

Statistical Thinking for Forensic Practitioners

Quiz on Part 1: Introduction

1 Recognizing steps of a scientific procedure

An important component of a scientific body of work (a paper, presentation, etc.) is the *abstract*. An abstract summarizes the major aspects of the entire paper including the purpose of the study, the research hypothesis investigated, the basic design of the study, and a summary of major findings or conclusions found as a result of the analysis. Statisticians often need to adapt to the conventions of a particular scientific field. This means understanding the purpose of a study without necessarily having all of the background knowledge of the study's authors. Even without domain knowledge, we can often identify the 4 components of a study or analysis in an abstract.

Read the following abstracts and summarize, in your own words or by quoting from the text, the 4 major aspects (purpose of the study, hypothesis investigated, study/experimental design, conclusions). Although these abstracts likely contain words or phrases with which you are not familiar, you should still be able to summarize the 4 major aspects.

(a) From [Ricci et al. \(2007\)](#):

In situ attenuated total reflection Fourier transform infrared (ATR-FT-IR) spectroscopic imaging has been used to obtain chemical images of fingerprints under controlled humidity and temperature. The distribution of lipid and amino acid components in the fingerprints from different donors left on the surface of the ZnSe crystal has been studied using an in situ FT-IR spectroscopic imaging approach under a controlled environment and studied as a function of time. Univariate and multivariate analyses were employed to analyze the spectroscopic dataset. Changes in the spectra of lipids with temperature and time have been detected. This information is needed to understand aging of the fingerprints. The ATR-FT-IR spectroscopic imaging offers a new and complementary means for studying the chemistry of fingerprints that are left pristine for further analysis. This study demonstrates the potential for visualizing the chemical changes of fingerprints for forensic applications by spectroscopic imaging.

- Purpose:
“[O]btain chemical images of fingerprints under controlled humidity and temperature” to “understand aging of the fingerprints”
- Hypothesis:
Use “[u]nivariate and multivariate analyses” to study the “changes in the spectra of lipids with temperature and time”
- Design:
Study the “distribution of lipid and amino acid components in the fingerprints from different donors left on the surface of the ZnSe crystal [...] using an in situ FT-IR spectroscopic imaging approach under a controlled environment” environment.”
- Conclusions:
There is “potential for visualizing the chemical changes of fingerprints for forensic applications by spectroscopic imaging”.

(b) From [Zhang et al. \(2013\)](#):

It is well known in optics that the refractive index is an important optical parameter of material. A novel method to measure refractive index of glass has been reported in this paper. This method can be used to measure the refractive index of the special laboratory prepared glass which is small, irregularly shaped by measuring its absorption spectrum. And we have measured the refractive index of the laboratory prepared germanium-lead glass (1) ($70\text{GeO}_2\text{-}10\text{Pb-}10\text{BaO-}10\text{K}_2\text{O}$), germanium-lead glass (2) ($60\text{GeO}_2\text{-}20\text{Pb-}10\text{BaO-}10\text{K}_2\text{O}$), germanium-lead glass (3) ($50\text{GeO}_2\text{-}30\text{Pb-}10\text{BaO-}10\text{K}_2\text{O}$) by measuring the absorption spectra of them with the new method. The experiment results show that the peaks position of the absorption shift forward the long wavelength and the refractive indexes increase with the increasing of Pb in germanium lead glasses. The above obtained refractive indexes are similar with the data which measured by the spectroscopic ellipsometry and the error less than 1%. The error analysis indicates that this method has high degree accuracy. We predict that the new method has a potential application in refractive index measurement for glass.

- Purpose:

“[M]easure refractive index of glass has been reported in this paper” because it “is an important optical parameter of material”

- Hypothesis:

A new method “to measure the refractive index of the special laboratory prepared glass which is small, irregularly shaped by measuring its absorption spectrum”

- Design:

“[M]easured the refractive index of the laboratory prepared germanium-lead glass (1) ($70\text{GeO}_2\text{-}10\text{Pb-}10\text{BaO-}10\text{K}_2\text{O}$), germanium-lead glass (2) ($60\text{GeO}_2\text{-}20\text{Pb-}10\text{BaO-}10\text{K}_2\text{O}$), germanium-lead glass (3) ($50\text{GeO}_2\text{-}30\text{Pb-}10\text{BaO-}10\text{K}_2\text{O}$) by measuring the absorption spectra of them with the new method”

- Conclusions:

“[T]he new method has a potential application in refractive index measurement for glass” with a high degree of accuracy

(c) From [Hare et al. \(2017\)](#):

In 2009, the National Academy of Sciences published a report questioning the scientific validity of many forensic methods including firearm examination. Firearm examination is a forensic tool used to help the court determine whether two bullets were fired from the same gun barrel. During the firing process, rifling, manufacturing defects, and impurities in the barrel create striation marks on the bullet. Identifying these striation markings in an attempt to match two bullets is one of the primary goals of firearm examination. We propose an automated framework for the analysis of the 3D surface measurements of bullet land impressions, which transcribes the individual characteristics into a set of features that quantify their similarities. This makes identification of matches easier and allows for a quantification of both matches and matchability of barrels. The automatic matching routine we propose manages to (a) correctly identify land impressions (the surface between two bullet groove impressions) with too much damage to be suitable for comparison, and (b) correctly identify all 10,384 land-to-land matches of the James Hamby study (Hamby, Brundage and Thorpe [AFTE Journal 41 (2009) 99–110]).

- Purpose:

”[H]elp the court determine whether two bullets were fired from the same gun barrel.”

- Hypothesis:

Proposal of “an automated framework for the analysis of the 3D surface measurements of bullet land impressions, which transcribes the individual characteristics into a set of features that quantify their similarities.”

- Design:

Apply method to “all 10,384 land-to-land matches of the James Hamby study (Hamby, Brundage and Thorpe [AFTE Journal 41 (2009) 99–110])”

- Conclusions:

“The automatic matching routine we propose manages to (a) correctly identify land impressions (the surface between two bullet groove impressions) with too much damage to be suitable for comparison, and (b) correctly identify all 10,384 land-to-land matches of the James Hamby study (Hamby, Brundage and Thorpe [AFTE Journal 41 (2009) 99–110]).”

2 Population of interest vs. sample

For this question, you will be given a description of a study or survey. Describe the population of interest and the sample.

- (a) A team of forensic researchers developed a method to distinguish between cartridge cases fired from the same firearm (“matches”) and those fired from different firearms (“non-matches”). Upon applying their method to a set of 780 cartridge case pairs, none of the pairs were misidentified.

- Population of Interest:

All cartridge cases. (To be more precise, we might say all *pairs* of cartridge cases since the team is interested in how cartridge cases relate to each other)

- Sample:

780 cartridge case pairs

- (b) The U.S. Census Bureau reported that 96.2% of all housing units in the United States responded to the 2020 census.

- Population of Interest:

All housing units

- Sample:

96.2% of all housing units

- (c) A mobile app developer surveyed 761 users to gauge their users’ enjoyment of the app.

- Population of Interest:

All users of the app

- Sample:

761 users of the app

- (d) A forensic footwear impression researcher collected 23,113 images of shoes from Zappos.com to analyze outsole patterns.

- Population of Interest:

All images of shoes (from Zappos.com could be added)

- Sample:

23,113 images of shoes from Zappos.com

- (e) Reporters from the New York Times polled 1512 Independent voters to determine whether the passing of Justice Ruth Bader Ginsburg affected who they would vote for in the 2020 election.

- Population of Interest:

All Independent voters

- Sample:

1512 Independent voters