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THE IMPACT OF CONTEXTUAL BIAS ON NOVICE EXAMINERS IN FIREARMS EXAMINATIONS AND FINGERPRINT ANALYSES

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THE IMPACT OF CONTEXTUAL BIAS ON NOVICE EXAMINERS IN FIREARMS EXAMINATIONS AND FINGERPRINTS ANALYSES

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Abstract

Despite efforts to maintain objectivity in analysis and interpretations, bias and human error still impact forensic science. Diversity in the perspectives, ideologies, techniques, and experience of forensic scientists generates a lack of standardized systems and methodologies in the analysis of evidence and introduces bias into forensic science. This leads to complications regarding interpretation and can result in subjectivity being introduced into testimony.

The literature discusses the importance of comprehending bias as a whole and its impact on various fields in forensic science. The use of subjective judgments can substantially influence the analysis of fingerprints, firearms, pathology, bite marks, and crime scenes. Subjectivity can occur due to previous contextual information being given to an individual prior to examination. Objective analysis is crucial for factual investigations and to prevent wrongful convictions. This study focuses on DNA contextual information and how it impacts the conclusions of novice analysts when analyzing firearms and fingerprints.

In this study, twenty-one participants from a forensic science analysis lab course conducted bullet comparisons and eighteen participants from an advanced fingerprint course analyzed fingerprints. A randomly assigned between-subject Fisher's exact test was used to analyze the data. In the examination of both fingerprints and firearms, participants were given contextual information regarding a crime scene, a suspect in custody, and whether DNA found at the scene matched, did not match, or was unknown to be a match to the suspect. Fingerprint novices were then asked to analyze and compare an unknown fingerprint from the crime scene to one of the suspects known prints and firearms novices were asked to compare a bullet collected from the crime scene to a bullet fired from the suspect's weapon. Examiners were also asked to indicate their level of confidence in their conclusions.

Results indicated that when novices were not provided contextual DNA information, they formed conclusions with 100% accuracy in both fingerprints and firearms examinations. Statistical analysis indicated that for the fingerprint task, there was no significant difference in the proportions of correct answers for all groups and no significant differences in the median confidence levels of participants in different groups. For the firearms task, there was also no significant difference in the proportions of correct answers for all groups. However, confidence levels for novices in the firearms task were significantly higher when no contextual DNA information was provided. In both fingerprints and firearms, participants had 100% accuracy in the conclusion when analyzing prints or bullets in the control group vs. lower percentages of accuracy in the experimental group in which participants were provided with DNA contextual information.

KEYWORDS: *contextual bias, firearms examination, fingerprint analysis*

Introduction

Background

Criminal and civil cases often involve forensic investigations; the science of associating people, places, and things to criminal activities (Houck & Siegel, 2010). Forensic scientists of diverse expertise assist in criminal investigations by analyzing evidence associated with the case (Starrs, 1991). Forensic disciplines vary from firearms analysis, fingerprint examinations, forensic molecular biology, forensic odontology, crime scene investigations, forensic pathology, forensic impressions, anthropology, etc. (Houck & Siegel, 2010).

Human nature is prone to error and biases that can influence research, judgments, observations, and other forms of reasoning (Veldcamp, 2017). In regard to forensic science, bias can impact analysis and testimony resulting in a misrepresentation of evidence (Dror, et al., 2017). Forensic science is a key component of the justice system and works to ensure the accurate interpretation of physical evidence as it applies to an investigation (James & Nordby, 2003). Forensic scientists are held accountable for their interpretations when analyzing evidence and are held to high standards in factual testimonies (James & Nordby, 2003). Forensic scientists must objectively collect and interpret data, utilize reliable and validated methods, and offer clear scientific explanations (James & Nordby, 2003).

The presence of bias can lead to the misinterpretation of facts and incorrect conclusions (Simundic, 2012). Bias can be intentional or non-intentional and can have a negative impact on results (Simundic, 2012). The presence of bias in interpretation may result in overlooking a correct or factual observation, leading to risky positions of decision-making (Roese & Vohs, 2012). Problems arise when bias influences forensic analysis and examinations. The importance and impact of forensic science disciplines within the justice system requires that bias in forensics be identified and mitigated and for data analysis and interpretations of forensic evidence be as reliable and objective as possible (Muro et al., 2015).

Problem Statement

In all forensic science disciplines, bias consistently remains a factor when interpreting evidence and drawing conclusions. There is a lack of understanding and research regarding the severity and impact of bias in evidence collection and analysis. When evidence is collected or viewed with bias, there can be distortion in interpretation that prevents true measures of results (Budowle et al., 2009). This impacts the significance of evidence, accuracy of interpretation, and how courtrooms perceive the evidence and expert witnesses.

In forensic science, there needs to be measures of control for factors leading to bias, such as preventing access to contextual information and prior knowledge. To reduce error rates due to bias, unified training should be implemented that includes training on subjective perspectives, controls, blind verification, and retesting (National Research Council II, 1996).

Purpose of the Study

The purpose of this study is to investigate the impact of contextual information on novices' analyses in two domains of forensic science; a fingerprint identification task and a firearms analysis task. It was anticipated that providing DNA-related contextual information would introduce bias in interpretation for both fingerprint analysis and firearms examination. It was hypothesized that bias from the DNA-related contextual information would impact the assessment of the evidence and result in an incorrect analysis of the data.

Review of Literature

Bias

Bias is deviating from rationality in making decisions or judgments (Blanco, 2017). It impacts humans from diverse backgrounds (Bernstein et al., 2011) and can distort conclusions from individuals of any age, race, religion, gender, culture, or any other defining factor (Jana & Mejias, 2018).

In forensic science it is imperative that examiners use objective measures and avoid subjectivity in their analysis. Subjectivity relates to an individual being influenced by their own opinions and is dependent on an individual's mental pursuit (Peeters, 2005). When an individual is given previous information, that prior information can affect the decision-making process (Preuschhof, et al., 2009). Therefore, results are not valid as they are processed through personal feelings, opinion, or taste (Pryzant, et al., 2020). This can occur on a conscious or subconscious level. Subjective ideologies and examinations are perspective-driven or situational, whereas the use of objectiveness is observer-independent and has an unquestionable truth that is associated with it (Rhue, 2019). Bias can impact all forensic science disciplines. It is imperative to understand how these biases influence forensic science analysis and interpretation.

There are several forms of bias. Implicit bias is associated with experience and memory, and it impacts the behavior of an individual in an unconscious way (Houwer, 2019). This type of bias is more behavioral and is often directed towards a specific social group (Houwer, 2019). Implicit bias can be difficult for an individual to recognize or control (Sukeura et al., 2018). The individual is unaware of the negative beliefs they hold (Santee et al., 2022). Conversely, explicit bias is recognized by an individual and is maintained with intentionality. It is bias in favor of one certain group over other groups but the individual maintaining the belief is conscious of the bias

(Santee et al., 2022). Contextual bias is a shift in an individual's decision due to the exposure of contextual information (Bogaard et al., 2014). Confirmation bias is when an individual will try to find evidence that only supports their held belief rather than evidence that disapproves it (Jones & Sugden, 2001). In regard to forensic science, it is important to examine all types of bias, but this study will focus specifically on how contextual information can impact implicit bias.

Bias in DNA Analysis

In order to investigate bias in DNA analysis, researchers Dror and Hampikian (2011) tested expert DNA analysts with irrelevant contextual information. The analysts were placed into two groups. Group 1 received extraneous contextual information and group 2 did not. Group 1 analysts were asked to examine the results of a criminal case involving a mixture DNA profile(DNA from several individuals mixed together) related to a gang rape case and were also provided contextual information regarding suspect 3, specifically that he had testified against the other suspects in return for a lesser sentence (Dror & Hampikian, 2011). The testimony of this assailant was inadmissible in court without corroborating evidence to support the assailant's claim, meaning the assailant's testimony would not be admitted into court if the DNA of the other suspects was excluded from the DNA mixture (Dror & Hampikian, 2011). The analysts were asked to examine the DNA mixture and determine whether the DNA from all of the suspects could be included, excluded, or if the evidence was inconclusive (Dror & Hampikian, 2011). Note, these analysts were also provided information regarding the concentration of the DNA, the DNA amplification conditions, and the electropherograms of the DNA in the sperm fraction extract. After analysis, all of the 17 expert analysts in group 1 (the extraneous contextual information group) concluded that suspect 3 and the suspects that were identified by suspect 3 as guilty could not be excluded as being contributors to the DNA mixture (Dror & Hampikian, 2011). Contextual information clearly biased group 1 analysts as they all reached the same conclusion.

Researchers then had the analysts in group 2 look at the same evidence without the extraneous contextual information effectively removing any bias this information might present (Dror & Hampikian, 2011). These analysts were also provided information regarding the concentration of the DNA, the DNA amplification conditions, and the electropherograms, (Dror & Hampikian, 2011).

In group 2 in which no contextual information was provided, only 1 of the experts reported that suspect 3 could not be excluded, 4 examiners concluded inconclusive, and 12 concluded suspect 3 was excluded from being a contributor (Dror & Hampikian, 2011). Looking at the conclusions, the results clearly indicate the presence of bias in the group 2 analyses. The examiners in this group followed the same guidelines and laboratory operating procedures yet did not reach the same conclusions amongst themselves (Dror & Hampikian, 2011). Individual differences, training, personality, and other factors led the examiners to reach different conclusions based on the interpretation of the same DNA mixture profile (Dror & Hampikian, 2011).

In an article by Krane (2015), examiner bias in relation to DNA profile interpretation is explained in detail. Often, the examiner views DNA data and interprets it in a subjective way towards a prior theory or expectation initially held by the examiner. When an analyst requests to discover a particular result from DNA, or asks for prior information, examiner bias becomes a prominent feature in forming a conclusion based on the information received (Krane, 2015).

Although bias can impact DNA analysis, Krane (2015) suggests methods for minimizing the effects. Blind testing can help minimize examiner bias (Krane, 2015). Using blind testing, analysts interpret the evidence samples that are provided without having any prior knowledge regarding the DNA profile of the possible suspect (Krane, 2015). Utilizing the blind testing design eliminates bias from prior contextual information; therefore, analysis results are more objective and reliable (Krane, 2015).

In a study by Jeanguenat, Budowle, and Dror (2017) the importance of managing irrelevant contextual information to minimize cognitive bias when analyzing DNA is addressed. The authors suggest using training and education to inform forensic examiners of the impact of bias on analysis. They also discuss the importance of using quality control manuals in labs with information pertaining to cognitive factors and ways to reduce bias (Jeanguenat, Budowle, & Dror, 2017). The authors emphasize the importance of implementing measures to decrease bias in all aspects of analysis, training exercises, and lab work (Jeanguenat, Budowle, & Dror, 2017).

Bias in Toxicology and Odontology

Forensic toxicologists utilize analysis techniques to aid in legal investigations regarding death due to drugs, poisons, and other illicit substances (Dudley, 2017). Hamnett & Dror (2020) tested the effect contextual information had on decision-making within the field of toxicology by giving third year forensic science and forensic chemistry undergraduate students an Abs value for five different cases and the Abs cut-off value, and then asking participants to decide if each case was in need of confirmation. The Abs value is a toxicity reference value and relates to the intensity of a color-change test due to a certain chemical. A cutoff value is a control numerical value that can be compared to the Abs value (Hamnett & Dror, 2020). Participants were given the Abs values and told to compare them to the cutoff value, or toxicity level, in order to determine if the case was presumptively positive or negative. Participants were divided into two groups. Half of the participants were provided contextual information that could lead to bias in interpretation (Hamnett & Dror, 2020). The prior contextual information reported age and ethnicity (Hamnett & Dror, 2020). Researchers found that participants in the group that was not provided additional information had a 6 to 12% error rate, while participants in the group that received information about age and ethnicity had a 21% error rate (Hamnett & Dror, 2020). In this study, presenting contextual information introduced subjectivity and impacted the analysis of raw data (Hamnett & Dror, 2020).

In an article by Page et al. (2011) cognitive bias as it influences experts in forensic odontology was examined. A forensic odontologist analyzes the dental remains of an individual who is deceased in order to identify the individual (Avon, 2004). Forensic odontologists can also assess information related to bite marks, or any dental evidence relating to a case (Dudley, 2017). In the article, the authors focused on both conscious and unconscious bias caused by extraneous information, specifically when bite mark evidence results in borderline or ambiguous conclusions (Page, et al., 2011). The study indicated that the use of certain terminology like the words “victim” and “suspect” can introduce bias into odontologists’ opinions (Page, et al., 2011). The study suggested that in order to minimize bias, experts can decrease their engagement with suspects and victims, limit access to extraneous information to minimize emotional influences, and exclude statements of certainty in reports (Page et al., 2011). According to the authors, decreasing external information minimizes the amount of subjectivity in the conclusion of the expert analyzing the bite marks or dental markings (Page, et al., 2011).

Bias in Forensic Pathology

Forensic pathology involves determining the cause, manner, and mechanism of death of an individual (Dudley, 2017). This is often accomplished through an autopsy to determine if the death is a homicide, suicide, or natural death (Dudley, 2017). Decision-making is crucial in this domain and prior contextual information can bias conclusions regarding the death (Dror, et al., 2021).

In one study by Dror et al. (2021), researchers tested how racial bias can impact a pathologist's decision-making processes during forensic examinations. In this study, 133 pathology experts were randomly assigned into two groups (Dror, et al., 2021). The first group was provided the following information: an African American, three year old child died shortly after being rushed to the hospital and their caretaker was the mother's boyfriend (Dror, et al., 2021). The second group was told that their deceased individual was a white, three year old child who died shortly after being rushed to the hospital and their caretaker was the child's grandmother (Dror, et al., 2021).

Results demonstrated bias in the expert's conclusions. In the first group where the deceased was an African American child and the caretaker was the mother's boyfriend, pathologists were five times more likely to conclude the cause of death was a homicide as compared to an accident (Dror, et al., 2021). In the second group in which the child was Caucasian and the caretaker was the child's grandmother, pathologists were two times more likely to rule the death as an accident (Dror, et al., 2021). Prior contextual information provided to experts increased the subjectivity in their analysis and introduced bias. Decreasing external information is important to minimize bias in examination.

Bias in Firearms Examination

Firearms identification involves the analysis and comparison of the surface contours of ammunition in order to determine whether they were fired from the same firearm (Bolton-King, 2015). Although scientific understanding is necessary in order to analyze firearms and ammunition, the discipline is broad and the training and experience of each firearm examiner impacts analysis (Bolton-King, 2015). Lack of training and experience can lead to incorrect interpretations and this can result in misidentifications, individuals being wrongfully convicted, and also have profound effects on the victims of a crime (Bolton-King, 2015).

Researchers Kerstholt et al. (2010) investigated bias in firearms examination. In their study, six qualified forensic firearms examiners analyzed six sets of bullets; three of the bullets were from the same firearm while the other three were fired from different firearms. All of the bullets were fired with the same pistol type to ensure the class characteristics were similar, but individual characteristics differed (Kerstholt et al., 2010). The case description given prior to analysis contained either biased information or unbiased information (Kerstholt et al., 2010). The crime type for both groups was the same (a shooting occurred in a location and an individual was killed), however the cases were different in regard to familiarity and exact detail (Kerstholt et al., 2010). Participants received both the neutral and biased condition within a 6-month period gap. The cases were as follows: a biased condition that contained contextual information stating there was one perpetrator and one crime scene, and a neutral condition where the context stated there were two perpetrators and two crime scenes (Kerstholt et al., 2010). Participants were to assess if the bullets were fired from the same firearm. In order to prevent any memory recall, cases were presented with a six-month gap period between them (Kerstholt et al., 2010). This study found contextual information given prior to analysis did not affect the participants' responses (Kerstholt et al., 2010). An overall statistical analysis indicated there were no significant differences between those examiners that were provided biased information and those examiners given neutral information (Kerstholt et al., 2010). However, for individual differences, none of the examiners concluded the bullet was fired from a different firearm when it was, in fact, fired from a different firearm. (Kerstholt et al., 2010). Examiners also differed in assessment conclusions when analyzing bullet patterns. For example, in case two, two examiners believed there was a partial match in the striations in the grooves, but three other examiners did not see any matches (Kerstholt et al., 2010).

Bias in Fingerprint Analysis

Latent fingerprints are prints deposited on a surface in residue present on an individual's friction ridge skin, typically subaqueous sweat from the pores (Kent, 2016). A latent print is typically developed using a powder technique, where powder is applied to the impression with a fiberglass brush (Sodhi & Kaur, 2001). The powder adheres to the moisture in the ridges of the print, leaving a darkened and visible print (Sodhi & Kaur, 2001). Note, chemicals can also be used to develop latent prints depending on the characteristics of the substrate the print is deposited on. After development, latent prints are submitted to the Automated Fingerprint Identification System for the latent print examiner to compare prints (Dudley, 2017, p. 55). Fingerprints remain constant throughout an individual's life. (Dudley, 2017, p. 55). Each print is unique to an individual due to the individual characteristics of friction ridge skin (Dudley, 2017, p. 55). As fingerprints are unique and permanent, they allow for individualization (Lee et al., 2001). If experts are exposed to any contextual information prior to analysis, this can skew results and introduce bias. One potential form of contextual information that can result in bias in fingerprint examination is the knowledge of DNA results (Stevenage & Bennet, 2017).

Researchers Stevenage and Bennet (2017) examined the impact of prior DNA knowledge (DNA match, DNA unclear, DNA does not match) on fingerprint examinations by placing 48 novices into two groups that varied by the amount of time they were allowed for examination and whether or not they received outside contextual information. The first group had a two second time constraint (amount of time allowed for analysis) and the second group had no time constraint (Stevenage & Bennet, 2017). Results for the matching trials in the no time pressure condition indicated there was no significant demonstration of cognitive bias (Stevenage & Bennet, 2017). Results for the matching trials in the time pressure condition indicated there was significant impairment in analysis when contextual information was misleading as compared to the control condition (Stevenage & Bennet, 2017). Results for the non-matching trial in no time pressure indicated cognitive bias was present, and performance was impaired when there was misleading contextual information; when there was no time constraint, analysts were still influenced by contextual DNA information, making misidentifications of the latent to the known (Stevenage & Bennet, 2017). Participant conclusions were impacted by misleading DNA information that was given prior to analyzing the prints (Stevenage & Bennet, 2017).

Langenburg et al. (2009) conducted a study to examine the difference between how bias influences novice fingerprint analysts and expert fingerprint analysts. In this study, 43 fingerprint analysis experts were placed into one of three groups: a control group, a low bias group, or a high bias group. Each group received a set of six unknown fingerprint impressions and fingerprint exemplars (Langenburg, et al., 2009). Participants in the control group received no contextual information before observing the prints, participants in the low bias group were given the prints to examine along with conclusions from a previous examiner who was trained to competency, and individuals in the high bias group were to examine the prints after reading a concluding statement regarding the analysis of the prints from an expert in friction ridge examination (Langenburg, et al., 2009). Additionally, 86 novices who had not had any experience in fingerprint examinations prior to the experiment received a semester of training and instruction and then after completing training participated in the same experimental design with the same parameters as the experts (Langenburg, et al., 2009). All participants were also asked to provide a confidence level regarding their analysis. Although fingerprint experts were influenced by bias, they did not make as many significant errors as the novices (Langenburg, et al., 2009). Also, experts in the high bias group had less confidence in their conclusions than experts in the control group (Langenburg, et al., 2009). Novices were also impacted by the contextual information; they formed more incorrect conclusions in the high and low bias groups than in the no bias group (Langenburg, et al., 2009). Both novice and experts had conclusions that were swayed by contextual information provided prior to analysis.

Bias in Crime Scene Investigation

In a study conducted by Eeden et al. (2016), 58 expert crime scene investigators were placed into three groups: one group was told the scene they would view consisted of a victim who committed suicide and the neighbor found the body; the second group was told the victim was murdered and the neighbor saw a man leaving the house that day; and the third group was a control group where participants were told there was no indication of cause of death and the neighbor had no information to give (Eeden et al., 2016). Computer generated images of an ambiguous, panoramic scene of the crime were given to participants (Eeden et al., 2016). These photographs provided detailed images of a woman hanging in a stairwell (Eeden et al., 2016). Participants were to read the contextual passage first, then view the scene, identify evidence, and reconstruct the events that occurred (Eeden et al., 2016). It was found that participants' assessments of the crime scene depended on the contextual information provided, especially in the murder and suicide conditions (Eeden et al., 2016). With the suicide condition, most reported "suicide" as a first impression of the scene and were confident with their report (Eeden et al., 2016). Most of the participants in the murder condition were indecisive in forming a conclusion when compared to the suicide group (Eeden et al., 2016). Less than half of the participants in the control condition reported murder to be the most likely scenario, specifically 8 out of the 19 individuals, while 7 reported suicide (Eeden et al., 2016). This study indicated that experts can be influenced by contextual information (Eeden et al., 2016).

To assess how bias impacts novices compared to experts in crime scene investigation, the same researchers Eeden et al. (2019) placed 58 expert analysts and 36 forensic science students into groups using the methodology from their previous research design, except in this study both novices and experts were randomly placed in the three conditions: group where the manner of death was determined to be suicide, group where the manner of death was determined to be murder, and the control group where manner of death was not given. In this study, the majority of experts and novices indicated that suicide was the most likely manner of death based on first impressions of the crime scene (Eeden et al., 2019). Most novices (10 out of 12) in the control group, where the manner of death was not given, stated suicide as the most likely scenario based on their first impressions. Similarly, most novices in the suicide group (11 out of 12) stated suicide to be the most likely cause (Eeden et al., 2019). Of the novices in the murder group, only 4 out of 12 stated murder as the most likely cause, while 5 stated suicide. Most experts (11 out of 20) in the murder condition stated suicide as the most likely manner of death based on their first impression of the scene, and in the suicide condition, most experts (17 out of 19) also stated suicide as their first impression of the scene. Fifteen out of the 19 experts in the control group stated suicide to be the first impression of the scene, while 4 others stated indecisive.

After processing the crime scene, participants gave a final and overall assessment of what might have happened. Half of the novices in the suicide condition stated the cause of death was suicide and half in the control group stated the cause was suicide. However, more than half of the novices in the murder condition stated the cause to be murder (Eeden et al., 2019). Majority of the experts in the suicide condition stated the cause of death to be suicide, majority in the neutral condition stated the cause to be murder, and more than half of the murder condition experts stated the cause was murder (Eeden et al., 2019). After processing the scene, statistically both novices and experts mainly believed the manner of death most likely to be murder in all conditions (Eeden et al., 2019).

This study demonstrated that regardless of experience, participants were impacted and influenced by contextual knowledge regarding the manner of death (Eeden et al., 2019). The presence of bias in both the experts' and novices' opinions support the idea that bias based on contextual information impacts decision-making.

Research from Smalarz et al. (2016) also examined bias as it affects subconscious thoughts related to criminal investigations. In this study, 225 undergraduates of U.S. origin were randomly placed in one of two groups. Each group received information about a different crime. Group 1 received information about a child molestation (stereotyped crime) and group 2 received information about an identity theft (non-stereotyped crime) (Smalarz et al., 2016). Participants were asked to read a report over a mock crime scene, examine a fingerprint that was found on the scene, and compare it to a known print (Smalarz et al., 2016). The report for the child molestation provided information of a six-year-old child reporting an individual taking them behind a shed and being inappropriately fondled (Smalarz et al., 2016). The identify theft report provided information regarding the theft of 20 individuals' identities (Smalarz et al., 2016). Half of the participants in each group were given a middle-aged white male's profile as a significant match found from the database, and the other half in each group were given a middle-aged Asian woman's profile as a significant match (Smalarz et al., 2016). Participants were also asked to answer a question regarding how much the suspect fit their expectations about the type of people who commit the crime. They had to respond on a Likert scale, 1 being not at all and 7 being very much (Smalarz et al., 2016).

Analysis of variance statistical tests were conducted and found that participants perceived the white man was a better fit than the Asian woman in terms of the type of person who would commit the molestation crime (Smalarz et al., 2016). It was found when the suspect fit a criminal stereotype and description, like the crime of child molestation and a white man as the suspect, participants were nearly twice as likely to incorrectly conclude the prints match (Smalarz et al., 2016). Decisions made by individuals in the identity theft group, or non-stereotyped group, were not affected by characteristics of the suspects (Smalarz et al., 2016). The conclusions made by individuals given information pertaining to the child molestation, were significantly impacted by the characteristics of the suspects when comparing the known and unknown print (Smalarz et al., 2016).

Purpose of Study

Individuals are often unaware of how bias affects their subconscious decision-making and judgment (Smalarz et al., 2016). Decision-making is defined as comparing and evaluating from several options (Yu et al., 2021). Contextual information in forensic science analysis can impact the outcome of a case. Perceptions and judgments can be impacted with information regarding details of victims, suspects, cases, prints, DNA, and other results of analyses. DNA was selected as the contextual information due to the objectivity it withholds in forensic science.

The purpose of the current study is to investigate the impact of contextual information on novices when given a fingerprint identification task or firearm analysis task. It is anticipated that providing DNA-related contextual information will introduce bias in firearms and fingerprint analysis, leading to incorrect conclusions. It is also anticipated that confidence ratings will be lower in the experimental groups (in which contextual DNA information is provided) as compared to the control groups (in which no contextual DNA information is given). This study is different than prior studies due to the nature of no time constraint, including both the analysis of fingerprints and firearms in regard to novice conclusions, and the contextual information that is provided is DNA related.

Methods

Participants

This study involved thirty-nine students from the University of Central Oklahoma who were recruited to participate as volunteers. Participants were students and novice examiners that had taken or were enrolled in the advanced fingerprint analysis course or the forensic science analysis lab course. Twenty-one participants from the forensic science analysis lab course completed the firearms examination and eighteen participants from the advanced fingerprint analysis course completed the fingerprints analysis.

Materials and Procedures

This study was conducted at the University of Central Oklahoma. The participants completed the study in class and had fifty minutes to complete the analysis task. Most participants did not take more than 30 minutes. The independent variable was the contextual DNA information that was given to participants in the experimental group. The accuracy in match or no match responses in the two forensic domains was the dependent variable. The researchers in this study composed an original scenario statement for the contextual information.

In this study, all of the fingerprint and firearm novices received the following case information: “The crime is a homicide. A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A suspect is currently in custody."

For the fingerprint participants, there was additional information regarding blood located on a firearm discovered at the scene. A swab of blood was taken from the firearm and sent to the DNA lab for analysis. A fingerprint was also found on the firearm and sent to the latent print lab for examination. In Group A, the contextual information stated that the DNA from the blood on the firearm was identified to the suspect. Participants were then asked to compare the fingerprint lifted from the firearm to the suspect in custody. The unknown and known fingerprints in Group A did not match. In Group B, the contextual information stated the DNA from the blood on the firearm was excluded as belonging to the suspect. Participants were then asked to analyze and compare the fingerprint from the firearm to the suspect prints. The unknown and known fingerprints in Group B did match. In Group C and Group D participants were told that it was unknown whether DNA was identified or excluded to the suspect. Group C had matching fingerprints and Group D had non-matching fingerprints. Participants were randomly placed into one of the groups.

For the firearms participants, there was contextual information stating blood was located on the firearm near the slide. A swab of the blood was taken for DNA analysis. The suspect's firearm was confiscated from his home using a warrant and shot into a water tank to recover a known bullet for comparison. In Group A, contextual information stated that the DNA from the blood on the firearm matched the suspect. They were also told a bullet was recovered from the victim. Participants were then asked to analyze and compare the unknown bullet from the victim to the known bullet from the suspect's weapon. The bullets in Group A did not match. In Group B, contextual information stated there was not a DNA match to the suspect. The bullets in Group

B were a match. In Group C and Group D, participants were told that it was unknown whether DNA was identified or excluded the suspect. Group C had matching bullets and Group D had non-matching bullets. Participants were randomly placed into one of the groups. See Table 1.

	Group A	**Group B**	**Group C**	**Group D**
Fingerprint	Non-matching prints, DNA match	Matching prints, DNA no match	Matching prints, DNA unknown	Non-matching prints, DNA unknown
Firearms	Non-matching bullets, DNA match	Matching bullets, DNA no match	Matching bullets, DNA unknown	Non-matching bullets, DNA unknown

Table 1: *Fingerprint and Firearm Groups and Conditions*

For both firearms and fingerprint analysis, participants were asked to write down conclusions regarding their examinations, specifically if the evidence when compared to the known exemplar matched, did not match, or if their examination was inconclusive. They also were to write a percentage on a scale of 0 to 100 regarding their confidence in their conclusion.

A randomly assigned between-subject Fisher's exact test was used to analyze and compare the data as it relates to correct conclusions for each group. A Kruskal-Wallis nonparametric test was used to compare confidence medians between groups. For significant p-values, a Dwass, Steel, Critchlow-Fligner pairwise multiple comparison test was used.

Results

This study focuses on the impact DNA contextual information has on novice analysts' conclusions when conducting fingerprint analyses and firearms examinations.

Analysis of Novice Conclusions

When comparing proportions between groups, the assumption that all expected counts are greater than or equal to 5 was not valid (i.e., there were not at least 5 participants in each group). Due to the small sample size, a Fisher's exact test was used to analyze the data and compare proportions between groups. In Group A for the fingerprint analysis task (non-matching fingerprints and DNA matching), 4 out of 5 participants (80%) correctly concluded the prints did not match. In Group B, (matching fingerprints and non-matching DNA), 5 out of 5 (100%) correctly concluded the prints did match. In control Group C, (matching prints and unknown information regarding DNA), 4 out of 4 (100%) of the participants concluded the prints matched. In control group D, (non-matching prints and unknown information regarding DNA), 4 out of 4 (100%) of the participants correctly concluded the prints did not match. In comparing the proportions (percentages), there was a p-value of 1.0000 indicating there was no significant difference between proportions and contextual information did not influence one group more than another. See Table 2.

Fingerprints	**Group**					
	A	B	C	D	Total	
Sample Size	5	5	4	4	18	p=1.0000 no significant difference between proportions
% Correct	80	100	100	100		

Table 2: *Fisher's Exact Test – Fingerprint Novices*

In regard to firearms analysis, for Group A, (non-matching bullets and DNA matching), 4 out of 7 (57.1%) of the participants correctly concluded the bullets did not match. In Group B, (matching bullets and non-matching DNA), 5 out of 6 (83.3%) of the participants correctly concluded the bullets matched. In control Group C, (matching bullets and unknown information regarding DNA), 4 out of 4 (100%) of the participants correctly concluded the bullets matched. In control Group D, (non-matching bullets and unknown information regarding DNA), 4 out of 4 (100%) correctly concluded the bullets did not match. A p-value of 0.3459 was found, indicating there was no significant difference between proportions and contextual information did not influence one group more than another. See Table 3

Firearms	**Groups**					
	A	B	C	D	Total	
Sample Size	7	6	4	4	21	P= 0.3459 not significant difference between proportions
% Correct	57.1	83.3	100	100		

`Table 3: *Fisher's Exact Test – Firearms Novices*

The following graph allows for a direct comparison of the percentages of correct conclusions made by fingerprint novices compared to firearms novices for each Group. For both Group A and Group B, firearms novices made more incorrect conclusions than fingerprint novices indicating they may have been more influenced by contextual DNA information. In control Groups C and D in which no contextual information was provided, all firearms and fingerprint novices accurately analyzed the data and formed correct conclusions. See Figure 1.

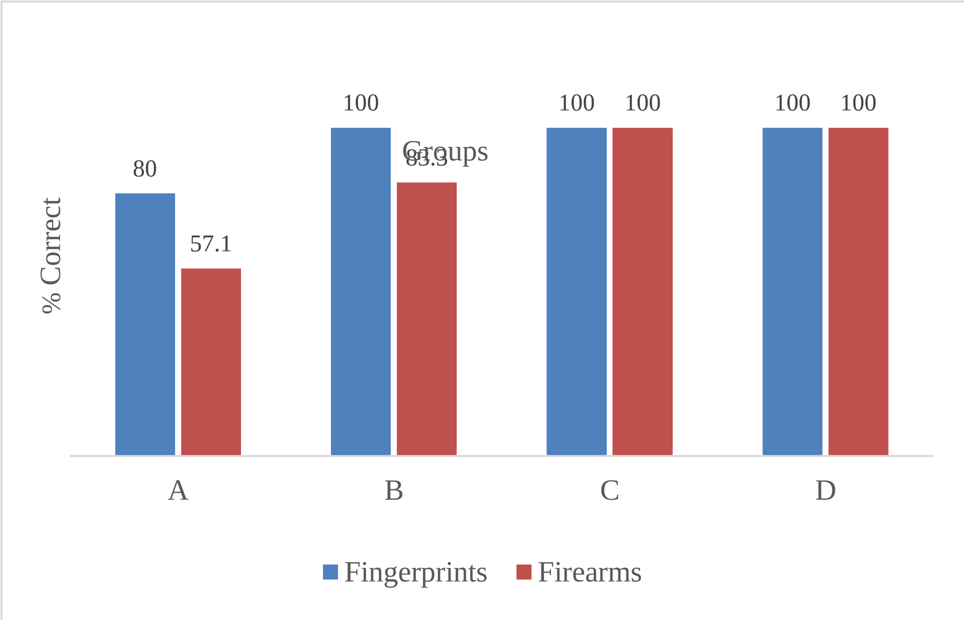

Figure 1*: Comparison of percentages of correct conclusions made by fingerprint novices and firearm novices for each Group*

Analysis of Confidence Values

Means between groups could not be compared due to the small sample size making the assumption of normality not valid. Therefore, a Kruskal-Wallis nonparametric test was used to compare medians between groups. For significant p-values, a Dwass, Steel, Critchlow-Fligner pairwise multiple comparison test was used. For fingerprint examinations, in Group A there was a 90% confidence median for the 5 participants; in Group B, there was a 95% confidence median for the 5 participants; in control Group C, there was a 97% confidence median for the 4 participants; in control Group D, there was a 95% confidence median for the 4 participants. With a calculated p-value of 0.3323, there was no significant difference between medians. In regard to fingerprint examinations, confidence levels were not significantly different between groups. See Table 4.

Fingerprints	Group					
	A	B	C	D	Total	
Sample Size	5	5	4	4	18	p=0.3323 no significant difference between medians
% Confidence Median	90	95	97	95		

Table 4: *Median value of confidence levels for fingerprint novices*

For firearms novices, the following was observed: in Group A, there was a 75% confidence median for the 7 participants; in Group B there was a 67.5% confidence median for the 6 participants; in control Group C there was a 99.5% confidence median for the 4 participants; and in control Group D there was a 97% confidence median for the 4 participants. With a calculated p-value of 0.0171, there was a significant difference between median confidence values. For example, in comparing Group A and Group C, there was a significant difference between the median values with p= 0.0367. Group A, which received contextual information that there was a DNA match from the scene to the suspect in custody, had a significantly lower median confidence value than Group C who did not receive contextual information regarding DNA analysis. Confidence values in this case suggest that DNA contextual information resulted in participants having lower confidence and higher doubt in their analysis as compared to the control which did not receive any bias-provoking information.

Overall, firearms novices had lower confidence in their conclusions when given contextual information. In Group A, the median confidence value was relatively low when compared to groups that did not receive contextual information. Participants had the lowest mean confidence value in Group B in which bullets were a match but the participants received contextual information that the DNA did not match the suspect. In control groups C and D, confidence median values were higher than confidence median values for groups A and B indicating that not having contextual information increased confidence in analysis. See Table 5.

Firearms	Group				Total	
	A	B	C	D		
Sample Size	7	6	4	4	21	p=0.0171 Significant difference between medians A vs C p=0.0367
% Confidence Median	75	67.5	99.5	97		

Table 5: *Median values of confidence levels for firearms novices*

Box-and-whisker graphs were created to show the distribution of percent confidence (minimum, 25^{th} percentile, median, 75th percentile, and maximum). The box-and-whisker graphs display the interconnections and relationships between groups, and aid in understanding how a data set as a whole behaves (Larsen, 1985). In Figure 2, the distribution of confidence medians is portrayed for fingerprints. Group A novices had the lowest confidence median when compared to Groups B, C, and D. In Figure 3, distribution of confidence medians between groups is portrayed for firearms. Both charts indicate that contextual information regarding DNA likely influenced confidence levels in analysis. See Figure 2 and 3.

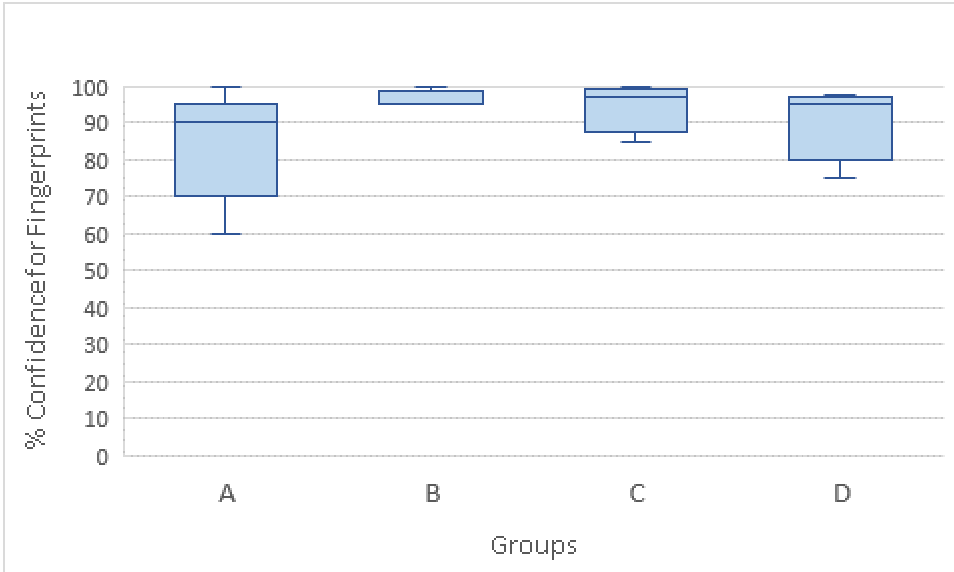

Figure 2: *Box and Whisker Graph – Confidence distribution for Fingerprints*

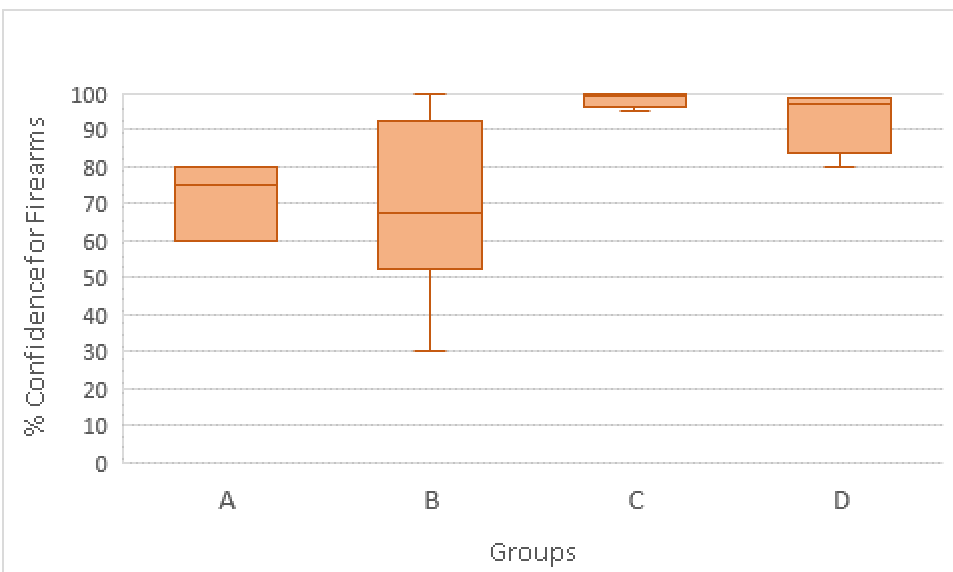

Figure 3: *Box and Whisker Graph – Confidence distribution for Firearms*

Discussion

Among forensic disciplines there are laboratory based methods such as DNA analysis that are perceived to be objective, while there are other disciplines that are based on the analyst's interpretation of patterns, such as fingerprints, which can be perceived as more subjective (National Research Council, 2009). This study was designed to investigate the impact of DNA-related contextual information, considered an objective form of analysis, on firearms examination and fingerprint analysis, pattern-matching disciplines that rely on examiner interpretation. It was hypothesized that bias from the DNA contextual information would impact the novices' analyses, resulting in bias and leading to incorrect conclusions.

This study provided some support for the hypothesis. Results indicated that DNA-related bias did impact analysts' conclusions. Participants in the control groups for both fingerprint and firearms analyses had no errors in their results. This indicated that when no DNA information was provided prior to examination of the prints or bullets, participants were able to reach correct conclusions based on their analysis of the features of the prints or the striations of the bullets without bias from additional contextual details. The analysis was strictly focused on the examination of the evidence. For the groups given DNA contextual information, there were some analysts that exhibited errors and incorrect results in their examination. This suggests that participants may have been more objective in their analysis when they were not given any additional details regarding the DNA matching or not matching the suspect. Note that these differences were observed but were not statistically significant between groups.

In regard to confidence levels, the median value for the firearms novices was statistically significant between groups ($p = 0.0171$). Confidence values for firearms novices were lower in the experimental groups A and B in which participants were provided contextual DNA information than in the control groups C and D which received no information regarding DNA results. Comparatively, the confidence levels of fingerprint novices showed no statistically significant differences between median values ($p = 0.3323$). Results indicate that confidence levels were impacted when given DNA contextual information and, in this study, firearms novices were more impacted by the additional information than fingerprint novices.

These results are important in regard to why examiners should not receive contextual information, DNA-related or otherwise, that is not relevant to their analysis. Background information and knowledge about a case can make a significant impact on how an analyst will evaluate and process the evidence (Ask et al., 2008). Understanding how DNA-related bias as well as bias from other contextual information can impact analysis is necessary for maintaining the integrity of the evidence and for developing bias-mitigating laboratory procedures. Limiting analysts' access to DNA-related information or other contextual information about a case prior to analysis can create more objectivity in analysis. With this knowledge, training in forensic science should be developed that emphasizes the importance of limiting analysts' access to knowledge of case details. Within labs, the use of quality control manuals that provide information regarding bias and cognitive factors and how they impact analysis as well as procedures regarding minimizing bias could help mitigate the issue.

Limitations

There are several limitations to this study. The results cannot be generalized to all novice analysts due to the small sample size of participants used. A larger sample size would allow for more powerful statistical tests. The participants were also students and not true novices and lacked experience in their domains especially when compared to experts. Also, this study focused only on two specific subjects of forensic science (fingerprints and firearms) and the contextual information given was DNA-related (information that is often viewed as objective and reliable). Assessing the impact of contextual information on other forensic science disciplines or using other contextual data may impact the results. Also, for the fingerprint task, novices were only asked to analyze a single known print for comparison rather than to compare to a ten-print card with multiple prints – this is not reflective of actual casework. Lastly, due to the lack of complexity, there may have been an increased number of correct results because these were not complex analyses.

Future Studies

Future research should focus on repeating the study with a larger sample size to allow for more powerful statistical analysis and to obtain more generalizable results. The impact of DNA contextual information could also be studied in disciplines other than fingerprint and firearms examinations (e.g., impression evidence, forensic chemistry, forensic odontology, etc.). This study may be replicated with experts used as participants rather than novices in order to perceive differences between novices and experts when analyzing evidence. Lastly, it may be replicated with different types of contextual information being provided to the examiners (e.g., case details, forensic toxicology reports, latent print results, etc.). DNA introduced bias possibly due to the perception that DNA is an objective test; therefore, other contextual information may impact the results and analysis differently.

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Appendix

FINGERPRINT CASE A

Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A firearm (pistol) was found at the scene and a suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis indicated that the DNA from the blood on the firearm was identified to the suspect. A fingerprint was also found on the firearm. It has been powdered and lifted and sent to the latent print lab for examination. Investigators are requesting that as the latent print analyst, you compare the latent fingerprint to the known fingerprint of the suspect in custody.

Instructions: Analyze the unknown print and the known print and determine whether the prints are a match, no-match, or undeterminable. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Unknown Print

Latent print powdered

and lifted from firearm

Known Print

Suspect: right thumb

Inked – 10-print card

Match No-Match Undeterminable

____________% Percent Confidence in Conclusion

FINGERPRINT CASE B

Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A firearm (pistol) was found at the scene and a suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis indicated that the DNA from the blood on the firearm can be excluded as belonging to the suspect or the victim. A fingerprint was also found on the firearm. It has been powdered and lifted and sent to the latent print lab for examination. Investigators are requesting that as the latent print analyst, you compare the latent fingerprint to the known fingerprint of the suspect in custody.

Instructions: Analyze the unknown print and the known print and determine whether the prints are a match, no-match, or undeterminable. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Unknown Print

Latent print powdered

and lifted from firearm

Known Print

Suspect: left index

Inked – 10-print card

Match

No-Match

Undeterminable

____________% Percent Confidence in Conclusion

FINGERPRINT CASE C

Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A firearm (pistol) was found at the scene and a suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis has not been completed and so there is no information as to whether the DNA from the blood on the firearm can be identified or excluded as belonging to the suspect or the victim. A fingerprint was also found on the firearm. It was powdered and lifted and sent to the latent print lab for examination. Investigators are requesting that as the latent print analyst, you compare the latent fingerprint to the known fingerprint of the suspect in custody.

Instructions: Analyze the unknown print and the known print and determine whether the prints are a match, no-match, or undeterminable. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Unknown Print

Latent print powdered

and lifted from firearm

Known Print

Suspect: left index

Inked – 10-print card

Match | No-Match | Undeterminable

____________% Percent Confidence in Conclusion

FINGERPRINT CASE D

Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A firearm (pistol) was found at the scene and a suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis has not been completed and so there is no information as to whether the DNA from the blood on the firearm can be identified or excluded as belonging to the suspect or the victim. A fingerprint was also found on the firearm. It was powdered and lifted and sent to the latent print lab for examination. Investigators are requesting that as the latent print analyst, you compare the latent fingerprint to the known fingerprint of the suspect in custody.

Instructions: Analyze the unknown print and the known print and determine whether the prints are a match, no-match, or undeterminable. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Unknown Print

Latent print powdered

and lifted from firearm

Known Print

Suspect: right thumb

Inked – 10-print card

Match No-Match Undeterminable

____________% Percent Confidence in Conclusion

FIREARMS CASE A

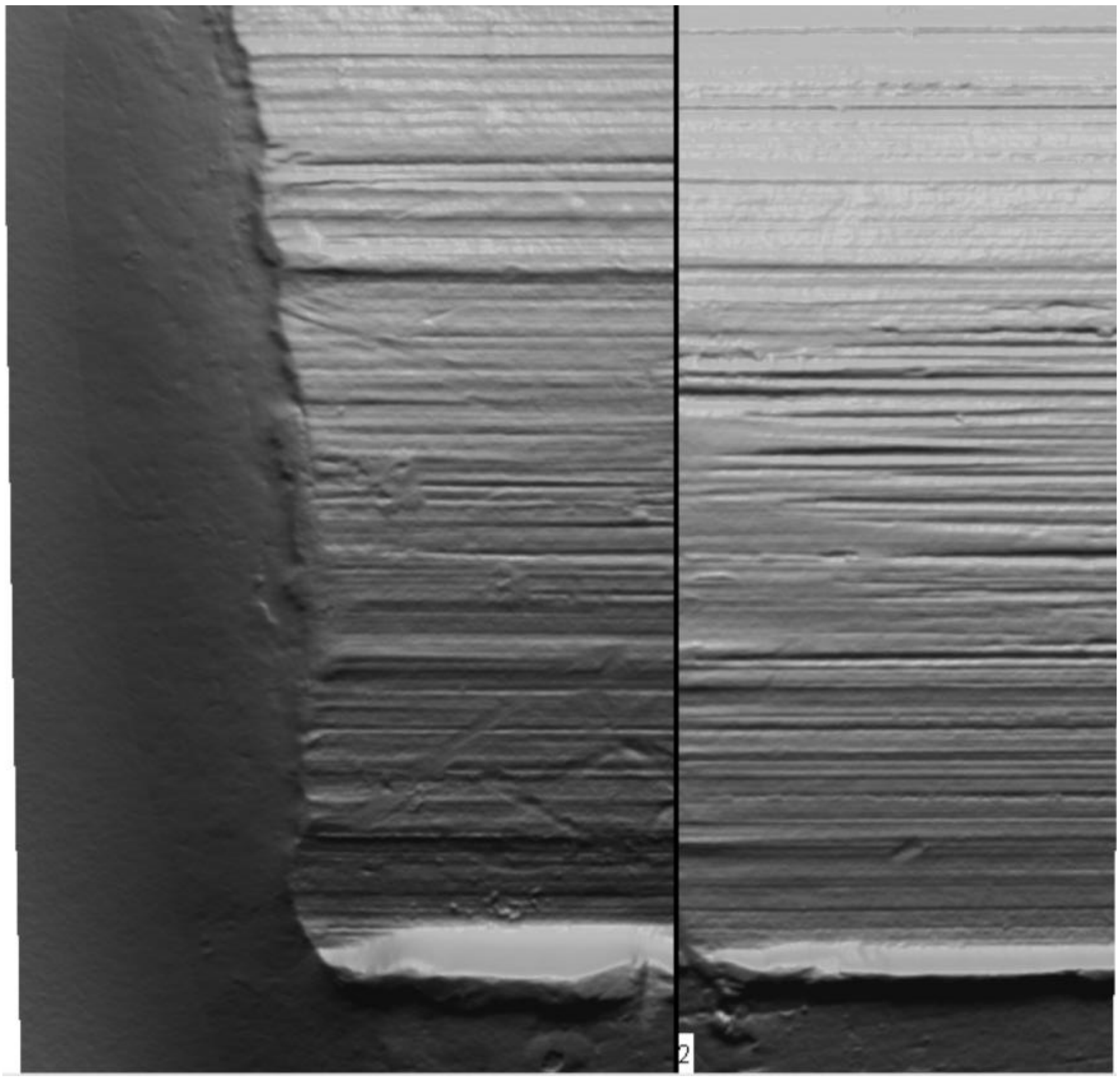
Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis indicates that the DNA from the blood on the firearm was identified to the suspect. A bullet was recovered from the victim. The suspect's firearm was confiscated from his home using a warrant. The firearm was shot into a water tank at the lab to recover a known bullet for comparison to the bullet recovered from the victim at the crime scene. Investigators are requesting that as the firearms analyst, you compare the unknown bullet from the crime scene to the known bullet from the suspect's weapon.

Instructions: Analyze the unknown bullet and the known bullet and make a conclusion of identification, elimination, or inconclusive. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Images will be analyzed using the computer program Cadre Forensics Virtual Viewer.

Identification Elimination Inconclusive

____________% Percent Confidence in Conclusion


2

FIREARMS CASE B

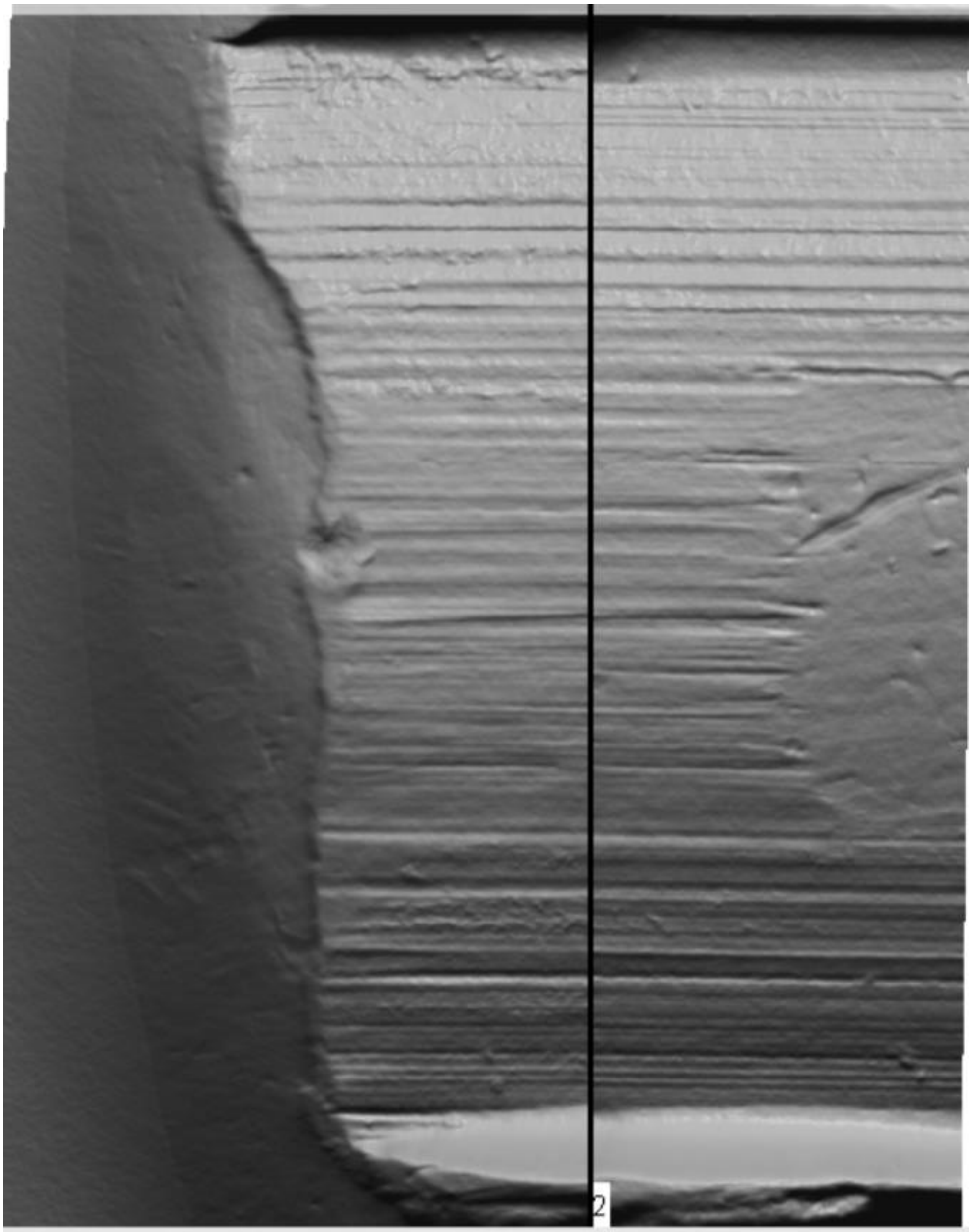
Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis indicates that the DNA from the blood on the firearm can be excluded as belonging to the suspect or the victim. A bullet was recovered from the victim. The suspect’s firearm was confiscated from his home using a warrant. The firearm was shot into a water tank at the lab to recover a known bullet for comparison to the bullet recovered from the victim at the crime scene. Investigators are requesting that as the firearms analyst, you compare the unknown bullet from the crime scene to the known bullet from the suspect’s weapon.

Instructions: Analyze the unknown bullet and the known bullet and make a conclusion of identification, elimination, or inconclusive. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Images will be analyzed using the computer program Cadre Forensics Virtual Viewer.

Identification Elimination Inconclusive

____________% Percent Confidence in Conclusion


2

FIREARMS CASE C

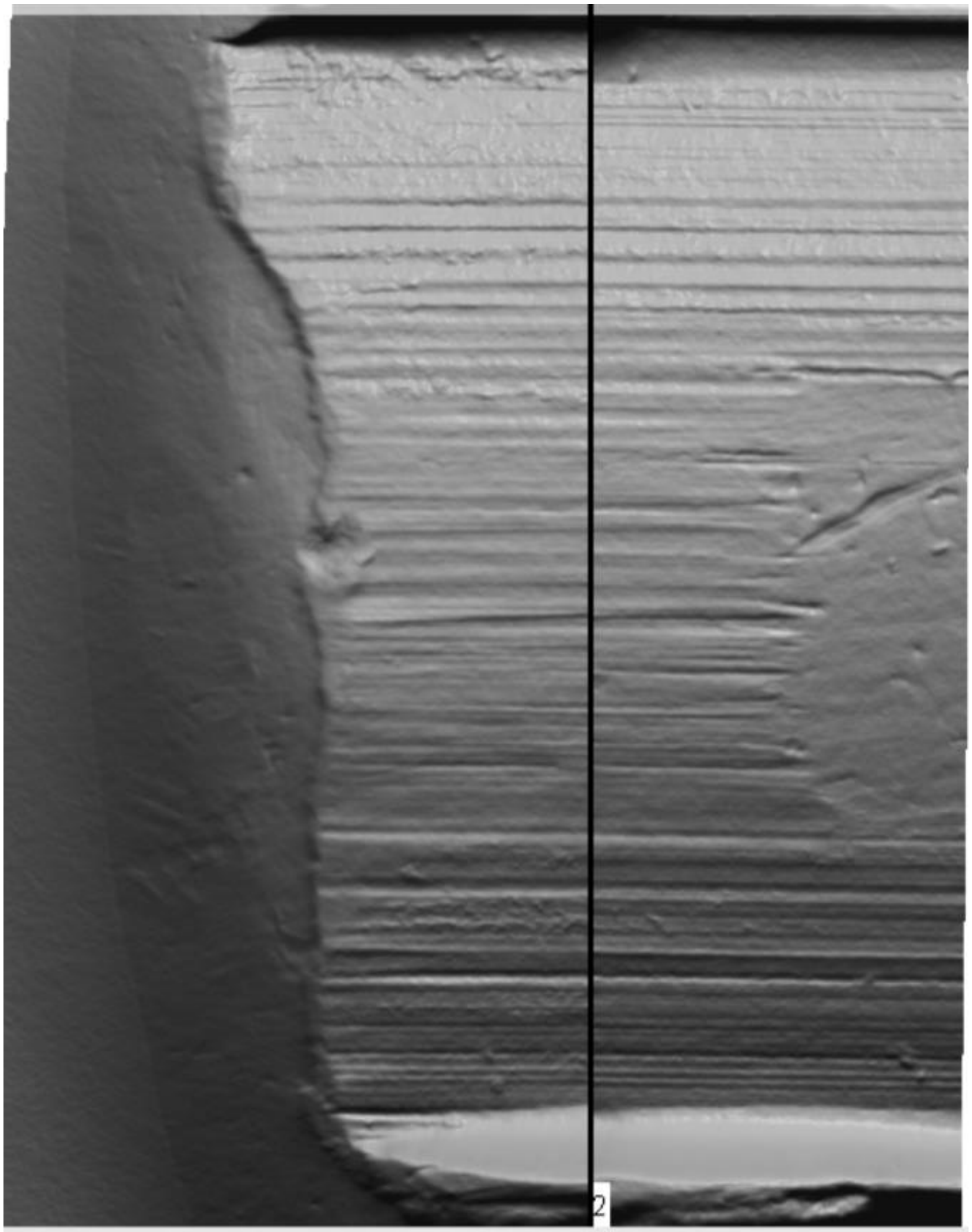
Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis has not been completed and so there is no information as to whether the DNA from the blood on the firearm can be identified or excluded as belonging to the suspect or the victim. A bullet was recovered from the victim. The suspect's firearm was confiscated from his home using a warrant. The firearm was shot into a water tank at the lab to recover a known bullet for comparison to the bullet recovered from the victim at the crime scene. Investigators are requesting that as the firearms analyst, you compare the unknown bullet from the crime scene to the known bullet from the suspect's weapon.

Instructions: Analyze the unknown bullet and the known bullet and make a conclusion of identification, elimination, or inconclusive. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Images will be analyzed using the computer program Cadre Forensics Virtual Viewer.

Identification Elimination Inconclusive

____________% Percent Confidence in Conclusion


2

FIREARMS CASE D

Scenario: A 24 year-old, male victim was found deceased in his home. The cause of death was a gunshot wound to the occipital lobe. A suspect is currently in custody. Blood was located on the firearm near the slide. A swab of the blood was taken from the firearm and sent to the DNA lab for analysis. DNA analysis has not been completed and so there is no information as to whether the DNA from the blood on the firearm can be identified or excluded as belonging to the suspect or the victim. A bullet was recovered from the victim. The suspect's firearm was confiscated from his home using a warrant. The firearm was shot into a water tank at the lab to recover a known bullet for comparison to the bullet recovered from the victim at the crime scene. Investigators are requesting that as the firearms analyst, you compare the unknown bullet from the crime scene to the known bullet from the suspect's weapon.

Instructions: Analyze the unknown bullet and the known bullet and make a conclusion of identification, elimination, or inconclusive. When finished, write a number in the percent section to represent how confident you are in your conclusions. This can range anywhere from 1%-100%.

Images will be analyzed using the computer program Cadre Forensics Virtual Viewer.

Identification Elimination Inconclusive

____________% Percent Confidence in Conclusion