

Test administrators were held accountable for the errors that they introduced to the system. By logging which test administrator collected data from each subject, errors could be corrected before they became more severe. The drop-down box shown in Figure 4.9 contained each of the test administrators’ names and was used to provide accountability in terms of the integrity of the data.

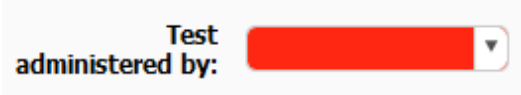

Figure 4.9 Test Administrator Name Selection

Using a continuous improvement philosophy, routine maintenance was used to ensure that the data were being correctly collected. If an error was discovered, the test administrator was informed of their mistake and instructed on how to correct the mistake he or she made. This maintenance showed that one test administrator had collected the images from the face station with the camera too close to the subjects' faces. This test administrator thought that the eye marks on the camera template were supposed to cover the subject's irises, rather than his or her whole eye. The test administrator was re-trained on how to collect at this station and did not repeat the same error again.

4.4 Post-Mortem Session

A post-mortem session was held three weeks after the conclusion of the data collection. Test administrators were asked about their experiences and opinions on scheduling, data quality, communication, database usage, and action requests during the data collection. A final section of the post-mortem included closing thoughts and recommendations for what would be done differently if the same project was repeated. The goal of the post-mortem was to aid future studies by improving current data collection practices.

4.4.1 Comments on Scheduling

Table 4.5 Test Administrator Comments on Scheduling

Question	Comment	Visit	Type
Were test administrator activities clearly defined?	Activities clearly defined through training and objectives were obvious.	2	Above satisfactory
Was the test administrator schedule realistic?	Never too many hours and the schedule kept it organized. Nice to have schedule consistency.	2	Above satisfactory
Was the subject schedule realistic?	*Visit two* never has more than 1 subject waiting. Scheduling did not make test administrators want to rush.	2	Above satisfactory
	Visit one contained crashing and debugging which caused schedule conflicts.	1	Below satisfactory
Was the test administrator schedule tracked and monitored?	Everyone knew when they were supposed to be working based on the schedule.	2	Above satisfactory
	Monitored through the "test administered by:" field in GUI.	2	Satisfactory
	An email reminder service or "clock-in" button would provide additional tracking.	2	Satisfactory
Was the subject schedule tracked and monitored?	Scheduling software made it easier to track and monitor appointments.	2	Above satisfactory
	When subjects were allowed to schedule themselves they would sign up for multiple appointments.	2	Below satisfactory
What was done well with scheduling?	Easy time frame for scheduling and software was very straight-forward.	2	Above satisfactory
What was done poorly with scheduling?	*Visit one* did not have enough test administrators so one person would work long shifts or multiple days in a row.	1	Below satisfactory

4.4.2 Comments on Data Quality

Table 4.6 Test Administrator Comments on Data Quality

Question	Comment	Visit	Type
Was an appropriate level of data quality specified?	*Visit two* made it a lot easier without manual data collection and new software.	2	Above satisfactory
	Face image collection directions were not clear when the study began.	1	Below satisfactory
	Visit one had much uncertainty with fingerprint and potential errors for labeling and typing.	1	Below satisfactory
What was done well in data quality management?	Process and software improvements from *visit one* to *visit two*.	2	Above satisfactory
What was done poorly in data quality management?	Comments from subjects were hard to record due to multiple screens.	2	Below satisfactory

In addition to the comments in Table 4.6, test administrators provided two recommendations. It was recommended that one "pilot subject" should go through the full data collection to test all processes and procedures. This will also provide training to new test administrators. It was also recommended that a second test administrator would aid in comment recording and subject feedback.

4.4.3 Comments on Communication

Table 4.7 Test Administrator Comments on Communication

Question	Comment	Visit	Type
Was there an agreed communication plan for test administrators?	Emails were sent out to test administrators but a central communication portal is needed for team messages. This will confirm that messages are read.	2	Below satisfactory
Was there open and appropriate communication within the project team?	There was open communication between members but messages were not confirmed as read.	2	Below satisfactory
Was there open and appropriate communication with the subjects?	It was easy to communication with subjects but they occasionally did not come to their appointments.	2	Satisfactory
What was done poorly in communication management?	Test administrators would like the project sponsor to be more involved to ensure procedures are correct.	2	Below satisfactory

Test administrators provided additional feedback on how to improve the communication with subjects. It was requested that communication with subjects during the data collection be standardized when possible. It was recommended that subject errors should be documented and responses should be recorded so that when errors are repeated, test administrators can provide reliable feedback.

4.4.4 Comments on the Database

Table 4.8 Test Administrator Comments on the Database

Question	Comment	Visit	Type
Were roles and responsibilities clear?	It was clear what to do and how to use the GUI.	2	Above satisfactory
What was done well with the database?	Checkboxes were useful for start-up activities.	2	Above satisfactory
What was done poorly with the database?	The scripts were useful as a guide for important information but were not followed verbatim.	2	Below satisfactory

Test administrators were not aware that it was mandatory to read the full scripts on each tab of the GUI. Instead, the scripts were used as guidelines for what to say to the subjects. To improve this, test administrators recommended that scripts should vary for each visit so they are not repetitive in multiple-visit studies.

4.4.5 Comments on Action Requests

Table 4.9 Test Administrator Comments on Action Requests

Question	Comment	Visit	Type
Was there an appropriate plan for errors if actions were needed?	It was clear how to report an error.	2	Above satisfactory
	Unclear who to assign some CARs/PARs to.	2	Below satisfactory
Were the CARs and PARs appropriate?	The CARs and PARs worked well and provided accountability to test administrators.	2	Above satisfactory
What was done well with CARs and PARs?	The “complete” button was useful to send an email to the test administrator it was assigned to and document the issue.	2	Above satisfactory
What was done poorly with CARs and PARs?	CARs and PARs were sometimes forgotten before being completed and the assignee was only reminded once.	2	Below satisfactory

To improve the action request system, test administrators provided two additional recommendations. These requests were originally tied to a specific subject record but it was proposed to make them independent and store in their own database for easy access.

It was also suggested that a test administrator task list would be created so that requests were completed on time.

4.4.6 Lessons for the Future

Overall, test administrators were more satisfied with *visit two* of this data collection than they were in past data collections. Due to the framework put in place, test administrators believed that future studies would become even more successful. The database was mentioned as a huge improvement and one test administrator mentioned that “the checklists and tabs in the test admin GUI decreased my stress level”.

It was recommended that future studies should use all electronic SOPs and they should continue to be located on the GUI for quick referencing. If the study was to be repeated, test administrators mentioned that the hardware and systems should be upgraded to fully optimize the GUI.

CHAPTER 5. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This study examined the amount of error introduced to a biometric system at various stations in a multimodal data collection. By introducing new training methods and creating database functionality to help test administrators, the amount of erroneous fields in the data collection was reduced. Test administrators were also instructed on a continuous improvement philosophy to aid future studies as well. Upon completion of this data collection, a post-mortem session was held to collect feedback from test administrators about any further improvements that could be implemented. Test administrators were also asked about what they liked and disliked about the data collection as well as the management tools used.

5.1 Conclusions

This study has shown that the test administrator plays an important role in the integrity of a subject's biometric data. Without logging test administrator actions, it is difficult to determine whether an error was caused by the subject, the test administrator, or an extraneous factor. Erroneous and missing data fields were greatly reduced by paying specific attention to the role of the test administrator. Standardized training and error reporting were key in instructing test administrators how to correctly collect data, as well as how to solve any issues that may occur. Over the course of the data collection, a

total of forty-four corrective action requests and five preventive action requests were filed and resolved. The use of CARs and PARs was essential to improving data collection and should be used in all future studies to provide accountability and also to keep records for the funding agency.

5.2 Future Work

Future data collections need to leverage the database and GUI put in place for this study as much as possible. Data collections can become even easier by implementing additional software needed to run the tests. Creating one uniform program will allow test administrators to focus on the data collection rather than on adjusting the tools. The post-mortem also showed that the test administrators enjoyed being able to enter any collected data straight into the database without needing to upload it at a later time. Additional efforts should make data uploading and entry as simple as possible.

The GUI created for this data collection is fully modifiable. The methodology of the test administrator data collection suite can be adapted for any future biometric data collection. Data entry fields can be easily altered, and the ability to look up a subject in the database will continue to help compile a broad database of subject data and demographics. The results from this study recommend that future iterations of the GUI should also implement the CAR and PAR system to continue to improve processes. The role of the subject and biometric system can also be examined by further database logic and error detection.

5.2.1 Future Work in HBSI

This study focused on quantifying and mitigating the amount of test administrator error in a biometric data collection. Future research should involve the classification of these errors by using the Human-Biometric Sensor Interaction (HBSI) model. The HBSI model has proven to be very effective in classifying the amount of error that the subject introduces to the system and needs to be adapted for the test administrator. Although the HBSI model was created with the intent of viewing subject error only, there is a portion of subject errors that is influenced by the test administrator. Incorrect decisions made by the test administrator can result in an incorrect presentation on behalf of the subject. An example of this would be telling the subject to use the incorrect finger during fingerprint sample collection, or not paying attention to the finger presented. Test administrators can cause errors that are classifiable in the HBSI model. Hicklin and Khanna (2006) address an error that occurs when a sample is associated incorrectly, such as mislabeled left and right irises, or an index finger labeled as a middle finger. These categories of errors would equate to a test administrator-caused concealed interaction in the HBSI model.

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APPENDICES

Appendix A IRB SUBJECT CONSENT FORM

Research Project Number

For IRB Office Use Only

RESEARCH PARTICIPANT CONSENT FORM

Multi-modal aging database collection for biometric research

Stephen J. Elliott, PhD
Purdue University
Department of Technology, Leadership and Innovation

Purpose of Research

This research will be used to test the performance of several biometric systems. An example of a biometric is a fingerprint, iris, signature and is used to identify individuals. Outcomes of this study will help in furthering the understanding of biometric system performance over time and how to improve such systems. This research is being conducted with other researchers from Bion Biometrics in Canada, and a research group at the University of Kent in the United Kingdom.

Specific Procedures

As a participant, you will be provided with a copy of this informed consent form to read and sign if you choose to participate. You will go through six stations which will collect information from you.

Station 1

At station 1, demographic information will be collected. This includes ethnicity, first name, middle name, last name, work category, contact information such as e-mail, phone, whether you have been in a biometric study before and what type of study (fingerprint, iris etc.), what your dominant hand is (the one you write with typically), and whether you wear contact lenses (specifically hard, patterned, soft, and/or colored). We will also ask whether you have any movement or muscle soreness that we would need to know about, such as arthritis or rheumatism at this time. Information such as your name, contact information will be kept separate in another database. We collect this information to make sure we can contact you in the future if you wish. Your signature at station 1 will be stored in a separate database.

Station 2

At station 2, you will have some skin characteristics measured, including temperature, skin texture, pigmentation, oiliness, moisture, elasticity, skin color and keratin – the outer layer of the skin. The device will take a picture of your dominant index finger. This information is used to understand how your skin can affect the performance of a biometric fingerprint reader. For example, dry fingers can cause lighter images and moist fingerprints cause darker images. We will note whether you have any head coverings on.

Station 3

At station 3, we will scan your driver's license and/or passport / visa. This is because we are measuring aging and we can get an official issue date. The following information is captured by the scanner: photo, signature, issue date, sex, height, date of birth, State of issue, country. We need this information in order to understand how aging affects your signature. For example, if your driver's license was issued five years ago, we can measure the photograph from your driver's license against the photograph taken at Station #6. We will delete the other information from the record. This is to maintain your privacy. You may also bring in current photographs taken from CVS or Walgreens as passport photos. These should have been taken within the last six months. For reimbursement you should bring a valid receipt. You will then move on to station 4.

Station 4

Here you will have your fingerprints taken, using a number of different sensors. We will take 6 images from your index finger, middle finger on both hands. We will try up to 18 times for each finger. If we cannot get six images in 18 tries, you will move onto the next fingerprint sensor.

_____ Initials _____ Date

Approved on 31-MAY-2012 Purdue IRB Protocol #: 1205012266 - Expires on: 30-MAY-2014
Research Project Number

Station 5

The next station is the iris station. This is set up in a similar process that you would find in an immigration hall. This particular camera is used for border security at an airport in London, England. You will walk up to the iris camera following the arrows on the floor, and standing in a red rectangular box. We will measure how far away you are from the camera. The camera will take a photograph of your eyes.We will ask you to repeat this twenty times.

Station 6

At station 6, you will have aphotograph of your face taken three times.

Station 7

At station 7, we will measure your fingerprints again, this time taking all four fingers at the same time, followed by the thumbs. This is set up in a similar process that you would find in an immigration hall. This particular device is used for border security in many international airports. We will repeat this three times.

Duration of Participation

This study consists of up to 8 visits over a period of a year, lasting approximately 45 minutes for visit 1, 45 minutes for visit 2 , 10 minutes for visits 3-7 and 20 minutes for visit 8. You do not have to participate in visits 3-8 if your schedule does not permit. Visit 8 can be scheduled up to 8 months away. This is to get another set of aging data.

Risks

This study poses minimal risk to you; no more than occurs in everyday activities. Biometric images will be collected without identifying information. The iris biometric images collected in this study will be included in a dataset will be delivered to AOptix who manufacture the device. The other data will be analyzed by the research group in Canada and United Kingdom. This data will not contain any personally identifiable information,; however there is risk that you could be identified causing a breach of confidentiality.

Benefits

There are no benefits to you as a participant. However, the administrator of fingerprint scanners may benefit from the result of this study as it will allow researchers to recommend guidelines to improve performance.

Compensation

You will be paid if you complete visits 1 and 2 ($20/visit) and 8 of the research study ($15). You will be paid an additional $5 separately at the completion of visit 2-7, for a maximum of $80. You will not be compensated for early withdrawal. All the collected information will be destroyed if you decide to withdraw from the study..

Confidentiality

The project's research records may be reviewed by the study sponsor, Department of Homeland Security (DHS) and AOptix, and by departments at Purdue University responsible for regulatory and research oversight.
Only authorized researchers from Purdue's BSPA laboratory AND AOptix involved in biometrics research will have access to the database. The data is does not contain any personally identifiable information, except for images of the iris and the demographic information above. Consent forms will be stored in the Biometric Standards, Performance and Assurance (BSPA) Laboratory. For the purposes of distributing your payment for completing the study, you understand that your name, social security number, and address shall be provided to the business office of Purdue University. Neither the BSPA laboratory nor AOptix or DHS will maintain your social security number after you complete the study. The database is locked in a secure location, with limited access rights to research team members only.

Voluntary Nature of Participation

You do not have to participate in this research project. If you agree to participate you can withdraw your participation at any time without penalty.

_____ Initials _____ Date

If you are interested in being contacted for future studies, please sign and date below.

_____	_____
Participant's Signature	Date

APPENDIX B TEST ADMINISTRATOR CONSENT FORM

Research Project Number

For IRB Office Use Only

RESEARCH PARTICIPANT CONSENT FORM
Test Administrator Study
Stephen J. Elliott, PhD
Purdue University
Department of Technology, Leadership and Innovation

Purpose of Research
This research will be used to test the performance of the test administrator. Outcomes of this study will help in furthering the understanding of test administrator error and its effect on biometric system performance over time.

Specific Procedures
As a participant, you will be provided with a copy of this informed consent form to read and sign if you choose to participate. You will participate as a test administrator during the data collection process. We will ask you for the following information: age, sex, level of education. You will also complete the Index of Learning Styles online which assesses how you learn. We will also periodically test you on the Biometrics Lab Quality Manual which you will read. You will also have to demonstrate competence with a trainer prior to working with the test subjects. When you are collecting data we will monitor your performance in the following ways – video and audio recordings and keystroke logging. The lab is under constant surveillance for security reasons, and these cameras will be recording audio and video. We will also use these recordings to understand potential data collection issues that may arise. For example, we are interested in how long a subject spends on a particular task, how data is saved and the number of trials that the subject does at each station. This helps us create metrics for our usability model.

Duration of Participation
You are asked to participate in at least one data collection cycle which lasts 45 minutes. You will have the opportunity to participate in more data collection cycles if you wish.

Risks
This study poses minimal risk to you; no more than occurs in everyday activities. The data will be used on journal articles and conference proceedings; however, you will not be identified in the videos. We will use video editing software to blur your face or features. There is risk that you could be identified causing a breach of confidentiality.

Benefits
There are no benefits to you as a participant.

Compensation

There is no compensation for participation.

Confidentiality
The project's research records may be reviewed by the study sponsor, DHS and AOptix, and by departments at Purdue University responsible for regulatory and research oversight.

Only authorized researchers from Purdue's BSPA laboratory involved in biometrics research will have access to the database. The data is does not contain any personally identifiable information, except for images of the iris and the demographic information above. Consent forms will be stored in the Biometric Standards, Performance and Assurance (BSPA) Laboratory. For the purposes of distributing your payment for completing the study, you understand that your name, social security number, and address shall be provided to the business office of Purdue University. Neither the BSPA laboratory or DHS will maintain your social security number after you complete the study.

_____ Initials _____ Date

Voluntary Nature of Participation
You do not have to participate in this research project. If you agree to participate you can withdraw your participation at any time without penalty.

Research Project Number

Contact Information
If you have any questions about this research project, you can contact Stephen Elliott elliott@purdue.edu. If you have concerns about the treatment of research participants, you can contact the Committee on the use of Human Research Subjects at Purdue University, Ernest C. Young Hall, 10th Floor, Room 1032, 155 S. Grant Street. West Lafayette, IN 47907-2114. The phone number for the Board's secretary is (765) 494-5942. The email address is irb@purdue.edu.

Documentation of Informed Consent
I have had the opportunity to read this consent form and have the research study explained. I have had the opportunity to ask questions about the research project and my questions have been answered. I am prepared to participate in the research project described above. I will receive a copy of this consent form after I sign it.

_____ _____
Participant's Signature Date

_____
Participant's Printed Name

_____ _____
Researcher's Signature Date

APPENDIX C TEST ADMINISTRATOR SURVEY

Test Administrator Survey

Default Question Block

Work hours On average, how many hours per week do you attend work/school?

- 1 - 10 hours per week
- 11 - 20 hours per week
- 21 - 30 hours per week
- 31 - 40 hours per week
- 41 or more hours per week

Shifts Do you prefer consistent shifts each week, or differing shifts?

- Consistent shifts each week
- Different shifts each week

Q41 Do you believe that the test administrator scheduling process could be improved?

- Yes
- No

Display This Question:
If Do you believe that the test administrator scheduling pro... **Yes** **Is** **Selected**

Q42 How could we improve it?

Data collection Identify to what degree you agree or disagree with each of the statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It is difficult for me to collect data from my friends.					
It is difficult for me to collect data from data collection "regulars".					
It is difficult for me to collect data from new (first time) participants.					

Q52 On a scale of 0 to 10, 0 being the worst and 10 being the best, how good of a data collector do you think you are?

Q60 Please respond with True or False to each of the following statements:

	True	False
I always protected the participants' rights.	○	○
I always act professional when the participant is present.	○	○
I allow participants to struggle and continue trying during difficult data collections.	○	○
I always respect the participants as experts.	○	○
I allow the participant to speak and record feedback.	○	○
I am unbiased when working as a test administrator.	○	○

Q21 Eyeverify Questions

Q32 During data collection, test administrators had differing roles. Please check all roles you believe you had in Eyeverify.

- ☐ Data collector
- ☐ Participant scheduler
- ☐ Test administrator scheduler
- ☐ Error reporter
- ☐ Data manager
- ☐ System designer

Q49 Who was in charge of the Eyeverify study?

Q55 During the Eyeverify study, was any information passed along to you from another test administrator. i.e. Did you gain information from anyone besides the person in charge?

- ○ Yes
- ○ No

Retake Did you ever doubt your own judgement during the capture procedure? i.e. did you ever think you may have forgotten which eye you were collecting or what stage you were on?

- ○ Yes
- ○ No

Display This Question:
If Did you ever doubt your own judgement during the capture ... Yes Is Selected

Retake2 When this occurred, did you retake the samples or just continue as normal?

- ○ Retook the samples
- ○ Continued with data collection

IP Do you believe that you ever caused a participant to have an incorrect presentation by creating an error?

- ○ Yes
- ○ No

Q43 Identify which of theses errors do you think you may have made during the Eyeverify study:

- ☐ iPhone too far from participant's face
- ☐ iPhone too close to participant's face
- ☐ Captured eye with participant's hair in the way
- ☐ Forgot to capture an eye
- ☐ Created motion blur from too much movement
- ☐ Used incorrect lighting mode
- ☐ Saved data as incorrect Subject ID

Q47 How many hours per week did you data collect during Eyeverify?

- ○ 1 - 10 hours per week
- ○ 11 - 20 hours per week
- ○ 21 - 30 hours per week
- ○ 31 - 40 hours per week
- ○ 41 or more hours per week

Distract During data collection did you:

- ☐ Check your phone
- ☐ Check Facebook
- ☐ Check email
- ☐ Use the computer to browse forums or other websites for fun
- ☐ Answer a phone call

Q38 Identify to what degree you agree or disagree with each of the statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I was originally excited for the Eyeverify study to begin.	○	○	○	○	○
My level of enjoyment for the Eyeverify study changed over time.	○	○	○	○	○
I feel that the graphical user interface (GUI) was easily usable.	○	○	○	○	○
I feel that the training I received was appropriate to properly manage the Eyeverify study.	○	○	○	○	○

Q25 Identify overall, how satisfied you were with your experience of each of the following:

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
iPhone	○	○	○	○	○
iTunes	○	○	○	○	○
External hard drive for data transfer	○	○	○	○	○
Error logging sheet	○	○	○	○	○

Strain

Identify to what degree you agree or disagree with each of the statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I feel that the Eyeverify study caused me physical strain.					
I feel that the Eyeverify study caused me mental strain.					
I feel that I was under a speed stress when I worked as a test administrator in the Eyeverify study.					
I feel that the speed stress impacted my performance as a test administrator.					
I feel that the Eyeverify test was too complicated.					
I feel that I was overloaded with tasks in the Eyeverify test.					

Q48 **How would you have improved the Eyeverify study?**

Q23 **DHS Questions**

Q19 **During data collection, test administrators had differing roles. Please check all roles you believe you had in DHS.**

- [ ] Data collector
- [ ] Participant scheduler
- [ ] Test administrator scheduler
- [ ] Error reporter
- [ ] Data manager
- [ ] System designer

Q51 **Who was in charge of the DHS study?**

Q56 **During the DHS study, was any information passed along to you from another test administrator. i.e. Did you gain information from anyone besides the person in charge?**

- ○ Yes
- ○ No

Q39 **Do you believe that you ever caused a participant to have an incorrect presentation?**

- ○ Yes
- ○ No

Q40 During data collection did you:

- Check your phone
- Check Facebook
- Check email
- Use the computer to browse forums or other websites for fun
- Answer a phone call

Q30 Identify to what degree you agree or disagree with each of the statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I was originally excited for the DHS study to begin.					
My level of enjoyment for the DHS study changed over time.					
I feel that the training I received was appropriate to properly manage the DHS study.					

Q24 Identify overall, how satisfied you were with your experience of each of the following:

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Single-print fingerprint devices					
Ten-print fingerprint device					
Iris recognition device					
Face recognition camera					
Signature recognition device					
Palm vein device					
Hand geometry device					
Moisture sensor					

Q26 Identify to what degree you agree or disagree with each of the statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I feel that the DHS study caused me physical strain.					
I feel that the DHS study caused me mental strain.					
I feel that I was under a speed stress when I worked as a test administrator in the DHS study.					
I feel that the speed stress impacted my performance as a test administrator.					
I feel that I was overloaded with tasks in the DHS study.					
I feel that I was overloaded with tasks in the DHS study.					

Q53 How would you have improved the DHS study?

Q27 Lumidigm Questions

Q33 During data collection, test administrators had differing roles. Please check all roles you believe you had in Lumidigm.

- ☐ Data collector
- ☐ Participant scheduler
- ☐ Test administrator scheduler
- ☐ Error reporter
- ☐ Data manager
- ☐ System designer

Q50 Who was in charge of the Lumidigm study?

Q57 During the Lumidigm study, was any information passed along to you from another test administrator. i.e. Did you gain information from anyone besides the person in charge?

- ○ Yes
- ○ No

Q41 Do you believe that you ever caused a participant to have an incorrect presentation?

- ○ Yes
- ○ No

Q42 During data collection did you:

- ☐ Check your phone
- ☐ Check Facebook
- ☐ Check email
- ☐ Use the computer to browse forums or other websites for fun

Q29 Identify to what degree you agree or disagree with each of the statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I was originally excited for the Lumidigm study to begin.	○	○	○	○	○
My level of enjoyment for the Lumidigm study changed over time.	○	○	○	○	○
I feel that the training I received was appropriate to properly manage the Lumdigm study.	○	○	○	○	○

Q28 Identify overall, how satisfied you were with your experience of each of the following:

	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Fingerprint recognition devices	○	○	○	○	○
Data transfer software	○	○	○	○	○

Q31 Identify to what degree you agree or disagree with each of the statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I feel that the Lumidigm study caused me physical strain.	○	○	○	○	○
I feel that the Lumidigm study caused me mental strain.	○	○	○	○	○
I feel that I was under a speed stress when I worked as a test administrator in the Lumidigm study.	○	○	○	○	○
I feel that the speed stress impacted my performance as a test administrator.	○	○	○	○	○
I feel that the Lumidigm study was too complicated.	○	○	○	○	○
I feel that I was overloaded with tasks in the Lumidigm study.	○	○	○	○	○

Q54 How would you have improved the Lumidigm study?

APPENDIX D TEST ADMINISTRATOR SURVEY RESULTS

1. On average, how many hours per week do you attend work/school?

#	Answer		Response	%
1	1 - 10 hours per week		0	0%
2	11 - 20 hours per week		1	14%
3	21 - 30 hours per week		1	14%
4	31 - 40 hours per week		2	29%
5	41 or more hours per week		3	43%
	Total		7	100%

2. Do you prefer consistent shifts each week, or differing shifts?

#	Answer		Response	%
1	Consistent shifts each week		6	86%
2	Different shifts each week		1	14%
	Total		7	100%

3. Do you believe that the test administrator scheduling process could be improved?

#	Answer		Response	%
1	Yes		4	57%
2	No		3	43%
	Total		7	100%

4. How could we improve it?

Text Response
More consistent scheduling
By improving communication and last minute schedule changes.
It depends on the task at hand, but a couple of things would be better communication and better organization.

5. Identify to what degree you agree or disagree with each of the statements.

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
1	It is difficult for me to collect data from my friends.	1	2	2	2	0	7	2.71
2	It is difficult for me to collect data from data collection "regulars".	2	3	2	0	0	7	2.00
3	It is difficult for me to collect data from new (first time) participants.	1	3	2	1	0	7	2.43

6. On a scale of 0 to 10, 0 being the worst and 10 being the best, how good of a data collector do you think you are?

#	Answer		Response	%
0	0		0	0%
1	1		0	0%
2	2		0	0%
3	3		0	0%
4	4		0	0%
5	5		0	0%
6	6		1	17%
7	7		3	50%
8	8		2	33%
9	9		0	0%
10	10		0	0%
	Total		6	100%

7. Please respond with True or False to each of the following statements:

#	Question	True	False	Total Responses	Mean
1	I always protected the participants' rights.	7	0	7	1.00
2	I always act professional when the participant is present.	5	2	7	1.29
3	I allow participants to struggle and continue trying during difficult data collections.	4	3	7	1.43
4	I always respect the participants as experts.	2	4	6	1.67
5	I allow the participant to speak and record feedback.	7	0	7	1.00
6	I am unbiased when working as a test administrator.	4	3	7	1.43

8. During data collection, test administrators had differing roles. Please check all roles you believe you had in Eyeverify.

#	Answer		Response	%
1	Data collector		7	100%
2	Participant scheduler		6	86%
3	Test administrator scheduler		3	43%
4	Error reporter		4	57%
5	Data manager		6	86%
6	System designer		1	14%

9. Who was in charge of the Eyeverify study?

Text Response
Jake
Steve
Grant maybe or Jake
Steve
Steve
N/A

10. During the Eyeverify study, was any information passed along to you from another test administrator. i.e. Did you gain information from anyone besides the person in charge?

#	Answer		Response	%
1	Yes		6	86%
2	No		1	14%
	Total		7	100%

11. Did you ever doubt your own judgment during the capture procedure? i.e. did you ever think you may have forgotten which eye you were collecting or what stage you were on?

#	Answer		Response	%
1	Yes		7	100%
2	No		0	0%
	Total		7	100%

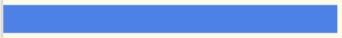
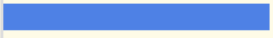
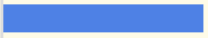
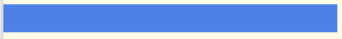
12. When this occurred, did you retake the samples or just continue as normal?

#	Answer		Response	%
1	Retook the samples		3	50%
2	Continued with data collection		3	50%
	Total		6	100%

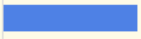
13. Do you believe that you ever caused a participant to have an incorrect presentation by creating an error?

#	Answer		Response	%
1	Yes		3	60%
2	No		2	40%
	Total		5	100%

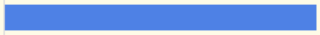
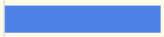
14. Identify which of these errors do you think you may have made during the Eyeverify study:

#	Answer		Response	%
1	iPhone too far from participant's face		5	83%
2	iPhone too close to participant's face		4	67%
3	Captured eye with participant's hair in the way		4	67%
4	Forgot to capture an eye		2	33%
5	Created motion blur from too much movement		3	50%
6	Used incorrect lighting mode		0	0%
7	Saved data as incorrect Subject ID		5	83%

15. How many hours per week did you data collect during Eyeverify?

#	Answer		Response	%
1	1 - 10 hours per week		2	33%
2	11 - 20 hours per week		4	67%
3	21 - 30 hours per week		0	0%
4	31 - 40 hours per week		0	0%
5	41 or more hours per week		0	0%
	Total		6	100%

16. During data collection did you:

#	Answer		Response	%
1	Check your phone		4	80%
2	Check Facebook		2	40%
3	Check email		4	80%
4	Use the computer to browse forums or other websites for fun		3	60%
5	Answer a phone call		2	40%

17. Identify to what degree you agree or disagree with each of the statements.

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
1	I was originally excited for the Eyeverify study to begin.	0	0	1	3	2	6	4.17
2	My level of enjoyment for the Eyeverify study changed over time.	0	1	0	2	3	6	4.17
3	I feel that the graphical user interface (GUI) was easily usable.	0	4	1	1	0	6	2.50
4	I feel that the training I received was appropriate to properly manage the Eyeverify study.	0	0	1	4	0	5	3.80

18. Identify overall, how satisfied you were with your experience of each of the following:

#	Question	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Total Responses	Mean
1	iPhone	2	1	1	2	0	6	2.50
2	iTunes	1	2	1	2	0	6	2.67
3	External hard drive for data transfer	0	1	2	3	0	6	3.33
4	Error logging sheet	2	3	0	1	0	6	2.00

19. Identify to what degree you agree or disagree with each of the statements.

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
1	I feel that the Eyeverify study caused me physical strain.	1	0	1	4	0	6	3.33
2	I feel that the Eyeverify study caused me mental strain.	1	1	2	2	0	6	2.83
3	I feel that I was under a speed stress when I worked as a test administrator in the Eyeverify study.	1	1	0	4	0	6	3.17
4	I feel that the speed stress impacted my performance as a test administrator.	0	0	0	0	0	0	0.00
5	I feel that the Eyeverify test was too complicated.	1	2	2	1	0	6	2.50
6	I feel that I was overloaded with tasks in the Eyeverify test.	1	2	3	0	0	6	2.33

20. How would you have improved the Eyeverify study?

Text Response
More consistent scheduling and better recruiting.
Have a stable place for the subject ot keep head that will cause less strain for the test admin
1). Change the tables to be smaller in width from subject . 2). use a static stand with chin rest for iphone capture. 3). setup auto saving script or naming convention script to auto save the files to prevent naming issues.
I feel the study would have been much better if the GUI ran better and also if there was a mount for the phone to help relieve strain and get consistent results.

21. During data collection, test administrators had differing roles. Please check all roles you believe you had in DHS.

#	Answer	Response	%
1	Data collector	5	100%
2	Participant scheduler	3	60%
3	Test administrator scheduler	0	0%
4	Error reporter	2	40%
5	Data manager	2	40%
6	System designer	2	40%

22. Who was in charge of the DHS study?

Text Response
Steve
Steve
Eric
Steve
Steve

23. During the DHS study, was any information passed along to you from another test administrator. i.e. Did you gain information from anyone besides the person in charge?

#	Answer	Response	%
1	Yes	4	80%
2	No	1	20%
	Total	5	100%

24. Do you believe that you ever caused a participant to have an incorrect presentation?

#	Answer	Response	%
1	Yes	2	40%
2	No	3	60%
	Total	5	100%

25. During data collection did you:

#	Answer		Response	%
1	Check your phone		2	50%
2	Check Facebook		2	50%
3	Check email		1	25%
4	Use the computer to browse forums or other websites for fun		1	25%
5	Answer a phone call		1	25%

26. Identify to what degree you agree or disagree with each of the statements.

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
1	I was originally excited for the DHS study to begin.	0	0	1	3	1	5	4.00
2	My level of enjoyment for the DHS study changed over time.	0	1	1	3	1	6	3.67
3	I feel that the training I received was appropriate to properly manage the DHS study.	0	0	1	4	0	5	3.80

27. Identify overall, how satisfied you were with your experience of each of the following:

#	Question	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Total Responses	Mean
1	Single-print fingerprint devices	0	3	1	1	0	5	2.60
2	Ten-print fingerprint device	0	0	0	4	1	5	4.20
3	Iris recognition device	0	2	1	2	0	5	3.00
4	Face recognition camera	0	1	1	3	0	5	3.40
5	Signature recognition device	0	2	1	2	0	5	3.00
6	Palm vein device	0	4	1	0	0	5	2.20
7	Hand geometry device	0	2	0	2	0	4	3.00
8	Moisture sensor	0	1	3	1	0	5	3.00

28. Identify to what degree you agree or disagree with each of the statements.

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
1	I feel that the DHS study caused me physical strain.	0	3	2	0	0	5	2.40
2	I feel that the DHS study caused me mental strain.	0	2	3	0	0	5	2.60
3	I feel that I was under a speed stress when I worked as a test administrator in the DHS study.	0	1	2	2	0	5	3.20
4	I feel that the speed stress impacted my performance as a test administrator.	0	0	0	0	0	0	0.00
5	I feel that I was overloaded with tasks in the DHS study.	0	1	1	3	0	5	3.40

29. How would you have improved the DHS study?

Text Response
Better recruiting
Better Test subject flow from station to station. A different room layout. Have two administrators in there, but also have enough subjects per hour to require two administrators.
It could have been more automated. The test admin had a lot of moving data around and doing extra things I think that could have been handled with more thought
I did not participate in DHS study
The fingerprint scanners were buggy and it was difficult to use the barcode system. The scanners have been removed already and the barcode system is gone. I only collected for 1 subject so I have no input on improvement

30. During data collection, test administrators had differing roles. Please check all roles you believe you had in Lumidigm.

#	Answer	Response	%
1	Data collector	5	100%
2	Participant scheduler	4	80%
3	Test administrator scheduler	3	60%
4	Error reporter	3	60%
5	Data manager	5	100%
6	System designer	0	0%

31. Who was in charge of the Lumidigm study?

Text Response
Steve
Grant
Grant
Steve
Grant
Steve and Grant

32. During the Lumidigm study, was any information passed along to you from another test administrator. i.e. Did you gain information from anyone besides the person in charge?

#	Answer	Response	%
1	Yes	5	83%
2	No	1	17%
	Total	6	100%

33. Do you believe that you ever caused a participant to have an incorrect presentation?

#	Answer	Response	%
1	Yes	3	50%
2	No	3	50%
	Total	6	100%

34. During data collection did you:

#	Answer		Response	%
1	Check your phone		1	50%
2	Check Facebook		0	0%
3	Check email		2	100%
4	Use the computer to browse forums or other websites for fun		0	0%

35. Identify to what degree you agree or disagree with each of the statements.

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
1	I was originally excited for the Lumidigm study to begin.	0	0	2	3	1	6	3.83
2	My level of enjoyment for the Lumidigm study changed over time.	1	1	3	1	0	6	2.67
3	I feel that the training I received was appropriate to properly manage the Lumdigm study.	0	0	1	4	1	6	4.00

36. Identify overall, how satisfied you were with your experience of each of the following:

#	Question	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied	Total Responses	Mean
1	Fingerprint recognition devices	0	0	1	4	1	6	4.00
2	Data transfer software	0	0	3	3	0	6	3.50

37. Identify to what degree you agree or disagree with each of the statements.

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Responses	Mean
1	I feel that the Lumidigm study caused me physical strain.	1	3	2	0	0	6	2.17
2	I feel that the Lumidigm study caused me mental strain.	1	3	2	0	0	6	2.17
3	I feel that I was under a speed stress when I worked as a test administrator in the Lumidigm study.	1	0	1	3	1	6	3.50
4	I feel that the speed stress impacted my performance as a test administrator.	0	0	0	0	0	0	0.00
5	I feel that the Lumidigm study was too complicated.	1	3	2	0	0	6	2.17
6	I feel that I was overloaded with tasks in the Lumidigm study.	1	3	2	0	0	6	2.17

38. How would you have improved the Lumidigm study?

Text Response
Not sure. Was not present.
Make the switching of sensors easier at night.
n/a
I have no suggestions at this time
Buffer time between appointments would have helped relieve the time stress

APPENDIX E TEST ADMINISTRATOR COMPETENCY QUIZ

Test Administrator Quiz

Default Question Block

Q1 **The quality document complies with these TWO international standards.**

- [ ] ISO 9000
- [ ] ISO 9001
- [ ] ISO 17025
- [ ] ISO 29120

Q2 **Hand-written amendments to the quality manual are permitted.**

- ( ) True
- ( ) False

Q3 **Improvements should be implemented:**

- ( ) After the data collection has concluded
- ( ) Continually throughout the data collection
- ( ) For future studies only

Q4 **This action request is issued before a problem occurs:**

- ( ) Corrective Action Request
- ( ) Preventive Action Request

Q5 **This action request is issued once a problem has already occurred:**

- ( ) Corrective Action Request
- ( ) Preventive Action Request

Q6 **This person has defined responsibility and authority for ensuring that the management system related to quality is implemented and followed.**

- ( ) Quality Manager
- ( ) Test Administrator
- ( ) Department Head
- ( ) Laboratory Director

Q7 **Cleaning and pest control activities are scheduled through Bill Cochran. He takes the role of the**

- ( ) Lab Director
- ( ) Building Deputy
- ( ) Lab Assistant
- ( ) Technical Manager

Q8 This is the person who reviews all Corrective Action Requests and determines the final action.

- Lab Director
- Building Deputy
- Lab Assistant
- Technical Manager

Q9 This form is filled out for any necessary purchase order.

- Form 7
- Form 10
- Form 12
- Form 16

Q10 This is a procedure where part of a biometric sample or product is taken to provide testing or calibration as a representative sample of the whole.

- Calibrating
- Recording
- Housekeeping
- Sampling

Q11 Equipment can be used beyond the calibration date.

- True
- False

Q12 All items in inventory need to be barcoded.

- True
- False

Q13 Opinions and interpretations can be included in a test report if clearly marked as such.

- True
- False

Q14 When receiving a customer complaint, the appropriate action is to:

- Remember it for later
- Fill out a Corrective Action Request
- Fill out a Preventive Action Request
- Ignore it

Q15 Employees (test administrators) are NOT required to attend a training session before data collecting.

- True
- False

Q16 This is a document that specifies or describes how an activity is to be performed.

- GOP
- SOP
- MOP
- OOP

Q17 The laboratory follows the methods for Controlled Access in its testing facilities.

- True
- False

Q18 Personnel working in the laboratory DO NOT need to maintain a record of all customer complaints.

- True
- False

Q19 Who can identify opportunities for improvement in operations or processes?

- Lab Director
- Technical Manager
- Test Administrators
- All of the above

Q20 Competency of laboratory employees can be tested at any time.

- True
- False

VITA

VITA

Michael Edward Brockly
College of Technology, Purdue University

Education

2013	M.S.,	M.S. Technology, Purdue University Thesis: The Role of Test Administrator and Error
2011	B.S.,	Industrial Technology, Purdue University

Experience

2013	Graduate Researcher, International Center for Biometric Research
2012-13	Graduate Teaching Assistant, Biometrics Standards, Performance and Assurance Laboratory
2012	Biometrics Intern, Booz Allen Hamilton
2010-11	Research Assistant, Biometrics Standards, Performance and Assurance Laboratory

Certifications

Security+ certified, CompTIA License C3CZ4NQ27HE128F2

Projects

Co-authored the development of test protocols for:

- DHS S&T Advances in the Human Biometric Sensor Interaction Model
- DHS S&T Biometric Uniqueness and Permanence Analysis
- Advancing Commercial Participation in the NSTIC Ecosystem
- Daon Product Test
- Eyeverify Data Capture

2013	Project manager on a DHS grant examining the role of the Human-Biometric Sensor Interaction model in multiple environments
2012	Managed the on-time and on-budget delivery of approximately 25 undergraduate research projects
2012-13	Served as a U.S. international delegate in the ISO/IEC JTC1/SC37 WG5
2011-12	Team member on a National Institute of Standards and Technology (NIST) grant. Analyzed biometric datasets for standard compliance and assessment of image quality.

2010-11 Team member on a DHS grant. Conducted video analysis for a data collection for fingerprint recognition

Conference Proceedings

- Brockly, M. E., & Elliott, S. J. (2013). Automatic Detection of Biometric Transaction Times. In *The 8th International Conference on Information Technology and Applications (ICITA 2013)* (pp. 196–199). Sydney, Australia. Retrieved from http://www.icita.org/2013/CD/papers/us-brockly.pdf.
- Brockly, M. E., & Elliott, S. J. (2011). Image Quality, Performance, and Classification – the Impact of Finger Location. In *The 7th International Conference on Information Technology and Application (ICITA 2011)* (pp. 300–303). Sydney, Australia. doi:978-0-9803267-4-1.
- Brockly, M., Guest, R., Elliott, S., & Scott, J. (2011). Dynamic Signature Verification and the Human Biometric Sensor Interaction Model. In *45th annual IEEE International Carnahan Conference on Security Technology* (pp. 253–258). Barcelona, Spain. doi:978-1-4577-0903-6.

Journal Articles

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