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CRITICAL REVIEW

GENERAL

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"Cannot Decide": The Fine Line Between Appropriate Inconclusive Determinations Versus Unjustifiably Deciding Not To Decide*

ABSTRACT: Inconclusive decisions, deciding not to decide, are decisions. We present a cognitive model which takes into account that decisions are an outcome of interactions and intersections between the actual data and human cognition. Using this model it is suggested under which circumstances inconclusive decisions are justified and even warranted (reflecting proper caution and meta-cognitive abilities in recognizing limited abilities), and, conversely, under what circumstances inconclusive decisions are unjustifiable and should not be permitted. The model further explores the limitations and problems in using categorical decision-making when the data are actually a continuum. Solutions are suggested within the forensic fingerprinting domain, but they can be applied to other forensic domains, and, with modifications, may also be applied to other expert domains.

KEYWORDS: forensic science, inconclusive determinations, forensic decision-making, human factors, decision models, deciding not to decide, cognitive forensics, fingerprint conclusions

In everyday life we have circumstances in which we "cannot decide" what to do. Such decisions may be very appropriate, for example, in situations where the available data are just insufficient for making a decision. However, in contrast, it may actually be a way to escape and avoid making a decision—although there are sufficient data to justify making a decision, we nevertheless "decide not to decide." Think of a situation where you are considering whether or not to go and see the doctor. It is not clear-cut: You are not suffering or showing too many symptoms, but you are clearly not well and healthy. In some such cases, there are insufficient data to make a determination, and the correct decision is to wait and see. However, in other such cases, the decision to wait and see is not justifiable. In these cases, the data justify going to the doctor, but because you are busy, or it is too much effort (i.e., you are lazy), or other reasons, such as a nominal cost to see the doctor/co-pay, worrying the doctor will think you are a "complainer" or hypochondriac, etc., you make an unjustifiable decision to wait and see, rather than actually going to see the doctor.

That is, you "decide not to decide" whether or not to go to the doctor. To be clear, "*deciding not to decide" is a decision*. The question is whether it is a justifiable decision or not. A more basic and extreme way to avoid making a decision altogether would be to just delude oneself from acknowledging that there is a decision to be made in the first place (e.g., not acknowledging the symptoms, or making excuses to dismiss them away as if they cannot be meaningful). Thus, denying that there is even something to decide (see Jean-Paul Sartre's notion of self-deception [1]).

Often it is a fine line between those circumstances that merit the decision that there are actually insufficient data to make a determination (i.e., an inconclusive decision), and those circumstances that one is merely (and unjustifiably) just avoiding making a decision (i.e., deciding not to decide). Although it is sometimes difficult to distinguish between those two circumstances, they are drastically different and distinct from one another. The former inconclusive decision reflects a correct decision based on the actual data (which does not justify making a determination of action), whereas the latter decision not to decide does not reflect the data (which actually justifies making a decision).

Expert Inconclusive Decisions

Such situations are not limited to everyday life of laypeople, but also apply to expert decision-making. For example, once you decide to go to the doctor, the doctor may need to determine whether a complicated and dangerous medical procedure is required. In one situation, the doctor cannot decide whether to recommend the medical procedure because the medical examination does not provide sufficient data to make an informed decision. In another situation, the doctor does not decide whether to recommend the procedure not because there are not sufficient data, but because of other reasons, for example, they lack self-confidence, or are afraid of being sued.

The medical doctor may send you for some tests to help them reach a decision. But here too, for example, the radiologist,

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examining images may have the same decision-making quandary. It may be an easy case, where the images clearly show (or clearly not show) a clinical diagnostic finding. However, in the more complex cases, if the radiologist decides not to decide, will it be justifiable? That is, will they justifiably determine that the quantity and quality of the data in the image are insufficient to make a clinical determination one way or the other, or, in contrast, there are sufficient data, but the radiologist will make an unjustifiable decision not to decide (which can have disastrous effects such as a delay in the diagnosis of cancer and starting treatment earlier).

Forensic Fingerprint

To untangle these situations, consider their respective implications and offer solutions to the problems, we examine expert fingerprint decision-making within the domain of forensic science. Fingerprint experts commonly report the decision of comparing two fingerprints (one latent print from the crime scene, and one exemplar fingerprint from the suspect) as a categorical conclusion. If the fingerprint expert determines that there is a sufficiently high degree of corresponding discriminating features between the two fingerprints, then the expert decides that the fingerprints originate from the same source, that is, an "identification." Conversely, if the expert determines that the discordances between the two fingerprints are sufficiently high, the expert decides that they originate from different sources, that is, an "exclusion." If the expert can neither decide an identification nor an exclusion, then the resulting decision will be an "inconclusive."

Deciding that one cannot reach an identification or an exclusion decision, and therefore deciding not to make a determination regarding the source (or nonsource) of a latent print, poses some intriguing challenges. The forensic community has given much attention to issues surrounding identifications, and lately to exclusion determinations (2). However, very little attention has been given to inconclusive determinations.

On the one hand, it is important to have the option, an alternative choice, to decide that something is inconclusive. Cognitive research has demonstrated the limited capacity of meta-cognition, that is, peoples' ability to know what they know, and know what they do not know (e.g., Ref [3]; Socrates already made this point thousands of year ago [4]). Knowledge about knowledge, meta-cognition, is often imprecise, at best, and most often people (and experts in particular) overestimate their abilities and are overconfident (for a review, see Ref [5]). People are just not very good in self-assessment as to what they know (and what they do not know) as well as their accuracy. The correlation between confidence and accuracy is not very high (e.g., Ref [6]).

Therefore, the fact that forensic examiners, and fingerprint experts in particular, decide that something is "inconclusive" is very reassuring—it demonstrates a certain level of caution. In a case with doubt, it is better to lean toward caution and determine "inconclusive," rather than making an incorrect "identification" or "exclusion" decision. By incorrectly deciding an "identification" the fingerprint expert makes a false-positive error (incorrect association). Conversely, by incorrectly deciding an "exclusion" the fingerprint expert makes a false-negative error (failure to associate the fingerprints to the same source).

However, on the other side, over-reliance on the option to decide "inconclusive" can be problematic too. The issues and challenges we raise in this article arise from the nature of fingerprint matching (which applies to other comparative forensic domains, such as firearms, footwear, and handwriting; as well as to other expert domains). A categorical decision framework, while the weight of the evidence is actually a continuum, results in a loss of precision and can obfuscate the weight of the evidence.

Furthermore, the use of categorical decisions can cause experts to artificially distort continuous data to fit the discrete categories, what is known in cognitive psychology as "categorical perception" (7). This has been shown in a wide range of domains, from color perception (where the data—the light frequencies—are a continuum, but the psychological perception places them within categorical bins [8,9]) to sexing of chicks (10).

Categorical perception has also been demonstrated in forensic fingerprinting (11). When 16 minutiae (points of corresponding similarities) were the threshold for determining if a match was sufficient for court purposes in the UK, examiners' perceptions were influenced by the bin category threshold. That is, given that 16 points were the threshold between categories, examiners tended not to observe and report 15 points of similarity. Thus, perception was influenced by the decision category, and gravitated away from the threshold. In other words, they psychologically contracted the continuous data toward the central categorical decision bins—a hallmark of categorical perception (7).

A Cognitive Perspective: Taking Into Account The Human Element

This illustrates the thinking and importance of our approach that takes into account the underpinning human cognitive process (see model in Fig. 1): "Assessments of forensic science have too often focused only on the data and the underlying science, as if they exist in isolation, without sufficiently addressing the process by which forensic experts evaluate and interpret the evidence. After all, it is the forensic expert who observes the data and makes interpretations, and therefore, forensic evidence is mediated by human and cognitive factors." (12). Hence, taking into account the human element and considering the cognitive factors that impact forensic decision-making is a critical part in forensic science (13,14). The data and evidence do not exist in a vacuum. It is important to consider the underlying cognitive processes involved in human decision-making. Ignoring the human elements is a huge oversight, as forensic decision-making (as with other expert domains) lays at the intersection of the data and cognitive decision-making processes (12).

Human decision-making processes involve dynamically and sequentially sampling the data. This relates to a descriptive model and theory of the cognitive processes and mechanisms of how the human brain accumulates and considers data (these models are highly developed in cognitive science, and we refer the interested reader to decision field theory (15) sequential sampling models (16), and their applications (17). The human decision-making mechanism involves the fingerprint experts dynamically and sequentially comparing the fingerprints, accumulating evidence over time. If they deem the weight of the evidence to cross a threshold (which can be subjective or not), then a "winner takes all" categorical conclusion is reached. If such a threshold is not reached, the weight of the evidence is not deemed to cross a decision threshold, then the default decision is inconclusive (Fig. 1).

Please note that models of fingerprint decision-making which only describe the similarity between the prints, the "actual"

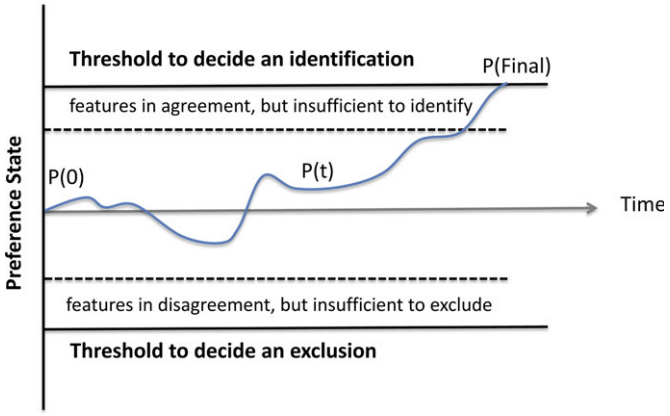

FIG. 1—*The horizontal axis represents the time interval, starting with the initial presentation of the two fingerprints at P(0). The vertical axis represents the expert's preference state. The evolution of the expert's state (the jagged curve in the figure) starts at P(0), and over time, changes and moves up and down P(t), as they compare the fingerprints, consider their similarities and differences, and determine the weight of the evidence. Once the comparison ends P(final), the decision of a match or an exclusion is determined by which threshold was exceeded; if no threshold has been crossed, then the expert is left with an inconclusive decision (the figure illustrates an identification decision).*

data, are neglecting the dynamic nature of human decision-making that actually underpin the experts' conclusions (12). For example, decision field theory and sequential sampling models (15,16) stipulate that human decision-making does not involve examining all information before reaching a conclusion, after all the evidence is considered, but rather, that information is examined a piece at a time, each one adding to the overall weight of the evidence, until a threshold is reached (which may be long before all the information is considered). This is partially due to the fact that the human brain has limited capacity and resources, and people are not optimal decision makers. This has far-reaching implications to forensic decision-making, and therefore, models must take into account and reflect the role and nature of the cognitive processes behind forensic expert decision-making, and factors that impact them, such as stress (14) and bias (12).

A Cognitive Model For Forensic Decision-making

Figure 1, the cognitive decision model is based on decision field theory (15), dynamic decision-making (17), and sequential sampling models (16) acknowledges and takes into account the specific mechanisms and nature of the human decision-making processes. These processes are dynamic and influenced by time constraints, bias, and other factors beyond the actual "data." It represents the interactions and intersection between the data (e.g., the similarities between the fingerprints) and the human decision-making cognitive processes—*it is this interaction that provides the resulting conclusions; not the data by itself, in isolation from the human decision maker* (12).

The initial state (see P(0) in Fig. 1) can be biased or neutral (neutral is reflected in Fig. 1, as the starting point, P(0), is in the midpoint between the two conclusions of identification and exclusion). The threshold bounds do not need to be symmetrical (for instance, the decision to reach an identification can be further away than that for an exclusion decision, i.e., require more evidentiary weight). The threshold bound can also change as a result of time pressure, and other factors.

Four Issues With Inconclusive Decisions

As discussed earlier, although inconclusive decisions can be appropriate and warranted in some instances, they can also be problematic and raise some serious questions and challenges: *First*, deciding inconclusive should *not* be regarded as "deciding not to decide," but it should be viewed as a decision with certainty that the quantity and quality of information are not sufficient to draw any conclusion regarding the source of the fingerprints. Hence, it is not a lack of certainty; inconclusive decisions should be very certain and a deliberate determination taken by the expert. As can be seen in Fig. 1 (excluding the areas of "features in agreement, but insufficient to identify" and "features in disagreement, but insufficient to exclude," discussed below), there is a clear area where the weight of the evidence is extremely limited, where the quantity and quality of information are far from the thresholds. In cases with such a low weight of the evidence, an inconclusive decision is not "deciding not to decide," but a very deliberate assignment to the categorical conclusion of "inconclusive." Thus, an inconclusive decision should be a reflection of the limited weight of evidence.

Second, an inconclusive determination may act as having an easy "way out" option. This is especially tempting given that many fingerprint experts may only regard incorrect identifications (or exclusions) as erroneous, whereas inconclusives are never considered erroneous decisions, but rather, are just differences in opinions (see Ref [18] for a discussion of the utility function wherein false positives and false negatives have negative utility, and inconclusive decisions have no utility).

This issue has implications on both the theoretical and the practical levels. On a theoretical level, if inconclusive decisions are regarded as neither false-positive errors nor false-negative errors, then inconclusive decisions cannot ever be erroneous (e.g., see SWGFAST (19) noting that inconclusive decisions are not false-positive nor false-negative errors). On a practical level, inconclusive decisions very rarely get to court and thus are not challenged, and most often not even verified (in contrast to fingerprint "identification" decisions that are required to be verified).

Therefore, inconclusive decisions may be tempting to make, as a way out of a conclusive decision, that will be scrutinized, perhaps challenged in court, and open to error. Indeed, and not surprising, data show that inconclusive decisions are not rare (20,21) and have been shown to include errors (22). In fact, approximately 10% of the time, an examiner viewing the same set of fingerprints twice (Level 5 in Dror, HEP expert decision hierarchy, [23]), will reach different conclusions (same examiner, same set of fingerprints), will waver between a conclusive determination and declaring that the comparison is inconclusive (24).

We must remember that inconclusive decisions have a net utility of zero, as they offer no actual practical information to the case (i.e., "Is it her fingerprint? I don't know"), but conversely are attractive options to the experts since there is supposedly no option (and therefore penalty) for error, because inconclusive decisions are not classified as false-positive or false-negative errors (e.g., Ref. [19]).

Third, some inconclusive decisions are near the decision threshold, but the data are not sufficient to make a determination. These inconclusive decisions do not represent sufficient weight of evidence to justify deciding an identification (or

exclusion) decision (see, in Fig. 1, the areas marked as "features in agreement, but insufficient to identify" and "features in disagreement, but insufficient to exclude"). In such cases, inconclusive decisions entail loss of valuable data. Because the decision is reported as "inconclusive," the weight of the evidence is lost by the imprecision and breadth of the vague "inconclusive" category. Almost an "identification," almost an "exclusion," and a true "inconclusive" are all within the broad category of "inconclusive." The inconclusive category is so broad that it does not properly convey the estimated weight of evidence (25,26). The magnitude of the weight of evidence is lost when "almost, but not quite an identification" is reported in the same manner and within the same categorical conclusion as "no correspondence, but cannot quite exclude." Both positions are represented within the broad and imprecise "inconclusive" decision category.

Fourth, probably the most controversial stance made in this article is that if there are sufficient data and information in the evidence, then one can, and indeed must, make a decision regarding the source of the latent print (i.e., identification or exclusion)—put more bluntly, one cannot, and should not, make an inconclusive decision. Thus, the option to decide an alternative choice of inconclusive should not be available when there is sufficient information to make a decision. Imagine a situation whereby an examiner has two sets of clear and complete ten prints fingerprint exemplars, but then reports "inconclusive." In this extreme case, the weight of the evidence is so overwhelming that the fingerprint expert should be able to make an "identification" or an "exclusion" decision. An inconclusive determination is an erroneous decision because the evidence does not support that decision. Hence, *we support developing criteria to determine situations where fingerprint examiners would not be allowed to decide "inconclusive" and will only have a binary decision choice: Either it is an identification or it is an exclusion*.

Proposed Solutions

The great challenge is in determining when inconclusive decisions can be considered an error and when they are justified. Transparency and accountability for inconclusive decisions is missing (at least, relative to identification and exclusion decisions) and is a first step. We suggest that when examiners make an inconclusive decision, they need to clearly document and justify their decision. This mere requirement may reduce the inconclusive decision as "an easy way out": It needs to be justified, and it must be transparent and documented in detail. We further suggest that under certain circumstances, where there is sufficient information, examiners will not be allowed to make an inconclusive decision (see details above). Below we discuss a few further possibilities and propose additional solutions.

Point number one, we support recent efforts to develop and introduce technology into the fingerprint examination process. We support the use of validated statistical models for reporting friction ridge evidence (26–30). The ability to appropriately estimate the weight of the evidence and then communicate that to the triers of fact goes a long way toward the issue of imprecise categorical decisions. The vague, broad category of inconclusive will become a discarded artifact of the past if and when a proper and validated model is employed. However, the introduction of statistics will bring its own set of issues to manage and will not remove the need to deal with the human and cognitive factors.

We also support the use of clarity assessment models (31). These models automatically assess the clarity of the latent print image and produce a score for the overall quality of the latent print. This removes some of the subjectivity and biases (32) in having the fingerprint examiner decide whether a latent print has sufficient clear and discriminating features to warrant a comparison. If fewer no-value latent prints are retained and compared, one is less likely to encounter the option of an inconclusive outcome (as well as fewer comparable latent prints may be disregarded and not subjected to comparisons). Additionally, in disputed cases, quality metric scores may be further evidence to shed light on a reported decision. One would expect high-quality scores in cases of identification or exclusion, and low-quality scores in cases resulting in an inconclusive decision. If an expert attempted to decide an inconclusive decision with a very high-quality score, this may be a red flag that the inconclusive decision is inappropriate for the latent print in question (assuming complete and legible exemplars are available). In any case, LSU (Linear Sequential Unmasking) needs to be used, so latent prints are first examined and documented without exposure to the "target" suspect prints (33)

Point number two, until such models are in place, qualified conclusions help to parse out the broad category of inconclusive. For example, forensic document examiners have several categories of association between the extreme ends of the decision spectrum. Between the "inconclusive" and the "identification" decision categories, they can also determine "indications," "probable," and "highly probable" (34). In fingerprints, there has been support for the addition of two new categorical decisions: "lack of sufficiency for individualization" and "lack of sufficiency for exclusion" (35). These decision categories represent the instances described in Fig. 1 just below the thresholds for "identification" or "exclusion."

However, as in any scale of conclusions, what is critical is that not only the categorical decision be clearly defined and communicated, but also that the relative magnitude of the categories must be communicated (36,37). In other words, the trier of fact must comprehend the entire scale, and appreciate where the reported category falls in the relationship to the other decision categories. Even though we cannot currently compute a statistic for the forensic document examiner category of "probable," it is critical that the triers of fact understand that this category represents a higher weight of evidence than "inconclusive" and "indications," but a lower weight of evidence than "highly probable" or "identification." Understanding the unspecified, unquantified weight of the evidence happens only when we understand the relative magnitude and the ordinal scale of conclusions, but even when we can specify and quantify the weight of evidence, we need to consider how these are perceived by the fact finder (37). There are two cognitive issues regarding forensic evidence: One is the perception, interpretation, and conclusions reached by the forensic expert, and the other is how the fact finders (be it the detective, judge, or jury) interpret and understand the expert's conclusion. We need to make sure that both take place in a manner that is circumscribed by what the evidence actually supports.

Point number three, to avoid overuse and abuse of "inconclusive" decisions and to reduce instances of "error" where the weight of the evidence is so great that an "inconclusive" is inappropriate, we support the use of a blind verification step. Fingerprint examiners are required to have all identifications verified by a second fingerprint examiner, but it is not practice (just recommended) for exclusion and inconclusive decisions. If the aim is to avoid errors, then it is important to have at least one other

expert blindly view the evidence to determine if inconclusive is appropriate.

Our recommendation is that at least one other examiner should blindly review the comparison and if disputed, the comparison should be given to multiple examiners to determine a consensus decision. The multiple examiners should first examine the fingerprints independently and blindly, and document their conclusions before being exposed to the other examiners' decisions or any group discussion. The need for review by additional examiners may be mitigated in cases where there are other latent prints that have been identified or excluded to the subject. Cases with singular conclusions to a subject resulting in inconclusive should be reviewed. Notably, the FBI engages in such practice (38). Langenburg, et al. (22) demonstrated that a surprising number of errors (unjustifiable inconclusive decisions) were found in inconclusive decisions in actual casework. This is further illustrated in the FBI black box study (24) that found that 10% of the time, the same expert will reach different conclusions on the same set of prints (see Level 5 in Dror HEP decision-making hierarchy [23]). This may be due to variability in the initial observation of the minutiae data (39,40), or the interpretation of these minutiae, two different and distinct sources for inconsistency in decision-making (23). Therefore, it makes sense to spend effort to properly review these decisions.

Ideally, these reviews should occur blindly, without context or knowledge of the original examiner's decision and other irrelevant contextual information (32,41,42). Because "inconclusive" decisions, by their definition, represent low-to-moderate weight of evidence, these cases will tend to bear marginal ridge detail and therefore are "complex." Previous research has shown the need for blinding techniques in complex cases (13).

Conclusions

Understanding forensic (and other expert) decision-making requires to understand the nature of the data, but also the human cognitive processes involved in decision-making. Examining the data in isolation, in a vacuum, without understanding the human element and their interactions is an oversight (12). The interaction between the expert and the data, see model in Fig. 1, underpins the decision.

We also make the point that the inconclusive decision is a broad and imprecise decision category for fingerprint examiners, encompassing the range of "almost an exclusion" all the way to "almost an identification." As such, the weight of the evidence may not be properly conveyed. However, it is an important decision option for analysts to utilize when they actually do not believe the weight of the evidence has surpassed a decision threshold into a definitive categorical decision (i.e., identification or exclusion; see Fig. 1).

Because inconclusive decisions are not regarded as error (they do not have the possibility of being false-positive or false-negative errors), an inconclusive decision may be a safe and easy decision choice. When used appropriately, it allows the examiner the option to avoid overcommitting to a definitive conclusion, but when overused and abused, it can be deemed an error when the weight of the evidence is incongruous with the inconclusive decision.

We proposed several solutions for managing inconclusive decisions. While some of the solutions require the continuing investment in future technology, we believe there are procedural controls that can be currently instituted in today's fingerprint forensic laboratories. The solutions are aimed to allow to make inconclusive decisions when appropriate, that is, when there is insufficient information to make an identification or exclusion decision; but not allow, and try to minimize, using inconclusive decisions as a way to decide not to decide and avoid making a decision when one is warranted.

The solutions we offer focus on the discipline of forensic fingerprinting, but can be easily applied to other comparative forensic domains (such as firearms, tire marks, and handwriting). With some extensions and modifications, they may well be suited to other forensic domains, as well as other expert domains. Our solutions are not mutually exclusive or exhaustive. The cognitive model we present is not incompatible with other models and approaches, it brings to the forefront and explores the interface between the cognitive processes of the human examiner and the forensic data.

Our model (see Fig. 1) illustrated the importance of taking into account the underlying human cognitive processes involved in decision-making. Models that only focus on and reflect the "data" neglect to reflect that the decisions are an outcome of the interaction between the data and human cognitive processes. Human expert performance and how the human element plays a role in forensic science are critical to consider (12,13,23).

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