The decisionalization of individualization

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A R T I C L E   I N F O

A B S T R A C T

Throughout forensic science and adjacent branches, academic researchers and practitioners continue to diverge in their perception and understanding of the notion of 'individualization', that is the claim to reduce a pool of potential donors of a forensic trace to a single source. In particular, recent shifts to refer to the practice of individualization as a *decision* have been revealed as being a mere change of label [1], leaving fundamental changes in thought and understanding still pending. What is more, professional associations and practitioners shy away from embracing the notion of decision in terms of the formal theory of decision in which individualization may be framed, mainly because of difficulties to deal with the measurement of desirability or undesirability of the consequences of decisions (e.g., using utility functions). Building on existing research in the area, this paper presents and discusses fundamental concepts of utilities and losses with particular reference to their application to forensic individualization. The paper emphasizes that a proper appreciation of decision tools not only reduces the number of individual assignments that the application of decision theory requires, but also shows how such assignments can be meaningfully related to constituting features of the real-world decision problem to which the theory is applied. It is argued that the *decisonalization of individualization* requires such fundamental insight to initiate changes in the fields' underlying understandings, not merely in their label.

"If you don't understand a problem from a Bayesian decision theory point of view, you don't understand the problem and trying to solve it is like shooting at a target in the dark." (Hermann Chernoff, from a personal communication to Martin McIntosh, quoted in [2, p. 6])

"Give me a place to stand, and I shall move the earth." (Sentence attributed to *Archimedes* [e.g., 3,4])[1]

1. Introduction

Academic researchers and practitioners in forensic science and other fields, such as medicine and the law, maintain divergent views about 'individualization', that is the reduction of a pool of potential donors of a forensic trace to a single source [5]. Viewpoints differ with respect to the definition, the scope

and the practical feasibility of individualization [1,6,7]. As a hallmark in the last decade, the report of the US National Research Council in 2009 [8] considerably stirred up the discussion by drawing a rather critical picture of the current state of the field. It triggered diverse reactions from institutions, practitioners and scholars, inspired scientific research and received attention in courtrooms in the US and beyond [9], but the situation as of today remains ambivalent. While it is largely uncontroversial that forensic traces such as fingermarks and toolmarks can have – depending on their quality – a considerable potential to help discriminate between competing propositions regarding common source, and that there are practitioners who are able to demonstrate reliable practice in trials under controlled conditions, the field's main struggle remains conceptual. This touches on two fundamental issues: first, the question of what strength is to be assigned to a comparison conducted in a given case, and second how particular conclusions can be justified through an argument.

The former of these two issues, value of evidence, is not dealt with in this paper. In forensic science, value of evidence is defensibly approached in terms of likelihood ratios or, more generally, Bayes factors, that feature a unified underlying logic

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[1] The relevance of this quote in the context of decision theory and forensic individualization will be discussed in Section 4 in this paper.

[10–13], although they may take different forms and degrees of technicality according to the domain of application (such as fingermarks [e.g., 14], DNA [e.g., 15], handwriting [e.g., 16], etc.). This paper concentrates on the latter of the above two issues – the justification of conclusions – by focusing on one recent movement in response to the NAS report, exemplified by the fingerprint profession. This movement gravitates around the notion of 'decision' as mentioned in the title of the document 'Guideline for the Articulation of the Decision-Making Process for the Individualization in Friction Ridge Examination'[2] issued by the Scientific Working Group on Friction Ridge Analysis, Study and Technology (SWGFAST).[3] In Section 3.1, this document acknowledges that "(...) it is now recognized that our conclusions are more appropriately expressed as a *decision*, rather than proof", and in Section 10.2.2, the following definition is given: "Individualization is the *decision* by an examiner that there are sufficient features in agreement to conclude that two areas of friction ridge impressions originated from the same source." [*italics* added by the authors] This prominent use of the term decision contributes to its more widespread adoption as standard terminology by many forensic practitioners across the so-called identification branches.

The field's shift to a new term, decision, remains dubious, however. In one of the most meticulous studies of the fingerprint profession's recent 'decision shift', Cole [1] reveals[4] that the term decision appears to be used merely as a new label without any fundamental change in conceptual understanding or actual practice. Most interestingly, in exchange with Cole, SWGFAST declared that it does *not* rely on decision theory as endorsed in papers such as [17,18], despite giving reference to such publications. While this can be seen as a deliberate choice that is open to any discussant of the topic, it is worth mentioning that such a choice is of no effect to the validity of decision theory itself, in particular its logic. Also, it is of no detriment to the interest that one may take in comparing current practices of the profession with the prescriptions that derive from (Bayesian) decision theory. The focus on such prescriptions on how to act under uncertainty represents an analytical approach to the notion of decision and is to be distinguished from the descriptive use of this notion for people's observable (decision) behaviour, intuitive or otherwise. In this article, we will concentrate on the analytical and normative approach to the notion of decision and argue that it can foster progress in fundamental understanding of core forensic science topics [e.g., 19] and, thus, should drive what we will propose to call the *decisionalization* (of individualization).

Besides the extreme position of those who do not endorse decision theory, there are others who are sensitive to the theory's logic but still refrain from applying the approach on grounds that they don't 'know' what numbers they ought to use in the various formulaic expressions, or what those numbers actually mean. In Bayesian decision theory, the numbers refer to probabilities and utilities[5] (or, alternatively, losses). While the meaning of probabilities in forensic science is well established, in particular the subjectivist belief type interpretation [18,20,21], the notion of utility is more recent and less well known [22,23].

Thus, in the current state-of-art, there is room for the study and discussion of the constituting elements of Bayesian decision theory – especially the utility component – from a forensic science point of view, which is the main aim of this paper. Section 2 recalls the principal elements of classical Bayesian decision theory, applied to the 'problem' of individualization, whereas Section 3 will focus on the choice of the utility scale and the subsequent derivation of the utility function. At this juncture, the paper will seek to justify the standpoint that the numbers to be assigned to utilities are *not* undefinable, and hence arbitrary, as claimed by critics, but can be given a clear interpretation. Most importantly, we will emphasize that this interpretation can embrace defining elements of the individualization task sketched at the outset, which represents a strong argument in favour of the relevance of Bayesian decision theory for inference and decision in forensic science. We will also point out that a close look at the decision theoretic formulation of individualization, under modest and reasonable assumptions, reduces the number of assessments that require the attention of the analyst. Section 4 will present a general discussion of the foregoing analyses and converge to conclusions highlighted in previous works, in particular the importance of understanding the normative character of the theory [24]. The discussion in Section 4 will also emphasize the natural role of traditional expressions of weight of evidence, in particular likelihood ratios, in the decision framework and the feasibility of illustrating the logic of Bayesian decision theory through fundamental insights from other fields, such as physics, that can be traced back to Archimedes in Ancient Greece. Readers well acquainted with decision theory may skip Section 2, but they should take notice briefly of the notation introduced there. Conclusions are presented in Section 5.

2. The Bayesian decision theoretic answer to the 'problem' of individualization

2.1. The basic elements of the decision problem

In Bayesian decision theory, the basic components of a decision problem are formalized in terms of three elements. Consider these elements in the context of forensic individualization as defined at the beginning of this paper (Section 1). In particular, suppose that there is trace material collected on a crime scene, such as a fingermark, and reference material is available from an individual (the suspect), considered to be a potential source of the fingermark. After comparative examinations between the fingermark and the fingerprints taken from the suspect under controlled conditions, individualization – our decision problem – may be brought up as an issue.[6]

The first decision theoretic element are the feasible decisions d, which define the decision space. To keep the discussion on a moderately technical level, let there be only two decisions, d_1, short for 'individualize', and d_2, short for 'not individualize'. For a development with the decision 'not individualize' broken down to the decisions 'exclusion' and 'inconclusive' see, for example, [17,19]. Note that the simple negation of the first decision is rarely a concise approach because, generally, there *are* explicit alternatives available and their respective merit ought to be appreciated [26]. Stated otherwise, the alternative must specify what to do if not individualizing.

When a choice has to be made, it is usually not known which state of nature actually holds. A second element, thus, is the list of uncertain events, also called states of nature, denoted θ. Clearly, in an individualization scenario, the states of nature that are

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[3] The discussion in this paper will mainly refer to the formative documents of SWGFAST in order to acknowledge the original source. Notice, however, that SWGFAST has undergone changes and became the Subcommittee on Friction Ridge, which is part of the Organization of Scientific Area Committees (OSAC).

[4] Cole's study [1] is based, in part, on SWGFAST replies on comments submitted during a public consultation process for one of its guideline drafts.

[5] A utility, in the context of the current discussion, is an expression of an individual's desirability for a given consequence, that is a result of a decision in the light of a particular state of nature. Section 2 will elaborate further on these terms.

[6] Note that another decision, not studied in this paper, relates to the question of whether or not to search for fingermarks on a receptor surface. See [25] for further details.