The Distinctiveness Effect in Fingerprint Identification: How the Role of Distinctiveness, Information Loss, and Informational Bias Influence Fingerprint Identification

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THE DISTINCTIVENESS EFFECT IN FINGERPRINT IDENTIFICATION: 
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AND INFORMATIONAL BIAS INFLUENCE FINGERPRINT 
IDENTIFICATION

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For all of those who walked with me along the way.
THE DISTINCTIVENESS EFFECT IN FINGERPRINT IDENTIFICATION:
HOW THE ROLE OF DISTINCTIVENESS, INFORMATION LOSS,
AND INFORMATIONAL BIAS INFLUENCE FINGERPRINT IDENTIFICATION

by

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Abstract

Fingerprint misidentification has become a concern for legal professionals, especially after the high profile misidentification of Brandon Mayfield as the Madrid train bomber and the first fingerprint related DNA exoneration of Stephen Cowans. The current studies examined how humans perceive the distinctiveness of fingerprints, whether distinctiveness effects found in face perception research are evident in fingerprint identification, and whether there are conditions under which the distinctiveness effect can be eliminated. Experiment 1 examined the distinctiveness effect and information loss, while Experiment 2 investigated the distinctiveness effect and its interaction with information loss and informational bias. In Experiment 1, results showed that participants demonstrated the distinctiveness effect on discrimination accuracy and response criterion, and that information loss (latent prints vs. plain prints) influenced discrimination accuracy. While the interaction between distinctiveness and information loss failed to reach the conventional level of significance, planned comparisons revealed that the distinctiveness effect was present only when complete perceptual information was available. Experiment 2 replicated the findings of Experiment 1 in demonstrating the effects of distinctiveness on response criterion, information loss on discrimination accuracy, and a significant interaction of these two variables on discrimination accuracy. Experiment 2 also demonstrated that informational bias influenced both discrimination accuracy and response criterion, and that this manipulation interacted with both the distinctiveness and information loss variables. Consistent with predictions, distinctiveness effects were observed only when the least amount of informational bias was present and when complete perceptual information was available. The theoretical and practical implications of these findings are discussed.
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The distinctiveness effect in fingerprint identification: How the role of distinctiveness, information loss, and informational bias influence fingerprint discrimination

Recent interest in wrongful convictions has opened a new realm of psycho-legal research devoted to understanding the underlying causes of such errors. The advent of DNA analysis as a means to identify the real culprit or exonerate a falsely convicted defendant has allowed researchers to identify the most important factors contributing to wrongful convictions. The Innocence Project estimates that the number one cause of wrongful convictions in the first 130 exonerations is eyewitness identification (101 cases), followed by false confessions (35) and informants/snitch testimony (21) (Causes and remedies, 2006). One field receiving a fair amount of attention lately is that of forensic identification evidence and the problem of junk science. According to Saks and Koehler (2005) an estimated 63% of the cases in the original 86 DNA exonerations involved errors due to a variety of identification methods within forensic science.

Saks (2000) states that forensic identification science “aim[s] to connect a crime scene object or mark to the one and only one source…to the exclusion of all others in the world” (p.881). Forensic identification evidence consists of DNA profiles, latent prints, bitemarks, hair and fiber analysis, handwriting analysis, footprints, shoe prints, and ballistics analysis (Thompson & Cole, 2006). Forensic science has recently come under scrutiny with the 2009 release of the National Research Council of the National Academies report on the state of forensic science in the United States. This report states that “[a]mong existing forensic methods, only nuclear DNA analysis has been rigorously shown to have the capacity to consistently, and with a high degree of certainty, demonstrate a connection between an evidentiary sample and a specific individual or source (NRC, 2009, p. 3-12). Such analysis has been used to exonerate individuals convicted on the basis of other forensic evidence. Based on proficiency examinations, Saks and Koehler (2005) estimated error rates for the various forensic sciences. For example, voice identification shows error rates as high as 63%, handwriting misidentifications range
between 40% and 100%, bitemark misidentifications have been as high as 64%, and microscopic hair misidentifications have been around 12%. Fingerprint identification has perhaps fared the best of the identification sciences, with proficiency examination error rates ranging from 4% to 6% (Saks & Koehler, 2005). While the misrepresentation or falsification of forensic science has contributed to 27% of the first 85 wrongful convictions (Saks & Koehler, 2005), the problem of misidentification is clearly a larger issue that questions the very scientific foundation of these forensic sciences, including issues of reliability, validity, and method.

**Latent Fingerprint Identification**

The history of fingerprinting and identification rests on the assumption that no two fingerprints are alike, even in twins. Cole (2001) reviewed this extensive history, asserting that even in ancient China, fingerprints were declared to be unique to an individual. Sir Francis Galton was a proponent of fingerprinting as an identification method. He assumed that fingerprints were genetic and allowed for the possibility that fingerprints could be similar between different individuals. However, in the early 1900s, fingerprint experts argued that the genetic influence would be largely outweighed by environmental influences exerted on the embryo during development. Fingerprint experts still argued that despite the existence of such similarity, identical twins proved the uniqueness argument. Identical twins do not have identical fingerprints, thus fingerprint experts argued for the uniqueness of all fingerprints. This argument fails to account for the likelihood “that two different fingers might produce similar looking latent fingerprint impressions” (Cole, 2001, p. 176). Similarity arguments made by fingerprint examiners relied upon the probability that no two entire prints could ever be similar; this argument failed to account for the likelihood that smaller portions of fingerprints might be similar. Given that latent fingerprint examiners (LPEs) are most likely to be asked to match partial latent impressions, the possibility of illusory similarity would seem even greater.
Fingerprint examiners claim to follow the ACE-V process; which stands for analysis, comparison, evaluation, and verification. The Scientific Working Group on Friction Ridge Analysis and Technology [SWGFAST] (2002) outlined this methodology for LPEs. In the analysis stage, the examiner determines whether the fingerprint is suitable for comparison to an exemplar. If the latent print passes this stage, examiners proceed to the comparison stage where they compare the latent to the exemplar side-by-side to determine if the ridge detail is in agreement. SWGFAST (2002) states that this decision-process is based in the “similarity, sequence, and spatial relationship” between the latent and the exemplar (§ 3.2). Examiners then proceed to the evaluation phase where they develop a conclusion based on the comparison in the previous step. They can either determine the latent print to be an individualization (they match), an exclusion (they do not match), or that the process was inconclusive such that the prints could not be categorized into either of the previous decisions. If the print is individualized, then it must proceed to verification, where the decision is evaluated by another LPE. Exclusions may or may not proceed to the final step. Often, LPEs testify that an identification “is based on an application of the infallible, virtually-error free, ACE-V comparison method” (Haber & Haber, 2008, p.144). However, the validity of this methodology has not been validated and LPE’s typically offer no proof that they followed such a procedure (Haber & Haber, 2008).

While latent fingerprint identification on the surface appears to be among the more reliable forensic identification procedures, scholars have begun to question the fundamental validity and reliability of the identification process (Cohen, 2003). The most prominent concern with fingerprint identifications has regarded latent print examiner [LPE] misconduc, such as instances of fingerprint fabrication by the New York State Police (Cole, 2001). Such deliberate misconduct by a forensic science entity often takes center stage in the headlines. Given the presumed infallibility of fingerprint identification, relatively little concern has been directed at the possibility of misidentifications. However, recent events have turned the spotlight on to the problem of fingerprint identification. In
particular, the prominent misidentification of attorney Brandon Mayfield in the Madrid train bomber case (Fine, 2006), the exoneration of Stephen Cowans (Cole, 2006b), and most recently a number of misidentifications by the Los Angeles Police Department fingerprint unit have led the social science community to question the science of fingerprint identification and the purported expertise of LPEs.

Brandon Mayfield was accused of the Madrid train bombing after the Federal Bureau of Investigations’ Latent Print Unit [FBI LPU] identified a latent print from a plastic bag at the scene as belonging to him. Despite a report from Spanish National Police [SNP] stating that the comparison of Mayfield’s exemplar and the latent print was an exclusion, the FBI arrested Mayfield. An independent examiner confirmed the FBI’s conclusion of Mayfield as the source, while the SNP had individualized the latent print to an Algerian, Ouhnane Daoud. On May 24, 2004, the FBI reviewed the SNP’s conclusion and rescinded their previous individualization (Fine, 2006).

Stephan Cowans was convicted of attempted homicide of a police officer in 1997, after latent print and eyewitness evidence identified him as the shooter. It was unclear as to how Cowans became the suspect, though he was alleged to have sold a hat to the suspect. Cowans was implicated in the crime after a latent print lifted from a water glass at the scene was individualized to his exemplar print. Six years later, the New England Innocence Project secured DNA review of the evidence left at the scene and analyses excluded Cowans as the perpetrator. The latent print was reviewed and Cowans print was then excluded as a match. This was the first DNA exoneration in which a conviction was largely based upon a fingerprint misidentification. Cowans was released in 2004 and a review of the Boston Police Department’s [BPD] LPU was initiated (Cole, 2006b, Know the cases, 2008).

The BPD LPU was closed down after the Cowans revelation, but was reopened late in 2005, with trained civilians taking the place of the original six police officers (Lavoie, 2005). It was suggested that the LPU was the place where police officers were sent if they were seen as a problem for the department or if they needed to be reprimanded (Cole, 2006b). In response to the Cowans misidentification, the
civilian group now in charge of the unit tested the BPD LPU’s knowledge of fingerprints and their identification. The proficiency exam results showed that LPE performance was not only poor on the written examination of knowledge (percentage of correct answers ranged from 47% to 65%), but their comparison performance was unacceptable. Although the LPEs knew they were being tested, it was unlike other proficiency exams because it was unannounced and proctored (Cole, 2006b). On the medium difficulty comparisons, examiners produced 36 of 75 false negatives, including one false positive identification. On the more difficult comparisons, examiners produced two false positives and 47 of 60 false negatives. Cole (2006b) asserts that the low rate of false positives fails to fully represent the entire nature of false positives because of the high number of comparisons on which a conclusion could not be reached (false negatives). He concludes that “[e]xaminers are avoiding the danger of making erroneous identifications by declining to identify large numbers of latent prints, and yet still committing erroneous identifications at an alarming rate” (Cole, 2006b, p. 50). The BPD LPEs were acting conservatively—they set a stringent criterion that led to fewer hits and fewer false alarms. These results give reason to be concerned that latent print misidentifications are an important problem with serious consequences in the legal system.

Fingerprint evidence has largely enjoyed an unchallenged history in the court system, at least since the 1940s when the American courts largely accepted the assumption that no two fingerprints were alike (Cole, 2001). Recently, American courts have begun to question the true scientific nature of latent print identification. Largely, this has been a result of questioning how well such ‘scientific’ techniques hold up against Daubert standards for expert testimony (Daubert v Merrill Dow Pharmecuticals, 1993; Cole, 2006a; Risinger, Saks, Thompson, & Rosenthal, 2002; Saks, 2000; Thompson & Cole, 2006).

One recent challenge against the admissibility of fingerprint evidence regarded the reliability of latent print identification in the case of U.S. vs. Llera Plaza (2002). In this case, Judge Pollack ruled that the ACE-V method of latent fingerprint identification met the Daubert criterion with respect to general
acceptance within the field, but that it failed to meet the criteria of scientific testing, scientific peer review, or knowledge of error rates. Judge Pollack ruled that testimony regarding the procedures specific to that case were admissible, but any testimony offering a conclusion regarding whether the latent print matched that of a defendant would be inadmissible. While Pollack later vacated that ruling and allowed for conclusion testimony (U.S. v. Llera Plaza), the initial ruling initiated a significant change in the way fingerprint evidence is treated by the courts. In 2006, a group of scientists submitted an amicus brief in Massachusetts v. Patterson (2005) to highlight the Daubert concerns surrounding latent print identifications (Siegel et al., 2006). The brief asked the Court to reverse the decision of the trial court and deny specific testimony from LPEs. The scientists asked the Court to bar testimony common to LPEs, specifically that an LPE could not testify that latent print identification has a zero error rate or indicate his or her confidence in their individualization. They also requested that no statements of individualization could be offered without also testifying about the base rates associated with fingerprints and proficiency examination data. Finally, the scientists requested a special jury instruction that would discuss the overall lack of base rates in this forensic science and the problems with and lack of proficiency examinations. The Massachusetts Supreme Court determined that the ACE-V methodology and latent fingerprint identification were reliable and met Daubert criteria. However, the Commonwealth had not sufficiently met its burden in establishing the reliability of such a method to simultaneous impressions and the case was remanded to a lower court for further proceedings.

Cole (2005, 2006b) has suggested that the problem of fingerprint misidentification may be underestimated in the world of wrongful convictions. Using research on criminal cases occurring between 1976 and 1980, he demonstrated that when latent prints were found, DNA was available in only 29% of those cases, while when hair evidence was available, DNA was present in 86% of those cases. With such a low prevalence of both DNA and fingerprint evidence at a crime scene, Cole argued that it was unlikely that errors of misidentification would be uncovered. Given that forensic science errors are
perceived as being highly unlikely, people may be less likely to attribute conviction errors to a latent print misidentification. Cole refers to this as the problem of exposure as he suggests that the better the purported value of the evidence (in this case, fingerprint evidence is highly valued), the lower the likelihood that people will believe that one could be wrongly convicted based upon it. Thus, appellate judges, for example, would be less likely to entertain appeals (or allow one to attempt to prove one’s innocence) when forensic evidence is questioned. If such a perspective is taken, Cole argues that the issue of misidentification in latent print identification is a much larger than many had anticipated.

Other aspects of latent print identification contribute to the problems surrounding its method and its claim of infallibility. While crime drama shows like Law & Order, NCIS, and CSI may lead their viewers to believe computers make precise forensic comparisons in a matter of minutes, the ultimate determination of source attribution in the case of latent print examination is made by a LPE (Thompson & Cole, 2006). Automated Fingerprint Identification Systems [AFIS], electronic databases that store and categorize fingerprints, became popular in identification bureaus during the late 1980s. AFIS allows LPEs to search a large number of fingerprints based upon a latent print taken from a crime scene to determine a list of possible matches (Cole, 2001). Although an initial search for possible matches can be conducted using AFIS, the LPE must make the final determination of whether any of the prints listed represents an exclusion, an individualization, or if the prints are inconclusive.

Despite LPE testimony regarding the objective nature of the process, in reality the identification of a latent print is somewhat subjective (U.S. v. Llera Plaza, 2002). LPEs are asked to compare a latent print, or a fingerprint taken from an object at the crime scene, with a print from a known source. Distortions in the latent print are common and can be caused by a variety of factors, including the material it was lifted from and the manner in which the suspect’s finger was placed on the object. These distortions often ensure that a given latent print will bear some dissimilarity with a known source, or exemplar (Thompson & Cole, 2006). Nevertheless, it is up to the examiner to determine whether
differences between the latent print and the known print are distortions or dissimilarities. According to the “one dissimilarity rule”, it takes only a single, unexplainable dissimilarity to render an exclusion (Thompson & Cole, p. 36). However, LPE’s do not rely upon any hard and fast rule for distinguishing between an explainable distortion and a dissimilarity that might yield an exclusion. For example, SWGFAST (2003) stated that an exclusion can be deemed when it “is the result of the comparison of two friction ridge impressions containing sufficient quality (clarity) and quantity of friction ridge detail which is not in agreement” and “when a latent print examiner, trained to competency, determines that two friction ridge impressions originated from different sources” (§ 3.3.2). Similarly vague are the requirements for a match or individualization. According to SWGFAST, “individualization occurs when a latent print examiner, trained to competency, determines that two friction ridge impressions originated from the same source, to the exclusions of all others” (2002a, §3.3.1).

There is also no consensus on the minimum number of points of similarity that must be identified to declare a match. Points of similarity are the number of matching points on a fingerprint that a LPE can use to individualize the print. American LPEs have no standard minimum number of points of similarity (Siegel et al., 2006; U.S. v. Llera Plaza, 2002). Some jurisdictions in the United States have a formal (or even informal) requirement, but it is not uniform across jurisdictions (Cole, 2001). In a conversation with an LPE in Central New York State, the LPE indicated that he typically would not make an individualization with less than 12 points, unless circumstances were extraordinary. He cited one example in which he viewed a trifurcation and could make the individualization based on this alone. Trifurcations, he claimed, were rare and he recalled having viewed only one in his years as an LPE. The FBI switched from using a minimum of 14 points of similarity to no minimum point requirement in the 1940s (U.S. v. Llera Plaza). In contrast, other countries have established minimum point standards--Italy requires 16 points of similarity while Bulgaria has a lower standard of 8 (European Fingerprint Standards, 2002; Siegel et al., 2006).
As a result of the aforementioned concerns, researchers have begun to investigate the fingerprint identification process. Given the large number of false negatives and therefore misrepresentation of false positives in the Boston Police Department LPU proficiency examinations, Cole (2006b) has called for signal detection analyses of identification decisions. LPEs in the BPD LPU had a conservative criterion but other examiners and departments may set a more liberal criterion. Thus it is important to separate true discrimination accuracy from response criterion. Important questions exist regarding the psychological processes involved in identification decisions and factors that can lead to misidentification. Preliminary research in this field has focused on questions such as “how well can laypersons complete identification tasks?” and “do LPEs possess expertise?”

One of the first studies to look at fingerprint identification involved student participants and assessed their identification accuracy. Vokey, Tangen, and Boychuck (2004) demonstrated that naïve laypersons can identify fingerprints with around 80% accuracy depending on which finger they were identifying, but that these individuals also demonstrate high false alarm rates (30%). Torry and Vokey (2005) further examined naïve laypersons’ ability to match latent fingerprints and found that participants correctly matched 86% of prints, while misidentifying prints 12% of the time. They also found that participants most easily identified index fingers and most often had difficulty matching pinkie fingers. These findings led Vokey and colleagues to conclude that naïve laypersons may complete the latent print identification task more successfully than previously thought and that the “expertise” of a LPE may not be necessary.

Aspects of criminal investigation have been shown to be influenced by the presence of biasing information. In the realm of interrogations and confessions, Kassin, Meissner, and Norwick (2005) found that investigators cannot accurately distinguish between true and false confessions and, more importantly, that these investigators held a response bias towards classifying confessions as true.
also Meissner & Kassin, 2002, 2004). Kassin, Goldstein, and Savitsky (2003) showed that interrogators who held a presumption of guilt conducted more pressure filled interrogations and this bias carried on to judgments of guilt or innocence by neutral observers as participants. Narchet, Meissner, and Russano (2007) demonstrated that when interrogators held a guilt expectation, they were less diagnostic of truth (as measured by the ratio of true confessions to false confessions).

Ask, Rebelius, and Granhag (2008) demonstrated the effect of bias on evidence interpretation. They hypothesized that when the interpretation of evidence is rather flexible, such as eyewitness evidence as opposed to DNA evidence, it can easily be discounted or supported depending on whether it is consistent with an initial hypothesis. DNA proved to be deemed reliable across all conditions, however, when eyewitness evidence was presented in the consistent condition, it was deemed reliable but its reliability significantly decreased when the evidence was inconsistent. Interestingly, when asked to support their evaluations of the eyewitness evidence, the police trainees offered some of the same arguments to support reliability as they did the unreliability (e.g. lighting and distance). These results show that confirmation bias plays a strong role in evidence interpretation in legal investigations.

Biased decision making need not be confined only to evidence interpretation by police officers during an investigation. Bias may also play a role in forensic identification as well. According to Risinger et al. (2002), observer effects may be particularly prevalent in forensic sciences as these subjective judgments can be influenced by suggestion and expectation. For example, Risinger et al. suggest that examiners may be subject to subtle or overt cues that could suggest what to look for in comparisons – cues that could lead a forensic scientist to declare a match, especially under conditions of ambiguity.

Dror, Peron, Hind and Charlton (2005) examined how such contextual information can influence fingerprint matching performance. The authors hypothesized that two components of processing could influence fingerprint identification performance: bottom-up processing (direct examination of the latent
print) and top-down processing (extraneous contextual information). Dror et al. reasoned that while top-down processing can make information processing faster and assist in interpreting information that is ambiguous or missing information, contextual information may be overvalued and thereby distort the processing of the objective information that is available.

Dror et al. (2005) used naïve subjects to examine whether manipulating the emotional context (top-down processing) and difficulty of the task (bottom-up processing) would influence participants’ ability to determine if two fingerprints were the same. Emotional state was manipulated by using background stories about the crime (i.e., burglary vs. murder) and photos of the crime scene (i.e., items that were stolen vs. gruesome photographs of the victim). The researchers found that when the fingerprints were unambiguous matches or exclusions, emotional context did not influence performance. However, when the fingerprint pair was ambiguous, a heightened emotional state made it more likely that the participants would declare the two fingerprints to be a match.

After determining that biasing information could influence the determination of a match, Dror and colleagues sought to extend their findings to professional LPEs. Dror, Charlton, and Peron (2006) used five professional LPEs and a pair of fingerprints they had previously determined to be a clear match in the course of their normal casework. The participants were presented with the pair of prints by a colleague and were told that these prints were the ones from the Madrid train bombing that the FBI had misidentified as a match. They were asked to determine if the prints had enough detail to make a determination, and if so, asked to determine if the pair were a match or non-match. Dror et al. also instructed the LPEs to ignore all extraneous information or contextual information and just focus on the prints in order to make their decisions. The results showed that only one LPE remained consistent, while the other four LPEs changed their previous determination! One LPE determined that there was insufficient information to make a decision and three changed their determination to a non-match. This demonstrated that contextual information did influence professional LPEs and “reflect[ed] cognitive
flaws and limitations in conducting objective and independent processing and evaluation of information” (Dror et al., 2006, p. 77).

While LPEs often receive information regarding a colleagues’ decision about an individualization or exclusion, Dror and Charlton (2006) wanted to examine the effect of more subtle biasing information. The researchers obtained eight fingerprint pairs from each of six professional LPEs, four of the pairs were previously determined to be individualizations and four were exclusions. Of these pairs, half were easy determinations and the other half were difficult determinations. Four prints were presented again without any biasing information: one easy individualization, one difficult individualization, one easy exclusion, one difficult exclusion. The pairs were then presented in a context opposite from the previous determination - namely, if the LPE had previously determined it to be an individualization, then it was presented as an exclusion and vice versa. Results showed that only two of the six LPEs were consistent with their previous decisions. Changes most often occurred in the difficult determinations category and with previous individualizations. Finally, most of the changes occurred when biasing information was presented, although two of the changes occurred when no contextual information was present. These findings replicated previous results, suggesting that professional LPEs are subject to subtle bias present in day-to-day workloads.

Even the way a fingerprint is examined may induce bias into the decision-making process. Cole (2006b) makes two important statements regarding the importance of similarity in latent print identification. First, he argues that similarity need not be of the entire print - only one part of the print must be similar enough for an identification to be made. In fact, an exemplar candidate print (or possible matching print from AFIS) only needs to be similar enough to a latent print in the way the LPE has marked the latent print, for it to be deemed a possible match. LPEs mark identifiable ridge characteristics or minutiae and their direction on the latent print before submitting it to an AFIS search. AFIS then returns possible matches that fit the criteria that the LPE has marked. While matching
minutiae do not increase an AFIS score, non-matching minutiae decrease the score. If a search returned no hits, the LPE will remark the print and resubmit it for another search, thus increasing the probability of an error. Cole (2001) proposed that the problem of fingerprint misidentifications does not typically occur in the 10-print to 10-print comparison but rather when attempting to compare a latent print to the 10-print rolled set. This is proposed because the circumstances under which the latent print was created were not controlled and thus the quality of the ridge detail could be compromised.

Second, Cole (2006b) suggests that in the context of accumulating similarities, the presence of one or more dissimilarities will not cause alarm. Rather, the dissimilarity may be explained away as a distortion in spite of the “one dissimilarity rule” (as discussed on p. 10). Similarities can become overvalued and dissimilarities can be easily explained; in effect, LPEs may be looking to confirm their hypothesis rather than disconfirming that the suspect is the perpetrator. While confirmation bias is outside the scope of the current study, similarity between fingerprints becomes a seemingly pervasive issue in need of research.

While all of these effects are potentially important in the context of fingerprint identification, anchoring effects (Tversky & Kahneman, 1974) may be particularly important because of the output AFIS gives LPEs. Anchoring is a cognitive heuristic where, under conditions of uncertainty, an initial start value biases the final outcome point. As such, individuals’ answers are often insufficiently adjusted and are biased toward that initial value (Tversky & Kahneman, 1974). Anchoring has been demonstrated to be a concern in civil cases where mock jurors awarded damages that were insufficiently adjusted from a starting point, whether it be an attorney suggesting compensation or a high cap value placed on punitive damages (Hastie, Schkade, & Payne, 1999; Robbennolt & Studebaker, 1999). Expertise does not appear to mitigate this effect in the courtroom, as judges are similarly influenced by sentencing requests of the prosecution (Englich & Mussweiler, 2001).
Risinger et al. (2002) suggested that anchoring effects could be prevalent in the identification sciences where subjective probability estimates are given. Fingerprint identification is perhaps a likely source of anchoring issues due to the AFIS output. While AFIS is only intended to produce a group of potential matches to the latent print, reliance on technology tends to place undue emphasis on the outcome. “The typical output…is a set of candidate fingerprints, with an accompanying score, ranked from most to least similar to the input latent print…loosely interpretable as being the probability of a correct match to the latent print” (Haber & Haber, 2008, p. 146). This score or information associated with the score (such as the ranking of the print) might induce the examiner to establish an initial confidence value when examining the latent and exemplar prints. However, the actual match may not be the highest ranking score or even in the top 10 potential matches.

Cole, Welling, Dioso-Villa, and Carpenter (2008) conducted AFIS simulations with three sets of fingerprints. Essentially, they entered a latent print into AFIS and searched for its match against a known database. For every latent print, there was a known exemplar present in the searchable database. In the two studies that used government databases, they found that the actual match received the highest score 75% and 70% of the time, ranked between 2 and 10 at 4% and 12% of the time, and ranked lower than the top 10 scores 21% and 18% of the time. If we are to take the highest score as the individualization, then the hit rate and classification error on these studies were 75% and 25% and 70% and 30%. Logistic regression on these errors produced error rates of 2.4% and 5.4%. In a study where AFIS searches were conducted on latent and rolled prints made by the researchers, top actual match ranked as the highest score 42% of the time, between the top 2 and 10 scores 6% of the time, and was not in the top 10 scores 52% of the time, for a hit rate of 42% and a classification error rate of 58%. The logistic regression produced an error rate of 4.5%.

Not only does AFIS give non-matching candidate exemplars high scores, the actual match may not appear until well after 10 fingerprints have been ranked before it or not on the list at all. If the AFIS
number is a high score, then perhaps dissimilarities may be more easily explained away as distortions. If the AFIS score is low, then dissimilarities may be more likely to be seen as such. If the matching print is given a low value in the AFIS output, then it may be more likely to be missed while a similar but non-matching exemplar ranked highly may be more likely to be misidentified. The role of the AFIS number in decision-making will be examined in the current studies.

*How do humans judge similarity of fingerprints?*

Similarity of fingerprints is an important concept, especially given its role in misidentifications like that of Brandon Mayfield. The claim that “no two fingerprints are ever alike” perpetrates the notion that similarity is almost unimportant in the world of an LPE. In court, LPEs make claims of identification to the exclusion of all others, often with 100% certainty, and regularly claim that there is no error rate. These are all claims that even DNA analysts cannot make (Siegel et al. 2006). Such testimony assumes that fingerprints will always be distinguished. However, it ignores the fact that distortions may increase subjective similarity and that uncertainty can increase the likelihood that contextual information can influence subjective similarity estimates.

A study by Lin, Liu, Osterburg, and Nichol (1982) examined the similarity of fingerprints in monozygotic twins (MZ), dizygotic twins (DZ), siblings, and unrelated individuals. They reported high similarity in the patterns of MZ twins and same-sex DZ twins. Those pairs that matched on the pattern characteristics were subjected to ridge count analysis. Ridge count correlations of fingerprints for MZ females was $r = .89$ and for MZ males, $r = .88$. In contrast, the correlations for DZ twin pairs ranged from $r = .57$ to .70 and unrelated population pairs had correlations ranging between $r = .29$ to .38. Minutiae were also examined and the results showed that 12 pairs of fingerprints out of 76 fingerprints were considered to be highly similar based on this characteristic. The researchers concluded that while twins’ fingerprints are highly similar, they can still be differentiated enough for an identification.
One concern about the method used in the Lin et al. (1982) study is that such a procedure is typically not used until LPEs are actually comparing the latent print to an exemplar print. LPEs often do not fully examine the latent print in terms of ridge count and minutiae before submitting it to an AFIS search or comparing it to the exemplar print of a known suspect (Haber & Haber, 2008). This process would take place after receiving a set of candidate exemplars, all of which would be associated with an AFIS probability or a suggestion that “we think this could be the perpetrator.” It would also take place after an initial impression of the degree of similarity. This initial judgment may influence whether the LPE decides to subject the exemplar to further comparison with the latent print. How humans judge the similarity of fingerprints thus becomes an important phenomenon to understand.

While the human perception of fingerprint similarity is relatively unexplored, it may perhaps be reasonable to rely upon findings from face perception literature. Fingerprints may be like faces in many ways—both stimuli maintain a consistent configuration of features, yet there are specific features that may be important to distinguishing among them (whether it be eyes or mouth for a face, or pattern characteristics such as arches or whorls for fingerprints).

Human similarity judgments made about faces have proven to be valuable in understanding how we discriminate faces. Related to the importance of similarity are the concepts of typicality and distinctiveness. Davies, Shepard, and Ellis (1979) demonstrated the importance of similarity between targets and distractors in face recognition. Davies et al. asked participants to sort a set of photographs into groups based on similarity. Participants grouped these faces into a median of 19 groupings and the researchers could then derive how frequently each face was paired with any other face. These scores were then submitted to a hierarchical clustering scheme analysis which resulted in four clusters, the major cluster was selected as the targets for the experiments. Distractors were chosen from either the same or different clusters. Experiments 1 and 2 sought to test how well participants could identify targets from within the same clusters and different clusters. Davies et al. found that false alarms were
influence by group membership - when presented with same-cluster photographs, participants false alarmed more often than when presented with other-cluster photographs. Experiment 3 tested the influence of similarity on recognition performance. When distractors were highly similar to the target, participants were confused and false alarms were twice as likely to occur, but there was no effect on hits. Davies et al. concluded that participants seem unable to select between targets and distractors when they both share highly similar physical characteristics.

Light, Kayra-Stuart, and Hollander (1979) found that, in general, unusual or distinctive faces are more accurately remembered than typical or similar faces. Across a series of studies, the authors found this effect across manipulations of rate of presentation, unintentional and intentional learning instructions, direction of gaze, and ratings of likeableness. Participants made more hits and fewer false alarms when faces were distinctive as opposed to typical. A final experiment provided evidence that similarity between items is the underlying structure of typicality and that typicality predicted recognition performance. Light et al. used ratings of interitem similarity and typicality ratings to conduct multiple regression analyses. First, there was a strong correlation between interitem similarity measures and typicality: the more similar two items were, the more likely they were judged to be typical. Second, the multiple regression analyses demonstrated that “faces that are more similar to other faces as less easy to recognize” (Light et al., 1979, p. 223).

Vokey and Read (1992) conducted a factor analysis in order to understand the factors associated with the typicality of faces. They found that typicality was composed of two factors: memorability and familiarity. Memorability was construed as how likely a face would be remembered while familiarity consisted of familiarity from a previous viewing and experience with other similar faces. Vokey and Read’s work extended the findings of Light et al. (1979) by not only stating that typical faces are more likely to be misidentified because of their similarity to other faces and because they are not rare in instances of memory.
Valentine (1991, 2001) proposed that faces are represented in a multidimensional face space, where they are distributed within the space based upon various features and perceptual dimensions. Located at the center of the space is a face considered average on each feature, clustered around which are typical faces. Distinct faces lie further from the center in a less dense area of space. These distinctive faces are better recognized because there are fewer faces located within their proximity that might serve as distractors. Scaling research and their associated models have largely confirmed Valentine’s face space model (cf. Byatt & Rhodes, 2004). This model lends additional support to the findings of Davies et al. (1979), Light et al. (1979), and Vokey and Read (1992) because of its proposition that density around a face within the space leads to the increased likelihood it could be confused. Also, the distance from the center of the space indicates how typical the face is, so more typical faces cluster towards the middle, while more distinctive faces are further away.

Understanding how humans judge typicality or distinctiveness may also further our knowledge of the factors that individuals find important when identifying fingerprints. A number of models (e.g., Valentine, 1991) propose that distinctiveness is a dimension along which stimuli are represented in memory. In such models, distinctiveness is an important dimension along which we define the discriminability of that item. The distinctiveness effect is a robust effect demonstrated in natural facial stimuli, caricatures, and non-facial stimuli (Dror, Stevenage, Ashworth, 2008; Newell, Chiroro, & Valentine 1999; Rhodes & Moody, 1990) and so it becomes important to identify whether conditions exist that would eliminate such an advantage for distinctive items. Eliminating the distinctiveness effect changes the way these items are represented, resulting in confusability of the items leading to poorer discrimination.

One can ask the question: under which conditions will an item become less discriminable in perceptual space? One example of what happens when distinctiveness is eliminated stems from research on the cross-race effect, or the finding that individuals more accurately remember own-race faces when
compared with other-race faces (Meissner & Brigham, 2001; for a recent review see Marcon, Meissner, & Malpass, 2008). According to Valentine (1991), other-race faces are clustered more tightly than own-race faces in the multidimensional space. Chiroro and Valentine (1995) demonstrated that own-race faces are represented according to distinctiveness but when individuals had little or no contact with other-race persons, distinctiveness effects only evident for own-race faces and were absent for other-race faces leading to poorer discrimination. The current experiments will investigate whether conditions exist where the effect of distinctiveness in fingerprints can be eliminated, creating perceptual confusion and thus influencing discrimination.

Two variables that may influence perceptual discrimination as a function of distinctiveness are information loss and informational bias. Information loss refers to the type of print usually found at crime scenes—a latent print. Latent prints are partial prints and typically only contain 21.7% of a rolled print (Meagher, Budowle, & Ziesig, 1999). Latent prints may eliminate some important distinctive perceptual information that influences discrimination. Changing the amount of information available may make normally distinctive fingerprints perceptually confusable and reduce an individual’s ability to discriminate between fingerprints. The second variable, informational bias, provides additional social information that an individual may or may not use and is not directly related to the perception of a stimulus. The informational bias in the current study is information provided by the AFIS system and relates to the match score provided for each match candidate print. The studies propose to examine whether the presentation of biasing information will eliminate the distinctiveness effect.

These variables have practical importance in addition to their theoretical importance. LPE’s typically attempt to identify crime scene latent prints that are a mere fraction of rolled exemplars and the latent prints are not taken under well-controlled conditions. In fact, the latent prints in the current studies are conservative estimations of latents in the real world. Information loss in real latent print identification situations is likely much greater than estimated here. With respect to the informational
bias manipulation, AFIS systems typically present a match score and its associated ranking with each match candidate rolled print. This is information presented to LPEs, and those individual examiners may or may not make use of such information. It is important to understand the effect that such information may have on identification decisions.

The current experiments

The present experiments examined the role of distinctiveness, information loss, and informational bias in the perception and identification of fingerprint stimuli. Specifically, Experiment 1 manipulated the distinctiveness of fingerprints, as well as information loss, both of which were hypothesized to influence identification accuracy. The loss of perceptual information may change the way fingerprints are represented in a perceptual space leading to poorer discrimination of fingerprints. Experiment 2 addressed the influence of distinctiveness, information loss, and informational bias. Given the theoretical framework of perception and distinctiveness and it is proposed that fingerprints are more often misidentified in conditions where ambiguity is present due to either information loss or informational bias. Individuals may also be more prone to biasing information as ambiguity and information loss increase. As such, it is important to understand not only the effect of biasing information on identification ability, but also the conditions under which distinctiveness and information loss may moderate informational bias.

Collection of Fingerprints and Distinctiveness Ratings

Fingerprint materials were obtained from approximately 125 students from the University of Texas at El Paso who were offered course credit in exchange for providing their fingerprints. Each individual was asked to provide three sets of fingerprints of their right hand. The author and two undergraduate research assistants fingerprinted the participants. Based upon his occupation as an intake officer in a detention facility, one of the research assistants was trained to take fingerprints. The author also received informal training from an FBI evidence technician regarding proper fingerprinting
procedure. Participants were instructed to wash their hands prior to the fingerprinting to remove any oils or debris in an effort to obtain clear fingerprints without noise. Based on the Federal Bureau of Investigation’s publication on rolling fingerprints (FBI, 1981), participants were instructed to stand in front of the fingerprinting station at a forearms length away, and to relax and avoid trying to assist the experimenter. If participants seemed to have difficulty relaxing, they were instructed to avoid looking at their hands and to fix their gaze on a distant point in the room. Using ink, fingerprint cards, and a fingerprint stand all of which met law enforcement quality standards, the experimenter took the rolled fingerprints of each finger on the right hand, followed by the plain prints (full fingerprints without any rolling), and partial patent prints (latent prints without a special process to reveal them; herein referred to as latent prints). If the experimenter was concerned that an impression was unacceptable (e.g., that the print was too light, dark or incomplete) then the experimenter reprinted that finger. In reality, latent prints generally constitute only 21.7% of a rolled print (Meagher, Budowle, & Ziesig, 1999) and suffer from problems associated with the way the print was deposited upon the surface. The latent prints from this database approximated 40% of the surface area of the rolled prints and were taken under well-controlled conditions using ink and fingerprint paper.

To manipulate distinctiveness in the following experiments, each of the fingerprints had to be rated according to their typicality. Sixty students from the University of Texas at El Paso Introduction to Psychology participant pool were recruited to rate these fingerprints. All students were given research credit for their participation in this study. Participants were shown 125 index fingerprints as targets to rate. Index fingerprints were chosen because according to Brooks (1975), the most common crime scene latent prints were thumbs, middle, and index fingers. The fingerprints were presented on PC computers running MediaLab software and images were displayed on 19” LCD monitors using a 1280 x 1024 resolution.
Upon entering the laboratory, participants were given an informed consent to read and sign if they agreed to participate. Participants were first asked to complete a series of 20 target-present (TP) and 20 target-absent (TA) match-to-sample identification tasks. In each trial, participants were presented with a target (plain) fingerprint and six possible (rolled) candidate prints. If the trial was TP, the true matching rolled print would be present among five other rolled candidate prints. Participants could choose one of the prints as a match or indicate that the matching print was not present. Hits and false alarms were computed for TP and TA trials; participants’ hits averaged $M = .58$ ($SD = .14$) and participants’ false alarms averaged $M = .57$ ($SD = .18$).

After participants completed the matching tasks, they were instructed that they would be asked to judge the typicality of a number of fingerprints. Participants were instructed: “You will be shown a set of seven fingerprints that have been selected at random. There will also be one target fingerprint in the bottom-center of the page and it will be labeled ‘target’.” Participants were further instructed that the fingerprints surrounding the target were chosen at random and that their presence was intended to provide them a sense of what other fingerprints in the population might look like. The instructions emphasized that their judgments should not be based on the specific context of fingerprints or the quality of the fingerprint, but that they should make a more general judgment.

For each target fingerprint, participants were asked: “How difficult would it be to distinguish this fingerprint from a group of other fingerprints?” was presented along with a Likert-type scale from 1 (not difficult) to 7 (very difficult). (It should be noted that following data collection, this rating scale was reverse coded such that higher values indicated greater levels of distinctiveness.) The fingerprint as well as the scale remained visible until participants chose a point on the scale. After 20 judgments, a screen appeared that instructed participants to break for 30 seconds. After the break, they were again instructed that they “are to make an overall judgment of how difficult it would be to distinguish the target from a
group of other fingerprints.” They were also reminded that the seven other fingerprints were chosen at random and should not be the basis of their judgment.

As a result of programming errors, only 113 fingerprints were consistently rated according to distinctiveness. Average ratings across prints ranged from 2.72 to 4.83 ($M = 3.96$, $SD = .40$) and higher values indicated greater distinctiveness. Given that the ratings were made across all of the major characteristic types (i.e.,: whorl, arch, and loop), only fingerprints whose major characteristics involved a loop or arch were utilized in the subsequent experiments. Loops are the most common prominent major characteristic and typically make up between 60 and 70% of fingerprints (Cole, 2001; Lennard & Patterson, 2007). While arches only constitute approximately 5% of fingerprints, they are most easily confused with loops. Often times, patterns that look like arches are in fact, loops. In order for a pattern to be classified as an arch, it must either lack a delta or the ridge count between the delta and core must be zero (Bridges, 1942; Lennard & Patterson, 2007). These fingerprints were then grouped into high and low distinctiveness groups that significantly differed in rated distinctiveness, $t(34) = 12.93$, $p < .001$. 
Experiment 1

The purpose of this experiment was to examine how distinctiveness and information loss influence the perceptual discrimination of fingerprints. One real world example of information loss is the latent print, or the partial fingerprint, LPEs are often faced with needing to identify. Latent prints may lack certain parts of the fingerprint or ridge characteristics used for identification. Conceptually, latent prints involve a loss of perceptual information, which when lost may result in aspects of distinctiveness being eliminated, which could then influence discrimination of that fingerprint. The current study used a match-to-sample paradigm in which participants were presented with a latent or plain print and were asked whether (or not) it matched a given rolled print. Distinctiveness of the latent print was also manipulated. It was hypothesized that both a main effect of distinctiveness and a main effect of information loss would be observed. First, a main effect of information loss was expected such that plain-to-rolled conditions would have higher accuracy than latent-to-rolled conditions, presumably because plain prints contain more information than latent prints. A main effect of distinctiveness was also expected, such that participants would be less accurate with latent prints that were rated as low in distinctiveness. An interaction between information loss and distinctiveness was also hypothesized. Situations that are more ambiguous (such as the lack of information in a latent print) should be less likely to show distinctiveness effects when compared with situations that are less ambiguous (such as a plain print that includes all relevant information).
Method

Participants. Seventy undergraduate students from the University of Texas at El Paso participated in this experiment. The majority of the students were female (67% female; 33% male) and participants’ mean age was 19.9 years. Most participants self-reported their ethnicity as Hispanic (78.6%), consistent with the population demographics of the region. All students were provided research credit for their participation in this study.

Materials. Latent, plain, and rolled index fingerprints that included loops or arches as a prominent characteristic were used as stimuli for this study. Foils for target absent trials were chosen randomly although they were matched for the same major characteristic as the target. Loop direction was also matched or the foil print was flipped to make sure the direction of the loop was consistent. The presentation of fingerprints were counterbalanced and randomized across target-absent and target-present conditions. Fingerprints used as targets were not used as foils and vice versa. A total of 54 fingerprints from the author’s database were identified consistent with these criteria. The study was conducted on PC computers running MediaLab software and images were displayed on 19” LCD monitors using a 1280 x 1024 resolution.

Design and Procedure. A 2 (Information Loss: plain-to-rolled prints vs. latent-to-rolled prints) x 2 (Distinctiveness of Fingerprint: high vs. low) x 2 (Trial Type: target present vs. target absent) mixed factorial subjects design was employed. Information Loss served as the between-subjects variable, while distinctiveness and trial type were manipulated within-subject.

Participants completed 36 match-to-sample trials involving 18 target-absent and 18 target-present presentations. Participants were presented with either a latent or plain fingerprint target along side of a rolled fingerprint and were asked to determine whether the two fingerprints were the same or different. Participants responded by selecting a button on the screen indicating ‘yes, they are the same’ or ‘no, they are not the same’. After completing all 36 trials, participants completed a demographics
questionnaire that included information about age, gender, and race/ethnicity. Participants were then debriefed and thanked for their participation.
Results & Discussion

A series of 2 (Information Loss: plain-to-rolled prints vs. latent-to-rolled prints) x 2 (Distinctiveness of Fingerprint: high vs. low) x 2 (Trial Type: target present vs. target absent) mixed factorial repeated measures analyses of variance (ANOVAs) were computed to assess the effect of the manipulated variables on signal detection measures of discrimination accuracy ($A_z$) and response criterion ($c$). Signal detection theory (SDT) was used to assess performance as a function of the manipulated variables. SDT, as classically defined (cf. Green & Swets, 1966), is used to understand detection (or decision) responses under conditions of uncertainty involving the presentation of a signal that must be detected among a background of noise. Measures of discrimination accuracy (such as $A_z, A', \text{ or } d'$) provide an estimate of a participant’s ability to discriminate between signal vs. noise distributions, while measures of response criterion (such as $B''$ or $c$) provide an estimate of a participant’s decision threshold along a single dimension of perceived familiarity. When the perceived familiarity of a stimulus meets or exceeds the threshold, the participant is believed to respond “yes” to indicate that the item has been experienced before. Hits (or the proportion of items that are correctly identified) and false alarms (or the proportion of items falsely identified) were used to estimate participants’ discrimination accuracy ($A_z$) and response criterion ($c$) in the present study. Research by Pastore, Crawley, Berens, and Skelly (2003) and Verde, Macmillan, and Rotello (2006) suggests that $A_z$, a monotonic transformation of $d'$, demonstrates greater accuracy, precision, and is more robust to changes in sample size, when compared with $A'$. These researchers also support $c$ as an appropriate measure of response criterion. As such, measures of $A_z$ and $c$ were used to estimate discrimination and response criterion, respectively.

Table 1 presents the proportion of hits and false alarms across conditions, while Table 2 presents the values for discrimination accuracy ($A_z$) and response criterion ($c$). For a discussion of the analysis of hits and false alarms, please see Appendix A. A significant main effect of information loss was found on discrimination accuracy ($A_z$), $F(1,68) = 18.78, p < .001, \eta^2_p = .22$. Participants demonstrated greater
discrimination accuracy for plain prints \((M = .81, SD = .14)\) when compared to performance with latent prints \((M = .70, SD = .14)\). As predicted, reducing the amount of information available to make a decision, as in a latent print compared to a plain print, increases the chances a print can be confused with another and thereby reduces discrimination accuracy. A significant main effect of distinctiveness was also observed, \(F(1,68) = 13.44, p = .001, \eta^2_p = .17\). Consistent with predictions based upon the face recognition literature (Valentine, 1991), participants demonstrated greater discrimination accuracy for highly distinctive fingerprints \((M = .80, SD = .18)\) when compared to fingerprints low in distinctiveness \((M = .71, SD = .16)\).

The predicted information loss x distinctiveness interaction on discrimination accuracy failed to reach significance, \(F(1,68) = 2.04, ns., \eta^2_p = .03\). Nevertheless, planned comparisons indicated that, as predicted, participants demonstrated the effects of distinctiveness when sufficient perceptual information was present (plain prints), \(t(34) = 3.78, p < .01\), but failed to show a significant effect of distinctiveness when perceptual information was lacking from the stimulus (latent prints), \(t(34) = 1.51, ns.\) (see Table 2).

Analysis of the response criterion \((c)\) data indicated a significant main effect of distinctiveness, \(F(1,68) = 4.56, p < .05, \eta^2_p = .06\). Participants appear to have adopted a more liberal criterion (i.e., they were more likely to say “yes” across trials) when presented with low distinctive prints \((M = -.07, SD = .71)\) compared to high distinctive prints \((M = .10, SD = .54)\). No other significant main effects or interactions were observed.

In summary, Experiment 1 demonstrated that the robust distinctiveness effect found in the face perception literature (Byatt & Rhodes, 2004; Valentine, 1991, 2001) is similarly evidenced in fingerprint identification. Highly distinctive fingerprints were significantly more discriminate when compared with prints lacking distinctive attributes. As expected, the results of Experiment 1 also demonstrated that identifying latent prints reduced accuracy because the ambiguity brought about by the lack of
information in the latent prints eliminated the distinctiveness effect. This suggests that latent prints are missing perceptual information that renders them confusable and difficult to discriminate.

Experiment 2 sought to replicate the current findings, specifically with respect to the interaction between information loss and distinctiveness, and to further assess the potential role of informational bias in fingerprint identification (Dror et al., 2005; Dror et al. 2006, Dror & Charlton, 2006; Risinger et al., 2002). Much like information loss, strong informational bias has the potential to increase confusability by eliminating the distinctiveness effect. Additionally informational bias could moderate or interact with task difficulty and distinctiveness. Only conditions were information is complete (plain prints) and the informational bias is minimal should produce the distinctiveness effect. These manipulations are not only theoretically but also practically meaningful as shown by recent concern about the identification disciplines of the forensic sciences.
Experiment 2

As discussed previously, a recent NRC report on the forensic sciences highlighted significant concerns regarding the role of cognitive biases in forensic science errors. Recommendation 5 of the report called for “research programs on human observer bias and sources of human error in forensic examinations” (NRC, 2009, p. S-18). While prior research has examined the effects of biasing emotional information, information regarding an individualization or exclusion decision, and biasing case information (Dror et al., 2005; Dror et al. 2006, Dror & Charlton, 2006), no studies to-date have examined biasing information that might stem from the AFIS system itself.

Cole and colleagues (2008) have provided evidence that AFIS does not always join the highest match score with the true fingerprint match, and that many times the true match does not even receive a match score within the top 10 scores. This allows for the possibility that a high initial start value in the form of the AFIS match score ranking can bias an LPE’s decision regarding a match. Unfortunately, much of the information regarding AFIS systems is proprietary, as private companies compete to provide law enforcement with such systems. As such, information about match scores, output, or even the actual algorithm used to generate match candidates are often inaccessible (for comment on this see Cole et al., 2008). In their study, Cole and colleagues grouped their AFIS findings into the following categories: position #1, positions #2 through #10, or not present on the AFIS output list. In the current study, these same groupings were used to present subjects with hypothetical output from the AFIS system. In the Cole et al. study, when a rolled candidate print was not on the AFIS list, it was present in the database but the AFIS system did not consider it similar enough to give it a match score. However, in the real world, a print may not appear on the AFIS list for that reason or because the true match does not exist in the database.

The goal of the current study was to assess the influence that informational bias (in the form of AFIS output rankings) might have on fingerprint identification. Consistent with Experiment 1, it was
predicted that both information loss and distinctiveness would influence fingerprint identification. In addition, AFIS output was expected to significantly bias participants’ responses. Finally, consistent with previous predictions it was expected that situations that increase ambiguity (such as lessened information or biased information) are more likely to eliminate the distinctiveness effect.
Method

Participants. Seventy-four undergraduate students from the University of Texas at El Paso participated in this experiment. The majority of the students were female (57% female; 43% male) and participants’ mean age was 20.03 years. Most participants self-reported their ethnicity as Hispanic (88.6%), consistent with the population demographics of the region. All students were provided research credit for their participation in this study.

Materials. Stimuli for this study were the same 54 fingerprints used in Experiment 1. The study was similarly run on PC computers running MediaLab software, with images displayed on 19” LCD monitors using a 1280 x 1024 resolution.

Design and Procedure. A 2 (Information Loss: plain-to-rolled prints vs. latent-to-rolled prints) x 2 (Distinctiveness of Fingerprint: high vs. low) x 2 (Trial Type: target present vs. target absent) x 3 (Informational Bias: #1 ranking vs. #2-10 ranking vs. not on the AFIS list) mixed factorial design was employed. Similar to Experiment 1, information loss was manipulated between-subjects, while distinctiveness, trial type, and informational bias were manipulated within-subject.

When participants arrived at the laboratory they were initially provided a training session that addressed how latent print examiners make decisions, how computerized technologies can assist decision making, and finally, how they would take on the role of a latent print examiner in the current study (see Appendix B for the details of this training). Following presentation of the training materials, participants were presented with a series of 36 match-to-sample trials (18 target-present, 18 target-absent) in which a latent or plain fingerprint and rolled fingerprint were presented alongside a comparison rolled print. Participants were provided with information regarding the rolled candidate fingerprint in the form of the AFIS match score ranking such that the fingerprint either received a ranking of #1 in the AFIS output, that its AFIS match score ranked it somewhere between #2 and #10, or that AFIS did not give the rolled candidate print a match score and it did not appear on the potential
candidate list. Based upon the available information, participants could respond that ‘yes, they are the same’ or ‘no, they are not the same’. After completing all 36 trials, participants were asked to complete a demographics questionnaire, including information about age, gender, and race/ethnicity. Participants were then be debriefed and thanked for their participation.
Results & Discussion

Table 3 presents the proportion of hits and false alarms across the cells of the design, with analysis of this data presented in Appendix A. As in Experiment 1, hits (or the proportion of items that are correctly identified) and false alarms (or the proportion of items falsely identified) were used to estimate participants’ discrimination accuracy ($A_z$) and response criterion ($c$) in the present study. A series of 2 (Information Loss: plain-to-rolled prints vs. latent-to-rolled prints) x 2 (Distinctiveness of Fingerprint: high vs. low) x 2 (Trial Type: target present vs. target absent) x 3 (Informational Bias: #1 ranking vs. #2-10 ranking vs. Not on the AFIS list) mixed factorial repeated measures ANOVAs were used to assess the effects of the manipulated variables on discrimination accuracy ($A_z$) and response criterion ($c$) (see Table 4).

A significant main effect of Information Loss was found on discrimination accuracy ($A_z$), $F(1,72) = 6.48, p < .05, \eta^2_p = .08$. Consistent with the results of Experiment 1, participants demonstrated greater discrimination accuracy for plain prints ($M = .85, SD = .19$) when compared with latent prints ($M = .74, SD = .19$). A significant main effect of Informational Bias was also found, $F(2,144) = 6.12, p < .01, \eta^2_p = .08$. Post-hoc analyses (Bonferroni corrected to $p = .02$) revealed significant differences between “AFIS rankings #2 through #10” ($M = .81, SD = .16$) and “Not on the AFIS list” ($M = .72, SD = .22$) conditions, $t(73) = 3.70, p < .001$, while the AFIS ranking #1 condition ($M = .77, SD = .21$) did not significantly differ from the other conditions, $ts(73) < 2.09, ns$.

A significant Information Loss x Distinctiveness x Informational Bias interaction was observed on discrimination accuracy, $F(2,144) = 3.48, p < .05, \eta^2_p = .08$. Two significant two-way interactions were also observed: Information Loss x Distinctiveness, $F(1,72) = 7.89, p < .01, \eta^2_p = .10$, and Distinctiveness x Informational Bias, $F(2,144) = 5.22, p < .01, \eta^2_p = .07$. Analysis of these interactions revealed several important findings. First, consistent with the findings in Experiment 2, the distinctiveness effect was only found to influence discrimination in the plain print conditions (see Figure
1. Paired samples t-test comparing latent high distinctiveness prints with low distinctiveness was not significant, $t(36) = -0.89, ns$. The paired samples t-test comparing plain high distinctiveness prints ($M = .87, SD = .18$) with low distinctiveness prints ($M = .77, SD = .18$) was observed to be significant, $t(36) = 3.15, p < .01$. Highly distinctive prints lose the benefits of distinctiveness as it relates to discrimination accuracy and become easily confused when there is a loss of perceptual information (as in a latent print).

Second, much like information loss, the presence of biasing information increased confusability by eliminating the distinctiveness effect (see Figure 2). With respect to the distinctiveness x AFIS interaction, a paired samples t-test indicated that the high distinctiveness and low distinctiveness Not on the list AFIS conditions were significantly different from each other, $t(73) = 3.22, p < .01$. The effect of distinctiveness was only evident in the condition where the least amount of biasing information was presented. Distinctiveness offers some protection when fingerprints are labeled as “Not on the AFIS list” as participants displayed greater discrimination accuracy ($M = .80, SD = .23$) when compared with low distinctiveness prints labeled “Not on the AFIS list” ($M = .65, SD = .33$). In all other conditions, the strong informational bias eliminated distinctiveness effects.

Finally, the distinctiveness effect was found only in the conditions, which were the least ambiguous: there was no ranking provided to bias the decision-maker and complete perceptual information was available in the form of a plain print (see Table 4). The three-way interaction was analyzed by splitting the data by Information Loss and conducting 2 (Distinctiveness) x 3 (Informational Bias) repeated measures ANOVAs. A significant Distinctiveness x Informational Bias interaction was observed only for the plain print condition, $F(2,72) = 8.32, p < .01, \eta_p^2 = .19$. Paired samples t-tests revealed that when the least amount of bias was present (Not on the List condition), participants demonstrated greater discrimination accuracy for highly distinctive prints, $t(36) = 4.89, p < .001; M = .92, SD = .15$, when compared with low distinctiveness prints ($M = .63, SD = .34$); however, distinctiveness effects were not present when AFIS rankings were provided, $ts(36) < 1.88, ns$. As
predicted and consistent with Experiment 1, distinctiveness effects were present only when the least amount of informational bias was present and there was no loss of perceptual information. All other conditions eliminated the distinctiveness effect and fingerprints became perceptually confusable which lead to the inability to discriminate between fingerprints.

With respect to response criterion \( (c) \), a significant main effect of distinctiveness was observed, \( F(1,72) = 25.90, p < .001, \eta^2_p = .27 \). This result replicated the findings in Experiment 1 such that highly distinctive prints engendered more conservative responding \( (M = .02, SD = .77) \) than less distinctive prints \( (M = -.44, SD = .76) \). A significant main effect of informational bias was also observed, \( F(2,144) = 25.30, p < .001, \eta^2_p = .26 \). Post-hoc comparisons (Bonferroni corrected to \( p = .02 \)) revealed that all levels of the informational bias manipulation were significantly different from each other. Participants engendered a significantly more liberal response criterion when the fingerprint had an AFIS ranking of #1 \( (M = -.70, SD = .92) \) when compared with a fingerprint with an AFIS ranking #2 through #10 \( (M = -.22, SD = .89) \), \( t(73) = 3.53, p < .01 \). Participants held a significantly more conservative response criterion when presented with a fingerprint that was Not on the AFIS list \( (M = .28, SD = 1.02) \) when compared with either the #1 ranking, \( t(73) = 6.47, p < .001 \), or the AFIS ranking #2 through #10, \( t(73) = 3.55, p < .01 \).

Finally, a two-way interaction between Information Loss and Informational Bias was observed, \( F(2,144) = 6.62, p < .01, \eta^2_p = .08 \) (see Figure 3). This interaction was analyzed by splitting the data by information loss and conducting a 2 (Distinctiveness) x 3 (Informational Bias) repeated measures ANOVA. A significant main effect of informational bias was observed for both the latent print condition, \( F(2,72) = 20.76, p < .001, \eta^2_p = .37 \), and the plain print condition, \( F(2,72) = 7.97, p < .01, \eta^2_p = .18 \). Post-hoc analyses (Bonferroni correction to \( p = .02 \)) for the latent print condition, revealed that participants engendered a significantly more liberal response criterion when the fingerprint had an AFIS ranking of #1 \( (M = -.89, SD = 1.30) \) when compared with an AFIS ranking of #2 through #10 \( (M = .05, \ldots \)
With respect to the plain print condition, post-hoc analyses revealed that participants demonstrated a more conservative criterion when a fingerprint was indicated to be Not on the AFIS list ($M = .09, SD = 1.45$) when compared to a ranking of #1 ($M = -.50, SD = 1.30$), $t(36) = 3.83, p < .001$, or a ranking of #2 through #10 ($M = -.49, SD = 1.26$), $t(36) = 3.24, p < .01$. Response criterion did not differ from when participants were presented with a fingerprint ranked #1 and #2 through #10, $t(36) = .07, ns$. In contrast to the latent print condition, for the plain print condition there seemed to be less criterion shift (although it was in a more conservative direction) when a fingerprint was ranked as Not on the AFIS list when compared to the liberal criterion set for the other conditions. This is consistent with predictions that in conditions where perceptual information loss was smallest, i.e. with the plain prints, informational bias would not have as great of an effect (as evidenced by the smaller effect size) on response criterion.
General Discussion

The purpose of the present study was to examine the factors that influence perceptual discrimination of fingerprints and the conditions that promote identification errors. Fingerprint misidentifications have recently been identified as having contributed to cases of wrongful convictions, false accusations, and false arrests. Prior research in the face discrimination literature has suggested that typicality or distinctiveness is a dimension along which faces are represented in a perceptual space and thus plays an important role in predicting discrimination accuracy for each item (Valentine, 1991). This study sought to extend these findings to fingerprints, a stimulus class that may be similar to faces. From a theoretical perspective, the goal was to understand the conditions under which fingerprints may be perceptually confusable as a function of eliminating the distinctiveness effect. First, information loss may create stimuli that are more confusable and thereby eliminate the distinctiveness effect. Second, based on the NRC’s (NRC, 2009) call to study the role of cognitive biases in the forensic sciences, the current study examined the role of biasing information and whether it might interact with information loss and distinctiveness to also eliminate the distinctiveness effect. Previous research by Dror and colleagues (Dror et al., 2006; Dror & Charlton, 2006) suggested that latent print examiners were not immune to bias and the current study sought to extend those findings to information provided by the AFIS system itself.

Theoretical Implications

Experiment 1 examined the influence of distinctiveness and the loss of perceptual information on fingerprint identification. Experiment 2 sought to replicate the findings of Experiment 1 and extend them by examining how informational bias (in the form of AFIS output rankings) interacted with these variables. Several important findings are drawn from this research. First, the effects of distinctiveness, information loss, and informational bias were observed in fingerprint identification. It was important to demonstrate that the robust effects of distinctiveness were observed using fingerprint stimuli and that
information loss and the presentation of biasing information influenced fingerprint identification. Both highly distinctive prints and plain prints were better discriminated than low distinctive prints or latent prints and informational bias influenced both discrimination accuracy and response criterion. These variables interacted such that the distinctiveness effect was observed only when complete perceptual information was available and the least amount of biasing information was provided.

Second, the robust effect of distinctiveness goes away when important perceptual information is lost. Specifically, when participants were presented with plain prints, which presumably involved more complete perceptual information, they were more likely to demonstrate the distinctiveness effect when compared with latent prints. Recall that is was estimated that the latent prints in the current study encompassed approximately 40% of the fingerprint information found in a rolled candidate print. Although this is larger than the estimation given by the FBI (21.7%; Meagher, Budowle, & Ziesig, 1999), there is still a significant loss of information. From a theoretical perspective, conditions that reduce information may result in clustering in the perceptual space. When stimuli are more confusable, they exist closer to each other in the representational space thus leading to poorer discrimination. These conditions could create problems for LPEs if they are susceptible to information loss which leads to perceptual confusability.

Finally, providing informational bias produces conditions that promote biased responding and this social information can interaction with information loss to eliminate the distinctiveness effect. Participants were susceptible to informational bias from AFIS output, especially when perceptual information was lost, and thus eliminated the distinctiveness effect. While such information should not directly effect the perception of stimuli, the presence of the strongest biasing information, AFIS rankings #1 and #2 through #10, influenced discrimination. While the role of bias has long been studied in psychological literature (Rosenthal, 1966; Rosenthal, 1994; Rosenthal & Jacobson, 1968; for a review see Risinger et al., 2002), this study is the first to demonstrate that bias from the AFIS output itself can
influence the discrimination of fingerprints. What is more concerning, however, is that the ranking information provided by AFIS is not necessarily diagnostic (Cole et al., 2008). While LPEs would likely never consider that such a ranking colors their decision or that it is unlikely the computer would lead them astray, these findings are reason for concern. One research question that remains is the extent to which LPE’s understand that certain AFIS information is not diagnostic and the degree to which they consciously or unconsciously rely upon ranking information.

**Practical Implications**

While the manipulations of distinctiveness, information loss, and informational bias all have important theoretical implications, it is important to remember that they have practical implications as well. In particular, both the lack of perceptual information and the presence of informational bias appear to alter the perceptual space and decision criterion used to discriminate fingerprints and thereby create the potential for errors in identification. The potential for actual misidentifications is a real concern for all LPEs, and the current research suggests conditions under which fingerprint identification could promote misidentifications. As such, the LPE community’s adherence to a “zero error rate” claim for latent print identification appears unwarranted.

Additionally, one must consider the stimuli used for the current experiments. The latent prints in the current experiments were taken under well-controlled conditions and presumably maintained a significant amount of information (whether in terms of the amount of fingerprint shown or the quality of ridge detail). In contrast, actual latent prints involve approximately 20% of the area of a rolled print and may involve the loss of important information in a variety of ways, including the lack of major characteristics of the print or the smudging of well-defined ridge characteristics. Consider the fingerprint from the Brandon Mayfield case: it was a partial print and contained many areas on the fingerprint where the ridge detail was ambiguous (Fine, 2006). The misidentification of Mayfield’s fingerprint suffered from both problems, a lack of informative area and ridge definition, both of which resulted in
the loss of perceptual information that could aid identification. Additionally, Mayfield’s print was ranked #4 in a candidate output list by the FBI’s AFIS computer (Fine, 2006), providing a condition where informational bias could have influenced the LPE’s decision-making. The findings from the current experiments suggest that this loss of perceptual information and the presence of informational bias (resulting in the lack of a distinctiveness effect) could have serious consequences for identification.

Limitations and Future Research

One criticism of this research may be that these experiments used naïve undergraduate participants as opposed to professional LPEs. Although one could argue that the current experiments were intended to model key psychological processes that play a role in fingerprint identification, the use of naïve participants may nonetheless be a valid concern. If LPEs are indeed experts, then the question becomes whether such individuals would be immune to the effects of perceptual information loss and information bias. As previously discussed, research by Dror and colleagues (Dror et al., 2006; Dror & Charlton, 2006) suggests that professional LPEs are susceptible to contextual information and cognitive biases. It may be the case that professional LPEs may demonstrate the same loss in discrimination as naïve subjects in the current study when there was a loss of perceptual information and additional biasing information. Research by Busey and Vanderkolk (2005) suggests that LPEs may be susceptible to information loss. If this is the case, then perhaps there should be some concern over the role information from AFIS output plays in an LPE’s decision-making or the role of socially provided information during the verification process. Future research should further examine the role of AFIS output in identification decisions and ways to eliminate the potential for such information to bias decision-making.

Nevertheless, the question of expertise is still one that demands further research to determine whether LPEs are in fact experts. Research by Busey and Vanderkolk (2005) suggests that naïve participants and professional LPEs may demonstrate some differences in performance related to the
perceptual expertise that LPEs develop. In particular, these researchers demonstrated that LPEs performed better overall, despite delay and noise-filled images, and demonstrated some evidence of configural processing. Future research could use eye-tracking technologies, which have been used to a large extent in expertise research to identify perceptual and identification differences between novices and experts. Research has demonstrated that expertise changes perceptual abilities, specifically in regards to change detection, shifts in similarity, and differential configural versus featural processing, when compared to novices in that area (Laurent, Ward & Williams, 2006; Reingold, Charness, Pomplum, & Stampe, 2001; Werner & Thies, 2000). Future research may use eye-tracking to determine if there are systematic differences in the way naïve participants and professional LPEs conduct visual fingerprint identification. These data could be integrated with behavioral data on differences between naïve laypersons and LPEs in perceptual identification of fingerprints. Additionally, it may be worth assessing how LPEs perceive fingerprint distinctiveness. Multidimensional space models akin to Valentine’s (1991, 2001) face space models may provide information on differences in how novices and experts represent fingerprints in a perceptual space.

Concluding Remarks

In conclusion, it is clear that information loss and informational bias both eliminate distinctiveness effects in fingerprint identification. Conditions that influence the way fingerprints are represented in perceptual space by inducing confusability directly impact how well two fingerprints can be discriminated. Future research should examine whether LPEs possess expertise and whether their role as experts, protect them from perceptual information loss and bias. Additionally, consideration should be given to how forensic scientists can protect themselves from the role of informational bias, which may be as seemingly harmless (if not diagnostic) as information from AFIS itself.
References


doi:10.1002/acp.1432.


Table 1

*Mean hit and false alarm values for Experiment 1.*

<table>
<thead>
<tr>
<th>Information Loss</th>
<th>Distinctiveness</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hits</td>
<td>Plain Prints</td>
<td>.74 (.24)</td>
<td>.71 (.25)</td>
</tr>
<tr>
<td></td>
<td>Latent Prints</td>
<td>.64 (.24)</td>
<td>.63 (.25)</td>
</tr>
<tr>
<td>False Alarms</td>
<td>Plain Prints</td>
<td>.21 (.21)</td>
<td>.37 (.24)</td>
</tr>
<tr>
<td></td>
<td>Latent Prints</td>
<td>.33 (.21)</td>
<td>.38 (.24)</td>
</tr>
</tbody>
</table>

Notes. Standard deviations are in parentheses.
Table 2

*Mean discrimination accuracy (Az) and response criterion (c) values for Experiment 1.*

<table>
<thead>
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<th>Distinctiveness</th>
<th>Information Loss</th>
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<th>Low</th>
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</thead>
<tbody>
<tr>
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<td>.76 (.21)</td>
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<tr>
<td></td>
<td>Latent Prints</td>
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<td>.67 (.21)</td>
</tr>
<tr>
<td>Response Criterion</td>
<td>Plain Prints</td>
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<tr>
<td></td>
<td>Latent Prints</td>
<td>.10 (1.00)</td>
<td>.03 (.75)</td>
</tr>
</tbody>
</table>

Notes. Standard deviations are in parentheses.
Table 3

*Mean hit and false alarm values for Experiment 2.*

<table>
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<tr>
<th>Informational Bias</th>
<th>Information Loss</th>
<th>Distinctiveness</th>
</tr>
</thead>
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<tr>
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<td></td>
<td>High</td>
</tr>
<tr>
<td>Hits</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plain Prints</td>
<td>.76 (.39)</td>
</tr>
<tr>
<td>#1</td>
<td>Latent Prints</td>
<td>.75 (.39)</td>
</tr>
<tr>
<td>#2 - #10</td>
<td>Plain Prints</td>
<td>.83 (.36)</td>
</tr>
<tr>
<td></td>
<td>Latent Prints</td>
<td>.60 (.36)</td>
</tr>
<tr>
<td>Not on AFIS List</td>
<td>Plain Prints</td>
<td>.73 (.36)</td>
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<tr>
<td></td>
<td>Latent Prints</td>
<td>.49 (.36)</td>
</tr>
<tr>
<td>False Alarms</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Plain Prints</td>
<td>.32 (.40)</td>
</tr>
<tr>
<td>#1</td>
<td>Latent Prints</td>
<td>.50 (.40)</td>
</tr>
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<tr>
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<td>Latent Prints</td>
<td>.24 (.41)</td>
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<tr>
<td>Not on AFIS List</td>
<td>Plain Prints</td>
<td>.14 (.32)</td>
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<td></td>
<td>Latent Prints</td>
<td>.28 (.32)</td>
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</table>

Notes. Standard deviations are in parentheses.
Table 4

*Mean discrimination accuracy (Az) and response criterion (c) values in Experiment 2.*

<table>
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<th>Informational Bias</th>
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<th>Distinctiveness</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Discrimination</td>
<td>Plain Prints</td>
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<td>.78 (.36)</td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>Latent Prints</td>
<td>.69 (.40)</td>
<td>.79 (.36)</td>
<td></td>
</tr>
<tr>
<td>#2 - #10</td>
<td>Plain Prints</td>
<td>.85 (.36)</td>
<td>.88 (.34)</td>
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<tr>
<td></td>
<td>Latent Prints</td>
<td>.80 (.36)</td>
<td>.79 (.34)</td>
<td></td>
</tr>
<tr>
<td>Not on AFIS List</td>
<td>Plain Prints</td>
<td>.92 (.34)</td>
<td>.63 (.46)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Latent Prints</td>
<td>.68 (.34)</td>
<td>.67 (.46)</td>
<td></td>
</tr>
<tr>
<td>#1</td>
<td>Plain Prints</td>
<td>-.24 (1.63)</td>
<td>-.76 (1.64)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Latent Prints</td>
<td>-.65 (1.63)</td>
<td>-1.13 (1.64)</td>
<td></td>
</tr>
<tr>
<td>Response Criterion</td>
<td>Plain Prints</td>
<td>-.47 (1.68)</td>
<td>-.51 (1.64)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Latent Prints</td>
<td>.42 (1.68)</td>
<td>-.31 (1.64)</td>
<td></td>
</tr>
<tr>
<td>#2 - #10</td>
<td>Plain Prints</td>
<td>.37 (1.44)</td>
<td>-.19 (2.03)</td>
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</tr>
<tr>
<td></td>
<td>Latent Prints</td>
<td>.69 (1.44)</td>
<td>.26 (2.03)</td>
<td></td>
</tr>
</tbody>
</table>

Notes. Standard deviations are in parentheses.
Figure Captions

*Figure 1.* Mean discrimination accuracy ($A_z$) values for the interaction between information loss and distinctiveness.

*Figure 2.* Mean discrimination accuracy ($A_z$) values for the interaction between distinctiveness and informational bias.

*Figure 3.* Mean response criterion ($c$) values for the interaction between information loss and informational bias.
Appendix A

Experiment 1

A series of 2 (Information Loss: plain prints vs. latent prints) x 2 (Distinctiveness: high vs. low) x 2 (Trial Type: target present vs. target absent) mixed factorial repeated measures analyses of variance (ANOVAs) were computed to assess the effect of the manipulated variables on hits and false alarms. As predicted, a significant main effect of information loss was observed, $F(1,68) = 7.21, p < .01, \eta^2_p = .10$, such that participants demonstrated more hits for plain prints ($M = .73, SD = .20$) than for latent prints ($M = .64, SD = .20$). No other significant main effects or interactions were observed for hits.

With respect to false alarms, a significant main effect of information loss was observed, $F(1,68) = 4.66, p < .05, \eta^2_p = .06$, such that participants demonstrated more false alarms for latent prints ($M = .36, SD = .18$) than plain prints ($M = .29, SD = .18$). A significant main effect for distinctiveness was also observed, $F(1,68) = 20.70, p < .001, \eta^2_p = .23$. As expected, participants demonstrated greater false alarms for less distinctive fingerprints ($M = .38, SD = .18$) than highly distinctive fingerprints ($M = .27, SD = .16$). A significant interaction between information loss and distinctiveness was observed, $F(1,68) = 4.74, p < .05, \eta^2_p = .07$. The pattern of results mirrored that of the findings for this interaction on discrimination accuracy (see Table 1).

Experiment 2

Similar to Experiment 1, a series of 2 (Information Loss: plain prints vs. latent prints) x 2 (Distinctiveness: high vs. low) x 2 (Trial Type: target present vs. target absent) x 3 (Informational Bias: #1 ranking vs. #2 through #10 ranking vs. Not on the AFIS list) mixed factorial repeated measures ANOVAs were computed. Consistent with the results of Experiment 1, a significant main effect of print type on hits was observed, $F(1,72) = 9.69, p < .01, \eta^2_p = .12$. Participants demonstrated greater hits for plain prints ($M = .77, SD = .20$) than for latent prints ($M = .66, SD = .20$). A significant main effect of distinctiveness was observed, $F(1,72) = 4.73, p < .05, \eta^2_p = .06$. Participants demonstrated fewer hits for
highly distinctive prints \((M = .69, SD = .16)\) when compared with less distinctive prints \((M = .74, SD = .17)\). A significant main effect of informational bias was also observed, \(F(2,144) = 25.04, p < .001, \eta^2_p = .26\). Participants demonstrated the fewest hits when the candidate print was listed as Not on the AFIS list \((M = .60, SD = .25)\) when compared with a ranking in position #1 \((M = .80, SD = .18)\), \(t(73) = 6.13, p < .001\) or with a ranking of #2 through #10 \((M = .75, SD = .18)\), \(t(73) = 4.77, p < .001\). Rankings of #1 and #2 through #10 were not significantly different from each other, \(t(73) = 1.75, ns\).

Two interactions on hits were observed. First, a significant information loss x distinctiveness interaction was seen, \(F(1,72) = 7.39, p < .01, \eta^2_p = .09\). This interaction was analyzed by splitting the file by information loss and conducting a one-way ANOVA on distinctiveness. A significant main effect was found on hits for only latent prints, \(F(1,36) = 10.25, p < .01, \eta^2_p = .22\) and the effect of plain prints was not observed, \(F(1, 36) = .18, ns., \eta^2_p = .01\). Participants demonstrated greater hits for low distinctiveness prints \((M = .72, SD = .23)\) than for highly distinctive prints \((M = .61, SD = .26)\) in the latent print condition, but showed no difference in hits for the plain print condition \((Ms = .76 and .77, SDs = .25 and .25, respectively)\).

Second, a significant information loss x informational bias interaction was found, \(F(2,144) = 7.36, p < .001, \eta^2_p = .09\). This interaction was also analyzed by splitting the file by information loss and conducting a one-way ANOVA on informational bias. Significant main effects were found for both latent prints, \(F(2, 72) = 21.41, p < .001, \eta^2_p = .37\), and plain prints, \(F(1, 72) = 8.94, p < .001, \eta^2_p = .20\). For the latent print condition, ranking #1 \((M = .82, SD = .17)\) was significantly different from #2 through #10 \((M = .66, SD = .21; t(36) = 3.83, p < .001)\) and Not on the AFIS list \((M = .51, SD = .26; \(t(t(36) = 6.31, p < .001)\). Ranking #2 through #10 also differed significantly from Not on the AFIS list \((t(36) = 2.98, p < .01)\). With respect to the plan print condition, ranking #1 \((M = .78, SD = .18)\) was significantly different from Not on the AFIS list \((M = .68, SD = .24; (t(36) = 2.61, p < .01)\), which was significantly different from ranking #2 through #10 \((M = .84, SD = .15; (t(36) = 3.81, p < .001)\).
With respect to false alarms, a significant main effect of distinctiveness was observed, $F(1,72) = 25.68, p < .001, \eta^2_p = .26$. Participants demonstrated greater false alarms for less distinctive prints ($M = .41, SD = .17$) than for highly distinctive prints ($M = .30, SD = .17$). A significant main effect of informational bias was observed, $F(2,144) = 12.48, p < .001, \eta^2_p = .15$. Participants produced the greatest number of false alarms when the candidate print was ranked in position #1 ($M = .44, SD = .24$) when compared with a ranking of #2 through #10 ($M = .31, SD = .21$), $t(73) = 4.26, p < .001$ or listed as Not on the AFIS list ($M = .30, SD = .20$), $t(73) = 4.17, p < .001$. Rankings #2 through #10 and Not on the AFIS list were not significantly different from each other, $t(73) = .15, ns$.

A three-way interaction between information loss, distinctiveness, and informational bias was also observed on false alarms, $F(2,144) = 3.60, p < .05, \eta^2_p = .05$ (see Table 3). Consistent with the discrimination accuracy data, this interaction suggested that the greatest effect of distinctiveness occurred in the plain print, “not on the AFIS list” condition. A significant distinctiveness x informational bias interaction was also observed, $F(2,144) = 3.29, p < .05, \eta^2_p = .04$. Pairwise comparisons revealed that, consistent with previous findings, the distinctiveness effect was only observed in the condition of least biasing information (“Not on the AFIS list”), $t(73) = 4.96, p < .001$. 
Appendix B

Today you will be playing the role of a forensic scientist. You will be asked to play the role of a Latent Print Examiner. The El Paso Police Department has asked for help from this laboratory with fingerprint identification.

In order to prepare you for this task, you will go through a training module. The training will give you information on:

1. How Latent Print Examiners make decisions
2. How computerized technologies can assist Latent Print Examiners
3. How YOU will be a Latent Print Examiner today!

When you have finished reading the page and you are ready to move on, click on the “continue” button. It will appear after a period of time.

What is a Latent Print Examiner? How do they make decisions?

-A Latent Print Examiner is a forensic scientist who compares latent fingerprints from a crime scene to a database of known fingerprints.

-Latent fingerprints are fingerprints left behind at a crime scene. Special techniques are used to reveal the latent print and the print is recovered by an evidence technician.

*Sometimes the print is visible to the naked eye. Evidence technicians will enhance and lift the print so it can be examined by a Latent Print Examiner at a later time.

-By comparing the latent print to fingerprints from known persons, the Latent Print Examiner can declare that the latent print matches the fingerprint of another person.
*The Latent Print Examiner can determine who was present at a crime scene or who the suspect is by using latent print identification!

*Computerized technologies that aid fingerprint identification are called “Automated Fingerprint Identification Systems” or AFIS. AFIS uses an algorithm to search large databases of fingerprints for possible matching prints to the latent print.

*An algorithm is a specific set of rules that solve a problem. In this case, it is like a formula with parameters that determine whether there is a match to a latent print.

-The AFIS retrieves the images of the possible matching prints and displays them, in descending order of likelihood of matching on a split screen next to the latent print. In the final stage of the process, a human Latent Print Examiner compares the prints to determine whether there truly is a match.

*So, prints are ranked from most likely to be a match (in position #1) to least likely to be a match.

-Each possible matching print has a match score associated with the print. A match score represents the AFIS algorithm’s view of the similarity of the prints. It can loosely be interpreted as the probability of a correct match to the latent print.

-Sometimes the true matching print is not rated #1 by the computer.
How YOU will be a Latent Print Examiner today!

The El Paso Police Department has asked for our help with a series of fingerprint identifications from recent cases.

We have been asked to examine how people make decisions when looking at fingerprints.

This is an important research endeavor and it will help us improve fingerprint identification.

It will be **YOUR JOB** to decide whether two fingerprints presented to you are matches.

-Rolled candidate prints are prints taken by the police department when a person is being booked for a crime.

-You will be shown a crime scene fingerprint on the left side of the page and then a rolled candidate print on the right side of the page.
The rolled print will be associated with a **match score ranking**, meaning the print with the highest match score will be rated “1”, and the next highest will be rated “2”, etc. Because exact match scores can vary depending upon the AFIS manufacturer or specific system, we will provide you with a ranking associated with the **match score**.

*So, a candidate rolled print with a ranking of #1 had the highest match score.*

*The next grouping of rankings are #2-10. These are the candidate prints with the next highest match scores.*

*A candidate rolled print that did not appear on the list was not in the rankings of #1-10. This does not necessarily mean that the fingerprint is not a match, just that the AFIS system did not consider the fingerprints to be similar enough to give it a match score.*

-You will need to decide whether the two fingerprints are the same. That is, are the prints from the same source (the same finger of the individual donated both the crime scene print and the rolled print)?

-Please be as accurate as possible! Take your role as a **Latent Print Examiner** seriously! This is YOUR opportunity to be like the forensic scientists on **CSI**!
Vita

Jessica L. Marcon was born March 28, 1982 in Auburn, New York. She is the first child of Patricia and Philip Marcon. She graduated from Jordan-Elbridge High School in Jordan, New York in 2000. She attended Miami University in Oxford, Ohio before transferring to the College of William and Mary in Williamsburg, Virginia in fall 2001. Ms. Marcon conducted a senior honors thesis (receiving Highest Honors) with Dr. Kelly Shaver in the area of Legal Psychology. She was awarded the Williams Prize for Outstanding Psychology Major. Ms. Marcon graduated cum laude from the College of William and Mary in May 2004 with a Bachelor of Arts in Psychology.

In August 2004, Ms. Marcon entered the Legal Psychology Ph.D. program at Florida International University where she began work Christian A. Meissner, Ph.D. In 2005, she joined the General Psychology Ph.D. program (legal psychology concentration) at the University of Texas in El Paso. She earned her Masters of Arts in Experimental Psychology from the University of Texas at El Paso in 2007. Ms. Marcon was the recipient of the UTEP Graduate School Dodson Dissertation Fellowship. She served as the Graduate Student member of the UTEP Legal Psychology Committee from 2008-2009 and was an instructor for both the Psychology and Criminal Justice departments. Ms. Marcon was also a research intern with the Army Research Laboratory at the Ft. Bliss Field Element. Ms. Marcon has published articles in the peer-reviewed journals of Psychonomic Bulletin & Review, Psychology, Crime & Law, and the Canadian Journal of Behavioral Science. Her dissertation was supervised by Christian A. Meissner, Ph.D.

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