STATISTICAL EVIDENCE IN CRIMINAL TRIALS: WHAT IS WRONG WITH IT?

Marcello Di Bello – Last update: October 30, 2012

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Can a criminal defendant be convicted on statistical evidence if his probability of guilt is sufficiently high? A rich literature developed on this question over the years, yet many thought that it would be of limited practical interest because the possibility that a defendant be incriminated on statistical evidence alone seemed to be far-fetched. Things have changed, however. DNA evidence, a powerful form of statistical evidence, is now a common presence in the courtroom, and some defendants have been recently convicted on only DNA evidence.[1] Unsurprisingly, this has revived interest in the question of whether a conviction is acceptable on statistical evidence alone.[2]

In the literature some hold that statistical evidence should raise no particular concern and that a conviction is acceptable so long as the defendant's probability of guilt is sufficiently high.[3] On the other end, among the critics of statistical evidence, we can identify two main strands: those who think that statistical evidence is *epistemically* deficient,[4] and those who see it as problematic on *politico-moral* grounds.[5] In this paper I focus on a less travelled line of argument, which I call

[1] For a historical introduction to DNA evidence in U.S. criminal trials, see (Kaye, 2010).

[2] Roth (2010) recently noted that a defendant's probability of guilt given DNA evidence is often astronomically high, and that this should be enough for a conviction. Lingertwood (2011), instead, argued that although DNA evidence might give rise to an astronomically high guilt probability, this need not be enough for a conviction because the process of legal proof is not probabilistic.

[3] This claim can be defended with the observation that *all* evidence is statistical, so that a criticism of statistical evidence would apply to any kind of evidence. See e.g. (Ball, 1961) and (Saks and Kidd, 1980).

[4] A common epistemic criticism is that statistical evidence rests on statistical generalizations which apply to many people and not to a specific defendant. Saks and Kidd (1980) rightly object that no evidence can (uniquely) identify a defendant. Consequently, the epistemic critique of statistical evidence takes other forms. Cohen (1977) argues that statistical evidence lacks evidential weight. Gärdenförs et al. (1983), Thomson (1986), Dant (1988), and Pardo and Allen (2008) argue that statistical evidence is not causally or explanatorily connected with the proposition to be proven, and Ho (2008) adds that its connection is merely probabilistic. Enoch et al. (2012) suggest that statistical evidence lacks epistemic sensitivity. Finally, Colyvan et al. (2001) complain that statistical evidence rests on arbitrary reference classes.

[5] On the moral front, Tribe (1971) thinks that statistical evidence dehumanizes the trial process, and in particular, Zuckerman (1986), Wasserman (1991), and Pundik (2009) think that it undermines the defendant's individuality and freedom. On the socio-political front, Sanchirico (2001) complains that statistical evidence creates distortional incentives for future criminals and Nesson (1979) thinks that it renders judicial verdicts too easily subject to social scrutiny.

procedural.[6] My focus on the procedural aspects is motivated by concerns for what happens in the courtroom, as opposed to concerns for possibly more abstract questions about the moral and epistemic features of judgments made on the basis of statistical evidence. I think that in order to address the problem of statistical evidence in the courtroom, we should take into account how the evidentiary burdens are allocated between prosecutor and defendant, and in particular, we should become clear on how a defendant can exercise his right to a defense.

Pivotal to my argument will be the notion of *specificity*. Whenever statistical evidence is used to support an incriminating narrative that has low specificity, I argue, the defendant's right to a defense is encroached upon; this situation exemplifies an improper use of statistical evidence. In contrast, whenever the incriminating statistics support a narrative that is sufficiently specific not to encroach on one's right to a defense, this constitutes a proper use of statistical evidence, or so I argue. The spirit of my argument is conciliatory: in distinguishing between proper and improper uses of statistical evidence, I hope to bring some concord in a debate that has been needlessly polarized between critics and supporters of statistical evidence in the courtroom.[7] The paper also touches upon the closely connected question of whether the criminal standard of proof *beyond a reasonable doubt* can be probabilistically quantified.[8] As I shall explain in due time, I think that a quantification, though helpful, misconstrues the procedural function of the standard of proof.

Before I begin, a short clarification on the words 'statistical' and 'probability' is in order. At its simplest, statistical evidence can be understood as consisting of three components: statistical data; a statistical/probabilistic *model*; the model's *output* in the form of a probability value attached to a proposition. Here is an example: a lottery consists of one million tickets (data); each ticket has an equal chance of winning (model); each ticket's chance of winning is one in one million (out-

[6] I wish to develop an insight by Stein (2005), p. 100, who suggests that statistical evidence cannot be subject to cross-examination.

[7] At least the debate was polarized when it began in the sixties and seventies: authors such as Tribe (1971), Cohen (1977), and Nesson (1979) vehemently objected to statistical and (standard) probabilistic methods in the courtroom, while authors such as Kaplan (1968), Cullison (1969), Finkelstein and Fairley (1970), and Kaye (1986) disagreed.

[8] The criminal standard of proof can be quantified by requiring that guilt be proven with a probability of 0.9 or 0.99 (the exact value is not important here). See (Simon and Mahan, 1971) and (Tillers and Gottfried, 2007). The U.S. Supreme Court in Holland v. U.S. (1954) has discouraged any definition of the criminal standard of proof because "attempts to explain the term 'reasonable doubt' do not result in making it any clearer" (348 U.S. 121, 140). Dershowitz (1997) has defined this "an act of abject intellectual cowardice" (p. 69) and Laudan (2006) has documented the confusion among legal practitioners about the meaning of the criminal standard of proof.

put). Concerning the meaning of probability or chance, in trial proceedings we are interested in the probability of unrepeatable and temporally prior events (e.g. whether the defendant killed the victim on October 10th, 1994), so the *subjective interpretation* of probability is the most appropriate.[9] On this interpretation, a probability value expresses a rational agent's *degree of confidence* that a proposition is true, as a result of taking into consideration the agent's evidence (as well as the agent's probabilistic model of the situation of interest).[10]

1 Proper and improper uses: Ennio and Eschaton

In examining the role of statistical evidence in criminal trials, two hypothetical scenarios will accompany us for most of the paper. I have decided to consider hypothetical scenarios because they keep the discussion manageable, although they might neglect the complexities of court cases.[11] Our first scenario involves DNA evidence, one of the most powerful forms of statistical evidence currently available.[12] The workings of DNA evidence are relatively straightforward. When traces of blood, semen, saliva, skin tissues, etc. are found at the crime scene, laboratory analyses can create a DNA *profile* from the traces. A DNA profile is a codified representation of select portions of the human genome, of those portions which tend to be different across individuals.[13] Once a profile is created from the traces, it is compared against a suspect's blood, semen, saliva, skin tissues, etc. from which another DNA profile is created. The purpose of the comparison is to find a

[9] The objective interpretation (in terms of frequencies or dispositions) is inappropriate because a unique past event must have objective probability of one or zero.

[10] Proponents of probabilistic methods in the courtroom—such as Kaplan (1968), Cullison (1969), Finkelstein and Fairley (1970), and Kaye (1986)—all endorse an epistemic (subjective Bayesian) interpretation of probability. Ramsey (1931) and de Finetti (1937) pioneered the subjective interpretation. Galavotti (2005) gives an excellent overview of the literature; Erikson and Hájek (2007) offer a more critical discussion of the nature of degrees of confidence.

[11] Redmayne (2008) makes a good case for considering hypothetical scenarios. Among others, Meester et al. (2007) pursue a more technical approach and compare different probability models and their application to criminal cases. Finkelstein and Levin (2001) offer a good survey of the uses of statistical evidence in the law.

[12] For a quick introduction to DNA evidence and its uses in the courtroom, see (Wasserman, 2008). For a more in-depth treatment, see (Kaye and Sensabaugh, 2000).

[13] On a chromosome we can individuate specific positions, called *loci*, who are "occupied" by a particular DNA sequence, called *allele*. In the eighties a British geneticist, Alec Jeffreys, discovered a number of loci whose alleles are different across individuals. Such loci are called Variable Number Tandem Repeats (VNTR) because what varies is the number of repetitions of a patter of nucleotides. A DNA profile conveys information about the allele sequences at a select number of highly variable loci. In the United States, the Combined DNA Index System (CODIS) created by the FBI requires that a DNA profile consists of 13 select loci. These 13 loci constitute a particular type of VNTR loci and they are called Short Tandem Repeats (STR) because the repeating pattern in the locus consists of a limited number of nucleotides. For more information, see Kaye (2010).

genetic *match* between the two profiles.[14] If a match is found, this would constitute strong but not infallible evidence that the suspect is the source of the traces found at the crime scene.

What makes DNA evidence particularly powerful is that DNA profiles, albeit not unique, are highly discriminating because they are very rare.[15] The rarity of a DNA profile is expressed by a frequency, sometimes as astronomically small as 1 in 50 billion, representing the profile's expected frequency in a population.[16] The lower the frequency, the more discriminating the profile and consequently the more probative the match. Importantly, a genetic match between a suspect and the crime traces is probative of whether the suspect is the *source* of the traces, but it does not establish that the suspect is *guilty*. For this reason, prosecutors typically argue in two steps. They establish that the traces at the crime scene could not have been left innocently, so that whoever left them must be guilty. To conclude their case and establish guilt, they can rely on DNA evidence and show that the suspect *is* the source of the traces. Consider now this scenario:

Parking. A woman is found dead in the woods. The investigators recover remnants of semen on her body, which is severely wounded; they also recover blood stains in a parking lot near the woods. Laboratory analyses show that some blood stains in the parking lot are the victim's, and also that the other blood stains and the semen on the woman's body share the same DNA profile. Forensic experts estimate that the DNA profile in question has a statistical frequency of 1 in 100 million. Finally, through a database search, it turns out that an individual in the neighborhood, Ennio, has a matching DNA.[17] Ennio is arrested and tried.

[14] What counts as a match is not uncontroversial. For one thing, DNA profiles created from different samples are never identical; they are *more* or *less* congruent. Typically, two profiles are said to match if they are sufficiently similar within a tolerance interval. Kaye (1993) proposes to replace the qualitative language 'match/non-match' with quantitive statements about the degree of congruence between two profiles. The second source of controversy about genetic matches is that forensic experts might be mistaken when they claim that two profiles match (e.g. because of contamination, switching of the samples, or because the two DNA profiles do not match at all). Thus, a reported match must not confused with an actual match. On how laboratory errors affect the probative value of DNA evidence, see (Thompson et al., 2003).

[15] Two individuals might share the same DNA profile; see (Weir, 2007) and (Saks and Koehler, 2008).

[16] As explained in footnote 13, a DNA profile coveys information about the DNA sequences (alleles) at select loci. Each allele has a certain frequency in a given population and such frequency is estimated by counting how many times the allele shows up in a database of DNA profiles. The bigger the database, the better the frequency estimate. Now, the frequency of the entire profile is calculated by multiplying the frequencies of the single alleles. Consequently, the more alleles are included in the profile, the lower the frequency. The multiplication of allele frequencies is justified on the assumption that each allele occurs independently of the others. This assumption is non-trivial and scientists debated it widely, though they have come to accept it; see (Kaye, 2010). On a different note, Buckleton (2005b) invites us to take the astronomically low frequencies of DNA profiles with a grain of salt, because the statistical and genetic models from which they are derived cannot be tested empirically when frequencies are too low.

[17] Running a profile through a database is now a common police practise; see (Roth, 2010). The traditional method is different: the police first identifies a suspect, and later tries to see if a sample from the suspect of his blood, saliva, semen, etc. genetically matches with the crime traces. The practise of database searches has generated a controversy among statisticians, who are divided on whether or not a match resulting from a database search has the same probative value as a match obtained in the traditional way. See (Balding and Donnely, 1996) and (Devlin, 2007).

At trial the prosecutor advances the following reconstruction of the crime: the perpetrator had or attempted to have sexual intercourse with the victim in the parking lot (which explains the perpetrator's semen on the victim's body); a fight ensued during which both the perpetrator and the victim were wounded (which explains the blood stains in the parking lot); finally, the perpetrator killed the woman with a knife (which explains the wounds on the victim's body) and hid her body in the woods. The prosecutor argues that Ennio is the perpetrator: he has a matching DNA profile whose frequency is as low as 1 in 100 millon. The prosecutor adds that, given the low statistical frequency of the DNA profile, Ennio's probability of guilt equals 0.99.[18] He concludes that 0.99 is a high enough probability to satisfy the criminal standard of proof.

There are many reasons to contest the prosecutor's argument: the laboratory analyses might be mistaken; the statistical frequency of the profile might have been miscalculated; the blood in the parking lot and the semen on the victim's body might not come from the same individual, or even if they do, they might have been left there innocently; etc. For the sake of argument, however, let us make the idealized assumption that the utmost care has been taken in the laboratory analyses and that the available evidence suggests that the traces have not been left innocently. In other words, let us assume that the prosecutor's estimate of Ennio's probability of guilt was properly calculated.[19] Indeed, this probability might change if new and contradicting evidence comes in, but on the currently available evidence the 0.99 estimate is our best guess.

Despite these idealized assumptions, the question remains of whether a conviction against Ennio is acceptable.[20] A couple of preliminary considerations suggest that it is. First, appellate courts in the United States recently upheld criminal convictions in cases similar to *Parking*.[21] Second, the incriminating evidence in *Parking* is strong: a prosecutor can seldom hope to collect any better evidence, and thus, if we were to deny the acceptability of a conviction in *Parking*, we would have to do the same in many others or virtually all criminal trials.[22] These considerations, however,

[18] To carry out the calculations, we can use Bayes' theorem; see the appendix to this paper.

[19] Some might object that guilt cannot be probabilistically quantified. My response is that guilt consists in physical and mental facts, and insofar as facts can be assigned probabilities, guilt can be assigned a probability as well. On the other hand, I agree that guilt in real cases might be too complicated to be quantified; I agree that quantifying guilt might have prejudicial effects. But these are pragmatic reasons not to quantify guilt. *Parking* is an idealized case and my discussion, too, is idealized.

[20] The question is whether a conviction is acceptable in *Parking*, not whether Ennio should necessarily be convicted.

[21] For a number of cases, see (Roth, 2010).

[22] Fingerprints and eyewitness testimonies are other types of evidence used in criminal trials, but they are not any stronger than DNA evidence. Both fingerprints and eyewitness evidence have been shown to be quite unreliable. On eyewitness evidence, see (Loftus, 1996), (Thompson, 2008), and (Crump, 2009); on fingerprint evidence, see (Zabell, 2005) and (Dror et al., 2006). An incriminating case stronger than the one in *Parking* would consist of two pieces of evidence (e.g. a piece of DNA evidence corroborated by eyewitness testimony). Sangero and Halpert (2007) argue that a conviction is never acceptable when it rests on one piece of evidence, be it DNA, fingerprint, or eyewitness evidence.

do not give a principled rationale for why a conviction is acceptable. One might suggest that the rationale is Ennio's high probability of guilt, but this answer is not without problems. For consider a scenario in which the defendant's probability of guilt is high, yet convicting him appears to be controversial:

Prisoners. A video recording shows that in a prison yard ninety-nine out of one hundred prisoners assaulted and killed the only guard on duty. In the recording, ninety-nine prisoners appear to deliberately participate in the killing; only one refrained. Their faces are unrecognizable, and no other evidence is available: no other witness was present; all prisoners escaped except one whose name is Eschaton; and after the crime, a fire erupted and destroyed most of the crime traces.

Eschaton is captured and tried. Given the 99:100 statistical rate of participation in the killing, the prosecutor argues that Eschaton's guilt is 0.99 probable and that Eschaton should be convicted because a high probability of guilt is enough to satisfy the criminal standard of proof.[23]

Admittedly, it is hard to imagine that a criminal case could resemble the one above. Yet, I invite the reader to make a leap of imagination and suppose that the facts of *Prisoners* hold. Those who are willing to entertain the supposition often have the gut reaction that something must be wrong with the prosecutor's argument against Eschaton.[24] To see what might be wrong with it, the argument can be broken down as follows:

(I) the statistics are trustworthy;

(II) given the statistics, there is a 0.99 probability that Eschaton participated in the killing;

(III) hence, Eschaton's guilt is 0.99 probable;

(IV) a high probability of guilt is enough to satisfy the criminal standard of proof.

Just like in *Parking*, if we accept a few idealized assumptions, steps (I) through (III) are hard to question, and I do not take issue with them here.[25] Step (IV) is the most controversial. If

The proposal is intriguing, but the worry is that it might render convictions nearly impossible.

[23]This is a modified version of a scenario by Nesson (1979).

[24]Wells (1992) tested people's reactions in scenarios similar to *Prisoners* and he demonstrated that most people feel uneasy in convicting *even when* the governing standard of proof is lower than 'beyond a reasonable doubt.'

[25]Step (I) is justified because the 99:100 statistical rate of participation is immediately derived by counting the number of participants in the killing. It is true that statistics can always be subject to criticism, but *Prisoners* is an idealized scenario and my discussion here will ignore this aspect. As for step (II), the probability that Eschaton *participated* in the killing is 0.99 because: first, 99 out of 100 prisoners participated in the killing; second, no other more specific information is known about Eschaton's or any other prisoner's propensity toward violence. (The subjective probability value of 0.99 results from some evidential information *and* the lack thereof, and it might be revised upwards or downwards if new information becomes available.) As for step (III), notice that the video recording shows clearly that those who participated in the killing did so deliberately; this establishes their *mens rea*. Consequently, if Eschaton participated, his guilt follows (and viceversa). This means that if there is a 0.99 probability that Eschaton participated in the killing, his guilt is 0.99 probable.

anything, this is what is problematic in the prosecutor's argument. But why cannot we understand the criminal standard of proof as merely requiring a high probability of guilt? What else is needed?

There is another question. While some appellate courts, as we've seen, find acceptable a criminal conviction in cases similar to *Parking*, legal scholars are unanimous in holding that a conviction in *Prisoners* is unacceptable.[26] What is the justification for such asymmetry? After all, in both *Prisoners* and *Parking*, the incriminating evidence consists of statistics, supplemented by other evidence, a video recording in *Prisoners* and traces of blood and semen in *Parking*; also, in both scenarios, the prosecutor uses statistical evidence to establish that the defendant's probability of guilt is high. Should we conclude, then, that the two scenarios are completely analogous? I think not because, as I shall argue in section 2, an important difference is that the incriminating narrative is more specific in *Parking* than it is in *Prisoners*. In sections 3 through 6 we will see that this difference has procedural implications in that the accused in *Prisoners* is virtually unable to defend himself, but not so in *Parking*. Finally, in section 7 I will suggest that one misconstrues the role of the criminal standard by equating it to a mere threshold probability of guilt.

2 SPECIFICITY

Many have noted that in *Prisoners* Eschaton's probability of guilt is high *but so is the guilt probability of any other prisoner*. If the statistical evidence incriminates Eschaton, by parity of reasoning, it incriminates any other prisoner.[27] In this sense, the statistics are not specific enough to discriminate a prisoner from the other; they are not specific enough to identify the prisoner who did not participate in the killing. What about *Parking*? At first, it would seem that the DNA evidence

Paralleling the argument in *Prisoners*, we can break down the argument in *Parking* as follows: (I) the statistics are trustworthy; (II) given the statistics, there is a 0.99 probability that the blood in the parking lot is Ennio's; (III) hence, Ennio's guilt is 0.99 probable; (IV) a high probability of guilt is enough to satisfy the criminal standard of proof. Just like in *Prisoners*, step (I) through (III) are plausible. These steps are justified because of a number of idealized assumptions. Step (I) is justified assuming that the statistics on the frequency of the DNA profile are reliable. As for step (II), from the assumption that Ennio's blood actually matches the blood in the parking lot, we can use Bayes' theorem to establish that Ennio is the source with a 0.99 probability; see the appendix to this paper. Finally, step (III) is justified on the idealized assumption that whoever is the source of the blood is the perpetrator of the crime.

[26] See, among others, (Nesson, 1979), (Stein, 2005), and (Ho, 2008).

[27] Nesson (1979) and Pundik (2011) make similar observations. Goldman (1976), Lewis (1996), Hawthorne (2004), and Kvart (2006) also make a similar point while discussing scenarios that resemble *Prisoners* (i.e. lotteries in which all tickets lose except one, or villages in which all barns are real except one).

therein identifies one individual, Ennio, as the perpetrator. The difference between the two scenarios, then, would be that in *Parking* the evidence has "discriminating power" and in *Prisoners* it does not. This point is intuitive but ultimately unconvincing. What if two other people share with Ennio the same DNA profile? If so, DNA evidence would be unable to discriminate between them and Ennio. In response, one could insist that it is improbable that other people share the same DNA profile with Ennio. But one could counter this response by saying that if it is just a matter of probabilities, we should be content with the fact that Eschaton's and Ennio's probability of guilt are both very high and thus accept that there is no relevant difference between the two scenarios. I do not know how to resolve this dispute and I suspect that focusing on the incriminating evidence as a way to distinguish between the two scenarios is doomed to fail.[28] My strategy, instead, will be to concentrate on the incriminating *narrative*, not the incriminating evidence. I will suggest that the difference between *Prisoners* and *Parking* lies in the different degree of specificity of the incriminating narratives. Let me explain.

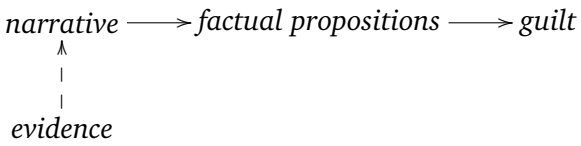
In establishing a defendant's *guilt* for a crime (murder, rape, theft, etc.), the prosecutor proves a number of *factual propositions* from which guilt follows in accordance with the substantive law governing the case.[29] To prove the factual propositions of interest, the prosecutor advances a *narrative* (a story, a theory) of the crime which describes what happened in a coherent way.[30] The narrative should be properly formulated: it should be supported by the *evidence* available to the

[28] In order to distinguish the two scenarios, we might invoke other notions besides the "discriminating power" of the evidence. For instance, Nozick (1983) and Roush (2006) defend a *tracking* view of knowledge and evidence. Williamson (2000, 2009) and Pritchard (2005) defend a *safety* view of knowledge. Finally, Achinstein (1978) thinks that the evidence should be *explanatorily* connected to the proposition it supports. Thus, the evidence in the two scenarios might differ depending on whether it is, or it is not, tracking, safe, or explanatorily connected with the proposition it supports. These proposals are promising but they require a lot of theoretical machinery to be appreciated. The tracking and safety views of knowledge depend on counterfactuals, about which see (Lewis, 1973). As suggested by Roush (2006), the notion of tracking can also be understood probabilistically by using likelihood ratios, about which see (Royall, 1997). Finally, the notion of explanation is philosophically controversial, about which see chapter 1 of (Woodward, 2003). A discussion of counterfactuals, likelihood ratios, and explanation would be bring me too far from the relatively circumscribed procedural point I want to make here.

[29] E.g. according to the common law, to prove murder, the prosecutor is expected to prove the *actus reus* as well as the *mens rea*. It is customary to distinguish matters of fact (e.g. whether the defendant intentionally killed the victim with a gunshot) from matters of law (e.g. whether intentionally killing with a gunshot is a second or first-degree murder). The distinction might be more nuanced; see e.g. (Hruschka, 1965), (Allen and Pardo, 2003), (Friedman, 1992b), and (Taruffo, 2009).

[30] On the role of narratives in the reconstruction of crimes, see (Anderson et al., 2005).

prosecutor;[31] and also, the factual propositions to be proven should follow from the narrative.[32] The relation of evidence, narrative, factual propositions, and guilt can be visualized as follows:



In *Parking*, the incriminating DNA evidence points to Ennio as the perpetrator of the crime. Though the evidence might be erroneous, the prosecutor took it at face value and committed himself to a narrative in which Ennio was the one who assaulted the victim, fought, used a knife to kill, left blood stains on the ground, hid the victim's body in the woods. This is the narrative that a prosecutor most naturally would commit himself to, at least when taking at face value the available crime traces and DNA evidence. In *Prisoners*, we know that the incriminating statistics leave undecided the identity of the lone prisoner who did not partake in the killing. Thus, the prosecutor's narrative should be something along the following lines: Eschaton, together with ninety-eight unidentified other prisoners, attacked the prison guard and killed him. This narrative is 0.99 probable on the evidence and it entails the proposition '*Eschaton participated in the killing*' from which guilt follows.[33]

We can now begin to appreciate the difference between *Parking* and *Prisoners*. The point I want to make is that the prosecutor's narrative in *Parking* is *more specific* than the prosecutor's narrative in *Prisoners*, in the sense that the former gives more information, more details, more particulars about the crime than the latter does.[34] What did Eschaton do during the killing? What role did he play in the killing? How did he kill the guard? To all these questions, the prosecutor's narrative

[31] At its simplest, the narrative should be highly probable on the evidence. But there might be additional requirements that the relation of evidential support should satisfy. Fitelson (2006) offers an excellent discussion of many probability-based accounts of evidential support.

[32] E.g. suppose the narrative asserts that the defendant stabbed the victim's with a knife and that the victim's death occurred immediately thereafter (as per medical doctor's testimony); the factual proposition that the defendant caused the victim's death follows from such narrative as a matter of shared knowledge and logic.

[33] See the justification of step (III) of the prosecutor's argument in footnote 25.

[34] A few examples should suffice to elucidate the notion of a narrative's degree of specificity: a narrative asserting that the perpetrator was a male with fair complexion in his fifties is more specific than a narrative describing the perpetrator as an adult male; a narrative which offers information about the identity of the perpetrator *as well as* the exact time and place of the crime is more specific than a narrative which *only* offers information about the perpetrator's identity; and so on. The specificity of a narrative can also be defined more precisely in terms of *informativeness*. For different accounts of informativeness, see (Carnap and Bar-Hillel, 1952), (Groenendijk and Stokhof, 1997), and (Floridi, 2004).

in *Prisoners* gives no answer. Instead, the narrative in *Parking* tells us that Ennio killed the victim in the parking lot, after an attempted sexual intercourse and during a fight; that he was wounded during the fight; and that he later transported the victim's body to the woods.

One way to understand the under-specificity of the prosecutor's narrative in *Prisoners* is to conceive of it as a disjunction of more specific narratives. Since there are one hundred prisoners in total, of whom ninety-nine participated in the killing, at least one hundred different narratives of the crime can be listed, as follows:[35]

100 narratives

N_1 : *Prisoner 1 did not participate; Eschaton and the others did.*
N_2 : *Prisoner 2 did not participate; Eschaton and the others did.*
N_3 : *Prisoner 3 did not participate; Eschaton and the others did.*
...
N_{99} : *Prisoner 99 did not participate; Eschaton and the others did.*
N_{100} : *Eschaton did not participate; the others did.*

As it turns out, each of the narratives above is equally 0.01 probable on the statistics.[36] Advancing any one of these narratives would be a losing strategy for the prosecutor because the available statistics do not support any of them. Absent other evidence, the prosecutor can resort to another narrative, call it *Eschaton-participated*, which is a *de facto* disjunction of 99 narratives, as follows:

100 narratives

N_1 : *Prisoner 1 did not participate; Eschaton and the others did.*
N_2 : *Prisoner 2 did not participate; Eschaton and the others did.*
N_3 : *Prisoner 3 did not participate; Eschaton and the others did.*
...
N_{99} : *Prisoner 99 did not participate; Eschaton and the others did.*

} *Eschaton-participated (disjunction of 99 narratives)*

N_{100} : *Eschaton did not participate; the others did.* } *Eschaton-did-not-participate*

Committing himself to *Eschaton-participated* is advantageous for the prosecutor because the narrative is 0.99 probable on the statistics.[37] The prosecutor in *Prisoners* need not be overtly aware of his choice of the narrative, but he ends up endorsing precisely *Eschaton-participated*, because he can only endorse a narrative which singles out Eschaton as a killer without identifying his ninety-eight co-perpetrators. Now, I should emphasize that *Eschaton-participated* lacks specificity, but not because it fails to identify the ninety-eight prisoners who partook in the killing with Eschaton—after all, knowing the identity of the co-perpetrators is unnecessary in a non-conspiracy case such as

[35] Depending on granularity, the narratives could be even more, if we consider an additional array of alternatives, e.g. concerning how fast each prisoner walked toward the guard; which weapons they were holding; what their facial expressions were like; etc. On the potentially infinite number of narratives, see (Friedman, 1992a).

[36] Given the statistics, Eschaton is 0.01 likely not to have participated in the killing, and so is any other prisoner.

[37] *Eschation-participated* is a disjunction of 99 narratives, each having a probability of 0.01. Summing the probability of each disjunct yields the probability of the disjunction (provided the disjuncts are inconsistent, as it is the case here).

Prisoners.[38] Rather, such narrative is less specific than the one in *Parking* because it does not tell us what Eschaton did during the killing and what role he played in the group of ninety-nine guilty prisoners. If *Eschaton-participated* holds, Eschaton could be *any* of the ninety-nine participants, and this is why the narrative is under-specified.

At this point, however, the reader might say: Why should the specificity of a narrative matter? What is the difference between Eschaton and Ennio? Aren't both of them in any case very likely to be guilty? In the rest of the paper we will see that a narrative's specificity is of tremendous importance for a defendant because it affects the exercise of his right to a defense. I discuss this topic from section 4 onwards, and in the next section, as a preliminary, I present an excursus on how an accused can defend himself.

3 Challenging the prosecutor

Once the prosecutor has made his incriminating case, the defendant can challenge it by introducing suitable *exculpatory evidence* of various kinds: common and expert knowledge, simulations, eyewitness testimonies, crime traces, etc. It is important not to confuse potentially and effectively exculpatory evidence. *Potentially* exculpatory evidence is *any* piece of information which, in the best judgment of a qualified defense team or of a rational fact-finder, might constitute a challenge to the prosecutor's case.[39] *Effectively* exculpatory evidence, instead, is evidence which actually weakens the prosecutor's case.[40] In other words, we should not confuse "attempting a defense" (i.e. gathering potentially exculpatory evidence) from "succeeding in a defense" (i.e. gathering effectively exculpatory evidence). When defendants are granted the right to a defense, this means that they should be in a position to gather potentially exculpatory evidence. They certainly aren't

[38] In conspiracy cases, the prosecutor has to show the existence of an agreed common plan or scheme to carry out the crime charged. This is not the case in *Prisoners*: each prisoner is assumed to have exercised violence against the guard without following a common plan.

[39] This notion is very inclusive. E.g. even when the defense lawyer is cross-examining a witness for the prosecutor, the witness' responses and their possible inconsistency with other evidence constitute potentially exculpatory evidence.

[40] The effectiveness of exculpatory evidence can be understood probabilistically, as follows: as the adversarial confrontation between incriminating and exculpatory evidence unfolds, the defendant's probability of guilt might increase or decrease; only if it (significantly) decreases, potentially exculpatory evidence counts as effective. The details are left to the judgment of a rational fact-finder but the process should at least be constrained by *Bayes' rule of update*; see, among others, (Dawid, 2002) and (Finkelstein and Fairley, 1970).

granted the right to a successful defense. In this background, I outline the defense avenues through which potentially exculpatory evidence can be put to use and the inherent limitations affecting its recovery; I say little or nothing about effectively exculpatory evidence.

One option for a defendant is to challenge the prosecutor's case internally by *cross-examining* whether it holds together. More precisely, since a prosecutor's case is essentially made up of the prosecutor's evidence and his narrative, cross-examination has two aims. It aims to show that the incriminating evidence is deficient, unreliable, or lacking trustworthiness.[41] It also aims to show that the narrative is incoherent, or that parts of the narrative are implausible or untenable.[42] These aims can be pursued by scrutinizing the prosecutor's evidence and his narrative against common knowledge of the world, scientific expertise, simulations, but also against witness testimonies, crime traces, statistics, etc.

The other option for a defendant is to challenge the prosecutor's case externally by presenting evidence in support of a counter-narrative which can establish the defendant's innocence. Call this *rebutting to* the prosecutor's case.[43] More precisely, when the defendant introduces evidence in support of an alternative narrative, this can either be a counter-narrative of the crime according to which another individual is the perpetrator or it can be an *alibi*-type counter-narrative according to which the defendant is unrelated to the crime.

To pursue a defense, be it in the form of cross-examination or a rebuttal, one needs to recover potentially exculpatory evidence. Three factors, however, restrict the recovery: the relevance of the evidence, one's resources, and the limited availability of the evidence.[44] The first factor is a requirement of common sense: the introduction of irrelevant evidence would cause complete disorder in trial proceedings. Relevant evidence, for my purposes, can be defined as evidence that, in the

[41] E.g. if the incriminating evidence consists in a witness testimony, cross-examining it means to show that the witness is dishonest, that the visibility conditions at the time of the crime were suboptimal, or that the witness' memory is weak; if the incriminating evidence is statistical, cross-examining it means to show that the statistics are flawed, the result of miscalculations, or based on an incorrect interpretation of the data. In both examples, potentially exculpatory evidence is needed to show e.g. the existence of bad visibility conditions or the occurrence of a miscalculation.

[42] E.g. the narrative asserts that the perpetrator strangled the victim with a piece of linen cloth, but post-crime forensic simulations show that linen cloth would break too easily.

[43] The distinction between cross-examining and rebutting is similar to the one by Pollock (1987) between *undercutting* and *rebutting* evidence. The defendant can also try other, much less common strategies, e.g. questioning the substantive law governing the case.

[44] A fourth constraint is legal: *inadmissibility* according to the law of evidence and procedure. See (Fisher, 2008) and (Allen et al., 2005).

judgment of a rational fact-finder, can support or challenge the prosecutor's narrative, or evidence that supports another narrative, be it another incriminating narrative or a counter-narrative.[45] For exculpatory purposes, relevant evidence is nothing but potentially exculpatory evidence, i.e. evidence that might constitute a challenge for the prosecutor's narrative or evidence supporting a counter-narrative. In the next section, we will see that what counts as relevant exculpatory evidence depends on the degree of specificity of the incriminating narrative.

The second factor concerns a defendant's intellectual and economic resources. Evidently, a defendant's resources affect his ability to recover exculpatory evidence, so that lawyers who are better skilled or better paid perform better. The law is aware that a disparity in resources will penalize or favour different defendants depending on their wealth, and thus it attempts to counter this problem by enforcing certain legal protections. For instance, *the right to counsel* ensures that all defendants have access to a minimum amount of resources.[46]

Finally, the third constraint is the limited availability of the evidence. A piece of (relevant) potentially exculpatory evidence might not be available in court, because it does not exist (e.g. a witness is deceased), or because though it exists it is not brought to court (e.g. an alive witness does not appear in court). The limited availability of the evidence has an adverse impact on defendants to which the law tries to remedy. Of course, when the evidence is unavailable because it is inexistent, little can be done. When instead the unavailability is due to circumstances that can be controlled, e.g. when a witness refuses to testify, measures such as *subpoena* or *disclosure* can be implemented as a safeguard for defendants.[47]

Let us look more closely at cases in which the (un)availability of the evidence in court cannot be controlled. The extreme case is one in which the evidence does not physically exist, e.g. when there are no crime traces. The legal system can exercise no control at all on physically inexistent evidence. A second, less extreme case is one in which a piece of evidence does not exist because of society's

[45]The *Federal Rules of Evidences*, rule 401, read: 'Evidence is relevant if (a) it has any tendency to make a fact more or less probable than it would be without the evidence; and (b) the fact is of consequence in determining the action.' A standard probabilistic rendering of the notion of relevance is given by Lempert (1977).

[46]E.g. the right to counsel is protected by the 6th Amendement to the U.S. constitution; Gideon v. Wainwright, 372 U.S. 335 (1963), mandates that a counsel should be appointed for all indigent defendants in all felony cases.

[47]E.g. the *subpoena duces tecum* compels a witness to appear in court and disclose relevant documents. For a recent discussion of the compulsory process in U.S. law, see Hewett (2007).

limited knowledge and technology, e.g. when the technology to analyze certain traces has not yet been invented. Though we might expect the legal system to encourage the development of forensic science, we cannot expect it to control the advancement of science.[48] These two cases indicate that even in the most defendant-friendly legal systems and even for the wealthiest defendants, the in-court availability of the evidence is not always controllable. We might say that the availability of the evidence is often *subject to luck*, in the sense that in many situations, despite a defendant's best efforts, the successful recovery of the evidence remains *unlikely*.[49] But although luck is widespread, it affects the availability of some kinds of exculpatory evidence more than others. To see this, compare the following types of evidence: simulations, common and scientific knowledge, expert testimonies, witness testimonies, crime traces, character evidence, and statistics.

(a) The availability of common knowledge or simulations is the least subject to luck; these are common and almost always available, at least for any reasonably equipped defendant.

(b) Slightly more subject to luck is the availability of relatively common scientific and forensic expertise about general phenomena concerning ballistic, eyewitness memory, the resistance of materials, physical and behavioural patterns, etc. The constraints on availability here are mainly confined to whether or not the needed scientific expertise exists, and as long as the phenomenon in question has been studied, there should be no obstacle to the recovery of the evidence.

(c) Finally, eyewitness testimonies and trace evidence, but also statistical data and character evidence,[50] are less common and their availability is significantly subject to luck: no witness might have been present during the crime; traces could have dissolved; the relevant statistics might not exist; etc.[51]

[48] The U.S. National Research Council has recently commented on how to strengthen forensic science; see (NRC, 2009).

[49] Luck is a pervasive phenomenon, and to use an expression by Lewis (1989), criminal defendants participate in a *penal lottery*. Convictions and acquittals depend on an unprejudiced jury, a talented lawyer, an impartial judge, the evidence recovered about the crime, money, etc. We can exercise some institutional control on these variables, but a degree of luck persists. Pritchard (2005) gives an account of luck in our epistemic practises.

[50] On character evidence, see a textbook in Evidence Law, e.g. (Méndez, 2008). For a general discussion of why character evidence is relevant, see (Redmayne, 2002).

[51] There might be internal variations as well. Because of sociological reasons, there may be more statistics or more witness testimonies about certain groups of people than about others. On this score, Banks (2001) describes how race influences the availability of witness testimonies.

This concludes my excursus on how an accused can defend himself and on the constraints affecting the recovery of exculpatory evidence. In the next section, I concentrate on how a defendant can cross-examine a prosecutor's narrative. In particular, I show that a more specific narrative can counter the restrictive effects due to relevance, resource shortage, and limited availability of the evidence.

4 The benefits of more specificity

In section 2 I suggested that *Prisoners* and *Parking* differ from one another because the incriminating narratives therein possess different degrees of specificity. The still open question is why a narrative's specificity should be important in trial proceedings. In this and the next section I answer this question by describing the benefits a defendant enjoys when he is confronted with a more specific narrative of the crime, and the harms he suffers from a less specific narrative, *as far as his ability to cross-examine the prosecutor's narrative is concerned*. In this section I motivate a couple of general claims about the benefits and harms associated with more specificity, and in the next section I apply these findings to Eschaton and Ennio.

To begin with, suppose a prosecutor's narrative in a homicide case is quite under-specified: it does not describe the weapon used in the crime; it does say how many people partook in the crime; it does not say how the victim was killed. To cross-examine this narrative, the exculpatory evidence will have to be quite extensive and able to challenge the "unspoken" possibilities that the unspecified narrative left open. The exculpatory evidence will have to consider poisoning, strangulation, stabbing, and many other ways in which the victim could have been killed; it will have to take into account the possibility that the perpetrator acted alone or with accomplices; etc. This means that an extensive body of knowledge and information would be required to challenge the narrative in question. Instead, if the prosecutor's narrative mentioned that the perpetrator was alone and that he poisoned the victim, the lawyer for the defense would only need to recover exculpatory evidence pertinent to the claims that the defendant acted alone and poisoned the victim; he would not need to consider the possibilities that the defendant acted in a group or that he killed the victim in other ways. This suggests a *first conceptual correlation*: the less specific a

narrative, the wider the body of evidence which is needed to challenge it; conversely, the more specific a narrative, the more circumscribed the evidence needed to challenge it.

This conceptual correlation has a practical consequence. As far as a defendant with infinite resources is concerned, how much evidence he needs does not matter: he would always be able to recover it (unless the evidence in question does not exist). But for a typical defendant, who is equipped with limited resources, gathering exculpatory evidence requires some effort, cognitive and monetary. In particular, a typical defendant is subject to the following practical constraint: the recovery of a more extensive body of evidence requires the investment of more resources, other things being equal; conversely, the less extensive the required evidence, the less burdensome its recovery.[52] Now, by merging the practical constraint and the above conceptual correlation, it follows that:

For the purpose of cross-examining the prosecutor's narrative, whenever the incriminating narrative is *more specific*, gathering potentially exculpatory evidence is *less costly* because a less extensive body of evidence is needed; conversely, whenever the incriminating narrative is *less specific*, gathering potentially exculpatory evidence is *more costly* because a more extensive body of evidence is needed;

But there is another effect of specificity. To illustrate, suppose the prosecutor's narrative asserts that the defendant alone strangled the victim with a piece of linen cloth. This is a rather detailed claim. A piece of potentially exculpatory evidence in this case can consist in the information that the defendant lacks the physical ability to strangle another human being or that linen cloth is a fragile fabric. The information about the resistance of linen fabric or about the defendant's ability to strangle the victim is relevant only because the incriminating narrative mentions that the defendant strangled the victim with a piece of linen cloth; if the narrative did not, such information—*by itself*—would be irrelevant. This suggests a *second conceptual correlation*: the more specific a narrative, the more pieces of evidence are relevant for cross-examining it; conversely, the less specific a narrative, the fewer pieces of evidence are relevant for cross-examining it. In other words, the more specific a narrative, the wider the range of relevant evidence; the less specific a narrative, the narrower the range of relevant evidence. (Be mindful of the difference between the two conceptual

[52] This correlation is based on the observation that e.g. to administer one hundred DNA tests is more burdensome than administering ten; or to interrogate one hundred witnesses is more burdensome than interrogating only ten; etc.

correlations: the first states that if a narrative is more specific, the extent of the evidence *needed* to cross-examine it narrows, while the second states that if a narrative is more specific, the extent of the evidence *relevant* to cross-examine it widens.)[53]

The second conceptual correlation has a practical consequence, as well. From section 3, we know that defendants might be unable to recover potentially exculpatory evidence because its availability is subject to luck, though some types of evidence are more subject to luck than others: the availability of common and scientific knowledge is minimally subject to luck, whereas the availability of eyewitness testimonies, statistics, and character evidence is significantly subject to luck. This suggests that if it were possible to cross-examine the prosecutor's narrative by means of common and scientific knowledge, one's dependence on luck would be minimized. Interestingly, if the above conceptual correlation is true, the range of relevant evidence widens proportionally with the narrative's degree of specificity, and thus, when a narrative becomes sufficiently specific, the range of relevant evidence will include common knowledge, simulations, and expert knowledge. This conclusion is confirmed if we return to the above example which involved a narrative asserting that the defendant strangled the victim with a piece of linen cloth: it is because of the narrative's specificity that a piece of scientific evidence about the resistance of linen fabric could constitute relevant exculpatory evidence. So, here is another effect of specificity:

For the purpose of cross-examining the prosecutor's narrative, whenever the narrative is *more specific*, the successful recovery of potentially exculpatory evidence is *less subject to luck* because a wider range of evidence is relevant. Conversely, whenever the narrative is *less specific*, the successful recovery of potentially exculpatory evidence is *more subject to luck* because a narrower range of evidence is relevant.

Hence, *as far as cross-examining the prosecutor's narrative is concerned*, the benefits of a more specific narrative are: less resources needed in the recovery of exculpatory evidence and less dependence on luck. Conversely, the harms resulting from a less specific narrative are: more resources needed and more dependence on luck.

[53] To merge the two correlations into one, we could say: the more specific a narrative, the more susceptible to be cross-examined; the less specific, the less susceptible. This is a consequence of a more general claim: logically stronger statements are more susceptible to be contradicted than logically weaker statements. E.g. the *conjunction* of A, B, C, and D, is more susceptible to be contradicted than the *disjunction* of A, B, C, and D, because a conjunction can be proven wrong by disproving *just one* of the conjuncts, while to disprove a disjunction *all* the disjuncts should be disproven. The notion of susceptibility is similar to Popper's notion of *falsifiability*; see (Popper, 1935, 2002).

5 How specificity affects Ennio and Eschaton

Comparing Eschaton and Ennio as defendants will exemplify the general statements made in the previous section. To begin with, recall that in *Prisoners* ninety-nine prisoners killed the warder and only one did not; Eschaton is the only one who had the misfortune to be captured and brought to court. From section 2, we know that the prosecutor's narrative against Eschaton is quite underspecified, for it consists in a *de facto* disjunction of 99 narratives. This disjunction does not tell us the role Eschaton played in the group of ninety-nine guilty prisoners, so that according to such narrative Eschaton could be any of them and he could have participated in the killing in various different ways. Now, in order to object to a disjunction without directly establishing that the contradictory proposition is true, one has to object to each single disjunct. Likewise, to cross-examine a disjunction of 99 narratives, Eschaton has to cross-examine each of them. To this end, he could simulate the 99 narratives of the crime left open by the prosecutor and he could show that each of them is untenable. But now recall the first conceptual correlation from the previous section: the less specific a narrative, the more extensive the evidence needed to challenge it. Thus, scrutinizing the plausibility of many alternative narratives requires an extensive body of evidence, and in turn, recovering an extensive body of evidence is very demanding, intellectually and economically. Presumably, Eschaton's resources are bounded, so it might very well be practically impossible for him to cross-examine the prosecutor's narrative. We would need a precise estimate of his resources to make a more dependable assessment here, but roughly speaking, Eschaton's situation does not seem to be any easier than that of a defendant who can hope to exculpate himself only by administering hundreds of DNA tests on all posible suspects.

(Incidentally, the problem of the excessive costs associated with scrutinizing 99 narratives individually could be solved if one piece of evidence were sufficient to cross-examine the narratives *at once*. But how? It's simple: a witness could testify that Eschaton did not participate in the killing; statistics and character evidence could suggest that Eschaton is very unlikely to have participated; it could turn out that other prisoners had better motives to kill than Eschaton; etc. In other words, the problem would be solved if Eschaton could find evidence in support of a counter-narrative, evidence that proves his own innocence. In the terminology of section 3, in doing so Eschaton would

no longer be engaged in cross-examination but in a rebuttal. I shall comment on this point in the next section.)

Now contrast Ennio's situation with Eschaton's. The prosecutor's narrative asserts that Ennio had (or attempted to have) sexual intercourse with the victim in the parking lot; that he engaged in a fight with the victim during which blood stains formed on the ground as a result of serious wounds, which both Ennio and the victim suffered; and finally, that Ennio killed the victim with a knife and hid her body in the woods. This narrative rests on three claims, among others: the perpetrator used a knife to kill; the victim's and the perpetrator's blood fell on the ground during a fight, roughly at the same time; the sexual intercourse took place immediately before the killing. The defense could challenge these claims by gathering exculpatory evidence suggesting a number of things: that while the wounds on the victim's body were caused by a knife, they were unrelated to the victim's death; that the victim's blood stains in the parking lot are more recent than the perpetrator's; or that the victim's death and the sexual intercourse occurred far apart in time. To support these objections to the prosecutor's narrative, different forms of exculpatory evidence could be introduced at this point. Let us consider a form of evidence whose availability is not highly subject to luck, such as expert testimony. Forensic experts could testify about how the wounds formed on the victim's body and whether they are connected to the victim's death; they could also testify about the blood stains found in the parking lot and the semen on the victim's body.[54] The expert testimony might suggest that something different happened from what the prosecutor's narrative asserts: maybe Ennio did not kill the victim with a knife, or maybe he did not kill her at all; maybe Ennio's and the victim's blood feel in the parking lot at separate times and the two events are not related; maybe Ennio had sex with the victim but this is unrelated to the killing. These are all examples of "reasonable doubts" which the defendant could raise.

It is important to appreciate that the expert testimony in question can potentially raise the reasonable doubts I've just described *because of the incriminating narrative's degree of specificity*. Let me explain. In accordance with the second conceptual correlation in the previous section (i.e. the more detailed the narrative, the wider the body of relevant exculpatory evidence), the expert testimony

[54] On bloodstains patterns analysis, see (James et al., 2005); on crime scene reconstruction, see (Gardner and Bevel, 2009).

in question is relevant for exculpatory purposes because the incriminating narrative specifies the weapon used in the killing, the place of the killing, and it asserts that the killing was immediately preceded by sexual intercourse. Absent these details, the expert testimony about the wounds, the blood and the semen—*by itself*—would be irrelevant to exculpate Ennio. Further, confronted with a relatively detailed narrative, the defense is not burdened with excessive economic or intellectual costs. The reason is that the needed exculpatory evidence is relatively circumscribed: as we've seen, the expert testimony about the wounds, blood, and semen could be enough to challenge the prosecutor's narrative. This exemplifies the first conceptual correlation, i.e. the more detailed the narrative, the less extensive the exculpatory evidence needed to challenge it.

Now, although Ennio is in a position to recover potentially exculpatory evidence for cross-examinining the prosecutor's narrative, he might still not succeed in his defense. This is inconsequential for my discussion. The important lesson here is that Ennio, unlike Eschaton, can gather potentially exculpatory evidence for cross-examinining the prosecutor's narrative. Eschaton is unable to do so because the narrative against him is too under-specified, with the consequence that it is too costly for him to gather the needed exculpatory evidence. This shows that the degree of specificity of the incriminating narrative does matter a great deal for defendants. But where does this leave us? We've seen that Eschaton is unable to cross-examine the prosecutor's narrative, but how worrisome should that be? One could argue that we need not worry so long as Eschaton has other defense avenues at his disposal, i.e. rebutting to the prosecutor's case or cross-examining the prosecutor's evidence. In the next section, however, I suggest that the possibility to cross-examine the prosecutor's narrative is a crucial component of one's right to a defense.

6 Right to a defense: what does it mean?

The right to present a defense is widely proclaimed in the constitutions of many countries.[55] In its utmost generality, this right ensures that a defendant should be able to present evidence and

[55]Defendants' rights are protected by the 6th Amendment to the U.S. Constitution; by article n. 11 of the Universal Declaration of Human Rights (1948); by article n. 67 of the Rome Statute of the International Criminal Court (1998); by article n. 111 of the Italian Constitution (1947); by article n. 24 of the Spanish Constitution (1978); by article 5.XXXVIII and 5.LV of the Brazilian Constitution (1988); and the examples could continue.

arguments against the prosecutor's case. This can be done in two ways: by presenting evidence in support of a counter-narrative, a narrative alternative to the one proposed by the prosecutor; or by cross-examining the prosecutor's case and raising "reasonable doubts" without offerring a counter-narrative. In section 3 I called these two options, respectively, *rebutting* and *cross-examining* the prosecutor's case. In what follows I offer a few tentative considerations for why the right to a defense should include the right to cross-examine the prosecutor's case, and also, for why the right to cross-examination should be construed broadly and include cross-examining the prosecutor's evidence *as well as* his narrative.

To begin with, the right to cross-examine one's accusers is deeply rooted in the common law.[56] But what is its justification? Many adduce *epistemic* considerations and regard cross-examination as an effective way to identify unreliable witnesses and evidence.[57] The rationale here is that if both parties do their best—the prosecutor by making his best incriminating case, and the defense by throughly cross-examinaning it—,we are more likely to discover whether the defendant is innocent or guilty. This is probably correct in theory, provided the prosecutor and the defense both seek the truth and introduce evidence of the best quality. The reality of trial proceedings, however, is different: the evidence is often poor, scarse, and fragmentary; time and resources are limited; and each party is more concerned with winning rather than with seeking the truth.[58] We do not know, then, whether the supposed epistemic virtues of cross-examination persist in actual legal proceedings.[59]

If the epistemic justification is unconvincing, we may try to justify cross-examination as a matter of *procedural fairness*. Fairness requires that both parties in the trial should be able to present evidence and arguments in support of their position. This is a restatement of the right to a defense,

[56] E.g. in U.S. law, see Alford v. U.S., 282 U.S. 687 (1931) ['cross examination is a matter of right' *at* 691].

[57] More than a century ago J.H. Wigmore in his *Treatise on the Anglo-American System of Evidence in Trials at Common Law* (1904) famously wrote that cross-examination is "the greatest legal engine for the discovery of truth." See also Davis v. Alaska, 415 U.S. 308 (1974) ['cross examination is the principal means by which the believability of a witness and the truth of his testimony are tested' *at* 316]; U.S. v. Salerno, 505 U.S. 317 (1992) ['in the Anglo American legal system cross examination is the principal means of cross-examining the credibility of a witnes whose testimony is false or inaccurate'].

[58] On the many limits and defects of the criminal justice system in the United States, see e.g. (Stuntz, 2011).

[59] As far as actual legal proceedings are concerned, the epistemic virtues of cross-examination have never been fully demonstrated, although they haven't been disproven either. For a review of the literature and an epistemic defense of cross-examination, see e.g. (Sanchirico, 2009).

which I take to be self-justifying. The right to a defense, we've seen, can be exercised by rebutting or by cross-examining the prosecutor's case. Here I wish to suggest that a defendant who is deprived of the possibility to cross-examine the prosecutor's case is altogether deprived of his right to a defense. The reason is that a defendant can rarely rebut to the prosecutor's case. Let me explain. To pursue a rebuttal, a defendant cannot rely on easily available forms of evidence such as common and scientific knowledge; rather, he needs to find testimonies, traces, character evidence and suitable statistics which can prove his innocence (rebutting to the prosecutor's case, after all, means to gather evidence in support of a counter-narrative that can prove one's innocence). But as we have seen in section 3, the availability of these forms of evidence is significantly subject to luck. *Prisoners* is an example. The evidence therein is very scarse: all prisoners fled from the crime scene except Eschaton; the guard is dead; no other witness was present during the crime; a fire erased most crime traces; Eschaton does not have an *alibi* because he was obviously there when the killing occurred. Eschaton is therefore unable to gather evidence for a rebuttal. The situation in *Parking* is similar. Presumably, no witness was present during the crime, except Ennio and the victim; the relevant crime traces have already been recovered by the investigators; probably Ennio does not have an alibi; no counter-statistics are available; etc. The evidential scarcity that characterizes *Prisoners* and *Parking* is not an exception; on the contrary, in most criminal cases the evidence is scarse and fragmentary, and thus it is rare that a defendant can gather evidence for a rebuttal through which he can prove his own innocence.[60] Cross-examination, then, is often the only way for a defendant to exercise his right to a defense. Absent even that possibility, the right to a defense would be rendered effectively null.

The above completes the first part of my argument, suggesting that the right to a defense is empty without the right to cross-examine the prosecutor's case. Now, this conclusion does not yet show that Eschaton has been deprived of his right to cross-examination. From section 5, we know

[60]We might ask why a defendant is unable to gather evidence for a rebuttal. Is it because he is guilty? Though attractive, this explanation is misleading. For instance, it does not apply to *Prisoners*. Eschaton's inability to find evidence for a rebuttal is not a consequence of his supposed guilt. Had he been innocent or guilty, this would have little effect on the availability of exculpatory evidence. More generally, the presence or absence of an eyewitness does not depend on whether one committed a crime or not; it depends o whether the witness happened to be there when the crime was committed. The same goes for statistics and character evidence. Even the presence or absence of crime traces is unrelated with guilt or innocence: it has more to do with the perpetrator's ability or inability to eliminate crime traces. All in all, I think no inference is justified from the absence of exculpatory evidence towards guilt.

that he cannot cross-examine the prosecutor's narrative, but he might still be able to cross-examine the prosecutor's evidence. (Recall: cross-examining the evidence means to challenge its reliability and trustworthiness; cross-examining a narrative means to challenge its plausibility, coherence, and compatibility with other evidence.) In fact, Eschaton can cross-examine the incriminating statistics: he can do so, for instance, by recounting the number of prisoners who participated in the killing. This strategy will certainly be unsuccessful—the statistics, after all, are hard to question—but strictly speaking, Eschaton still enjoys the possibility to gather *potentially* exculpatory evidence; and the right to a defense ensures that a defendant should be in a position to gather potentially, not effectively exculpatory evidence. Does Eschaton still retain his right to cross-examination, then? The answer to this question depends on how we interpret such right. We might interpret it broadly, as including the right to cross-examine the prosecutor's evidence *together with* the right to cross-examine the prosecutor's narrative. We might also interpret it minimally, as including the right to cross-examine the prosecutor's evidence *or* the prosecutor's narrative. Only on the broad interpretation would Eschaton be deprived of the right to cross-examination—and below I shall advance a few suggestions in favour of the broad interpretation.

Cross-examination typically serves the purpose of scrutinizing the prosecutor's evidence *as well as* his narrative. Take the example of an eyewitness. Cross-examination tests whether the witness' eyesight or hearing is good, or whether the lighting conditions were suitable for the eyewitness to see what he claims he saw. This is an instance of cross-examining the evidence. But cross-examination *also* tests whether the story (narrative, theory) of the crime which the eyewitness is telling holds together, has no gaps or inconsistencies. This is an instance of cross-examining the narrative (in this case, the witness' narrative, which presumably is part of the prosecutor's narrative). It would be a halved cross-examination one in which the defense lawyer had the opportunity to ask questions about the visibility conditions under which the witness saw the crime, but he was incapacitated to examine whether the witness' narrative had gaps or inconsistencies. As far as the *oral testimony* of a witness is concerned, then, cross-examination consists *both* in cross-examining the evidence and in cross-examining the narrative.[61]

[61] In the common law tradition, the right to cross-examination emerged in the context of oral testimony. See e.g. the statement by Justice Antonin Scalia in Crawford v. Washington, 541 U.S. 36, 43 (2004), that 'the common-law tradition is

When the target of cross-examination is statistical or expert evidence, a statistician will take the stand, testify as to the matter he is expected to report about, and make himself available for cross-examination. But here is where the difference between *Parking* and *Prisoners* surfaces again. As we have seen in section 5, while the defense in *Parking* can cross-examine the prosecutor's evidence *and* narrative, in *Prisoners* the only available option is to cross-examine the prosecutor's evidence, not his narrative. It follows that Eschaton can exercise his right to cross-examination only partly, at least compared to cases of oral testimony, and in general, to cases such as *Parking* in which the incriminating narrative is detailed enough to be susceptible to cross-examination.

7 Probability and the criminal standard of proof

In the previous section, I've suggested that the right to a defense should include the right to cross-examine the prosecutor's case, which can be inclusively construed as consisting of cross-examining the prosecutor's evidence *and* his narrative. I've also suggested that on the inclusive interpretation Eschaton has been partly deprived of his right to cross-examination. Yet, a doubt lingers: Eschaton is 0.99 likely to be guilty; this is a high guilt probability, an indicator of a seemingly strong prosecutorial case against him. What more are we to expect from the prosecutor? In this section I respond to this line of argument and I also address the more general question of whether the criminal standard of proof can be probabilistically quantified.

Let me begin by emphasizing that the nature of trial proceedings is dialogical; legal proof consists in a back-and-forth between proof and counter-proof. By *proof* I refer to the prosecutor's case, consisting of the incriminating evidence and the incriminating narrative; by *counter-proof* I refer to the defendant's challenges against the prosecutor's case, in the form of a rebuttal or cross-examination. Given this background, I suggest that we understand the criminal standard of proof "dialogically" in relation to the process of proof and counter-proof. This means that the standard is met *only after* challenges have been leveled *and* resisted. Those who think that a high guilt probability is enough to meet the criminal standard are only partly right. If a high guilt probability

one of live testimony in court subject to adversarial testing.' The live, oral testimony of a witness made cross-exmination a natural instrument to scrutinize the evidence; in contrast, cross-examining a document or fingerprint traces is much less natural.

is the result of a prosecutor's case *which has resisted challenges*, high guilt probability is enough to meet the criminal standard.[62] But high probability, in and of itself, is not enough if it rests on a prosecutor's case *which has gone unchallenged*.[63]

We should now become clear on what it meas that a prosecutor's case has gone unchallenged. It can mean that the defendant has not yet challenged it, though he is in a position to do it. But more interesting for my argument is when a prosecutor's case goes unchallenged because the defendant, despite his best efforts, is incapacitated to level challenges. In either case, there are two types of challenges against the prosecutor's case: rebuttal and cross-examination (and, in turn, cross-examination can target the incriminating evidence or the incriminating narrative). If the conclusion of the previous section is correct, a defendant has a right to cross-examination and he should not be deprived of the possibility to challenge the prosecutor's case by cross-examinining it. A more precise characterization of the criminal standard of proof would therefore be as follows: if a high guilt probability is the result of a prosecutor's case *which has survived cross-examination*, high guilt probability is enough to meet the criminal standard; it is not enough to meet the standard if it is the result of a prosecutor's case *which has avoided cross-examination*.[64]

As far as cross-examination is concerned, Ennio and Eschaton are in different situations. Section 5 shows that Eschaton is unable to cross-examine the prosecutor's narrative, and not because he tried and failed. The prosecutor shielded himself from criticism by adopting an under-specified narrative, consisting of a disjunction of 99 more detailed narratives. The situation for Ennio is different because, as section 5 shows, he is in a position to cross-examine the prosecutor's narrative. Crucially, what accounts for this difference is that in one scenario the prosecutor's narrative is more specific and it can be subject to challenges, while in the other the prosecutor's narrative evades challenges because of its under-specificity. If the narrative in *Parking* were subject to cross-

[62] In probability theory, some distinguish between the probability of a proposition from the *resiliency* of the probability assignment. Resiliency is a measure of the stability of a probability assignment in light of future (possibly contradicting) evidence; see (Skyrms, 1977). In the context of trial proceedings, resiliency can be interpreted as resistance to challenges, so that the criminal standard of proof can be construed as requiring a high and resilient probability of guilt.

[63] The law of procedure is very sensitive to the importance of challenges being leveled against the prosecutor's case. The 6th Amendment to the U.S. constitution and the relevant case-law protect defendants against the ineffective assistance of counsel. A lawyer failing to raise challenges against a prosecutor's case is one who has failed to effectively assist his client.

[64] Along similar lines, see (Stein, 2005, p.100).

examination and it survived it, it see no objection to a conviction. The same goes for *Prisoners*, but the problem here is that the prosecutor's narrative cannot be subject to cross-examination in the first place.

Are we to conclude, then, that the criminal standard is not (and cannot be) met in *Prisoners*? This will depend on our interpretation of the right to cross-examination. On my suggested characterization, the criminal standard is met whenever the defendant's probability of guilt is high—the precise value is not important here—*and* such probability rests on a prosecutor's case *which has survived cross-examination*. If we understand the process of cross-examination broadly, as consisting in a scrutiny of the incriminating evidence *as well as* of the incriminating narrative, the criminal standard in *Prisoners* cannot be met because Eschaton is incapacitated to cross-examine the prosecutor's narrative. Yet, he can still cross-examine the prosecutor's evidence (though somewhat vacuously), so if we understand cross-examination more minimally, the previous conclusion does not follow. So, how are we to understand the right to cross-examination, broadly or minimally? I began to address this question in the previous section by saying that such right is typically construed broadly, at least in the case of cross-examining lively witnesses. I shall sketch a few more ideas on cross-examination and its connection to narrative specificity in the next, and final section.

8 Specificity and criminal justice

Let me recapitulate my argument thus far. In this paper I commented on the role of statistical evidence in criminal trials and proposed a novel way to look at the matter. Instead of looking at the evidence as such, in section 2 I suggested that we examine the incriminating narrative supported by the evidence. My suggestion was that there is nothing intrinsically deficient about statistical evidence, and to this end, I used *Parking* as an example of a proper use of statistical evidence and *Prisoners* as an example of an improper use. What differentiates the two is the degree of specificity of the incriminating narrative in each scenario. In section 4 I described the benefits associated with a more specific narrative, and the harms resulting from a less specific narrative. I argued that the benefits are twofold: confronted with a more specific narrative, a defendant will need less resources and less luck to recover exculpatory evidence; conversely, confronted with a less specific narrative,

he will need more resources and more luck. In section 5, *Prisoners* served as an illustration of the harms associated with a narrative that is poor in specificity; in contrast, *Parking* served as an example of the benefits associated with a more specific narrative. As it turned out, Eschaton was deprived of the possibility to cross-examine the prosecutor's narrative, but Ennio wasn't, and this asymmetry was attributed to the different degree of specificity of the incriminating narratives they had to face. In section 6, I suggested that Eschaton's impossibility to cross-examine the prosecutor's narrative amounted to a restriction of his right to cross-examination, and in general, of his right to a defense. Finally, in section 7, I examined the question of whether a high probability of guilt is enough to meet the criminal standard of proof. I reasoned that probability alone is not enough: for the standard to be met, I suggested, the prosecutor's case should be subject to challenges and resist them.

The benefits associated with a more specific narrative should now be clear, at least *at the procedural level*. The open question of the paper is how to understand the right to cross-examination. Should it include the right to cross-examine the prosecutor's narrative, or is the cross-examination of the evidence (but not of the narrative) enough for the exercise of such right? We have seen that a way to ensure that a defendant can cross-examine the prosecutor's narrative is by requiring that a prosecutor's narrative be sufficiently specific to be susceptible to cross-examination. Thus, another way to pose our open question is: How robust should the demand for a specific narrative be? Answering this question goes beyond the scope of this paper. My task here has been to investigate what the demand for specificity is and which party in the trial gets injured if the demand is not honoured. I argued that specificity should be understood in terms of "narrative specificity" and that a narrative which is poor in specificity harms defendants.

Interestingly enough, the resulting harm can also manifest itself more broadly at the systemic level. If prosecutors were explicitly allowed, or even encouraged to put forward narratives with a minimal degree of specificity, just like in *Prisoners*, they might start doing it more often. If so, more defendants will find themselves unable to introduce exculpatory evidence and unable to challenge the prosecutor's narrative. As a consequence, the overall accuracy of the criminal justice system will decrease, at least on the assumption that the less evidence is available about a crime—evidence

coming from both sides—, the less likely it is that an accurate judgment will result.[65] So, although the demand for specificity is not exclusively rooted in epistemic values, its systematic disregard might have negative epistemic consequences at the systemic level.

But besides protecting and acquitting possibly innocent defendants, a legal system should also aim to convict criminals and reduce crime. A too strong reverence for specificity might harm the system's ability to identify and convict criminals. For instance, in *Prisoners*, because of the condition of inherent evidential scarcity, the prosecutor would be unable to recover any more evidence, and thus he would be unable to advance a more specific narrative. This means that the prosecutor would be unable to comply with the demand for more specificity, except by halting the trial against Eschaton. Is halting a trial against a defendant who is very likely to be guilty an acceptable price to pay? The answer depends on how many scenarios like *Prisoners* there are, and any pronouncement is premature without empirical data on the type of statistical evidence used in criminal trials, and on how often it is used and in what kind of cases.[66]

If it is a too drastic remedy to halt a trial against a defendant on the ground that the prosecutor's narrative is under-specified, we may select a number of less drastic measures to honour specificity. For instance, without putting any general prohibition in place, prosecutors could be discouraged from relying on under-specified narratives if appellate courts were openly sensitive to the demand for specificity. Alternatively, if a narrative that is poor in specificity forces a defendant to need more economic and intellectual resources, the justice system might protect the defendant by granting him more resources or more time to put together a defense.

All in all, two further questions emerge from the investigation of this paper. One is how to

[65] Although the use of manipulating and deceiving evidence might undermine the claim in the text, the correlation "more evidence/more accuracy" should hold good for the trial system overall, unless defendants are systematically prone to introduce misleading evidence.

[66] Cases like *Prisoners* are so remote that we might safely assume that there won't be many of them. Yet, similar cases in which statistical evidence plays an important role might appear more frequently. For instance, they could involve statistical estimates about the amount of drug illegally transported; on the role of statistical sampling in drug trafficking cases, see (Izenman, 2003). If fighting drug trafficking is overwhelmingly important, a demand for specificity might be harmful for a country's criminal justice system. On the other hand, one significant datum, already available, is that in some countries only a very small portion of criminal litigations is decided by means of standard trial proceedings. For instance, in 2009 more than 85 percent of all criminal litigations in U.S. federal courts resulted in a conviction by plea bargaining; see (Motivans, 2011), and more generally, on the rise of plea bargaining, see (Fisher, 2003). Hence, given the widespread recourse to plea bargaining, a demand to honour specificity is unlikely to have any paralyzing effect on the criminal justice system.

apportion the costs and benefits associated with taking seriously the demand for specificity. The other question is how to implement the demand itself (e.g. by halting trials, by giving defendant more resources, etc.). As remarked above, the task of this paper has been to address the foundational question of what the demand for specificity is and the question of which party in the trial gets injured if the demand is not honoured. I argued that specificity is a feature of an incriminating narrative, and that defendants facing under-specified narratives will be the adversely affected party.

APPENDIX: DNA EVIDENCE AND PROBABILITY OF GUILT

I have assumed that Ennio's probability of guilt in *Parking* equals 0.99. In this appendix I illustrate how Bayes' theorem can be used to arrive at this probability value. In general, for a body of evidence E and hypothesis H, one formulation of the theorem is as follows:

$$\frac{P(H|E)}{P(\neg H|E)} = \frac{P(E|H)}{P(E|\neg H)} \times \frac{P(H)}{P(\neg H)}.$$

In other words,

$$\textit{posterior odds} = \textit{likelihood ratio} \times \textit{prior odds}.$$

The posterior probability $P(H|E)$ is usually given by $\frac{PO}{1+PO}$, were PO are the posterior odds.[67]

When a case involves DNA evidence, in order to establish the probability of guilt, we should first determine the probability that the defendant is the source of the genetic traces found at the crime scene—and Bayes' theorem is very useful to determine the source probability. Let S be the proposition that the defendant is the source of the crime traces; let M be the proposition that the defendant and the traces match; let f represent the frequency of the DNA profile in question. We want to know the probability of S given M. By replacing H with S and E with M, Bayes' theorem reads:

$$\frac{P(S|M)}{P(\neg S|M)} = \frac{P(M|S)}{P(M|\neg S)} \times \frac{P(S)}{P(\neg S)}.$$

Let us begin by estimating the prior probabilities $P(S)$ and $P(\neg S)$. One option is that, for a suspect population of n individuals, $P(S) = 1/n$. This assumes that each individual is equally likely to be the source. Is this plausible? And how large is the suspect population? The largest suspect population is the earth population, but we could also take the population of a town or a country. Another option consists in taking the smallest possible value for $P(S)$, maybe even smaller than $1/n$, with n the earth population. The rationale is that there are incredibly many ways in which one could have left traces at the crime scene, and these ways are more in number that the total

[67] The pages that follow have benefited from reading (Dawid, 2002), (Thompson et al., 2003), (Robertson and Vignaux, 1995). and (Buckleton, 2005a).

earth population.[68] Yet another option is that we consider an interval of prior probabilities and we assess their impact on the posterior probability.[69] This might be the most sensitive approach to take. All in all, assigning prior probabilities is difficult and it is one of most contested issues in the application of Bayes' theorem to criminal trials. On the other hand, we should always begin somewhere; any reasoning begins with an assumption, and the need to assign prior probabilities only makes this explicit.

Next, we need to determine the value of $P(M|S)$, which is typically set to one. The reason is that if the defendant actually left the traces, the laboratory analyses would show a match. This is a simplification, for the laboratory analyses might fail to show a match even though the defendant did leave the traces (what is called a *false negative*). I leave this complication aside and put $P(M|S) = 1$. Finally, we should determine the value of $P(M|\neg S)$. If the defendant is not the source, what is the probability that a match would turn up? This is typically taken to be equivalen to the frequency f of the DNA profile. Again, this is a simplification because the defendant might not possess the DNA profile in question although laboratory analyses show that he does (what is called a *false positive*). Complications aside, we have:

$$\frac{P(S|M)}{P(\neg S|M)} = \frac{1}{f} \times \frac{P(S)}{P(\neg S)}.$$[70]

It is now useful to give some numerical examples. By varying the prior probability assignments and the frequencies of the DNA profile in question, the posterior odds are as follows:

$P(S) \approx$ Prior Odds	frequency	Posterior Odds	$P(S\|M)$
1 in 1 million	1 in 100 million	100	0.99
1 in 100 million	1 in 100 million	1	0.5
1 in 1 million	1 in 1 billion	1000	0.999

From the table, it is clear that Ennio is 0.99 likely to the source of the crime traces if his prior probability of guilt is 1 in 1 million and if the DNA profile has a frequency of 1 in 100 million.

[68] See (Friedman, 2000).
[69] See (Finkelstein and Fairley, 1970).
[70] This simple analysis can be found, among others, in (Dawid, 2002) and (Balding, 2005).

Note that I used a simplified Bayesian formalization of DNA evidence. The likelihood ratio was taken to be $1/f$, with f the frequency of the DNA profile. Part of the simplification here is that $P(M|\neg S) = f$, which does not take into account the possibility of a false positive in the laboratory report (i.e. the laboratory reports a match but in fact the two samples do not match). Another simplification is that $P(M|S)$ was assumed to equal one. This does not take into consideration the possibility of a laboratory false negative. A more sophisticated Bayesian formalization can take into consideration these complications.[71]

The value 0.99 that Bayes' theorem yields corresponds to the *source probability*, but what we need is an estimate of the *guilt probability*. How do we get from one to the other? Since *Parking* is an idealized scenario, we can assume that the crime traces found at the crime scene were left by a guilty individual, or at least, we can assume that it is highly probable that they were. Thus, $P(G) \approx P(S) \approx 0.99$. Strictly speaking, however, $P(G) < P(S)$. This means that, in order to have $P(G) \approx 0.99$, we should require that the source probability be higher than 0.99. For the source probability to be higher than 0.99, we would need the frequency of the DNA profile to be lower than 1 in 100 million or the prior probability of Ennio being the source to be higher than 1 in 1 million. I leave to the reader the task of adjusting the scenario *Parking* accordingly.

[71] See (Thompson et al., 2003), (Robertson and Vignaux, 1995). and (Buckleton, 2005a). More generally, see (Schum and Kadane, 1996).

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