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WHAT ARE WE COMPARING IN COMPARATIVE NEGLIGENCE?

PAUL H. EDELMAN*

I. INTRODUCTION

As the majority of jurisdictions in the country have moved from contributory negligence to comparative negligence in tort cases, judges commonly ask juries to assign a percentage of negligence¹ to each of the parties involved in a negligence tort. While the practice of apportionment has become commonplace, the theory behind it is little understood. What exactly does it mean to assign percentages of negligence in a negligence case? The nature of the fault may be quite different for each party, making it quite difficult for the jury to combine them. Do the units used to measure the amount of negligence matter? Should the jury apportion negligence in some absolute way or in some relative way? None of these questions have obvious answers, and no scholar has addressed how juries should make these assessments.²

* © Paul H. Edelman. Professor of Mathematics and Law, Vanderbilt University. I have profited from the comments of Mark Brandon, Lisa Bressman, Robert Cooter, John Goldberg, Michael Green, Chris Guthrie, Saul Levmore, Richard Nagareda, Robert Rasmussen, Margo Schlanger, Suzanna Sherry, Robert Thompson, and Christopher Yoo.

1. There are a plethora of words other than “negligence” one might use to describe what juries are asked to apportion in tort cases. The *Restatement (Third) of Torts* cites “responsibility,” “fault,” and “causation” as other terms that are commonly used. RESTATEMENT (THIRD) OF TORTS: APPORTIONMENT OF LIAB. § 8 cmt. a (2000). It prefers the term “responsibility” since “[a]ssigning shares of ‘fault’ or ‘negligence’ can be misleading because some causes of action are not based on negligence or fault,” and “‘causation’ wrongly suggests that indivisible injuries jointly caused by two or more actors can be divided on the basis of causation.” *Id.* I focus only on negligence torts between two parties, therefore the concern expressed by the *Restatement* over the use of “negligence” is not warranted in my situation. Moreover, as will become clear in Section III, I will clarify what I mean by apportioning negligence in terms of shortfalls from reasonable levels of care, thus the use of the term negligence is not inappropriate. It is also the term most commonly used in the courts. The downside of using “negligence” is the possible confusion between the level of care taken and the tort itself. See JOHN C. P. GOLDBERG ET AL., TORT LAW, RESPONSIBILITIES AND REDRESS, 135 (2004). But since I am solely concerned with negligence torts and this analysis is based on the presumption that all the elements of a negligence tort have been met, there should be little cause for confusion.

2. Scholars have compared the efficiency of comparative negligence to other tort regimes. See, e.g., WILLIAM M. LANDES & RICHARD A. POSNER, THE ECONOMIC STRUCTURE OF TORT LAW 80–82 (1987); Tai-Yeong Chung, *Efficiency of Comparative Negligence: A Game Theoretic Analysis*, 22 J. LEGAL STUD. 395 (1993); Robert D. Cooter & Thomas S. Ulen, *An Economic Case for Comparative Negligence*, 61 N.Y.U.L. REV. 1067 (1986); David Haddock & Christopher Curran, *An Economic Theory of Comparative Negligence*, 14 J. LEGAL STUD. 49 (1985); Daniel Orr, *The Superiority of Comparative Negligence: Another Vote*, 20 J. LEGAL STUD. 119 (1991); Daniel L. Rubinfeld, *The Efficiency of Comparative Negligence*, 16 J. LEGAL STUD. 375 (1987). But efficiency alone cannot

A small hypothetical will help illustrate the problem: The owner of a building is negligent in its asbestos abatement. He rents the building to a smoker who subsequently contracts lung cancer. The smoker sues the owner of the building for his medical costs. The building owner claims as a partial defense that the renter's smoking contributed to his disease. How should a jury apportion negligence in this case?

The building owner's negligence might be quantified using the difference between what he spent on abatement and what an adequate abatement would have cost. Alternatively, the jury might use the percentage of the cost of an adequate abatement that was actually spent by the owner. Or the jury might use some other method entirely.

It is no more obvious how to assess the smoker's negligence. Should it be the number of packs smoked per day? The cost of the number of packs? The total cost spent on cigarettes during the renter's lifetime? The personal utility that the smoker would lose if he were to quit smoking? Something else entirely?

Even if the jury crosses these hurdles, its job is not over. Jury members next have to apportion the blame between the parties. How should they combine the measurements of individual negligence into a percentage of the total amount of negligence? What is the correct way to compare, say, the shortfall in the cost of abatement with the number of packs of cigarettes smoked in a day? How should the jury even approach these questions?

The consequences of the jury's assignment are potentially huge. In some states, a plaintiff who is assessed fifty percent or more of the fault is barred from recovery entirely. And even if the assignment does not serve as a complete bar, the percentages assigned are used to apportion the damages. In spite of the significance of the assignment, no guidance is given to the jury as to what to do.

This Article begins the formal study of how juries should calculate the percentages of negligence they are required to provide. Based on the standard model of negligence from law and economics, I will provide a specific framework for juries to use. This framework determines fault assessment based on different kinds of negligence torts. I distinguish among the methods of apportionment by examining the incentives they give for the parties to exercise care. As a consequence of this analysis, I

distinguish the alternative methods of apportionment. The issue requires separate consideration.

make specific recommendations for jury instructions in comparative negligence cases.³

This Article proceeds in four parts. After a brief discussion in Section II of what juries are asked to do in assigning responsibility in comparative negligence cases, I will introduce three new concepts to analyze the nature of negligence cases. In Section III I classify two party negligence cases as being either *commensurable* or *incommensurable*, depending on whether the nature of the care to be taken by the two parties lies on the same or incomparable scales. Since a jury will be called upon to compare the levels of care taken and their ability to do so is radically different in the two cases, this distinction is an important one in comparative negligence regimes.

Associated with these two different kinds of negligence cases are two different measures for the percentage of negligence that juries are called upon to produce in a comparative negligence regime. One measure, the *percentage of absolute negligence*, assesses the percentage in terms of the deviation from the reasonable level of care in absolute terms. The other, the *percentage of relative negligence*, assesses the percentage in terms of the level of reasonable care taken by the parties. The former measure requires a direct comparison of levels of care, while the latter does not require such a comparison.

In Section IV of this Article, I introduce two different models of the relationship between levels of care and damages. The first, the *additive care model*, assumes that the damages are solely a function of the total amount of care taken, and the care taken by one party can act as a direct substitute for the care of the other. The second model, the *multiplicative care model*, assumes that the care taken by each party acts as an amplifier (or attenuator) for the other, but not as a direct substitute. By analyzing these models, I show that under the additive care model using the absolute percentage of negligence will align the assessment of negligence with the apportionment of damages. Similarly, in the case of the multiplicative care model, the relative percentage of negligence achieves the correct alignment of negligence and damages.

Section V ties these three pairs of concepts together: I recommend that the method to assess the percentage of negligence be tailored to the nature of the negligence so as to correctly align the assessment of negligence

3. Throughout this Article, I will concentrate on negligence cases consisting of two parties: a plaintiff who has suffered harm and a defendant. This restriction will help simplify the exposition. Nevertheless, the approach I develop generalizes naturally to negligence cases with multiple tortfeasors.

with the apportionment of damages. Following a brief conclusion in Section VI, the paper closes with a technical appendix, establishing the claims made throughout the paper.

II. THE CONTOURS OF COMPARATIVE NEGLIGENCE

In this section I discuss what sources are available to guide juries in apportioning negligence in a comparative negligence regime. I will consider three sources: jury instructions, the *Restatement of Torts*, and a sense of rough justice. As will become evident, each of these methods has its shortcomings, and none of them adequately addresses the core problem of how to compute negligence apportionment.

In the forty-six states that have adopted comparative negligence,⁴ juries in negligence actions are routinely asked to assign shares of negligence to the parties. The percentages assigned, which must add to one hundred percent, are used in two ways. In states with modified comparative negligence, if the plaintiff is deemed responsible for fifty percent or more of the negligence, then she may be barred from any recovery.⁵ That is, the assignment of the percentage of negligence, in and of itself, can affect the disposition of the case.

If the state follows a pure comparative fault regime, or if the percentage of negligence assigned to the plaintiff is less than fifty percent, then the assigned percentages of negligence are used to apportion the damages. The defendant will be responsible for the same percentage of the damages as they are assessed in negligence. The plaintiff's recovery will be reduced by the percentage by which she was found negligent. So, if the damages are found to be \$1,000, and the plaintiff is found to have been twenty-five percent negligent while the defendant is found to be seventy-five percent negligent, then the defendant would be liable for $0.75 \times \$1,000 = \750 .

4. Maryland, Virginia, North Carolina, Alabama, and the District of Columbia continue to use contributory negligence. VICTOR SCHWARTZ, *COMPARATIVE NEGLIGENCE* § 1.05[e][3], at 29 (4th ed. 2002).

5. This is a slight oversimplification of the differences among modified negligence regimes. In some states, the plaintiff may be barred from recovery if his negligence is equal to or greater than that of the defendant. In other states, the plaintiff is barred if his negligence is strictly greater than that of the defendant. Schwartz cites fourteen states in the first category and twenty-one states (and the Virgin Islands) in the second. Oddly, he has Oklahoma listed in both. In South Dakota, the plaintiff is barred from recovery if his negligence "is more than slight." *Id.* § 3.01, at 58.

As an example of the kind of inquiry that juries make, consider this verdict form that has been approved by the Supreme Court of Colorado for use in comparative negligence cases:⁶

We, the jury, present our Answers to Questions submitted by the court, to which we have unanimously agreed:

QUESTION NO.1: Was the defendant, _____, negligent? (yes or no)

ANSWER NO. 1:

QUESTION NO. 2: Was the defendant's negligence, if any, a proximate cause of the plaintiff's claimed (injuries) (damages) (losses)? (yes or no)

ANSWER NO. 2:

QUESTION NO. 3: Was the plaintiff, _____, contributorily negligent? (yes or no)

ANSWER NO. 3:

QUESTION NO. 4: Was the plaintiff's contributory negligence, if any, a proximate cause of (his) (her) claimed (injuries) (damages) (losses)? (yes or no)

ANSWER NO. 4:

QUESTION NO. 5: If you have answered all the four foregoing questions "yes," then you are to answer this question:

Taking the combined negligence that proximately caused the (injuries) (damages) (losses) as 100 percent, what percentage of that negligence was attributable to the defendant and what percentage was attributable to the plaintiff?

ANSWER NO. 5:

Percentage of combined negligence attributable to defendant,
_____ : _____ %

Percentage of combined negligence attributable to plaintiff,
_____ : _____ %

6. *Id.* § 17.04[c], at 369 (citing Richard W. Laugesen, *Colorado Comparative Negligence*, 48 DEN. L. J. 469, app. at 495 (1972)). For a similar special verdict form from Tennessee, see GOLDBERG ET AL., *supra* note 1, at 387.

Total: 100%

QUESTION NO. 6: If you have answered Questions 1 and 2 “yes,” state the amount of damages, if any, sustained by the plaintiff and proximately caused by the (accident) (occurrence), without regard to the contributory negligence of the plaintiff, if any.

ANSWER NO. 6: \$_____.

If the answers to the first four questions are all “Yes,” the judge uses the remaining answers in two possible ways. First, if the percentage of combined negligence attributable to the plaintiff is fifty percent or greater, then under Colorado law the plaintiff is barred from any recovery.⁷ Second, if the plaintiff is not barred from recovery, the defendant is liable for the percentage of damages equal to the percentage of combined negligence that he was apportioned in Answer No. 5.

It is critical to note that, under these instructions, the apportionment of negligence is distinct from the computation of damages. The jury is meant to determine the apportionment of negligence without regard to the amount of damages in question. Thus, they are asked to work with the abstract ideas of negligence instead of the more concrete value of damages. Only after the percentage of negligence is decided are the damages assessed to the plaintiff, discounted by an amount equal to the percentage of negligence assigned to him. The jury is never required to determine the relationship between each individual party’s behavior and the amount of damage produced.

For a somewhat different view of what juries should do in a comparative negligence case, consider the discussion of assigning shares of responsibility in section eight of the *Restatement (Third) of Torts: Apportionment of Liability*:

§ 8. Factors for Assigning Shares of Responsibility

Factors for assigning percentages of responsibility to each person whose legal responsibility has been established include

(a) the nature of the person’s risk-creating conduct, including any awareness or indifference with respect to the risk created by the conduct and any intent with respect to the harm created by the conduct; and

7. COLO. REV. STAT. § 13-21-111(3) (2005). As noted earlier, some states bar recovery only if the percentage strictly exceeds fifty percent. *See supra* note 3.

(b) the strength of the causal connection between the person's risk-creating conduct and the harm.⁸

Part (a) of this two-prong assessment is quite compatible with the previous discussion of what juries should do. It is focused solely on the behaviors of the parties without respect to any relationship between those actions and the damages generated.

Part (b), on the other hand, is quite different. It focuses on the connection between the behavior of the party and the harm. The term "strength" is left undefined,⁹ but it would seem to be a more refined measure of causation than proximate cause, since the proximate cause threshold has already been crossed. It also focuses on "the harm" rather than the accident, suggesting the jury should be concerned with the amount of harm each party generated rather than their contribution to the negligence itself.

The notion that the percentage of negligence should reflect the amount of harm each party's actions generated is intuitive and just, but it presents troubling questions. In comparative negligence, it is necessarily true that both parties' actions led to the harm. At the same time, it is impossible to isolate exactly which actions caused which damages. As noted in the *Restatement*, "[a]ssigning shares of 'causation' wrongly suggests that indivisible injuries jointly caused by two or more actors can be divided on the basis of causation."¹⁰

A second-best solution harnesses the economic incentives that the tort system provides to the parties.¹¹ More specifically, the tort system provides incentives for the parties to take an optimal level of care, and it makes possible the assignment of responsibility on this basis. Rather than look to the actual damages generated by each party, if such an inquiry is even possible, we might instead ask how the level of care chosen by each party increased the expected damages from an accident. For example, one might know what the increase in expected damages in a car accident is as a function of speed. Then, in a traffic accident case, one might be able to specify the percentage of the expected damages generated by a speeding automobile. Potentially, this percentage could be used to allocate the

8. RESTATEMENT (THIRD) OF TORTS, *supra* note 1, § 8.

9. Comment (c) helpfully remarks that "[t]he comparative strength of the causal connection between the conduct and the harm depends on how attenuated the causal connection is, the timing of each person's conduct in causing the harm, and a comparison of the risks created by the conduct and the actual harm suffered by the plaintiff." *Id.*

10. *Id.* at § 8 cmt. a.

11. *See, e.g.*, RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW § 6.1 (6th ed. 2003).

actual damages. One might think that it is no easier to allocate actual damages based on an apportionment of expected damages than it is to deal with the actual damages in the first place. But, as I will subsequently show, the move to expected damages simplifies the question considerably.

None of this is to say that juries actually make their decisions in accordance with any of these frameworks. They might ignore whatever question is put to them and simply produce a rough justice that is driven by a desired outcome. They might adjust the apportionment of negligence to distribute the damages in an equitable manner, adjust the damages so as to guarantee a certain payout to the defendant, or some combination of these strategies. While one cannot guarantee that juries will be controlled by the questions that are asked or even fully understand what those questions are, it is not unreasonable to think that the questions posed will frame their inquiry and influence their deliberations. Moreover, if the questions that are posed to them are indeterminate, ill-posed, or poorly phrased, then there is little or no chance that the jury will feel constrained to respond only to them.

III. APPORTIONING NEGLIGENCE

In this section I develop the formal framework for how to apportion negligence. It consists of three sub-sections. The first confronts the problem of comparing the negligence of the parties when the nature of the care to be taken is vastly different for each. The second subsection describes the formal model, adapted from a classical law and economics approach to torts. Using this model, I introduce two distinct methods of apportioning negligence. In the last subsection, I describe how these methods are applied in different circumstances.

A. Commensurable and Incommensurable Care

Consider the following two negligence hypotheticals:

Hypothetical I: Driver A is speeding down a road at fifty miles per hour in a thirty-mile-per-hour zone. Driver B, going in the opposite direction down the same road, makes a left-hand turn in front of A without signaling. The two cars collide. Driver B sues A for negligence, and A claims that B was at fault as well.

Hypothetical II: The owner of a building does a negligent job of asbestos abatement. He rents the building to a smoker, who subsequently contracts lung cancer. The smoker sues the owner of the building for his medical costs.

If these cases were to be tried, the juries would most likely have to decide on the relative levels of negligence for each of the parties. Yet, the inquiry is different in these two hypotheticals. In the first hypothetical, the nature of the care to be taken is the same for the two parties: drive safely. Juries might sensibly compare the care taken by each of the drivers because, at least conceptually, a single scale applies to both.¹²

By contrast, the second hypothetical presents the jury with the challenge of comparing apples to oranges. The nature of the care to be taken by the owner of the building is with respect to proper asbestos abatement procedures. The nature of the care to be taken by the lessee is with respect to leading a healthy life. How is a jury to measure one against the other in anything but an ad hoc way? The types of care fall on different, incommensurable scales, making a direct comparison impossible. Indeed, any comparison a jury purports to make is simply ad hoc.

The challenge is to disaggregate the two types of torts and create fault assessment methods for each. I will call a negligence tort in which the care taken by the parties lies on a common scale a *commensurable* tort and one for which the types of care lie on different scales an *incommensurable* tort. This use of the term *commensurable* is consistent with some, although not all, of its uses in legal academia.¹³ Whether a negligence tort is commensurable or incommensurable depends, to some extent, on the specificity of the nature of care at issue. For example, all negligence torts would be commensurable if we were to specify the nature of care as “being careful.” On the other hand, my first hypothetical could be characterized as incommensurable if the nature of the care of driver A is described as “don’t go too fast” and that of B is “don’t turn without signaling.” Nevertheless, this distinction will help focus attention on the problems the jury confronts in deciding comparative negligence.¹⁴ Note that I am not asserting that the parties’ behavior cannot be compared in an incommensurable tort. Rather, I am claiming that they cannot be compared

12. It is interesting to note that in the *Restatement*, all the illustrations of assigning fault involve car accidents, thus keeping the inquiry as simple as possible. See *RESTATEMENT (THIRD)*, *supra* note 1, § 8 cmts. b, c, illus. 1–7.

13. In particular, it is consistent with Ruth Chang, *Introduction to INCOMMENSURABILITY, INCOMPARABILITY, AND PRACTICAL REASON 1* (Ruth Chang, ed., Harvard Univ. Press 1997). For further discussion of other legal uses of the term, see Matthew Adler, *Law and Incommensurability: Introduction*, 146 U. PA. L. REV. 1169 (1998).

14. The difficulty facing juries in incommensurable torts has been noted before. See *RESTATEMENT (THIRD)*, *supra* note 1, § 8 reporter’s note to cmt. a.

in the same straightforward way as in commensurable torts. More work is necessary.¹⁵

Allowing for incommensurable scales of care may seem jarring in a paper that adopts a law and economics framework. Indeed, whether there is such a thing as incommensurability is the subject of considerable debate.¹⁶ The typical law and economics approach would be to monetize care, thus making all torts commensurable. This is certainly appropriate for torts where the nature of negligence is an inadequate investment in care, e.g., not fencing a swimming pool or not providing a life guard. In those cases, it makes sense to identify the shortfall in negligence with the cost of providing due care.

However, the assumption that one can always monetize the level of care is problematic for three reasons: it may be very unclear how to monetize the care, the monetization may not capture the level of negligence, and juries, who are asked determine the apportionment of negligence, may not view negligence in this fashion.

Consider the following hypothetical: A joyriding teenager decides that it would be fun to try and drive blindfolded. Needless to say, an accident ensues. How should we monetize the teenager's negligence? Does it equal the value of the blindfold, or the amount of money that would persuade him not to drive blindfolded? Would either of these amounts (or any other plausible valuation) come close to capturing our intuitive sense of the extent of the teenager's negligence? Would any such amount be plausible to a jury? It seems clear that monetization in this situation is just not a viable way to proceed.¹⁷

B. Absolute and Relative Negligence

I now proceed to the formal description of how to apportion negligence. I develop two different methods. The first is applicable only to commensurable torts, but the second can be applied to either commensurable or incommensurable torts.

15. This is the distinction between incommensurability (the lack of a common scale) and incomparability (the inability to compare two things). Certainly incomparability implies incommensurability, but the converse need not be true. For further discussion of this distinction, see Chang, *supra* note 13, at 4–7.

16. See, e.g., Chang, *supra* note 13; Symposium, *Law and Incommensurability*, 146 U. PA. L. REV. 1169 (1998); Cass R. Sunstein, *Incommensurability and Valuation in Law*, 92 MICH. L. REV. 779 (1994).

17. It is worth noting that most of the rest of the paper is not dependent on rejecting the idea that care can always be monetized. Most of the concepts and distinctions will apply even if one believes that all torts are commensurable.

For commensurable torts, the percentage of negligence for each of the parties has a natural definition. Because the tort is commensurable, there is some scale of care on which we can plot the amount of care taken by the parties and the reasonable level of care required to avoid negligence (which, in principle, might be different for each of the parties). That is, let the level of reasonable care be denoted by x^* and y^* for the two parties A and B, respectively, and let their chosen levels of care be x' and y' .¹⁸ If both parties are negligent then $x' < x^*$, and $y' < y^*$. Let Δx be the difference between the level of reasonable care and the chosen level, i.e., $\Delta x = x^* - x'$, and similarly for Δy . Then the total amount of negligence is given by

$$(x^* - x') + (y^* - y') = \Delta x + \Delta y.$$

The percentage of the total negligence due to party A is

$$\frac{\Delta x}{\Delta x + \Delta y},$$

and the amount due to B is

$$\frac{\Delta y}{\Delta x + \Delta y}.$$

The task of assigning percentages of negligence, in the commensurable case, can be accomplished by working with the absolute deviations from reasonable care. I will refer to these as the percentages of *absolute* negligence. This definition of the percentage of negligence has been considered previously by Cooter and Ulen.¹⁹

It is worth noting that the percentages of absolute negligence can be computed solely from information on the relative size of the negligence. That is, if A is deemed to be twice as negligent as B, then we can conclude that $\Delta x = 2\Delta y$, and hence the percentage of absolute negligence of A is two-thirds and that of B is one-third. If the tort is commensurable, then the

18. I am assuming here, and throughout the rest of the Article, that care is usefully modeled as a continuous variable. This assumption is not necessary in this section, but it will be in the next. If care is truly binary (either one is careful or one isn't), then the analysis in this paper is inappropriate, since it would be impossible in any meaningful sense to quantify the amount of negligence. I believe that in the vast majority of situations, however, there is a gradation of care, and that is sufficient for my needs.

19. Cooter & Ulen, *supra* note 2, at 1103. Cooter and Ulen initially adopt this method of assigning percentages of negligence. However, they immediately reject it as "not, however, the best representation of the law." *Id.* They then argue that "a good measure of the contribution is the relative increase in expected accident losses due to each party's negligence." *Id.* Thus, they explicitly identify the percentage of negligence with the percentage of expected costs associated with their level of care. Since the purpose of this paper is to unpack the relationship between percent negligence and percent damages, I will not be as quick to dismiss this formulation as they were.

inquiry into the relative size of the negligence is a coherent question to ask a jury.²⁰

For incommensurable torts, the calculation of absolute percentages is not possible. The definitions of Δx and Δy still make sense, because each difference is computed with respect to only one scale, but the incommensurability of the two scales means that the sum $\Delta x + \Delta y$ has no real meaning. How, then, should we go about relating the two standards of care?

To do this, we can work with percentages of reasonable care rather than the amount of care itself.²¹ That is, we can measure the relative amount of care of A by the value $\Delta x/x^*$ and the relative amount of care of B by $\Delta y/y^*$. These values are dimensionless; they measure the percentage of reasonable care each party took, but it is no longer in terms of particular scales of care. Thus, we can sensibly add these numbers to find the total negligence

$$\frac{\Delta x}{x^*} + \frac{\Delta y}{y^*} = \frac{y^* \Delta x + x^* \Delta y}{x^* y^*}.^{22}$$

The percentage of this negligence attributable to A is

$$\frac{\frac{\Delta x}{x^*}}{\frac{y^* \Delta x + x^* \Delta y}{x^* y^*}} = \frac{y^* \Delta x}{y^* \Delta x + x^* \Delta y},$$

and that attributable to B is

$$\frac{\frac{\Delta y}{y^*}}{\frac{y^* \Delta x + x^* \Delta y}{x^* y^*}} = \frac{x^* \Delta y}{y^* \Delta x + x^* \Delta y}.$$

I will refer to these measures as the percentages of *relative* negligence.

20. This is not strictly true as it depends on the nature of the scale and not just on the existence of a scale. Suppose we measure two objects and one has the temperature 35°C and the other is 70°C. We might be tempted to say that the second object is twice as hot as the first. But if temperature is measured in Fahrenheit, then the temperatures would be 85° F and 158° F, respectively, and the second object is not twice as hot. So, the claim that one object is twice as hot as the other is contingent on the scale itself and not on the existence of a scale. For further details on meaningful and meaningless statements about measurements see Fred S. Roberts, *Measurement Theory*, in *ENCYCLOPEDIA OF MATHEMATICS AND ITS APPLICATIONS* 71 (G. Rota ed., 1979).

21. This is not unlike the economist's use of price elasticity of demand, rather than the slope of the demand curve, as a way to circumvent the choice of units.

22. While adding incommensurable values is of dubious validity, there is no such problem with taking products as is done in this calculation. For a more familiar example, the unit of momentum is mass times velocity.

The choice of relative percentages has the additional benefit of giving the same outcome independent of the scale used for negligence.²³ As an illustration, suppose two people were asked to compute the percentage of the speed limit a car was traveling. It would not matter if the speed (and the limit) was measured in terms of miles per hour, kilometers per hour, or furlongs per fortnight, the answer would be the same. So, to this extent, even if jurors disagree on the scale of care they may get the same answer for the percentage of reasonable care taken.

It is important to note that, even though incommensurable torts necessitated the definition of percentages of relative negligence, the definition makes sense for commensurable torts as well. Thus, percentages of relative negligence give an alternative method for apportioning negligence to that of absolute negligence in the case of commensurable torts. I will return later to the question of which method should be applied when either can be used.

The percentage of relative negligence attributable to A is governed by the product of the absolute negligence of A with the level of reasonable care for B (algebraically, $y^*\Delta x$). That is, small absolute amounts of negligence by A are amplified by the level of care that B should reasonably take. What is the intuition behind this? The fact that B's reasonable standard of care (y^*) is quite high would imply there is a large risk of damage inherent in the situation. This implies that minimally negligent behavior by A could lead to an overall large drop in the total level of care.

Consider the following hypothetical: An independent contractor, A, is hired to do a hazardous job at a factory owned by B. As part of the contract, B is to provide a protective suit to A. Suppose B provides a suit that is somewhat substandard, but A does not button it securely. While completing the job, there is an accident that results in serious injury to A. Had A buttoned the suit securely he might have been harmed to some degree, but not nearly as much.

The level of negligence of A, measured in absolute terms, is not very large. Surely everyone has failed to button a piece of clothing securely at one time or another. But because he was in a particularly risky situation, indicated by the fact that B's reasonable level of care was high, the relative negligence on the part of A is quite substantial.²⁴

23. More precisely, the outcome is independent of any multiplicative change of scale.

24. Not coincidentally, the damages were mostly due to A as well.

C. Applying the Measures

While the absolute percentages of negligence are inapplicable to incommensurable torts, the relative percentages are applicable to all negligence torts. When do the two measures coincide? They will agree when $x^* = y^*$. That is, if the levels of reasonable care are identical then the absolute percentages of negligence are the same as the relative percentages. The larger the gap between the reasonable levels of care, the greater the difference between the two measures becomes.

To further illustrate the situation in which the choice of the two measures matters, consider the following hypothetical: Homeowner, A, leaves a loaded gun, with the safety off, on the kitchen table. Her invited guest, B, sees the gun and, assuming it is unloaded, proceeds to practice his “quick-draw,” resulting in him accidentally shooting himself in the foot.

If we view this as a commensurable tort, where the scale of care is “taking care with firearms,” then clearly both parties have been negligent. We might continue to observe that the level of reasonable care for A, the homeowner, should be considerably higher than that of B, the visitor. The homeowner has a duty to keep obviously dangerous items away from her guests. We would expect a gun owner to take more precautions with her weapon in anticipation of visitors. The guest was clearly negligent for playing with a gun, but his level of reasonable care would seem to be lower than that expected of A.

Because this example involves a commensurable tort, either the absolute or relative percentages of negligence could be used to establish comparative negligence. Yet the levels of reasonable care are so different that these measures are likely to produce vastly different values. How should we choose between the two measures?

One thing we might ask is which of these two methods gives the appropriate incentives to the parties to take due care. Unfortunately, that inquiry will not be dispositive. As Cooter and Ulen show,²⁵ both of these methods provide efficient incentives when the parties are fully informed.²⁶

If efficiency concerns will not help choose, perhaps equity concerns will. As discussed in Section II, one desirable characteristic of an allocation of negligence is that the allocation apportions the damages to the parties in relation to the extent their actions produced an increase in the

25. Cooter & Ulen, *supra* note 2.

26. This follows from minimal alterations in the analysis in the Mathematical Appendix (B). See *id.* at 1104.

expected damages. We can choose between the two methods of apportioning negligence by seeing which method does a better job meeting this goal. To do this, I will introduce two different models describing the relationship between levels of care and expected damages.

IV. ADDITIVE AND MULTIPLICATIVE CARE

In the previous section, I introduced two methods of assigning percentages of negligence based on the levels of care of the participants. One of the methods applies only to commensurable torts, while the other applies to both commensurable and incommensurable torts. In this section, I will investigate when these percentages of negligence are consistent with the percentages of expected damages generated by the two parties' actions.

In order to make the connection between responsibility and expected damages, I will need a model of how levels of care translate into expected damages. A common model is to assume that there is a function $D(x,y)$ that describes the expected damages given the levels of care.²⁷ Typically one would assume as little as possible about the nature of the function $D(x,y)$; the only commonly enforced requirements concern the behavior of the partial derivatives.²⁸ For my inquiry, however, it is necessary to specify more completely the function $D(x,y)$.

I will focus on two special cases for how the function $D(x,y)$ behaves. The first case is where $D(x,y) = q(x + y)$ for some function q . That is, the expected damages due to the choices regarding levels of care are dependent on the sum of the individual levels of care. I will refer to this situation as *additive* care. In additive care, the care taken by one party can act as a substitute for the care taken by the other. So, for example, in the case of car accidents (for instance, Hypothetical I from the previous section) additional care by one car could compensate for the lack of care by the other. In Hypothetical I, if the speeding car had been going slower or the turning car had waited until the speeding car had passed, the accident could have been avoided. The additive care model seems most applicable to commensurable torts, since it assumes that one party's care is directly substitutable (in a one-to-one relationship) by the other's.

The second special case of significance is when $D(x,y) = p(xy)$ for some function p . In this model, the expected damages are a function of the product of the levels of care. I will refer to this situation as *multiplicative* care. In multiplicative care, each party's care does not act as a substitute

27. See, e.g., STEVEN SHAVELL, FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW 183 (2004).

28. *Id.*

for the other, but rather as a magnifier of it. So, for instance, in Hypothetical II from the previous section, the remaining asbestos in the building compounded the effect of the smoking by the lessee but additional care by the lessor could not act as a substitute for it.²⁹ That is, the lessor could not act to lower the risk inherent in the lessee's smoking.³⁰

The multiplicative care model can be applied to either commensurable or incommensurable torts, but there would seem to be a particular affinity to incommensurable torts. If the levels of care are incommensurable, they are less likely to act as substitutes as opposed to amplifying factors. From a more formal perspective, by taking a product of the levels of care one need not worry that the units of care are not the same for each of the parties.

Both of these prototypical models of the relationship between care and the expected damages satisfy the minimum requirements for such functions, but their behaviors are really quite different. The differences have implications for the relationship between negligence and damages, as well as for classical questions about the "least cost avoider."³¹

The advantage of using this formal model is that it allows us, as a mathematical matter, to separate the contribution to the expected damages that each party makes by his actions. Suppose, as before, that party A takes a level of care x' and her level of reasonable care is x^* . Similarly, B's chosen level of care is y' , his reasonable level of care is y^* , and the function that describes the expected damages in terms of the level of care is $D(x,y)$. Thus, the expected damages produced by the combined actions of A and B are $D(x',y')$, whereas if they each had chosen reasonable levels of care one would expect damages amounting to $D(x^*,y^*)$.

Can we say anything meaningful about how much of the additional expected damages are due to the behavior of each party separately? Suppose that A had chosen the reasonable level of care x^* , but B had chosen the substandard level y' . Then certainly B would be responsible for the additional expected damages $D(x^*,y') - D(x^*,y^*)$ produced by his actions. Similarly, were B to have behaved reasonably (choosing y^*) and

29. Smoking and exposure to asbestos do, in fact, interact multiplicatively in the causing of lung cancer. See P. N. Lee, *Relation Between Exposure to Asbestos and Smoking Jointly and the Risk of Lung Cancer*, 58 OCCUP. ENVIRON. MED. 145 (2001).

30. Daniel Farber has noted via e-mail that the distinction between additive and multiplicative care is less clean than it might first appear. By making an exponential change in variables, one can change additive care in to multiplicative care, or vice versa. That is, if we let $v = \ln x$ and $u = \ln y$, then $p(xy) = p(e^v e^u) = p(e^{u+v}) = q(u+v)$. Thus, what is multiplicative care in the variables x and y is additive care in the variables u and v . E-mail from Daniel Farber to author (Sept. 9, 2006) (on file with author).

31. See SHAVELL, *supra* note 27, § 2.11.

A behaved unreasonably (choosing x') then A would be liable for the additional expected damages $D(x',y^*) - D(x^*,y^*)$. A fundamental theorem of several-variable calculus states that, under suitable conditions, the sum of these two individual contributions is a good approximation for the total increase in the expected damages.³² Moreover, one can estimate the percentage of each of the individual contributions without knowing very much about the functions themselves. Some examples will help clarify many of these ideas.

Example 1: Additive Care.

Suppose that the expected damages due to an accident are given by the formula

$$D(x,y) = \frac{1000}{x+y},$$

where x and y are the levels of care taken by the two parties, A, and B, respectively. Suppose that the levels of reasonable care are given by $x^* = 100$ and $y^* = 200$, and that the chosen levels of care are $x' = 99$ and $y' = 199$. The additional expected damages generated by the choice of less-than-reasonable care is

$$\Delta D = D(99,199) - D(100,200) = \frac{1000}{298} - \frac{1000}{300} = 3.3557 - 3.3333 = 0.0224.$$

The power of the formalism I have developed will now become evident. Using the differential approximation from several-variable calculus, one can identify how much of the additional expected damages are attributable to each of the parties. If x' and y' are close to x^* and y^* , then the contribution due to A is approximated by

$$\frac{1000}{(x^* + y^*)^2}(x^* - x') = \frac{1000}{300^2}(100 - 99) = (0.0111) \times 1 = 0.0111,$$

and similarly the contribution due to B is given by

$$\frac{1000}{(x^* + y^*)^2}(y^* - y') = \frac{1000}{300^2}(200 - 199) = (0.0111) \times 1 = 0.0111.³³$$

This differential approximation accounts for almost all of the additional expected damages:

$$\Delta D \approx \frac{1000}{(300)^2}(100 - 99) + \frac{1000}{(300)^2}(200 - 199) = (0.0111)(1) + (0.0111)(1) = 0.0222,$$

32. THOMAS H. BARR, VECTOR CALCULUS 195 (2d ed., 2001).

33. This is just an application of the standard differential approximation from several variable calculus as discussed by Barr. *See id.* *See also* Appendix, *infra* Section VII, for the general statement.

where the first term in the sum corresponds to the contribution due to A's negligence and the second term corresponds to B. This is not a perfect equality (although, in this instance, it is good to three decimal places), but it will be close as long as the chosen level of care is not too far from the reasonable level of care.

One might reasonably ask about situations in which the levels of care chosen are sufficiently far from the established reasonable levels so as to render the differential approximation useless. The standard law and economics response is that, under the usual hypotheses, perfect information will result in the parties choosing reasonable care, so that it is only under uncertainty that either party will act negligently.³⁴ If that is the case, it is reasonable to assume the uncertainty will result in only small deviations from the level of reasonable care, and so the differential approximation should be accurate. Conversely, the choice of a level of care far from the reasonable one might well be considered evidence of wanton disregard or deliberate indifference, which would allow for punitive damages. The addition of punitive damages could account for the difference between the differential approximation and the actual amount of expected damages generated.

In Example 1, the two parties play an equal part in generating the additional expected damage. Which of the two negligence apportionments agrees with this? The absolute percentages for A are

$$\frac{\Delta x}{\Delta x} + \Delta y = \frac{1}{1} + 1 = \frac{1}{2}$$

and, similarly, 1/2 for B. That is, the absolute percentages are exactly what we want.

By contrast, if relative percentages were used A would be assigned

$$\frac{y^* \Delta x}{y^* \Delta x + x^* \Delta y} = \frac{200 \times 1}{200 \times 1 + 100 \times 2} = \frac{2}{3},$$

and B would be assigned the remaining 1/3. Thus, in this circumstance, the absolute percentage is the better method to use for assigning comparative negligence.

Example 2: Multiplicative Care.

Consider a different function describing expected damages:

$$D(x,y) = \frac{1000}{xy}.$$

34. Cooter & Ulen *supra* note 2, § 2(B).

If we choose the same values for reasonable care and chosen level of care as in Example 1, then the additional expected damage generated by the negligence is

$$\Delta D = D(99, 199) - D(100, 200) = \frac{1000}{99 \times 199} - \frac{1000}{100 \times 200} = 0.05076 - 0.05000 = 0.0076.$$

As before, we can decompose the additional expected damage into its two constituent parts:

$$\Delta D \approx \frac{1000}{100^2 \times 200} \times (100 - 99) + \frac{1000}{100 \times 200^2} \times (200 - 199) = 0.0005 + 0.00025 = 0.00075$$

where the first term in the sum corresponds to the portion contributed by A and the second is that contributed by B. In this case, the additional expected damages generated by A's conduct are twice that of B's.

Because the values for reasonable care and chosen level of care are the same in this example as in Example 1, the absolute and relative percentages are the same as the ones we previously computed.³⁵ As demonstrated in Example 1, the absolute percentages give rise to an even split of the negligence. The relative percentages, however, are split two-thirds for A and one-third for B. Thus, in this example, the relative percentages give the better answer for assigning comparative negligence.

What do these two examples show us about when it is appropriate to use absolute percentages and when to use relative percentages? Example 1 illustrates additive care, where the expected damages are solely a function of the sum of the levels of care, and one party's care can act as a substitute for the other. In this example, the absolute percentages of negligence allocate the damages in the proportions by which the expected damages were generated. It is always the case that, in situations of additive care, the choice of the absolute percentages of negligence allocates the damages in the proportions by which the expected damages were generated by each party.³⁶

Example 2 illustrates multiplicative care, i.e., the expected damages are solely dependent on the product of the levels of care. In multiplicative care, the levels of care of each party act, not as a substitute for the other, but rather as an amplifying factor. The example illustrates what is true in general: for situations of multiplicative care, the choice of relative

35. The measures of percentage responsibility are computed solely in terms of the chosen level of care and the established level of reasonable care. One need not know anything about the function that relates levels of care to damages in order to make the calculation. See *supra* Section III for details.

36. See *infra* Section VII (Technical Appendix, Proposition 1).

percentages of negligence will allocate damages to each party in the proportions by which the expected damages are generated.³⁷

Thus, there are reasons to make both methods of apportioning negligence available. The method of absolute percentages is superior to the method of relative percentages when the tort is best described by additive care. The reverse is true if the tort is best described by multiplicative care.

V. THE RELATIONSHIP AMONG THE FACTORS

In the two previous sections I have introduced three pairs of concepts: commensurable and incommensurable torts, absolute and relative percentages of negligence, and additive and multiplicative care. In this section, I will tie these ideas together to provide a framework that courts and juries can use to analyze comparative negligence cases.

The most rigorous and precise connection is between the methods of apportioning negligence and the nature of the connection between care and damages. When care is additive, using absolute percentages of negligence will apportion the damages in the proportions by which the expected damages are generated. When care is multiplicative, relative percentages of negligence will similarly apportion the damages.

The connection between these two concepts and the remaining pair, commensurable/incommensurable torts, is necessarily less precise and more intuitive. If the tort is commensurable, when the nature of the care of each party is the same, either the absolute or relative percentages of negligence can be applied. The calculation of the absolute percentages relies on being able to add the levels of care, and hence it is necessary that the levels of care be commensurable. However, one could just as well compute the relative percentages of negligence if the tort is commensurable.

If the tort is incommensurable, however, it is not possible to compute the absolute percentages of negligence. Instead, one must employ the relative percentages. By working with relative percentages, we can avoid comparing the levels of care directly and instead work with dimension-free quantities. In situations where the levels of care of the parties cannot meaningfully be compared, there is little else that one can do.

And what of the relationship between commensurable/incommensurable and additive/multiplicative models? This is the most

37. See *infra* Section VII (Technical Appendix, Proposition 2).

speculative of the connections. Additive care can only adhere in situations for which the care of one party can completely substitute, in a one-for-one manner, for the care of the other.³⁸ This would suggest that the nature of the tort is commensurable since the types of care themselves are substitutable. However, it need not logically follow that all commensurable torts are best modeled by additive care.³⁹

If the tort is incommensurable, then the nature of the care of each party is incomparable. My intuition is that incomparable kinds of care cannot substitute for each other as in additive care, but are more likely to act as amplifiers (or attenuators) for each other. That is, incommensurable torts are likely to be best modeled by multiplicative care.

What are the implications of this for judges and juries? It suggests that, in comparative negligence cases, the instructions to the jury on how to compute the percentage of negligence should depend on the type of negligence tort in question. If the tort is commensurable and the nature of the care is additive, then the jury should be instructed to assess the percentage of negligence in absolute terms, i.e., how far was the party from taking reasonable care? If the tort is incommensurable or if the nature of care is multiplicative, then the jury should be asked to compute the percentage of negligence in relative terms, i.e., what percentage of reasonable care did each party take? By adjusting the calculation for the percentage of negligence depending on the nature of the tort and/or the nature of the care, we can allow the jury to make a coherent judgment and align the proportion of negligence with the proportion of damages that the parties might have expected to generate by their actions.

To be specific, if the tort is incommensurable or the nature of the care is multiplicative, the Colorado special verdict form⁴⁰ might be altered in the following way to reflect it:

QUESTION NO. 5: If you answered all the four foregoing questions “yes,” then you are to answer the next two questions. Note that the percentages requested need not add to 100%:

a) What percentage of reasonable care did the defendant take? As an example, 50% would indicate that the defendant took half as much care as he should have.

38. By one-for-one I mean that a decrease of one unit of care by one party can be compensated for by an increase of one unit of care by the other.

39. Although, at the moment, I am unable to provide a convincing example of a commensurable tort exhibiting multiplicative care.

40. *Supra* text accompanying note 6.

ANSWER NO. 5 a): The percentage of reasonable care taken by defendant _____ : ____%.

b) What percentage of reasonable care did the plaintiff take? As an example, 50% would indicate that the plaintiff took half as much care as he should have.

ANSWER NO. 5 b): The percentage of reasonable care taken by defendant _____ : ____%.

From the answers to these two questions, the judge can compute the relative percentages of negligence and then assess damages.⁴¹ If the jury is to be informed of the implications of its assignments for barring recovery, the form should include some statement like, "If the percentage assigned in ANSWER NO. 5 a) is smaller than that in ANSWER NO. 5 b) then the plaintiff will be barred from recovery of damages."

As an example of how this inquiry into relative percentages of negligence might lead to a significantly different outcome from the absolute percentages, consider Hypothetical II from Section III.⁴² Suppose it would cost the owner \$1,000,000 to abate the asbestos in his building, but he negligently performs the task at a cost of only \$900,000. Suppose the lessee smokes two packs of cigarettes per day and the level of non-negligent behavior, with regard to smoking, is only one pack per day. In addition, suppose the measure of negligence for the owner is the money spent on abatement, and the measure of negligence for the smoker is the inverse of the number of packs per day smoked.⁴³

What is the apportionment of responsibility under absolute percentages? The negligence on the part of the smoker is one pack per day and that of the building owner is \$100,000. How a jury would proceed from here is difficult to say, but \$100,000 is a lot of money relative to an extra pack a day habit. They might easily find the building owner has the preponderance of the responsibility here.

As was noted earlier,⁴⁴ smoking and exposure to asbestos interact in a multiplicative fashion to produce lung cancer, and so the computation of

41. I have phrased these questions in terms of percentage of reasonable care because I think that is easier to describe and somewhat more intuitive. The relative percentages of negligence would be obtained by subtracting these numbers from 100.

42. For an informative discussion of practical issues in apportioning negligence in cases such as this, see Michael Green, *A Future for Asbestos Apportionment*, CONN. INS. L. J. (forthcoming 2007) (on file with author).

43. So reasonable care for the smoker is $1 / 1 = 1$ and this particular smoker is exercising the level of $1 / 2 = 0.5$. The choice of units is, of course, arbitrary.

44. See Lee, *supra* note 29.

relative percentages of negligence would be more appropriate. The owner was ten percent negligent,⁴⁵ and the smoker was fifty percent negligent.⁴⁶ Thus, the percentages of relative responsibility are about sixteen percent for the owner and eighty-four percent for the smoker.⁴⁷

Of course, this proposed modification will put added responsibility on the judge to decide which of the methods of assessing percentage responsibility applies. But jury instructions are often the subject of controversy in tort actions, and one would expect that the courts will adopt general guidelines quickly.

VI. CONCLUSION

Throughout the United States, juries are routinely asked to apportion negligence among plaintiffs and defendants. Yet juries are given very little, if any, guidance on how to proceed. This Article demonstrates that there are at least two conceptually distinct ways of apportioning negligence and that they provide different incentives to take care. Whether those incentives are in alignment with the expected damages the parties produce based on their choice of care depends on the nature of the tort. Different torts may require different apportionments to correctly align the damages.

I hope that the framework developed in this paper will foster further inquiry into the workings of comparative negligence. The theoretical underpinnings of this regime are much more subtle than they first appear. A careful parsing of the questions (and answers) is sorely needed.

VII. TECHNICAL APPENDIX

In this appendix, I adapt the basic law and economics framework for the study of negligence to analyze the assignment of damages under a comparative negligence regime. The traditional use of this framework is not to study damages, but rather to investigate the relative efficiencies of comparative negligence to other negligence regimes such as strict liability, contributory negligence, etc. Nevertheless, these formal models are ideal

45. The owner spent \$900,000 of the required \$1,000,000 and so performed at ninety percent of reasonable care. I am assuming here that the level of exposure to asbestos is inversely related to the amount of money spent on abatement.

46. The smoker who smokes two packs a day has chosen a level of care equal to 0.5 and so the percentage negligence taken is $(1 - 0.5) / 1 = 0.5$.

47. See *supra* text accompanying note 22.

for sharpening our intuitions about the relationship between responsibility and liability.

A. *The Standard Model*

I will follow the standard model of accidents in which there is a victim, V, and an injurer, I, both of whom can take care to lower the risk of accident.⁴⁸ If x and y are the levels of care taken by V and I, respectively, assume that the expected damages due to an accident is given by the function $D(x,y) > 0$, which is decreasing in both variables. Taking care is costly, so let c_I and c_V be the costs per unit care for I and V. Under these assumptions, the expected social cost of an accident is

$$SC(x,y) = c_I x + c_V y + D(x,y)$$

where $c_I x$ and $c_V y$ represent the costs to the parties of taking care and $D(x,y)$ is the expected cost of an accident. Let x^* and y^* be the court-designated thresholds of reasonable care. It would be typical to assume that the pair (x^*,y^*) is also the socially optimum point, i.e., where the social cost is minimized, but I need not make that assumption for what follows. It is important to note that this choice of levels of reasonable care entails the expectation of some accidents. This is because care is costly, and so it is inefficient to try to eliminate all accidents.

Suppose that, for whatever reason, the parties exercise less than the reasonable care. Due to miscalculation, incompetence, willfulness, or some other reason, the parties choose x' and y' as their levels of care, where $x' < x^*$ and $y' < y^*$. Since both parties have chosen to exercise less-than-reasonable care, they would both be found negligent were an accident to occur. Let $\Delta x = x^* - x'$ and $\Delta y = y^* - y'$.

What is the appropriate way to compute the “percentage of combined negligence attributable”⁴⁹ to each party? There are two natural ways to proceed, and both will play a role in the subsequent analysis. The first is to say that the total amount of negligence in the situation is given by $\Delta x + \Delta y$, and so the percentage of that negligence attributable to V is $\Delta x / \Delta x + \Delta y$ and that attributable to I is given by $\Delta y / \Delta x + \Delta y$. That is to say, the negligence of each party is measured as the absolute difference between the level of care taken and the level of due care where the total amount of negligence is the sum of the negligence of each party. I will call this the percentage of *absolute negligence*.

48. See SHAVELL, *supra* note 27, at 183; see also Cooter & Ulen, *supra* note 2, at 1102.

49. See SCHWARTZ, *supra* note 4, § 17.04[c], at 370 (Question No. 5).

There is another way to approach this problem, however. Suppose we measure the amount of negligence of a party as the percentage shortfall in the amount of care taken from the level of reasonable care, i.e., the negligence attributable to V is $\Delta x/x^*$, and that attributable to I is $\Delta y/y^*$. If we calculate negligence in this fashion then the total amount of negligence is

$$\frac{\Delta x}{x^*} + \frac{\Delta y}{y^*} = \frac{x^* \Delta y + y^* \Delta x}{x^* y^*},$$

the percentage of negligence attributable to V is

$$\frac{\frac{\Delta x}{x^*}}{\frac{x^* \Delta y + y^* \Delta x}{x^* y^*}} = \frac{y^* \Delta x}{x^* \Delta y + y^* \Delta x},$$

and the percentage of negligence attributable to I is

$$\frac{\frac{\Delta y}{y^*}}{\frac{x^* \Delta y + y^* \Delta x}{x^* y^*}} = \frac{x^* \Delta y}{x^* \Delta y + y^* \Delta x}.$$

I will call this the percentage of *relative negligence*.

To distinguish between these two methods of assigning negligence, I will examine what incentives they give to the parties to take care. The apportionment of negligence is used to apportion the damages. To provide the appropriate incentives to the parties, the apportionment of damages should represent the percentage of the expected damages for which each party is responsible. Given that there is expected damage for which no one is liable, it makes sense to assign damages according to the amount generated over and above the baseline acceptable amount. By our assumption, the parties are exercising levels of care of x' and y' , and so the expected increase in damages produced by that choice is

$$D(x', y') - D(x^*, y^*) = \Delta D$$

which we can approximate by

$$\Delta D \approx -\frac{\partial D}{\partial x}(x^*, y^*)\Delta x - \frac{\partial D}{\partial y}(x^*, y^*)\Delta y. \quad (1)$$

50. This is the differential approximation from several-variable calculus. See *supra* note 32. The negative signs are because I have chosen the Δ 's to be positive, and the partial derivatives are negative by assumption.

The first term in the sum represents the contribution of V to the increase in damages, and the second term is the contribution of I to the increase. Note that this approximation is good if Δx and Δy are small. If there is a large deviation from the standard of reasonable care, i.e., if the Δ 's are large, then this approximation does not apply. On the other hand, if the deviation from reasonable care is large, then perhaps the standards of gross negligence apply, and thus punitive damages can be assigned to correct for the errors introduced.

In order to proceed further, I will need to identify two paradigmatic situations. The first is one in which the levels of care are commensurate, what I will call *additive* care. The other is one in which the levels of care are incommensurate. This I will call *multiplicative* care. In order to make this precise, I will have to restrict my attention to two special choices for the function $D(x,y)$.

B. Additive Care

In the case of additive care, I will assume that the function $D(x,y)$ is of the form

$$D(x,y) = q(x+y),$$

where $q > 0$, and $q' < 0$. This assumption is saying that the levels of care of V and I are commensurable, i.e., they make sense to add together and the probability of an accident is a function of the sum of the levels of care.

Under this assumption Equation (1) becomes

$$\Delta D \approx -q'(x^*+y^*)\Delta x - q'(x^*+y^*)\Delta y.$$

The percentage of the new damages attributable to V is

$$\frac{-q'(x^*+y^*)\Delta x}{-q'(x^*+y^*)\Delta x - q'(x^*+y^*)\Delta y} = \frac{\Delta x}{\Delta x + \Delta y}.$$

Similarly, the percentage of damages attributable to I, is

$$\frac{\Delta y}{\Delta x + \Delta y}.$$

These percentages are exactly the percentages of absolute negligence.

Proposition 1: In the case of additive care, using the percentage of absolute negligence results in an apportionment of damages according to the percentage of expected damages that each party generated.

C. *Multiplicative Care*

In the case of multiplicative care, I will assume that the function $D(x,y)$ is of the form

$$D(x,y) = p(xy),$$

assuming again that $p > 0$, and $p' < 0$. This assumption amounts to saying that the levels of care of V and I are incommensurable, and so the appropriate units for measurement of care overall is the product of the two types of care.

Under the multiplicative care assumption, Equation (1) becomes

$$\Delta D \approx -p'(x^*y^*)y^*\Delta x - p'(x^*y^*)x^*\Delta y.$$

The percentage of the new damages attributable to V is

$$\frac{-p'(x^*y^*)y^*\Delta x}{-p'(x^*y^*)y^*\Delta x - p'(x^*y^*)x^*\Delta y} = \frac{y^*\Delta x}{y^*\Delta x + x^*\Delta y}.$$

Similarly the percentage of damages attributable to I is

$$\frac{x^*\Delta y}{y^*\Delta x + x^*\Delta y}.$$

These percentages are exactly each party's percentage of relative negligence.

Proposition 2: In the case of multiplicative care, using the percentage of relative negligence results in an apportionment of damages according to the percentage of expected damages that each party generated.

