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Strengthening forensic DNA decision making through a better understanding of the influence of cognitive bias

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ABSTRACT

Cognitive bias may influence process flows and decision making steps in forensic DNA analyses and interpretation. Currently, seven sources of bias have been identified that may affect forensic decision making with roots in human nature; environment, culture, and experience; and case specific information. Most of the literature and research on cognitive bias in forensic science has focused on patterned evidence; however, forensic DNA testing is not immune to bias, especially when subjective interpretation is involved. DNA testing can be strengthened by recognizing the existence of bias, evaluating where it influences decision making, and, when applicable, implementing practices to reduce or control its effects. Elements that may improve forensic decision making regarding bias include cognitively informed education and training, quality assurance procedures, review processes, analysis and interpretation, and context management of irrelevant information. Although bias exists, reliable results often can be (and have been) produced. However, at times bias can (and has) impacted the interpretation of DNA results negatively. Therefore, being aware of the dangers of bias and implementing measures to control its potential impact should be considered. Measures and procedures that handicap the workings of the crime laboratory or add little value to improving the operation are not advocated, but simple yet effective measures are suggested. This article is meant to raise awareness of cognitive bias contamination in forensic DNA testing and to give laboratories possible pathways to make sound decisions to address its influences.

1. Introduction

Cognitive neuroscience research is making a positive impact on the field of forensic science by raising awareness to the effects of human factors in forensic decision making. Cognitive contamination or bias is inherent in all human beings due to the architecture and operation of the brain. However, it is important to understand that although bias exists it does not always result in an incorrect interpretation, just as enacting bias reduction steps will not guarantee that laboratory results will be error free. Nevertheless, forensic scientists should continue to improve and seek mechanisms to minimize error due to bias. Weaknesses in processes have been discovered and some are due to bias. These situations give forensic scientists an opportunity to critically examine their workflow and make improvements where applicable.

First and foremost, the most effective action that can be taken is proper and cognitively informed training and education. Without it solutions may be ignored and the results of cognitive research can be misunderstood which in turn may make them appear off putting, abstract, and even intangible. An important step in the reduction of cognitive contamination is to accept that all humans are biased and that forensic experts have a responsibility to address the effects of bias that may cause erroneous conclusions. Thus, it is important for forensic scientists to appreciate that bias exists, identify where bias resides and affects interpretation, and where to implement practices to reduce cognitive contamination.

In forensic DNA workflows, analysis, interpretation, and comparison of forensic DNA does involve subjectivity, and hence the results depend on human cognitive processes [1]. The NIST Inter-Laboratory Mixture Studies also showed that there is variation in DNA mixture interpretation practices, some of which are incorrect [2,3]. Some of the incorrect interpretations were due to use of reference profiles to determine whether allele drop out has occurred [4,5], often referred to as reference material or target suspect driven bias [6,7]. While solutions such as

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using probabilistic genotyping software can reduce variation in interpretation among examiners, use of interpretation software does not necessarily make interpretation bias free. Some subjectivity, i.e., the human element, is involved in software development, requirements gathering, creation of code, and testing, as well as in determining input (signal vs. noise, sampling, etc.) and the final evaluation of software output. While it can reduce user variation, currently technology alone will not eliminate cognitive bias. The best approach is to recognize and properly address subjectivity and bias to proactively reduce the influence of various factors that can negatively impact, even on a subconscious level, forensic DNA decision making.

Factors that impact bias cannot be managed by mere willpower or the individual alone. A systems approach is required. Appropriate quality assurance and control steps are needed to minimize influences that may affect decision making steps throughout a forensic DNA examination. Varying levels of potential biasing information that can influence the forensic examiner have been suggested [3,8]. Several methods have been proposed to manage bias sources such as: sequential unmasking [9], case manager model [10], Linear Sequential Unmaking (LSU) [11], and context information management [6]. Some elements of these proposals have merit, while other components are unwieldy and impractical to apply directly in every case (e.g., [12]). Triage approaches allow putting in place measures only when needed and not across the board in every case [10].

There are realities and constraints of work in forensic DNA laboratories that need to be considered. For example, some information about the crime will be required to effect a proper analysis. Also, communication with investigators is part of information gathering that is necessary for proper decision making for analysis of samples, such as which samples and what markers to analyze. However, such communication could be controlled by use of a case manager instead of direct communication with an examiner [10], or, at the very least, such communications need to be documented (e.g., [13]). Being too extreme and over reacting to the dangers of bias can result in degrading existing good practices (for a debate on this issue, see [14], and responses [15,16]). Thus, actions to reduce cognitive bias should be balanced against practical considerations such as cost/benefit analyses, effects on operational output, ease of implementation, overall expected reduction in error, enabling communication, and utilizing knowledge and experience.

This article describes some of the issues and possible solutions to implement processes for an effective DNA workflow that may reduce influences of cognitive bias. Obviously, some bias factors have a greater effect than others. Thus, not all factors need to be mediated. However, by having awareness, the community can develop sound and practical solutions to reduce cognitive bias and/or be able to assess it. The discussion herein is meant to generate dialog about recognizing and reducing bias in forensic DNA examinations. There are likely several creative solutions that can be offered by a cognitively informed community, but an important aspect to managing bias is to have an open discussion of the issues so reliable outcomes can be obtained even with the ever-present inherent bias that all humans harbor. Lastly, the reader is cautioned to understand that this article stipulates that cognitive bias does not necessarily translate into an error in interpretation. While opportunities for cognitive contamination may arise nevertheless examiners can (and often do) make correct interpretations. However, by identifying potential factors of bias, one can focus on ways to improve a process and where and when to review legitimate concerns. Indeed, the community already has some practices to reduce the effects of bias, e.g., technical and administrative reviews. Current practices performed properly in some DNA laboratories, and effective training already have contributed to a reduction in bias effects.

2. Education and training

Proper and cognitively informed education and training about bias factors may be the best way to inform examiners and make them more conscious of its effects. There are currently seven main factors that can introduce cognitive bias within the laboratory setting (Fig. 1). In brief, they include: case trace evidence that provides irrelevant information within the evidence itself; case reference materials that provide a 'target' that can drive the forensic decision, rather than the evidence itself; case information that provides contextual irrelevant information; expectations that arise based on the examiners experience; environment in which forensic decision making occurs, such as being part of a team within the adversarial system; training and examiner motivations; and the cognitive architecture of the human brain that relies on selective attention, mental representations, and other cognitive mechanisms.

One of the action items recommended in the external audit of the Department of Forensic Sciences DNA Laboratory in Washington DC was, "Training and continuing education of staff should include lectures on cognitive bias, how it affects interpretation, and telltale signs to identify when it may arise." As well as: "The Panel recommends additional training, this training should include topics focused on minimizing potential for cognitive (interpretation) bias [4]".

Throughout the steps of the DNA processing workflow, from sampling through communicating the results, these factors potentially could influence decision making. Awareness can promulgate discussion on best avenues to apply the information and ways to minimize bias, but awareness by itself, without active measures, not an effective means to reduce bias.

3. Quality assurance measures

Once properly trained, laboratories may consider inserting a section on human and cognitive factors in their quality manuals or technical procedures (however named) that highlight features to reduce bias. Considering how information and data flow through the DNA testing process, laboratories may examine their process flow and outline effective steps to reduce examiner exposure to biasing elements, where possible.

Forensic investigations begin at the crime scene where evidence is collected, documented and preserved for testing. Just as physical contamination from the crime scene can affect forensic results, contextual contamination at the crime scene can affect forensic DNA analysis at the laboratory. Bias at the crime scene can impact downstream DNA analysis by:

1. The selection of evidence that is ultimately delivered to the laboratory for testing [8,17].
2. The bias cascade effect which may cause irrelevant information from the crime scene to influence and impact work performed in the laboratory [6].

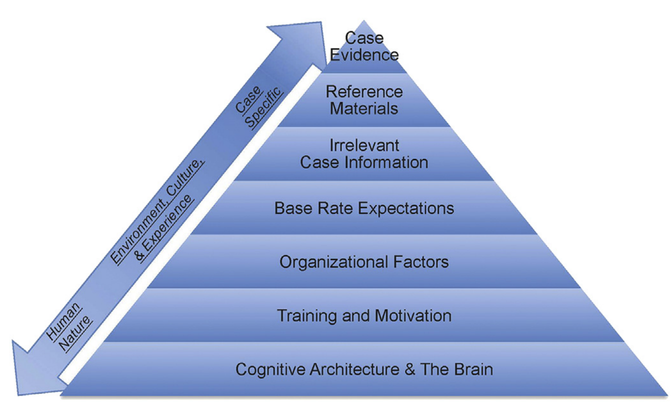

Fig. 1. Different sources of bias: seven potential sources of bias that may affect forensic decision making.

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The first of these influences is not directly controlled by the laboratory. Strong communication and feedback between crime scene investigators and DNA examiners will improve the front-end process. The second one, i.e., bias cascade effect, is important and should be appreciated. Irrelevant information may influence the DNA examiner and is not needed for the examiner to perform forensic work. Efforts should be taken to reduce exposure to task-irrelevant information. But being realistic, even with mechanisms in place, exposure to irrelevant information may occur. Therefore, awareness is the first best approach to combat cognitive bias. When awareness is suggested, two things should be emphasized: First, awareness must be underpinned by a deep understanding of cognitive insights. A one or two hour presentation may present introductory material and have value but a more in-depth training is strongly advocated. Second, while awareness is necessary, it is insufficient to reduce bias: active steps must be taken to address bias influences as mere will power does not control bias.

Documentation is another process that already should be in place as it can memorialize situations where bias may have impacted the decision process. Incoming letters, e-mails and notes will be part of the case file. The content of telephone and face-to-face communications should be documented and logged. Training in documentation of irrelevant communications could improve the process. Steps forward could include determining where in the process flow the examiner is likely to be exposed and affected by bias, and what actions can reduce the exposure. Furthermore, it is important to note that documentation is not merely about having records on what has transpired, but the need to document (and the required format, etc.) impact the work itself; it is a tool that shapes how examinations take place [8].

Setting up practical cognitive quality assurance procedures can minimize and substantially reduce the influences of cognitive contamination. Having reasonable practices is important because of constraints that may make some suggested practices unwieldy and may not offer sufficient improvement that justifies their implementation. A properly done, cognitively informed, risk assessment should be considered before enacting bias reduction practices. Furthermore, a triage approach may be helpful, whereby cases and instances with high risk of bias entail certain measurements, which are not needed for every case [10].

4. Review process

In a forensic DNA workflow, standards for technical and administrative reviews have been established for 100% of cases as a way to try and increase accuracy and reduce possibly biasing elements. Thus, the review process is a critical component of a quality system that can, if done properly, reduce influences of bias. Evaluation of assignments for review, blind verification, and how disagreements are resolved and documented are important considerations in addressing cognitive bias influences that may arise.

During the review process the totality of the case is evaluated with an aim to ensure there is an appropriate and sufficient basis for scientific conclusions, consistency of laboratory policies, and editorial correctness (e.g., [18]). However, base rate expectation bias can play a role in technical review when examiner and reviewer are routinely paired. When not randomized (or rotated), a reviewer may be influenced by his/her views of a laboratory colleague, place certain expectations based on a reviewer's experiences with an examiner's qualifications, or performance on past cases. Additionally, an examiner could become aware of what types of comments a reviewer may provide and thus focus on those issues and not give proper consideration to other aspects of the case analysis. Thus, assignment of technical review could be strengthened by rotating or randomizing reviewers and making the review blind (see below).

A main purpose of a technical review is to verify accuracy or correct error, and to make sure that the results are communicated appropriately. In some cases the technical review process is not as independent as it could (and should) be, and even the verification is not blind. It may be impossible to make the process entirely blind (e.g., who was the initial examiner, especially in a small laboratory), but laboratories could consider making it as blind as reasonably possible. Structuring the flow of the technical review could be an effective process to reduce the reviewer's knowledge of the examiner's interpretation. If a technical review is effective, the processing examiner would not need to change operationally much of the process regarding control of information, analysis or interpretation.

Even without an entirely blind verification, review can be strengthened by considering the process for resolving and documenting disagreements. During the review process, the technical reviewer may disagree with some aspect (s) of the examiner's work product. It is common for disagreements to be resolved by coming to a consensus. If not already in place, this process should be documented. The procedure for conflict resolution is problematic. For example, there can be pressure to agree so as not to escalate any disagreement to a supervisor or technical leader (e.g., so it potentially will not arise in the courtroom). Documenting and handling of disagreements in a way that supports the possibility of disconcordance, could not only be beneficial for reducing bias but, can be an important learning opportunity and a benefit overall for the forensic science community.

For the most part, technical and administrative review changes typically are documented by a single cross through, corrected, and dated/initialed by the examiner. However, if technical or administrative changes are performed on materials such as the case report and allele table, the original documentation and then technical reviewer's notes may not be retained. Maintaining records of all changes once a case file is submitted for review will help laboratories identify trends, improve their quality assurance procedures, and create a culture of transparency.

If the hierarchical approach of having the technical leader make determinations in disagreements is used, organizational influenced bias may be introduced. In a hierarchical approach, the technical leader could be influenced by a variety of biasing factors, such as a priori favoring one individual's more than another's opinion. In addition, the technical leader's opinion may be viewed as 'final/correct' and thus used for communicating the result. In instances where the examiner does not agree with the technical leader, documenting the disagreement and reporting the result as inconclusive with no retribution may best address biases by the technical leader and support an open culture. Quality, transparency and integrity can be improved by disclosing the initial disagreement between the examiner, reviewer, and technical leader clearly in the case file or report.

5. DNA analysis and interpretation

Although implementing changes in the review process is important so as to identify and mitigate bias, simple procedural changes in the analysis and interpretation can be an effective way to minimize bias in the first place. During data analysis, the examiner evaluates the DNA profile(s). The data are inspected for overall quality to determine if any laboratory examination steps should be repeated, pass or fail qualities, amplification or CE artifacts, whether it is single source or a mixture, etc. To reduce effects of reference material bias ('target' suspect driven bias - see Fig. 1), the evidence profile should be analyzed and annotated prior to evaluating (and even exposure to) the reference profiles; this process has been referred to as [part of] sequential unmasking [9], and Linear Sequential Unmasking (LSU) [11]. If evidence is analyzed in the correct sequence, reference material bias should have minimal impact on the decision making. However, if the examiner is exposed to reference material prematurely, suspect driven bias can (and has) easily arisen [3].

The LSU procedure is intended to ensure that the evidence from the crime scene is driving the decision process, rather than the target known reference sample profile (where examiners are looking for the suspect in the evidence). The approach to examine the evidence first,

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in isolation, and only then the suspect (or other appropriate reference sources), is not limited to DNA but is applicable to many forensic domains including fingerprinting, firearms, and handwriting. The FBI, for example, has implemented an LSU like approach in forensic fingerprinting: "Unlike some forensic laboratories, the FBI Laboratory uses a "linear" approach, requiring examiners to complete and document their analysis of a latent fingerprint before viewing any known fingerprints or moving to the comparison and evaluation phases. The FBI Laboratory's increased focus on a linear approach was at least in part a response to the OIG's findings regarding the role of circular reasoning in the Mayfield error" [19].

In DNA, examples of target suspect driven bias are determining allele drop out by concluding the alleles that the suspect has, that are not seen in the evidence, must be due to allele drop out (as opposed to first determining the potential of allele drop out based on the quality of results in the evidence profile). Alternatively, another example of such bias is using the presence of a rare allele, such as an off ladder allele, in an evidence and reference profile to drive the interpretation phase to fit the reference profile.

When calculating the combined probability of inclusion (CPI) it is imperative to select only loci where allele drop out is unlikely [20]. In examples of suspect driven bias, the examiner properly labeled all alleles in the crime scene DNA profile, but uses (misuses) the reference sample DNA profile to select which loci did and did not experience allele drop out. If the same alleles that the suspect (or victim) has were observed, then the locus would be used for the CPI calculation. In contrast, if the same alleles that the suspect has were partially or not observed at all, the locus (or loci) were deemed inconclusive for the CPI calculation. This interpretation using the reference profile is one of the most pervasive unintentional cognitive biases being practiced among DNA examiners and can be minimized by using LSU [11]. Documentation of the order of interpretation of crime scene evidence profiles and where allele drop out may be possible before reviewing a reference profile(s) will reduce the suspect driven bias. Interpretation of evidence should be documented and include as appropriate: the number of contributors, major or minor contributors, loci suitable for comparison/statistics (for manual and semi-continuous probabilistic genotyping statistics), if the profile is suitable for continuous probabilistic genotyping, if the profile is unsuitable for comparison, etc. Note that interpretation here could apply to some loci and not all.

It is noted that after the initial assessment of the crime scene evidence profile, it is proper to subtract out a contributor profile when there is good support that the contributor is known, such as with an intimate sample. If so, the known contributor's reference profile should not be considered until after the evidence profile is fully evaluated. Even then, the known reference profile should be subtracted without referring to a suspect's (or if appropriate victim's) profile. The deduced profile should be documented before referring to the other reference profile(s) – see details in the LSU procedure [11].

There may be legitimate reasons during comparison that the examiner determines that the original evidence interpretation should be modified. While standard operating procedures help identify thresholds and peak height balances to aid in interpretations, outliers do exist. An outlier may become apparent once the evidence profile has been compared to the reference profile, such that an incorrect major or minor profile (or more likely portion of) was originally deduced. One example is a peak whose height is above the stutter threshold and it resides between two large allele peaks that differ by two repeats in size. The increased height of the stutter may be due to contribution of forward and back stutter. Another example includes poor resolution of two alleles that differ in size by one base pair in the crime scene sample profile but is better resolved in the reference sample profile. If so, the changes of the original analysis are allowed in the LSU procedure, but doing so, and the reasoning behind it, must be documented [11].

Suggestions have been made to stipulate confidence levels at the initial analysis of the evidence profile, such that the evidence profile interpretation (or segments of it) is categorized as easy, medium, or hard – and then changes are allowed after exposure to the suspect profile, but limited to the lower confidence [11]. The feasibility of this may be challenging since there are no current standards for determining the degree of difficulty and confidence, which are subjective and can vary among examiners. However, it is important that a laboratory track when changes are made to a crime scene profile after being exposed to the reference sample. This action can provide important data for improving procedures. For example, if changes are being made consistently to a certain category (e.g., 3-person complex mixtures vs. 2-person mixtures) of profiles after being exposed to the reference material, the laboratory could then further develop better quality assurance and technical SOPs to address issues where they are most likely to arise.

6. Control of information

Another approach to reduce bias would be to control the exposure of case related information, i.e., context management of the information provided to the DNA examiner [6] - see Fig. 1. This suggestion allows full exposure to pertinent information that is required to properly process the case, but not irrelevant biasing information. Sometimes it is easy to determine what is relevant (see Table 1) and what is not, other times this task will be challenging. Such determinations could be done by a case manager, who will decide what information is needed and what is irrelevant – i.e., context management. Case submittal paperwork usually includes a case description, list of evidence being submitted, descriptions of known reference samples, medical paperwork, identification of victim and suspect, and request for testing; all of which should be provided. Sometimes the case submittal includes other details which are task irrelevant and can contribute to cognitive contamination, such as past criminal convictions of the suspect, other lines of evidence implicating the suspect (such as eyewitnesses and a suspect confession), and the belief by the investigator that the suspect has committed the crime and DNA typing is only needed to confirm that assertion.

It is common and essential for an examiner to understand the request for testing, to clarify paperwork, and most importantly to make sound judgments on what to analyze and what genetic markers

Table 1
Examples (not exhaustive) that illustrate what is task relevant information that may be needed during DNA processing.

Task relevant information	Description of relevancy
Date of crime	Age of evidence
Storage conditions	Storage of evidence, especially if not optimal
Type of crime	Type of crime (for example to determine best DNA extraction method, batching of samples, or to select rapidly mutating Y STRs to differentiate brothers)
Results of any biological fluid testing (if available)	The lack or presence of specific biological fluids such as blood, semen, or saliva; may determine extraction methods and how samples are batched (e.g., high quantity versus low quantity)
Case identifiers	Helps verify the evidence is labeled correctly and to properly process knowns and unknowns separately; help determine case batching such that suspected high quantity and low quantity unknowns can be processed separately
Evidence location	Determine if items could be combined or processed separately
Intimate versus non-intimate	Determine if it is reasonable to assume a known contributor

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Table 2
Examples (not exhaustive) that illustrate what is task irrelevant information that are not needed for DNA typing and may contribute to bias decision making.

Task irrelevant information	Description of irrelevancy
Suspect	Criminal history or/and confession (even their name can reflect ethnicity and introduce bias)
Eyewitness information from investigator on scene	Details about the scene, who was involved or what occurred
Victim personal history	Information such as the victim was under the influence of drugs or alcohol, or was a prostitute
Results of other forensic examinations	Presence or lack of other forensic evidence
Submitters	Expected outcomes based on investigation results, or even just desired outcomes

would be most relevant. For example, if the issue is to differentiate two brothers on a very limited quantity of DNA, one may consider typing rapidly mutating Y STRs. Thus, it would be important to know the persons of interest relationship. At this stage an opportunity may arise in which an examiner could be exposed to task irrelevant information such as additional details regarding the crime, past history of the victim or suspect, and what the submitter is 'hoping to find.' The exposure to task irrelevant information may be unavoidable during a direct conversation with a submitter (e.g., investigator or attorney). Using a case manager is one way that may solve this problem as the DNA examiner doing the work will not have direct contact with the submitter; all contact will be through the case manager who will manage what information flows between the submitter and the DNA examiner [10].

Another way to reduce this potential bias is for laboratories to identify the information that is commonly provided during the agency specific case submission process that is relevant to effective analysis of the submitted evidence and what information is irrelevant that may lend itself to creating cognitive contamination. Guidelines could be established as part of the laboratory practice that define these features. Although these decisions may vary on a case-by-case basis, a lexicon of both acceptable and task irrelevant factors would go a long way to reduce the risk of such bias. Cognitively informed training is essential, as it will provide tools for understanding how information can bias examiners. Examples of possible task relevant and irrelevant information are presented in Tables 1 and 2, respectively. Relevancy may lend itself to specific DNA processing decisions such as type of sampling, extraction, purification, choice of test(s), reprocessing methods, request for additional reference samples, etc. Irrelevant information could impact an examiner's observations, evaluation, interpretation and inadvertently affect the conclusions rendered.

If these influences cannot be properly managed in the first place, and have a demonstrated influence within a laboratory system, then a variety of approaches have been described that may help to reduce case information bias, such as the case manager and context management. In these approaches an individual or series of individuals take on a role, rotating or permanent, to control and reduce exposure of the examiner to irrelevant information [6,11,21]. The 'case manager', who must be trained properly in cognitive bias and be competent in identifying task relevant and task irrelevant information, filters the information and provides the examiner only with the relevant information needed to perform the task of DNA analysis. There would be minimal-to-no involvement between the case manager and examiner (and no direct contact between the examiner and the submitter), until that examiner fully concludes the work, including documenting and communicating final analyses and conclusions.

A suggestion under this framework is to provide the examiner with only a case manifest, either for a single case, or batched cases, that contains only task relevant information. Alternatively, case submission forms could be modified such that an examiner receives only relevant information. If relevant information is lacking then it would be appropriate to contact the submitter. However, the approach suggested in the article stipulates that it would not be appropriate for an examiner to have direct contact with the submitter [6]. If and when an examiner requires more information (or, alternatively, a submitter needs to convey information to an examiner), a case manager (or another third uninvolved person) would gather the appropriate information [10].

It is important under this framework that everyone understands their roles in the case workflow and the control and management of information in order to successfully use this approach to reduce bias. Hence, it must be determined and understood what information is needed, by whom, and when [6,7]. The potential downside of this approach is that it can create a sterile work environment that could stifle communication and creativity. It is worth noting that communication is an extremely important part of enhancing practices. As a note of caution, it is possible that the case manager could influence the testing strategy based on case specific information provided or knowledge of the performance of an examiner(s), so this approach (as any approach) is not perfect. It is important to strive to minimize bias and enhance forensic DNA decision making.

Case material biases (see Fig. 1) also can be introduced though medical history paperwork enclosed with the physical evidence, information contained in written letters being submitted for DNA testing, and evidence labeling that contains task irrelevant information. For example, labels might include assumptions about biological fluids such as calling an item semen or blood without any testing. Trace evidence influences can be difficult, if not impossible, to control and more thought should be given to addressing this potential biasing factor.

If trace evidence or case evidence influences are encountered during sampling and they are not already documented in the case file, noting what they are in the case examination laboratory notes provides transparency. Managing this type of bias in other ways, such as covering potentially biasing case descriptions, is logistically challenging but may be worth considering if it negatively biases an examiner(s). With increasing use of IT systems in forensic laboratories, controlling who has access, to what information, and when, may become more feasible and easier to implement.

7. Conclusions

There should be no disagreement that forensic experts are susceptible to biases as are all human beings [7,8]. Specifically, for DNA analysis, there have been noted bias and reliability issues with DNA mixture interpretation [1–4]. The biases encountered during the DNA workflow are independent of the examiner acting ethically and being competent. Rather they are how the brain handles and utilizes information. The human brain is effective by not being passive and not processing information only based on the data (what is called bottom-up information). It utilizes a whole range of cognitive processes that rely on other information (what is called top-down), such as past experience, expectations, and context - the human mind is not a camera.

This article identifies these influences in the context of forensic DNA workflow. Hopefully awareness is raised and laboratories embrace taking steps to receive appropriate cognitive bias training. Moreover, where appropriate and useful to improve processes laboratories consider taking actions to reduce bias by examining quality assurance procedures, case review processes, analysis and interpretation, and control of information. When biasing influences cannot be avoided,

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acknowledgment of their existence and proper documentation would create greater transparency and a scientific open-culture.

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