Beyond any Reasonable Doubt between Science, Jurimetrics and Criminal Procedure: New Perspectives?

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The advent of artificial intelligence applied to law raises many doubts about the correct application of the reasonable doubt criterion and its elaboration according to the scientific method. The aim of the paper is to find the right algorithmic formula resulting from the right compromise between logic and interpretation of the presumption of innocence.

Introduction

We start from a premise. The criminal procedure is divided into four phases. Initially, the formulation of a hypothesis of reconstruction of the trial event is required. The investigator in the preliminary phase and, then, in the trial the parties (Public Prosecutor and Defendant) and the Judge himself, formulate one or more hypotheses of reconstruction of the facts. Assuming that a story is made up of a plurality of events, each of which can have the most disparate causes, one first tries to list all the possible causes of each event, thus delimiting the scope of the reconstructions that can be abstractly proposed; then, among those that can be proposed, one chooses the hypothesis of reconstruction of the event that appears most probable in a certain perspective of coordination among the different possible causes of the plurality of events[1]. Chosen as a hypothesis, it is proposed a "story" that explains the story in question, deductively drawing all the consequences that give meaning to this "story".

This allows one to test whether the story finds confirmation in other facts that were ignored or not considered significant in the immediate case, but which assume relevance in the particular perspective selected. The particularly complex framework mentioned above and the attempt at criterion interpretation ("Beyond Any Reasonable Doubt": B.a.r.d.) has strained the relationship between science, mathematics, and law. Is there a way to manage this complexity through scientific tools that tend to a certainty or absolute truth, not only procedural? In this short article we analyse the consequences of the Italian codification of reasonable doubt through a comparison with American jurisprudence and doctrine. An attempt will be made to formulate a valid epistemological theory considering past logical-legal theories in order to understand and make less cryptic the criterion B.a.r.d. The

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[1]Anderson, Schum & Twining (2005).

objective is to understand if the criminal process can be represented through a statistical process. It is essential to re-evaluate the legal epistemology trying to identify what concrete meaning is attributable to reasonable doubt.

The Current Status of Criterion B.a.r.d.

The criterion beyond any reasonable doubt of Anglo-American matrix follows the adversarial system[2]. The unfounded verdict of the jury has reduced: the tests of reasonableness of doubt, the epistemic importance of cross-examination, the evidentiary inferences, the appreciation of alternative hypotheses[3]. The connections between evidence and decision therefore assume cryptic dimensions.

The article 5 L. n. 46 of 2006 (Law Pecorella) has introduced the principle B.a.r.d. in the Italian system through art.533.1 cpp. The Pecorella Law has avoided doubts about the interpretation of the rule itself, which is configured as a rule of evidence and a rule of judgment for the establishment of guilt and for the pronouncement of conviction of the defendant[4].The criterion B.a.r.d. is closely related to the rule "in dubio pro reo" and the principles of the presumption of innocence of the accused, the exclusive burden of proof of guilt on the prosecution, the obligation to state reasons for the judgment[5]. The B.a.r.d.'s rule focuses on the logical-epistemic profiles of evidence and decision-making alongside the values underlying the criminal due process[6].

Therefore emerges the concept of unreasonable doubt that legitimises as such a pronouncement of conviction: this happens when the uncertainty depends on the lack of a minimum feedback in the emergencies of the trial and is outside the natural order of things and normal human rationality[7]. Ergo, the judge must verify the doubt that surrounds the alternative reconstructive hypothesis. The prosecution's claim that the defendant is guilty acquires high plausibility only to the extent that some relevant evidence has been established as true that can be easily explained if the defendant is guilty, but would be difficult if the defendant were innocent[8]. If the hypothesis of guilt is equally compatible with a hypothesis of innocence, then the prosecution's case is not strong enough to justify a conviction. In fact, it is preferable to acquit a guilty person than to convict an innocent person[9].

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[2]Langbein (2003).

[3]Sheppard (2003).

[4]Marzaduri (2007) at 88; Paliero (2006) at 73-82.

[5]Dershowitz (2007).

[6]The standard analysis with scientific method provides three syllogisms: deduction in which the conclusion is unknown, induction in which the major premise is unknown, abduction in which the minor premise is unknown. See Iacoviello (2006); Paulesu, (2009); Edgington (1985); Fiandaca (2005); Illuminati, (1979).

[7]Cass., Sez. I, 21 maggio 2008, Franzoni, in Ced. Cass., n. 240763, Cass., Sez., IV,12 novembre 2009, Durante, in Ced. Cass., n. 245879.

[8]Whitman (2008)**.**

[9]Caprioli (2009) at 51.

Complexity and Mathematics: The Attempt to Explain B.a.r.d.'s Criterion

Algorithmic complexity management occurs through the causal explanation of an event (H) as a function of a given piece of evidence (E).

Bayes' theorem evaluates the impact of a given evidence E on the personal degree of belief of a judge G in relation to a given reconstructive hypothesis H[10]. The criminal process according to jurisprudence is governed by the law p (HK) = r, where the probability (p) of the hypothesis (H) is proportional to the degree of consistent information (K), introduced into the process through the acquisition of evidence, and as K increases, the degree of resistance (r) to falsification of the hypothesis increases[11].

For example:

- H0 the defendant is innocent (no hypothesis is true unless there is sufficient evidence to reject it);
- H1 the defendant is guilty if there is not enough evidence to reject H0 when H0 is not true, because there is not enough evidence to reject the hypothesis H0. As K increases, r (probability of conviction, probability of rejecting H0 and affirming H1) increases. If K is lower, the lower r (the probability of convicting H1 and accepting H0) will be. It follows that the prosecutor must prove that H0 is false to prove that H 1 is true.

If G, the adjudicating party, believes that the accusatory hypothesis H ("T killed C with a knife") is true, on the basis of a number of evidentiary findings E1 we are faced with Bayes' quotient, the ratio of P(E|H) to P(E| -H).The plausibility of the accusatory hypothesis appears, therefore, directly proportional to the Bayes ratio, which becomes an index on which to base and quantify the belief in a hypothesis in the light of evidence. If 0 (corresponds to the total lack of confidence in the hypothesis H), and 1 (the unattainable certainty of its truth) as the Bayes quotient increases, the probability of H (truth) increases, where the value 1 is the threshold above which the accusatory hypothesis H is more probable than -H (falsehood).

Following Bayesian reasoning, there is greater belief in H on the basis of the single piece of evidence E1 only if E1 supports the accusatory hypothesis[12]: P(E1|H)>P(E1|-H).

Carnelutti recognised a certain usefulness to algebraic functions as "heuristic devices", able to bring out the tendency prevalence or not of the hypotheses of guilt and non-guilt (in the usual form H and -H) without, however, adopting any mathematical criteria for the precise weighing of the probability of each hypothesis[13].

The risks connected to the theoretical adoption of demonstrative procedures structured according to the scheme, proper to formal truths, affirmation/negation

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[10]Allen (1997).
[11]Allen (2011).
[12]Tribe (2004).
[13]Carnelutti (1963) at 9; Carnelutti (1961a) at 338; Carnelutti (1961b) at 29.

have shifted the attention to the dialectical conception of truth, where the principle of the right to cross-examination is no longer considered only as a limit and a control of the activity of the prosecutor or the judge, but rather as a logical form of the investigation procedure and, ultimately, as a guarantee of the reliability of its results[14]. In a causal sense, it seeks to calculate the probability of an event that is a consequence of another[15].

Clearly, the use of a scale of 0 to 1 does not allow for a full degree of conviction (100%) of the validity of charge H on the part of G. A very large amount of evidence, even in the case of strong disagreement, will stabilise the overall quotient, but will not raise the threshold of conviction[16]. In the case of 10 trials (E), of which, for nine of them, P(H|E1→9) is consistently at 90%, if even the last event gave Bayes' ratio a percentage figure of 90%, the overall (iterative) threshold would remain at 90%, but at the same time make the figure statistically more reliable.

Very rarely, in fact, does the degree of rational belief remain unchanged over the course of the survey. What we see, on the contrary, is the modification of H's degree of belief, either in terms of increase or decrease, so that evidential reasoning can be defined as a "progressive rational determination" of the probability of the accusatory hypothesis, continually recalculated as the complexity of the evidentiary framework increases.[17] The iterative approach to Bayes' theorem consists in repeating the calculation of the weight of P(H) with respect to the results acquired from time to time. It is fully probative of the proof E1 only when it is able to validate H, with a weakening of -H, or vice versa.

Thus, it can be said that Bayes' theorem is a logical-probabilistic function describing the correct procedure for revising confidence toward a hypothesis in light of a set of tests.[18] Thus, a method of calculating P(H) quantifies not only the preponderance of evidence canon of the civil trial, but also the far more ambiguous beyond a reasonable doubt canon[19]. In the specific context of the criminal trial, the application of a Bayesian model allows one to test whether the "personal probability that the prosecution's version [Ha] is true compared to the defence's

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[14]Williams (2002) at 101.

[15]Viganò (2013).

[16]Allen (1994).

[17]AA.VV. (2006) at 113. The abduction of H is followed by the deduction of all possible consequences of H, to be sought at the crime scene. Given H for true, if the subjective probability of observing E1 is almost identical to that found in the case of the truth of -H, then E1 is irrelevant. In the case of irrelevant evidence, the coefficient on the ratio result is 1 due to the equivalence of P(E|H) and P(E|-H) while evidence that is statistically not in agreement with H generates a coefficient of less than 1 by substantiating -H, (the numerator being smaller than the denominator). If the probability of observing E1 given H is 0.8 on the 0→1 scale, the corresponding probability of observing E1 if the defendant is innocent (-H) must necessarily inform the remaining 0.2. Under this assumption, the odds ratio is much higher than 1, namely equal to 4, denoting a much higher probability of H with respect to E than -H. The statistical probability of observing E1 in the truth case of the charge hypothesis H [P(E1|H)] is higher than the statistical probability of observing it in the -H case [i.e. P(E1|-H)].

[18]Black (1984); De Finetti (1970).

[19]Allen, (1981).

version [Hd]", but at the same time imposes, the verification that the critical probability threshold P (reasonable doubt) is exceeded[20].

The Failure of Jurimetrics

It is intimately immoral to convict a man by calling him a criminal, saying to oneself, 'I believe there is a probability of one to twenty that this accused is innocent, but "I am willing to take the 1/20 risk of sacrificing him wrongly, in the interest of public safety and my own personal safety[21]." Immoral is setting a threshold of reasonable doubt once and for all, which means admitting a certain threshold of risk of convicting an innocent person. Doubt is said to be unreasonable when the probability of the accusatory hypothesis based on the available premises is separated by only one for a negligible interval[22].

Legal Bayesianism which presents itself as a theory that is not only "true" but capable of solving almost all problems in the evaluation of evidence, has suffered considerable criticism. Even Italian jurisprudence[23] has set this threshold at a limit value of 1, basically 99% or 99.999%. However, the numerical identification of the critical threshold does not seem to be within the reach of mathematical interpretation, especially since in itself, as recalled, the existence of a threshold that allows the judge to convict the accused even knowing that there is a certain margin of probability of his innocence is a cost of precision intimately immoral.

The new legal Bayesianism has sought to resist this through the inclusion of an evidentiary gap figure in Bayes' theorem. Based on these considerations, in a model of judgment that perceives the need for completeness or, at least, sufficiency of evidence, one should compare the data found. In the logic of reasonable doubt, the proof of H (innocence) does not work simply because it is not necessary.

On the contrary, such an application exposes the judgment to unwanted efforts, since the proof beyond a reasonable doubt of the falsity of a hypothesis does not differ, in terms of methods of ascertainment and difficulties, from the proof of its truth with the difference that, while for the purposes of conviction such an intellectual and economic effort is reasonable, the proof of innocence appears completely unnecessary and uneconomical, since the trial is called to examine only the propositional truth of the charge[24].

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[20]Pardo & Allen (2008).
[21]Taroni, Bozza & Vuille (2018).
[22]Masera (2007).
[23]Cass., Sez. I, 3 marzo 2010, Giampà, in Ced. Cass., n. 247449. 65 V. Cass., Sez. IV, 8 luglio 2010, n. 36343, in Dir. pen. proc., 2010, p. 1427. 66 V. Cass., Sez. III, 15 aprile 2010, n. 21396, in dejure. Cass., Sez. II, 11 gennaio 2007, Messina, in Ced. Cass., n. 235716. 67 V. Cass., Sez. feriale, 27 luglio 2010, n. 30576, in dejure. Corte Cost., 24 gennaio 2007, n. 26,. Cass. Sez. Un., 30 ottobre 2003, Andreotti and others, est. Canzio. Cass., Sez. I,18 aprile 2006, n. 22023, in dejure. Cass., Sez. II, 21 aprile 2006, Serino, in Ced. Cass., n. 233785. Cass. Sez. IV, 17 giugno 2011, Giulianelli, in Ced. Cass., n. 250903. Cass., Sez. IV, 4 aprile 2013, n. 19749, in dejure. Cass. Sez. III, 20 giugno 2013, n. 37373, in Dir. giust. online, 2013, 13 Cass., Sez. I, 21 aprile 2010, Erardi, in Dir. pen. proc., 2011, p. 203; Della Torre (2014).
[24]Ubertis (2009).

The failure of Bayesian theory is also due to the attempt of the Swedish EVM model to explain reasonable doubt. The Evidentiary Value Model (EVM) was developed independently to resolve the doubts raised by the codification of the concept of free and rational belief of the judge. On the Bayesian concept, the Swedish model maintains the idea that belief in a hypothesis H is quantifiable and that Bayes' theorem represents the basic model for calculating the evidentiary weight of an individual piece of evidence[25].

However, we rule out that belief formation resides in a mere statistical determination of the probability of observing H in light of E, but EVM proposes to define judgment as an assessment of the "evidentiary relationship" between the accusatory hypothesis and the acquired compendium of evidence. Thus, the judge is not primarily concerned with establishing the truth of the *factum probandum*, but with establishing that there is an adequate "evidentiary relationship" as to the presence, or possible presence, of a causal or logical link between the evidence and the subject since even a high degree of conviction of the truth of an accusatory proposition "beyond a reasonable doubt" has judicial value only if it is established on the basis of an "adequate" evidentiary relationship that justifies it[26].

Evaluating the evidence would then mean estimating the probability that individual pieces of evidence from time to time "prove" the hypothesis. In dynamic terms, the Evidentiary Value Model allows one to combine the different values of the evidentiary ratio (A) of the individual pieces of evidence acquired with respect to the hypothesis H, through an expression of the type: where the relationship between each individual evidentiary value is disjunctive and independent since the question is not "whether all the evidentiary facts prove the [H] issue, but whether some of them do.

The justification, however, of a belief placed at the heart of the argument must never result in a mere identification of the causal law capable of explaining the greatest number of similar hypotheses. One must think that the evidence has been supported by further evidence, also because, otherwise, the reasonable doubt that a health damage has had other causes (or concomitant causes) appears difficult to overcome if one considers each specific case[27].

In other words, the doubt about the conduct of the crime must be compatible with the conviction, if it is in any case certain that the defendant has committed the crime in question would otherwise be an abnormal expansion of responsibility, in violation of the guarantee of responsibility for their actions[28].

For this reason, the statistical data on which Baianism is based must be belied by the peculiarities of the concrete case, whose probative force does not seem to be numerically quantifiable[29]. The rule of sharing the burden of proof requires that the prosecution, in formulating its reconstructive hypothesis, must present evidence that excludes any reasonable doubt of innocence.

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[25]Taruffo (2009).
[26]Iacoviello (2006) at 3869
[27]Piemontese (2004) at 740; D'Alessandro (2012).
[28]Centonze, (2001) at 287.
[29]Simon & Mahan (1971); Kageghiro & Stanton (1985).

Only if this result is obtained, the presumption can be said to be won; in the opposite case, that is, in the case in which there is a reasonable doubt that the accused is really guilty, the judge cannot do anything but acquit. If, as it seems, these considerations are generally valid, it follows that the criterion of "reasonable doubt" cannot be quantified. In essence, the reasonableness of the doubt cannot be "weighed" in percentage terms: to say that it "counts" more than 5%, or more than 10% (or more than 0.1‰) ends up being a meaningless statement.

The numerical result of the Bayesian procedure also depends on subjectively fixed elements (think of the choice of the population of individuals who may have left the organic trace from which it was extracted a certain DNA profile), which only at a later stage can be processed according to the canons of logical-probabilistic schematism[30].

Bayesian theory does not offer mechanical rules of calculation to be applied automatically, but sets the boundaries within which the decision of the judge must move, requiring, as any logical rule, an explanation of those premises that are often more or less inadvertently concealed when making judgments[31].

The Epistemological Theory

Traditionally, in the Anglo-American context, this is referred to as the rule of decision, meaning that jurors are instructed to acquit if there is a reasonable doubt of guilt, and to convict if the evidence leaves only unreasonable doubt[32].

In fact, B.a.r.d. also establishes a standard of evaluation, insofar as the reasonableness of the doubts must be evaluated on a reasonable basis. More recent American theory focuses on the error distribution function.

The norms of evidence have this function in that they distribute the possible errors of the decision makers, favouring in the case of the criminal norm the false negatives (acquittal of the guilty) over the false positives[33] (conviction of the innocent).Reasonable doubt is sufficient to falsify the description of the fact, even in the presence of total evidentiary confirmation and its truth: this must be able to be extrinsic in a motivation that is explained through logical categories and that is respectful of the principle of non-contradiction a state of doubt understandable to any rational person[34]. Reasonable doubt must be a qualified doubt. And because it is a rule of judgment, the reasonableness requirement does not have to be motivated. So there is an identification of an evaluative threshold of reasonable doubt in motivation through logical categories.

Above this threshold, the gradations of intensity of doubt all go toward the certainty of innocence; in the opposite case, we are in the presence of an irrelevant doubt that leaves the field to the procedural certainty of guilt. For the law of evidence to be truly regulatory, it must regulate the interaction between what is

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[30]Callen (1982).
[31]Tillers & Green (2003) at 275
[32]Laudan (2003) at 297; Minhas (2003) at 127
[33]Fassone (1997).
[34]Ramadan (2003) at 233.

given at trial and the resulting inferential process that depends on the knowledge and beliefs of the investigator through the evidentiary process that manifests that interaction. Beyond a reasonable doubt, then, is a principle of prudence and seriousness that should guide the formation of the judge's belief about the facts[35].

The B.a.r.d. does not express a real legal rule but an ethical principle on the basis of which the judge can condemn only if he is certain of the guilt of the accused. Reasonable doubt exists when, faced with the description of the fact that establishes guilt, it is nevertheless possible to formulate a reasonable alternative hypothesis around the same fact.

Thus, one can have either the hypothesis contrary to the starting hypothesis or one or more hypotheses different from the starting hypothesis. A reasonable hypothesis is defined as a narrative of the fact that appears normal or more properly plausible[36]. The concept of verisimilitude does not imply probability, much less proof, of the fact, but implies something other than mere theoretical possibility. It is based on reference to the normal course of events or, if you like, to the maxims of experience.

It is a criterion of practical reasonableness: if it is not possible to imagine a plausible alternative version of the fact, it can be said that the proof of it does not meet any reasonable doubt. If, on the other hand, at least one possible alternative version can be hypothesised, then whatever the evidence for the fact, conviction cannot be pronounced.

The problem lies in justifying reasonable doubt with respect to the foundation of the starting hypothesis. In this way, the meaning of the standard depends on criteria that vary over time and space, as the cultures from which the criteria of normality and verisimilitude are drawn change. The purpose of the trial is to try to explain why that fact (that crime) happened.

The law of evidence must regulate the interaction between what is given at trial and the resulting inferential process that depends on the knowledge and beliefs of the investigator through the evidentiary process that manifests that interaction[37]. This allows for the testing of whether the story finds corroboration in other facts that were ignored or not considered significant in the immediacy, but which assume relevance in the case of choice.

The strategy for the balance between science and law consists in shifting the decision-making primacy of the judge, entrusting him with the task of assessing the reliability and relevance of the scientific evidence presented by the expert witness, by means of a grid of evaluation criteria[38]: (i) whether the theory or technique employed at the basis of the evidence has been tested and is falsifiable; (ii) whether the theory or technique has been peer reviewed and published; (iii) the rate of error, known or potential, associated with the theory or technique; and, finally, (iv) whether the theory or technique has been generally accepted by the relevant scientific community.

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[35]Ramadan (2004) at 64.
[36]Chinnici, (2006).
[37]Blaiotta & Carlizzi (2018).
[38]Haack (2015) at 39.

These criteria emphasise the autonomy of the judge with respect to scientific knowledge, the conception of science as functional to the ascertainment of truth in the trial, that is, of science referring to the trial context[39]. Scientists must increase confidence in the evidence they present during a proceeding, through ethical behaviour that excludes scientifically unsound methods and recourse to bad science; they must also be able to present their knowledge in a coherent and comprehensible way for legal practitioners. Legal professionals must accept and understand that science is rarely absolute: confidence and comprehensibility inherently rely on a symbiotic relationship between science and its scientists and the law and its jurists, and on adherence to guidelines and standards that distinguish what is accepted and incontrovertible from topics open to debate and investigation.

The Logical Theory

The subjectivity of the decision must be based on the arguments of the statement "x is proven beyond a reasonable doubt"[40].The Daubert judgment of 1993 provoked Popper's theory of falsifiability, according to which science proceeds through falsification of statements, and Hempel's logical positivism, according to which a scientific theory must have empirical verifications that confirm it[41].

The risk, underlined by many, of using junk science (bad science) in trials, consisting of knowledge that, although presented as tested and scientific, escapes any assessment of scientificity[42]. In Daubert there is a paradox. The judge appoints the expert precisely because he is not able to make a scientific assessment himself, and the judge is expected to evaluate the outcome of the expert evidence in order to determine whether it is worth using it to decide on the facts[43]. Therefore, it is assumed that the judge can make an ex-post evaluation of scientific knowledge that he did not possess ex ante. North American jurisprudence, on the other hand, highlights Daubert's weaknesses in the case of criminal judgments[44].

According to these considerations, "logical probability" can be defined as the relationship between a hypothesis and the elements that confirm its reliability[45].In fact, in light of the trial results, the case must be framed in the area of operation of the law of coverage or in the field of validity of the maxim of experience, so that

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[39]Laudan (2006) at 35

[40]Copi & Cohen (1999)*; Zaza (2008).*

[41]Welch (2006); Neufeld (2005).

[42]Berman & Mcclennen (2012).

[43]Caprioli (2008) at 3529.

[44]*Coffin* v. *United States* 154 U.S. 432 (1895); *Woolmington* v. *Dpp*, A.C. 462,473-481(1935); *Johnson* v. *Louisiana*, 406 U.S. 356 (1972).

[45]Haack (2007). Cass. sez. un. 11 settembre 2002 n. 30328, Franzese. It is not allowed, especially from the epistemic point of view, «to deduce automatically and proportionately from the statistical probability coefficient expressed by the law of coverage the confirmation of the hypothesis», especially when it comes to the use of a «notion "weak even if always of a statistical test per sample, therefore the doubts about the correctness are not groundless (rectius, justification) of the inference which led to the finding that the causal link of an injurious event was established from the incidence of the case in similar cases.

there is the certainty of beyond a reasonable doubt, regardless of the statistical validity of the scientific law or the abstract convertibility of the maxim.

The common denominator is the standard of trial certainty which means logical probability beyond a reasonable doubt. If there are relevant facts that only make sense under the innocence hypothesis, then acquittal is required. In short, this proposed standard requires that a conviction is warranted if and only if: (a) The hypothesis of guilt can explain most of the relevant facts of the case; (b) The hypothesis of innocence cannot justify any important evidence that is unexplained on the hypothesis of guilt. Evidence is literally incomprehensible without rules of language and logic, but it is simply accepted that an investigator can process information and deliberate on it[46]. However, it frequently happens that in the attempt to find confirmation of the reconstructive hypothesis formulated, new facts are discovered from which the need for modification or some adjustment of the proposed "story" arises.

Therefore, the selection of the relevant conditions of the event is the result of a circular process, which ends when all the elements acquired have been used to confirm the hypothesis[47]. The last stage is the attempt to falsify the hypothesis: considering the alternative hypotheses and proving their unfoundedness. Thus, refutation increases explanatory power. Relative plausibility theory is the best explanation of legal evidence to date[48]. Differential diagnosis involves the elimination and inclusion of hypotheses based on the differentiation of data points. To some extent this is like forming a story, but the conceptual gaps involving the nature of the evidence and the unique context of scientific endeavours are remarkably unresolved.

Criminal Trial or Statistical "Trial"?

The most recent analyses by scholars of epistemology identify the cause of the uncertainty emerging from post-Daubert jurisprudence and doctrine precisely in the lack of coherence of the Daubert rules themselves on the philosophical-scientific profile[49]. The Court in the Daubert case has improperly referred to Popper's theories, which do not provide the judge with the criteria to establish either if an element of evidence is truly scientific or if it is reliable[50]. Even more serious is how the Court has erred in its claim to explain what distinguishes a scientific method from a non-scientific method and in having identified the concept of "scientific" with "reliable"[51]. The better the evidence with respect to a theory, the more likely it is that this theory is true: scientific evidence should not be treated in an exclusively formal and logical way, but it is necessary to take into account that science is also about our interactions with the world and, therefore, the context. A

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[46]Tarski (1969) at 31.
[47]Haack (2006).
[48]Haack & Sallavaci (2014).
[49]Popper (1969).
[50]Popper (2002); Popper (1963); Cohen & Nagel (1934).
[51]Jasanoff (2001) at 372.

reasonable solution is to show that, however improbable, this hypothesis is still possible in a pragmatic sense, i.e. in the context of what actually "could happen".

The fundamental principle, at the basis of all procedural systems, developed and consolidated since Daubert establishes that the evidence provided by the expert is not binding for the judge and that, however complex it may be, the judge has the burden of interpreting and reworking the information content independently[52]. Particularly in the European context, especially in the criminal field, important normative bases for the discipline of scientific evidence in the distinct moments of the admission, the assumption and the use of the evidence contribute to define the role of science in the process; moreover, several sentences establish criteria for the validation of non-established scientific knowledge[53]. If, on the other hand, one was to fall below this minimum standard, one would be faced with a doubt that does not exist, because in reality there is a certainty: the procedural certainty of guilt. Can the criminal justice process be reduced solely to a statistical hypothesis test? The answer is still evolving. For now, the following considerations can be made.

The reliability of a theory depends on the studies that support it; the factual basis on which they are conducted; the breadth, rigorousness and objectivity of the research; the degree of support that the facts give to the thesis; the critical discussion that accompanied the elaboration of the study. Finally, from the judge's point of view, the identity, unquestioned authority, and independence of the person handling the research, and the purposes for which he or she is moving, are of pre-eminent importance. In summary, the criminal process is like a test of statistical hypotheses (statistical process) because its purpose is to collect evidence to prove a thesis, (the burden of which is initially the impulse of the prosecutor who then the defence refutes) and because the prosecutor wants to falsify the innocence of the accused and then prove his guilt. It is well known that the way to prove a hypothesis is not through corroborating evidence, but through falsifying alternative evidence.

Scientific research, in fact, shows that even a large amount of data in favour of a theory are not sufficient to prove it, while one against can be decisive to make it fall, emphasizing the importance of a "falsifying look" in the critical evaluation of the facts. However, our mind is built on the principle of verification: in front of a hypothesis that seems plausible, and therefore in front of a story, a plausible story, the common attitude is to look for evidence that supports it[54]. It is anything but an "irrational" proceeding of the human mind, the unusual, the improbable is always lurking. We cannot but take note of this reality: in practice, the most probable hypothesis can be false and the one that appears most unlikely to be true. However, it is not only the accusation and the story linked to it that takes the form of a narrative. The criminal trial also possesses within itself, constitutively, a narrative structure: in all judicial systems, a trial begins with a charge presented by the prosecutor, that is, a hypothesis of guilt. The defence presents an alternative hypothesis, but only as a second hypothesis. This order of presentation, guilt and

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[52]Arcieri (2017).

[53]Corte e.d.u., 4 giugno 2013, Hanu c. Romania; Corte e.d.u., 9 aprile 2013, Flueras c. Romania; Corte e.d.u., 5 marzo 2013, Manolachi c. Romania; Corte e.d.u., 5 luglio 2011, Dan c. Moldava.

[54]Haack (2012); Fuselli (2008) at 52.

innocence, has a significant impact on the formation of the judgment, because the consideration of a first hypothesis makes the acceptance of an alternative hypothesis less likely. This is the so-called inertia effect: once a hypothesis has taken root in the cognitive system, it becomes difficult to modify it with information that, presented first, could have been influential.

Of course, the order of presentation cannot be changed, and therefore the narrative plausibility of the story hypothesised by the prosecution always precedes the presentation of that hypothesised by the defence, for this reason it dominates it and needs, in order to be true, a smaller number of evidentiary elements than the defence thesis needs. The accusation, after having been subjected to the procedures of confirmation or falsification of the reconstructive hypotheses of the fact put forward by the parties, brings with it, before the final decision of the judge, also the argumentative sequence foreseen by the procedural structure. The judge's problem is not to seek an impossible certainty, but to increase the degree of probability and reduce the margin of error to a rationally and socially acceptable threshold. It is debated whether statistical frequencies (when they exist, which in most cases they do not) can provide proof of a fact, to the widely prevailing opinion is in the negative, since it is said that statistics serve to make predictions by measuring the possibility of the occurrence of an event (or the frequency of a risk) in a given context but do not serve to determine the probability that an unknown event has already occurred[55]. In any event, the percentage in which a statistical frequency is expressed indicates the tendency frequency of an event, but does not correspond to the degree of evidence about the occurrence of that event[56]. The judicial body must therefore obtain a degree of confirmation fixed by law in order to consider the reconstructive hypothesis put forward by the party as proven[57]. It is always up to the judge to ultimately determine the probative value of the facts and therefore to establish whether in the concrete case the 'degree' of proof required by law has been reached[58].

Conclusion

The differences between science and law, as far as evidence and evidentiary procedures are concerned, can be addressed with the tools of epistemology, but a "legal epistemology", that is, an epistemology that investigates the relationship between evidence, scientific research and litigation-driven research that addresses the relationship between probability and justice; and that clarifies the role of expert scientific testimony in the difficult balancing act between inadmissibility and completeness. However, it has also been argued that the adjective "reasonable" means "plausible" and is not equivalent to "logical" or "rational," since otherwise a

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[55]Saini (2009).
[56]Picinali (2018).
[57]Lempert (1977).
[58]Bona (2014).

conviction would never be reached. In fact, one can never exclude the existence of a doubt understood in a logical-rational sense, because one could always assume the innocence of the accused, even in the presence of an overwhelming probative picture of guilt. Although it cannot identify a unitary conception of reasonableness, it can certainly recognise the existence of a sort of minimum threshold, above which we must guide us, inevitably, in the direction of innocence.

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