# "ONE FOR THE ROAD" — THE RELIABILITY OF RETROGRADE EXTRAPOLATION AND THE IMPLICATIONS FOR VERMONT STATUTES

**Ellen J. Abbott***

## INTRODUCTION

> *The most striking contradiction of our civilization is the fundamental reverence for truth which we possess and the thoroughgoing disregard for it which we practice.*
>
> —Vilhjalmur Stefamssom[1]

Vermont's number one highway safety problem is the drunk driver.[2] Approximately 75% of all alcohol-related fatal collisions from January 1980 through December 1987 involved an operator with a blood alcohol content (hereinafter referred to as BAC) of 0.10% or more at the time of operation.[3] While accidents attributed to alcohol continue to increase, drunk driving convictions

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* Ellen Abbott, J.D. *magna cum laude*, Vermont Law School, 1989. She is currently working as an attorney with David L. Cleary Associates in Rutland, Vermont, specializing in insurance defense litigation.

1. *Quoted in* L. TAYLOR, DRUNK DRIVING DEFENSE § 8.0, at 631 (2d ed. 1986).

2. GOVERNOR'S HIGHWAY SAFETY COMMISSION, GOVERNOR'S HIGHWAY SAFETY PROGRAM, FY 1989 HIGHWAY PLAN 33 (1989) [hereinafter referred to as HIGHWAY PLAN] (available by writing to State of Vermont, Agency of Transportation, 133 State Street, Montpelier, Vermont 05602). The Fatal Accident Review Committee, a subcommittee of the Governor's Highway Safety Commission, asserts that this figure is not a realistic indicator of the drunk driving problem in Vermont. The figure does not include the typical "fender bender" because the operator is not subject to a breath alcohol test unless there is probable cause. Consequently, the Highway Commission relies upon the fatal collision statistics as a basis for its premise that drunk driving is Vermont's number one highway problem. *Id.*

Forty-eight percent of all fatal collisions reviewed in 1988 were attributed to alcohol. *Id.* As of January 1989, the Fatal Accident Review Committee had reviewed 90.6% of the fatal accidents which occurred in 1988. *Id.*

In 1987, approximately 52% of all fatal traffic collisions were alcohol related. HIGHWAY PLAN, *supra* at 37. From 1980 through 1987, fatal traffic collisions attributed to alcohol consumption varied between a high of 57.5% in 1981 to a low of 41% in 1985. *Id.*

3. *Id.* The blood alcohol content was determined by submitting the individual to either a breath test or a blood test. VT. STAT. ANN. tit. 23, §§ 1200(3), 1202(a) (1987 & Supp. 1990). These tests are used to determine the amount of alcohol in the blood. *See* NATIONAL HIGHWAY TRAFFIC SAFETY ADMIN., U.S. DEPT. OF TRANSPORTATION, PUB. NO. DOT-HS-804-033, RESULTS OF NATIONAL ALCOHOL SAFETY PROJECTS 1 (1979) (no longer in publication). The result is also known as blood alcohol concentration. *See* NATIONAL HIGHWAY TRAFFIC SAFETY ADMIN., U.S. DEPT. OF TRANSPORTATION, PUB. NO. DOT-HS-805-563, METHODS FOR ESTIMATING EXPECTED BLOOD ALCOHOL CONCENTRATION 2 (1980) (available through the National Technical Information Service, Springfield, Virginia 22161) [hereinafter ESTIMATING BAC]. This publication has not yet been superseded.

have drastically declined in recent years.[4] This may indicate a need to change Vermont's laws on drunk driving to increase the number of convictions and reduce the number of accidents attributed to alcohol.

In Vermont, it is unlawful for an individual with a BAC of 0.10% or more to operate a vehicle.[5] In addition, Vermont statutes provide that the numerical results of a BAC test shall create certain permissive inferences during criminal prosecution for driving under the influence (hereinafter DUI).[6] Generally, in order for the state to secure a DUI conviction, it must "produce evidence of the defendant's condition at the time of operation."[7] Thus, Vermont statutes usually require the prosecution to relate the numerical results of the BAC test back to the time of vehicle operation.[8]

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4. Information provided by the Agency of Transportation, State of Vermont, Administration Building, 133 State Street, Montpelier, Vermont 05602. In 1980, there were 2336 convictions. In 1981, there were 2861 convictions, an annual increase of 22.4%. In 1982, there were 3534 convictions, an annual increase of 23.5%. In 1983, there were 4321 convictions, an annual increase of 22.3%. In 1984, there were 4253 convictions, an annual decrease of 0.05%. In 1985, there were 3942 convictions, an annual decrease of 7.1%. In 1986, there were 3396 convictions, an annual decrease of 13.9%. Finally, in 1987, there were 3002 convictions, an annual decrease of 11.6%. *Id.*

Drunk driving used in this context refers to any of the driving under the influence offenses codified in VT. STAT. ANN. tit. 23, § 1201 (1987 & Supp. 1990); *see infra* note 17 for language of the statute.

5. VT. STAT. ANN. tit. 23, § 1201(a)(1) (1987 & Supp. 1990). The General Assembly is currently considering several amendments to Vermont's drunk driving laws, including reducing the BAC threshold for illegal operation from 0.10 to 0.08. S. RES. 48, Vt. Gen'l Ass. (1991). This bill has been passed by the Senate and is currently in the Joint Conference Committee. Telephone conversation with Janet Lenard, Vermont Legislature Council (Apr. 29, 1991).

6. *Id.* § 1204. Vermont also has a statute which provides for a loss of one's license to drive for failure to take a breath test. *Id.* § 1205(a). The license may be suspended for six months. *Id.* This is twice as long as the minimum 90-day sentence for a first drunk driving conviction. *Id.* § 1206(a).

7. State v. Dumont, 146 Vt. 252, 253, 499 A.2d 787, 789 (1986). *See also* State v. Rollins, 141 Vt. 105, 110, 444 A.2d 884, 886-87 (1982) (to fulfill its burden of proof, State must establish that the blood alcohol reading from the time of the test relates back to the time of operation); State v. Dacey, 138 Vt. 491, 497, 418 A.2d 856, 859 (1980) (to permit the inference that the defendant was under the influence at the time of operation, there must be expert testimony relating the blood-alcohol test results back to the time of operation).

8. VT. STAT. ANN. tit. 23, § 1204(a)(3) (1987 & Supp. 1990). *See also* State v. Blake, 151 Vt. 235, 237, 559 A.2d 676, 677 (1989); State v. Gray, 150 Vt. 183, 187, 552 A.2d 190, 193 (1988); *Dumont*, 146 Vt. at 254, 499 A.2d at 788-89; *Rollins*, 141 Vt. at 110, 444 A.2d at 886-87; *Dacey*, 138 Vt. at 497, 418 A.2d at 859. *But see* State v. Dupree, 151 Vt. 644, 559 A.2d 693 (1989). The State is not required, under § 1201(a)(2), to relate BAC back to the time of operation of the vehicle in the absence of trial by jury, where the judge specifically stated that no inference could be drawn from defendant's BAC. *Id.* It should be noted, however, that the Vermont Legislature is considering eliminating the need for relation back evidence

The following article focuses on the scientific method utilized to ascertain an individual's BAC at the time of the operation of a vehicle. The method is referred to as retrograde extrapolation.[9] "Retrograde extrapolation is the process whereby the result of a blood alcohol test taken sometime after an incident is used to determine the blood alcohol concentration at the time of the incident."[10]

Retrograde extrapolation and BAC are used as evidence of the defendant's condition during DUI prosecutions.[11] This type of evidence has prompted heated controversy and given rise to numerous studies.[12] Careful analysis of these studies indicates that retrograde extrapolation is an unreliable method of determining a defendant's condition at the time of operation. The inadequacies of retrograde extrapolation extend beyond mere technical inaccuracies to problems which are inherent in the basic premises and calculations of this technique.[13] These inadequacies render retrograde extrapolation inherently untrustworthy[14] and therefore inappropriate for use as evidence to convict drunk drivers.[15]

This article examines Vermont law regarding drunk driving offenses. The article then critiques the calculation of retrograde extrapolation and the faulty presumptions underlying the calculations. In conclusion, the article evaluates alternatives to the

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altogether. S. Res. 48, Vt. Gen'l Ass. (1991).

9. S. Brent & S. Stiller, Handling Drunk Driving Cases § 3.9, at 36 (1985); E. Fitzgerald & D. Hume, Intoxication Test Evidence: Criminal and Civil §§ 3:18-3:19, at 102-03 (1987) [hereinafter Intoxication Test Evidence]; L. Taylor, *supra* note 1, § 6.0.2, at 399.

10. L. Taylor, *supra* note 1, § 6.0.2, at 400-01 (quoting Dr. Richard Jensen of Minneapolis, Minnesota, in his capacity as an expert witness for the defense).

11. *Id.*

12. *See generally* Holford, *Clinical Pharmacokinetics of Ethanol*, 13 Clinical Pharmacy 273 (1987); Jones, *Status of Alcohol Absorption Among Drinking Drivers*, 14 J. Analytical Toxicology 198 (1990) (titled letter to the editor) [hereinafter *Status*]; Jones, *Problems and Pitfalls of Backtracking BAC to the Time of Driving*, 3 DWI J. L. & Sci. 1 (1988) [hereinafter *Problems*]; Lewis, *Back Calculation of Blood Alcohol Concentration*, 295 Brit. Med. J. 800 (1987).

13. *See infra* notes 63-116 and accompanying text.

14. *See, e.g.*, State v. Magoon, 128 Vt. 363, 366, 264 A.2d 779, 781 (1970) ("[t]he controlling consideration is whether the evidence given by the operator, concerning the test and its results, is trustworthy"). Trustworthy has been defined as "deserving of trust or confidence; dependable; reliable." The Random House Dictionary of the English Language, Unabridged (2d ed. 1987). *But see* State v. Burack, 133 Vt. 482, 484, 346 A.2d 192, 194 (1975) ("[t]he test for a foundation of admissibility of evidence is not absolute certainty").

15. E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, §§ 3:18-3:19, at 102-03 (1987).

utilization of retrograde extrapolation to convict drunk drivers under Vermont law.

## I. Vermont Statutes and Vermont Case Law

> *It is likewise to be observed that this society [of lawyers] hath a particular chant and jargon of their own, that no other mortal can understand, and wherein all their laws are written, which they take special care to multiply; whereby they have wholly confounded the very essence of truth and falsehood.*
>
> —Jonathan Swift[16]

The Vermont statute regarding the operation of a vehicle while under the influence of intoxicating substances sets forth three offenses.[17] The first offense under title 23, section 1201(a)(1) of Vermont Statutes Annotated, is a per se violation which states, in effect, that an individual may not operate a vehicle with 0.10% or more by weight of alcohol in his or her blood.[18] The second offense under title 23, section 1201(a)(2) states that an individual may not operate a vehicle if he or she is "under the influence of intoxicating liquor."[19] The final offense, under title 23, section 1201(a)(3), states that an individual may not operate a vehicle while "under the influence of any other drug or under the combined influence of alcohol and any other drug to a degree which renders the person incapable of driving safely."[20]

The state *must* introduce evidence of the individual's BAC at the time of operation in order to convict under the per se offense, because the statute prohibits driving with a BAC of 0.10% or

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16. *Quoted in* L. Taylor, *supra* note 1, at 1.

17. Vt. Stat. Ann. tit. 23 § 1201 (1987 & Supp. 1990). The statute states in pertinent part:

> (a) A person shall not operate, attempt to operate, or be in actual physical control of any vehicle on a highway while:
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> (1) there is .10 percent or more by weight of alcohol in the blood, as shown by analysis of the person's breath or blood; or
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> (2) under the influence of intoxicating liquor; or
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> (3) under the influence of any other drug or under the combined influence of alcohol and any other drug to a degree which renders the person incapable of driving safely.

18. *Id.* § 1201(a)(1).

19. *Id.* § 1201(a)(2).

20. *Id.* § 1201(a)(3).

more.[21] The offense, therefore, requires the state to introduce evidence of retrograde extrapolation.[22] In contrast, the second and third offenses under title 23, section 1201 do not require the state to introduce evidence of BAC. Therefore, evidence of retrograde extrapolation is unnecessary in order to convict a defendant under title 23, section 1201(a)(2) or (a)(3).[23]

The state may introduce the numerical results of a BAC test under the second and third offenses in order to take advantage of permissive inferences as codified by title 23, section 1204.[24] Prior to 1987, however, section 1204 provided that the numerical results of a BAC test gave rise to three presumptions. First, if BAC was .05 or less, the presumption was that the individual "was not under the influence of intoxicating liquor."[25] Second, a BAC above .05 but less than .10 could be considered by the fact-finder in conjunction with other evidence "in determining whether the individual was under the influence of intoxicating liquor."[26] Third, any BAC in excess of .10 created the presumption that the defendant was intoxicated in violation of section 1201(a)(2) or (a)(3).[27]

Under the statute, it was not clear whether the introduction of the numerical results of BAC also required evidence of retrograde extrapolation.[28] The Vermont Supreme Court decision in *State v. Dumont* clarified the issue of whether the numerical results of a BAC test were properly admissible to establish a presumption under section 1201(a)(2), without any corresponding evidence relating the BAC to the time of operation.[29] In that case, the defendant asserted that the admission of the BAC result of .13 without

21. State v. Dumont, 146 Vt. 252, 254, 499 A.2d 787, 788-89 (1985); *see also* State v. McQuillen, 147 Vt. 386, 518 A.2d 25 (1986); State v. Carter, 142 Vt. 588, 458 A.2d 1112 (1983); State v. Rollins, 141 Vt. 105, 444 A.2d 884 (1982).

22. *Dumont*, 146 Vt. at 254, 499 A.2d at 788-89.

23. State v. Dupree, 151 Vt. 645, 559 A.2d 693 (1989); State v. Bushey, 149 Vt. 378, 381, 543 A.2d 1327, 1329 (1988); State v. Zantanos, 150 Vt. 648, 552 A.2d 387 (1988).

24. VT. STAT. ANN. tit. 23, § 1204 (1987 & Supp. 1990) (amended 1987).

25. *Id.* § 1204(a)(1).

26. *Id.* § 1204(a)(2).

27. *Id.* § 1204(a)(3).

28. The plain language of section 1204 indicates that retrograde extrapolation is probably required for the introduction of the numerical results of BAC under the three presumptions. For example, the statute states that "the amount of alcohol in a person's blood or breath *at the time alleged* . . . shall give rise to" various presumptions, in proceedings regarding the operation of a motor vehicle. VT. STAT. ANN. tit. 23, § 1204(a) (1987) (emphasis added). This language is identical in the amended version of the statute. *See id.*

29. State v. Dumont, 146 Vt. 252, 499 A.2d 787 (1985).

evidence of retrograde extrapolation was prejudicial.[30] The Vermont Supreme Court agreed, holding that if the state introduces the numerical value of the BAC, then the state must relate the BAC back to the time of operation.[31] The court reasoned that, although the probative value of the test result was marginal, the risk of prejudice to the defendant was substantial. The court stated that "[a] jury might erroneously use a numerical test result which has not been related back to the time of operation as evidence of actual intoxication at the time of the offense, particularly if the jury is familiar with the 0.10% blood alcohol content presumption . . . ."[32]

Subsequently, in 1987, the Vermont Legislature amended section 1204. Although the first three inferences provided for in the statute are essentially identical, the Legislature created an additional permissive inference.[33] Title 23, section 1204(a)(4) provides that a BAC of .15 or more, obtained "within two hours of the alleged offense," shall establish the permissive inference that the defendant is in violation of the second and third offenses under section 1201.[34]

This new inference is an exception to the rule that, in order to introduce the numerical results of a BAC test, the state must introduce evidence of retrograde extrapolation. A careful reading of the statute indicates that, where the BAC exceeds .15 within two hours of operation, evidence of retrograde extrapolation is not required.[35] If a BAC is taken more than two hours after operation,

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30. *Id.* at 253, 499 A.2d at 788.

31. *Id.* at 255, 499 A.2d at 789. *See also* State v. McQuillen, 147 Vt. 386, 388, 518 A.2d 25, 26 (1986).

32. *Dumont*, 146 Vt. 252, 255, 499 A.2d 787, 789 (1985). The court also stated that:

> [i]n view of the marginal additional probative value of the numerical result, and the danger of its misuse by the jury, expert testimony concerning the blood-alcohol content test in a (a)(2) prosecution should be strictly limited to whether the test demonstrates that the defendant did, in fact, consume an intoxicating liquor . . . .

*Id.*

33. The Legislature also changed the heading of the statute, substituting "permissive inferences" for "presumptions." This change appears to have little substantive impact. *See* VT. STAT. ANN. tit. 23 § 1204 (1987 & Supp. 1990); *see also*, State v. Bushey, 149 Vt. 378, 381 A.2d 1327, 1329 (1988) (referring to the standards set forth under § 1204 as permissive inferences).

34. *Id.* § 1204(a)(4).

35. *Id.* The language of the statute states that a BAC of .15 or more obtained "*at any time within two hours* of the alleged offense . . . shall [create] a permissive inference that the person . . . [was] in violation of section 1201(a)(2) or (a)(3)." *Id.* (emphasis added).

however, then the state is required to relate the test back to the time of operation.[36] Therefore, with the exception of section 1204(a)(4), the state cannot use the numerical test results of the BAC test without retrograde extrapolation. The statute, however, does not preclude the state from introducing evidence that a blood or breath test was administered and that the defendant had consumed intoxicating liquor.[37] For example, the court may rely on the testimony of an arresting officer regarding the defendant's behavior, or circumstantial evidence indicative of impaired driving.[38]

As the foregoing demonstrates, retrograde extrapolation is critical to both the state's prosecution and the accused's defense. Prosecution under the per se offense requires a BAC of 0.10% at the time of operation. In addition, the permissive inferences available to the parties under the statute depend upon the numerical BAC at the time of operation, excluding the 0.15% presumption. Consequently, evidence of retrograde extrapolation plays an extremely important role in DUI convictions, and in many situations, plays the ultimate role in conviction.

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36. There are no cases which directly support this proposition; however, this is a logical conclusion based on the fact that the introduction of the numerical result of the BAC test generally requires evidence of retrograde extrapolation. *See* State v. Olson, 153 Vt. 226, 234, 571 A.2d 619, 624 (1989) (where admission of BAC test results taken two and one half hours after vehicle operation was permissible because state offered evidence of relation back). *See generally infra* notes 37-38 and accompanying text.

37. State v. Zanatos, 150 Vt. 648, 552 A.2d 387 (1988) (holding that the trial court may admit evidence showing the defendant consumed alcoholic beverages); State v. Bushey, 149 Vt. 378, 380-82, 543 A.2d 1327, 1329-30 (1988) (where the defendant failed to object and the numerical results of the BAC test were not admitted, the trial court did not err in the admission of expert testimony that, based on the inadmissible BAC results, the defendant probably had eight or nine drinks); State v. Dupree, 151 Vt. 644, 559 A.2d 179 (1989) (trial court did not err in the admission of a .18 BAC test result without retrograde analysis where: 1. the trial court fact-finder was the judge; and 2. the judge recognized that he could not infer that the defendant was intoxicated during operation based on the BAC result). In such cases, the state generally must refrain from introducing the numerical result of the evidence. *Bushey*, 151 Vt. 378, 381, 543 A.2d 1327, 1329 (1988); State v. McQuillen, 147 Vt. 386, 388, 518 A.2d 25, 26 (1986); State v. Dumont, 146 Vt. 252, 255, 466 A.2d 787, 789 (1985).

38. State v. Anderson, 152 Vt. 297, 298-99, 565 A.2d 1342, 1343 (1989). The court upheld a conviction based on the officer's testimony that the defendant's breath smelled of alcohol, the car was parked off the highway, the key was in the "on" position, and the motor fan was running. This case prompted a heated dissent written by Justice Gibson and joined by Chief Justice Allen. Justice Gibson asserted that the majority decision was erroneously based on experience and intuition, rather than viable prosecution evidence which linked the defendant's state of inebriation to the time of vehicle operation. *Id.* at 301, 565 A.2d at 1344-45 (Gibson, J., dissenting). *See generally* State v. Willette, 142 Vt. 78, 451 A.2d 821 (1982); State v. Clark, 130 Vt. 500, 296 A.2d 475 (1972).

## II. Retrograde Extrapolation

*A beautiful theory, killed by a nasty, ugly little fact.*
—Thomas H. Huxley[39]

### A. *The Theory behind Retrograde Extrapolation*

Retrograde extrapolation is the process of calculating BAC at the time of vehicle operation,[40] based on a breath or blood test usually administered within two hours after an individual is pulled over for suspicion of DUI.[41] The experts assume that BAC has peaked at the time of the test.[42] "Peaking" means that the alcohol ingested has been completely absorbed by the body's system and is being eliminated by ordinary bodily functions.[43] In order to account for alcohol which may have been eliminated between the time of vehicle operation and the administration of the test, experts calculate an estimated elimination rate.[44] The rate is then added to the BAC test result and the expert testifies that this result is the BAC at the time of operation.[45] The expert's seemingly

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39. *Quoted in* L. Taylor, *supra* note 1, § 6.6, at 528.

40. *See supra* notes 9-11 and accompanying text; Fitzgerald & Hume, *The Single Chemical Test for Intoxication: A Challenge to Admissibility*, 66 Mass. L. Rev. 23, 24 (1981) [hereinafter *A Challenge to Admissibility*]. *See generally* Coutts, *Back Calculation of Proportion of Alcohol*, 52 J. Crim. L. 132 (May 1988); S. Brent & S. Stiller, *supra* note 9, §§ 3.1, 3.11; R. Erwin, Defense of Drunk Driving Cases, § 14 (1966); L. Taylor, *supra* note 1, §§ 6.0, 6.8.

41. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 24.

42. S. Brent & S. Stiller, *supra* note 9, § 3:11, at 43; E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, § 2:30, at 47; Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 24-25.

43. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 24.

44. *See generally*, S. Brent & S. Stiller, *supra* note 9, § 3:10, at 36-38. *See also* Letter from Harold Stowe, Analytical Chemist, Agency of Human Services, State of Vermont Department of Health, to Ellen J. Abbott (Feb. 22, 1989) [hereinafter Stowe Letter] (describing a Vermont State Chemist's calculation of BAC based on retrograde extrapolation in preparation for court testimony). For example, Joe, who weighs 180 pounds, was picked up for drunk driving at 9:00 p.m. Joe's BAC test at 10:00 p.m. had a result of 0.15% BAC. The retrograde extrapolation calculation would be as follows:

> 0.15% [The BAC Test] + (0.015% [estimated alcohol elimination] x 1 [number of hours since driving]) = 0.165% BAC at the time of operation.

Some experts will subtract the amount of BAC for one drink if they know that a drink was taken within one hour of being picked up for drunk driving. Therefore, if Joe had one drink within the hour, the expert would subtract 0.021%, which is the estimated amount of alcohol absorbed with one drink by a 180 pound person. The result would be 0.165% - 0.024 = 0.141% BAC at the time of operation. *Id.* at 2.

45. Stowe letter, supra note 44, at 1.

simple calculation is, however, fraught with errors.[46]

### B. *The Faulty Presumptions behind the BAC Test*

#### 1. *The Physiology of Intoxication*

When an individual consumes intoxicating liquors, he or she is actually ingesting ethanol or ethyl alcohol (grain alcohol).[47] Alcohol ingested by the mouth passes first into the stomach.[48] "As long as it remains in the stomach it does not affect the individual's functioning and behavior."[49] Once in the stomach, between five and thirty percent of the alcohol is absorbed through the stomach wall into the blood stream.[50]

The alcohol which does not pass through the stomach wall moves down into the small intestine.[51] In the small intestine, the alcohol is absorbed through the intestine wall into the blood stream.[52] "The rate of absorption through the wall of the small intestine is ten or more times as fast [as the rate of absorption in the stomach] . . . ."[53]

Once the alcohol is in the blood stream, it travels through the portal vein until it reaches the liver.[54] The elimination of alcohol from the blood stream begins in the liver, "the primary organ for

46. E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, §§ 3:18-3:19, at 102-03; Jones, *Problems*, *supra* note 12, at 1; Jones, *Status*, *supra* note 12, at 198-99; Lewis, *supra* note 12, at 295.

47. L. Taylor, *supra* note 1, § 6.0.1, at 401. *See generally* S. Brent & S. Stiller, *supra* note 9, §§ 3.1, 3.11. Alcohol is ingested, but not digested. There is no chemical breakdown of alcohol in the body's system. D. Dennison, T. Prevet, M. Affleck, Alcohol and Behavior 39, 40 (1980).

48. S. Brent & S. Stiller, *supra* note 9 § 3.1, at 26; E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, § 2:2, at 10-11; L. Taylor, *supra* note 1, § 6.0.1, at 401.

49. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 28.

50. *Id.*

51. E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, § 2:3, at 11; L. Taylor, *supra* note 1, § 6.0.1, at 392-93.

52. L. Taylor, *supra* note 1, § 6.0.1, at 393. The process of absorption is "a simple biochemical process of diffusion, which will continue as long as the concentration of alcohol in the stomach and intestines is higher than that in the blood." This process is completed when the "entire gastrointestinal tract reaches equilibrium with the remainder of the body . . . ." *Id. See generally*, S. Brent & S. Stiller, *supra* note 9, §§ 3:1-3:11.

53. Stowe Letter, *supra* note 44, at 2. However, one study found that the absorption of alcohol in the intestine is not sufficiently defined by the standards of pharmacokinetics description which adds another element of unreliability to retrograde extrapolation. Holford, *supra* note 12, at 290.

54. L. Taylor, *supra* note 1, § 6.0.1, at 393.

eliminating alcohol from the body."[55] Only a portion of the alcohol is eliminated at this point.[56] The bloodstream carries the remaining alcohol to the lungs and then to the brain.[57] It is only when the alcohol reaches the brain that "[the] individual's ability to perceive, make judgments, and coordinate movements" will be affected.[58] This phenomenon is referred to as "intoxication."[59]

### 2. *BAC Tests and Their Relationship to the Brain*

The most common methods of determining the amount of alcohol in the brain are blood tests and breath tests.[60] Blood tests are conducted by gas chromatography, which measures the weight of ethyl alcohol in the blood stream.[61] Breath tests, on the other hand, indirectly measure ethyl alcohol in the bloodstream by using infrared spectrometry to calculate the amount of alcohol vapor present in the breath.[62] Even if these two methods accurately measure alcohol in the blood, "[t]he alcohol measured in the blood is not necessarily indicative of the effect on the brain."[63]

The amount of alcohol absorbed into the body is proportional to the percentage of water present in the body fluid or tissue being tested.[64] As blood possesses a higher percentage of water then does the brain, muscle, and soft tissues, the measure of alcohol in the blood is always greater than the level of alcohol present in the brain.[65] The amount of alcohol absorbed in the brain is estimated

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55. E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, § 2:6, at 14. *See also*, L. Taylor, *supra* note 1, § 6.0.1, at 393.

56. L. Taylor, *supra* note 1, § 6.0.1, at 393. Alcohol in excess of the liver's capacity for alcohol elimination circulates in the bloodstream. E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, § 2.6, at 14.

57. L. Taylor, *supra* note 1, § 6.0.1, at 393.

58. *Id.* at 394.

59. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 31.

60. *See generally*, R. Erwin *supra* note 40, § 15.01, at 322 (discussing blood tests), § 16.01, at 358 (discussing breath tests); E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, §§ 4:1-4:27 (discussing breath and blood tests); L. Taylor, *supra* note 1, §§ 6.1-6.8 (discussing breath and blood analysis).

61. Thompson, *Determining Blood Alcohol Concentration: Two Methods of Analysis*, 46 Mont. L. Rev. 365, 368 (1985).

62. *Id.* at 373-74.

63. L. Taylor, *supra* note 1, at § 6.0.1, at 394. *See* S. Brent & S. Stiller, *supra* note 9, § 42, at 51 (noting that because of individual differences in tolerance, correlations between BAC and behavior are "risky business").

64. L. Taylor, *supra* note 1, § 6.0.1, at 394. *See also* Jones, *Status*, *supra* note 12, at 198.

65. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 25-26; L. Tay-

to be approximately seventeen percent less than the amount of alcohol in the blood.[66] The ratio for the concentration of alcohol in the blood to the concentration of alcohol in the brain, "varies so widely according to the individual [that] generalizations about a given individual [are] very suspect."[67]

Not only does the ratio vary from individual to individual, but the same amount of alcohol in the bloodstream will affect different individuals in dissimilar ways.[68] A study conducted by the Alcohol Research Center at the University of Colorado concluded that individuals may acquire a tolerance for alcohol over a period of time. More significantly, the study found that a tolerance may exist after only one encounter with alcohol.[69] The study also found that individuals with a BAC of 0.10% had poor judgment, balance, and muscle control.[70] Test subjects, however, who maintained a BAC of 0.10% for three hours, although legally intoxicated, actually improved their test performance.[71] The study concluded, in part, that "some people were able to perform as well while legally drunk as they had when sober."[72]

In addition, researchers recently found no correlation between peak BAC and impairment.[73] Individuals felt the effect of alcohol much sooner than the recorded peak BAC.[74] This is significant because the individuals tested felt the effects of the alcohol while the BAC was rising and not at peak BAC.[75]

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LOR, *supra* note 1, § 6.0.1, at 394. *See also* Jones, *Status, supra* note 12, at 198 (asserting that alcohol concentrations in venous blood lags behind concentrations in arterial and capillary blood).

66. L. TAYLOR, *supra* note 1, § 6.0.1, at 394.

67. *Id.* Science has provided a ratio for predicting the probable BAC based on the number of drinks consumed by an individual. J. TARANTINO, DEFENDING DRINKING DRIVERS, § 202, at 2-5 (2d ed. 1990). The ratio factor is generally referred to as "Widmark Factor R." The ratio differs from men to women. In men, the ratio is between .46 to .86 with an average of .67. Women, on the other hand, have a lower ratio because of their larger proportion of fatty tissues. L. TAYLOR, *supra* note 1, § 6.0.1, at 394. *See* E. FITZGERALD & D. HUME, INTOXICATION TEST EVIDENCE, *supra* note 9, §§ 2:15-2:22 (for a general discussion of Widmark and similar formulas).

68. L. TAYLOR, *supra* note 1, § 6.0.1, at 397.

69. *Id.* at 396-97.

70. *Id.* at 397.

71. *Id.*

72. L. TAYLOR, *supra* note 1, § 6.0.1, at 397.

73. Radlow & Hurst, *Temporal Relations Between Blood Alcohol Concentration and Alcohol Effect: An Experiment with Human Subjects*, 85 PSYCHOPHARMACOLOGY 260 (1985).

74. *Id.*

75. *Id.*

Consequently, the amount of alcohol in the bloodstream does not necessarily correspond to the amount of alcohol in the brain or the level of impairment. A testifying expert will assume, however, that the ratio of the alcohol in the blood to the alcohol in the brain remains constant. The expert also assumes that individual tolerance levels are invariable.[76] These faulty presumptions invalidate BAC test results and retrograde extrapolations because an individual can be more or less impaired than the calculations indicate.

### C. *The Faulty Presumptions behind Retrograde Extrapolation*

Retrograde extrapolation assumes that the BAC test is taken after the BAC has peaked.[77] Peaking occurs when the blood/alcohol ratio reaches its highest level.[78] The two factors critical to determining peak BAC are the rates at which the body absorbs and eliminates alcohol.[79] The absorption rate and elimination rate vary depending upon the individual. However, a testifying expert usually has no access to relevant information regarding individual characteristics when calculating retrograde extrapolation.[80]

#### 1. *Absorption*

The process of retrograde extrapolation presumes that it takes approximately twenty to forty-five minutes for ingested alcohol to be completely absorbed by the body.[81] If the expert knows when the individual consumed the last drink, the expert will reduce his test results to take into consideration the elimination of alcohol.[82] The problem with the calculation is that neither the rate of absorption nor the rate of elimination is constant.[83] Scientific studies conclude that the rate of absorption is affected by the consumption

76. L. TAYLOR, *supra* note 1, § 6.0.2, at 409-11.

77. *See* Stowe Letter, *supra* note 44, at 1; *see also* Jones, *Status*, *supra* note 12, at 198 (asserting that retrograde extrapolation is erroneous because most drivers' BAC is not at peak during operation).

78. *See supra* note 40 and accompanying text.

79. Stowe Letter, *supra* note 44, at 1. *See* J. TARANTINO, *supra* note 67, § 201, 2-3 to 2-5; L. TAYLOR, *supra* note 1, § 6.0.1, at 394-95.

80. Stowe Letter, *supra* note 44, at 2.

81. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 24-25.

82. Stowe Letter, supra note 44, at 2.

83. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 27. *See generally* Jones, *Status*, *supra* note 12; Holford, *supra* note 12; Lewis, *supra* note 12; Jones, *Problems*, *supra* note 12; J. TARANTINO, *supra* note 67, § 202.

of food, type of alcohol ingested, gender, and physical condition.[84]

Food consumption has a significant impact on the absorption rate of alcohol and the reliability of retrograde extrapolation.[85] In a study conducted by the U.S. Department of Transportation, researchers concluded that the type of food, amount of food, and time of ingestion in relation to alcohol intake effects the absorption rate.[86] The study examined the effect of various characteristics of food on alcohol absorption.[87] The variables used were "the nutritive density (calories), weight, volume, and the protein-carbohydrate-fat composition of food" and the time the food was consumed.[88] The results showed that foods which are high in calories, weight, and volume reduced the absorption rate of the alcohol almost fifty percent as compared to no food.[89] The study also concluded that even small amounts of food will lower absorption rates.[90]

These lower absorption rates occur because alcohol remains in the stomach until the food is digested.[91] After the food is digested, the alcohol is absorbed into the system. For example, five ounces of alcohol consumed on an empty stomach results in a BAC peak of 0.09% within forty minutes. When food is ingested the alcohol peaks at 0.03% in two hours.[92]

Absorption rates are further affected by the type of alcohol ingested.[93] Alcohol mixed with carbonation, such as beer, soft drink mixers, sparkling wines, and champagne, will peak earlier and at a higher BAC than straight alcohol drinks, such as marti-

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84. S. BRENT & S. STILLER, *supra* note 9, § 3:1, at 28-29; J. TARANTINO, *supra* note 79, § 202, 2-7 to 2-8.

85. E. FITZGERALD & D. HUME, INTOXICATION TEST EVIDENCE, *supra* note 9, § 2:9, at 16 (noting that "food has a dramatic effect upon the rate of absorption of alcohol"); L. TAYLOR, *supra* note 1, § 6.0.2, at 401 (stating that food causes considerable delay in the rate of absorption).

86. ESTIMATING BAC, *supra* note 3, at 4.

87. *Id.*

88. *Id.* at 6.

89. *Id.*

90. ESTIMATING BAC, *supra* note 3, at 6.

91. *Id. See also* L. TAYLOR, *supra* note 1, § 6.0.1, at 394.

92. ESTIMATING BAC, *supra* note 3, at 6.

93. S. BRENT & S. STILLER, *supra* note 9, § 3.1, at 27. *See also* C. LEAKE & M. SILVERMAN, ALCOHOLIC BEVERAGES IN CLINICAL MEDICINE 50 (1966); Note, *Driving with 0.10% Blood Alcohol: Can the State Prove It?*, 16 U.S.F. L. REV. 817, 825 (citing NAT'L INSTITUTE ON ALCOHOL ABUSE AND ALCOHOLISM, U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, *Facts About Alcohol and Alcoholism*, 7-8 (Pub. No. DHHS (ADM) 80-31)) [hereinafter *Can the State Prove It?*].

nis.[94] In addition, the same amounts of different hard liquor will peak at varying rates.[95]

Women tend to reach peak BAC more quickly than men because of differing body composition.[96] Alcohol is absorbed in proportion to the amount of water in the body. Because women have more fatty tissue, and water is concentrated in fatty tissue, women tend to absorb alcohol faster than men.[97]

Finally, physical condition affects the rate of absorption. Gastritis lowers the rate of absorption because it causes the stomach to retain foods for longer periods of time, thus reducing the absorption rate. Other medical problems, such as malnutrition, can reduce or increase absorption rates.[98] Consequently, the experts' reliance on the presumption that the BAC will peak within twenty to forty-five minutes is misguided.

### 2. *Elimination*

Retrograde extrapolation assumes that alcohol is eliminated from the body at a constant rate of 0.015% per hour.[99] This assumption, however, is incorrect: the elimination rate varies from person to person depending upon habits, metabolism, and state of health.[100]

Drinking habits affect elimination more than any other variable. An alcoholic's elimination rate averages as high as 0.030% alcohol per hour.[101] This is twice as high as the average rate used by most retrograde extrapolation calculations. The elimination rate for a social drinker averages 0.015% per hour, while non-drinkers average a rate of 0.012% per hour.[102] Therefore, elimination is not constant and depends upon an individual's drinking behavior.

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94. S. Brent & S. Stiller, *supra* note 9, § 3:1, at 28. *See also* Holford, *supra* note 12, at 286.

95. C. Leake & M. Silverman, *supra* note 93, at 49-50. *See also* Fitzgerald & Humes, *A Challenge to Admissibility*, *supra* note 40, at 30; Holford, *supra* note 12, at 286.

96. Dubowski, *Absorption, Distribution, and Elimination of Alcohol; Highway Safety Aspects*, J. of Studies on Alcohol 98, 100 (Sept. 10, 1985) [hereinafter *Absorption*].

97. *Id.*; L. Taylor, *supra* note 1, § 6.0.1, at 394.

98. S. Brent & S. Stiller, *supra* note 9, at § 3:1, at 28.

99. J. Tarantino, *supra* note 67, § 202, at 2-5 to 2-6. The elimination rate is normally referred to as "Widmark Factor B." *Id. See also* L. Taylor, *supra* note 1, at § 6.0.1, at 394.

100. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 30.

101. L. Taylor, *supra* note 1, § 6.0.2, at 405; Winek & Murphy, *The Rate and Kinetic Order of Ethanol Elimination*, 25 Forensic Sci. Int'l 159, 159 (1984).

102. Winek & Murphy, *supra* note 101, at 159.

The body also tends to eliminate subsequent drinks faster than the first drink.[103] One study indicates that when individuals are given two drinks at separate intervals, the first drink is eliminated at approximately 0.013% per hour, whereas the second drink is eliminated at 0.016% per hour.[104]

Further, individual metabolism affects elimination rates. When alcohol reaches the liver, it is converted into energy by means of a chemical reaction which involves enzymes, alcohol dehydrogenase (ADH) and nicotinamideadenine dinucleotide (NAD).[105] The amount of NAD found in the body will determine the elimination rate.[106] The greater the amount of NAD the faster the alcohol is metabolized.[107] The amount of NAD available to process alcohol depends upon the chemical make-up of the particular individual and the amount of alcohol already in the liver.[108]

Alcohol is also eliminated through breath, urine, perspiration, and tears.[109] Depending upon the metabolism of a particular individual, alcohol eliminated through these body organs could vary between two and eight percent.[110] For example, approximately two percent of alcohol may be eliminated by hyperventilation and not more than three percent of alcohol may be eliminated by urination.[111]

Several other factors affect elimination rates. Some medical conditions, such as cirrhosis and other liver infirmities, can cause a slower elimination rate.[112] Also, older people have a tendency to eliminate faster than younger people.[113] Women who take contraceptives containing steroids may eliminate alcohol almost twice as

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103. Wilson, Erwin, & McClearn, *Effects of Ethanol: I. Acute Metabolic Tolerance and Ethnic Differences*, 8 ALCOHOLISM: CLINICAL AND EXPERIMENTAL RES. 226, 228 (1984).

104. *Id. See generally* L. TAYLOR, *supra* note 1, § 6.0.2, at 405 (stating that elimination rates increase significantly after the first drink).

105. S. BRENT & S. STILLER, *supra* note 9, at § 3:6, at 33.

106. *Id.*

107. *Id.*

108. *Id.* Some studies indicate that even the normal range of elimination varies from as low as 0.006% to as high as 0.040%. *Id.* at 34. *See also* Boqusz, Pach & Stasko, *Comparative Studies on the Rate of Ethanol Elimination in Acute Poisoning and in Controlled Circumstances*, 22 J. FORENSIC SCI. 446 (1977).

109. S. BRENT & S. STILLER, *supra* note 9, § 3:7, at 33; *see also* Holford, *supra* note 12, at 288.

110. S. BRENT & S. STILLER, *supra* note 9, § 3:7, at 33.

111. *Id.* § 3:7, at 34.

112. *Id.* § 3:8, at 34.

113. Dubowski, *Absorption*, *supra* note 96, at 98.

fast as women who do not.[114] Eating certain foods, especially those containing fructose, may increase an individual's elimination rate.[115] And finally, strenuous exercise can also eliminate alcohol at a faster rate.[116] These variations disprove the assumption that alcohol is eliminated at a rate of 0.015%.

### 3. *Conclusion*

As the previous discussion demonstrates, retrograde extrapolation is fraught with problems of reliability. The method begins with the presumption that a BAC test, given an hour after operating a vehicle, represents peak BAC. The problem with this assumption is threefold. First, alcohol is absorbed at different rates depending upon the consumption of food, the type of alcohol consumed, and the gender of the drinker. Therefore, an expert cannot accurately testify that an individual has peaked prior to or at the time of the BAC test. Instead, the individual could have peaked after the arrest or even after administration of the BAC test.

Second, the expert assumes that the individual peaked during operation of the vehicle or prior to operation. Consequently, the expert calculates the elimination rate as if one of these two conditions is true. In the event that the individual is actually absorbing rather than eliminating the alcohol, retrograde extrapolation calculates a false BAC result for the time of vehicle operation. Finally, the calculation presumes that each person eliminates alcohol at a constant rate of 0.015%, in spite of the fact that this numerical value changes considerably due to variables which affect the elimination rate.

Problems associated with retrograde extrapolation may either benefit or harm the defendant. For example, retrograde extrapolation would result in an inappropriately low BAC test result if the defendant has a low elimination rate. This result would be beneficial to the defendant. In contrast, if the defendant's BAC level peaks after the BAC test is administered, the BAC results would be too high. These results will occur because retrograde extrapola-

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114. *Id.*; *see also* Holford, *supra* note 12, at 285; J. TARANTINO, *supra* note 67, § 202, at 2-5. Studies have also shown that the average woman eliminates alcohol 1.25 times faster than the average man. *Id.*

115. S. BRENT & S. STILLER, *supra* note 9, § 3:8, at 35. Foods such as honey and fruit contain fructose. *Id. See also* ESTIMATING BAC, *supra* note 3, at 59.

116. S. BRENT & S. STILLER, *supra* note 9, § 3:8, at 35.

tion calculations are based on a constant elimination rate, even though the body may in fact be in the initial process of alcohol absorption. The BAC results, therefore, do not represent the defendant's "true" BAC.

Dr. Kurt Dubowski summarized the status of retrograde extrapolation accurately when he wrote:

> [i]t is unusual for enough reliable information to be available in a given case to permit a meaningful and fair value to be obtained by retrograde extrapolation. If attempted, it must be based on assumptions of uncertain validity, or the answer must be given in terms of a range of possible values so wide that it is rarely of any use. If retrograde extrapolation of a blood concentration is based on a breath analysis the difficulty is compounded.[117]

Retrograde extrapolation begins with a faulty premise and adds to it hypothetical averages and improper assumptions. Using these assumptions, retrograde extrapolation attempts to calculate the BAC at the time of operation. The calculations are based on the hypothetical average person and ignore the many variables that can drastically affect the results.

## III. Application to Vermont Law

> *An error is the more dangerous in proportion to the degree of truth which it contains.*
>
> —Henri Frederic Amiel[118]

The problems with retrograde extrapolation may lead to absurd results. The following hypothetical exemplifies the possible results of retrograde extrapolation.

Hypothetical:

After a long day at work, Carrie stopped by the local pub for a drink. It was a hot summer day and she wanted a thirst quenching drink. Carrie ordered an 'Iced Tea', a drink containing three shots of eighty proof liquor. After ordering the drink, she remembered that her mother was coming over for dinner that night and she needed to get home in a hurry. She quickly finished her drink and

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117. Mason & Dubowski, *Breath-Alcohol Analyzers: Uses, Methods, and Some Forensic Problems — Review and Opinion*, 21 J. Forensic Sci. 9 (1976).

118. *Quoted in* L. Taylor, *supra* note 1, § 6.0, at 389.

drove toward home.

In her rush to get home, Carrie was pulled over for speeding. The police officer noticed Carrie's agitated state and smelled alcohol. Suspecting a drunk driver, he brought her to the police station and administered the BAC test. The test was administered approximately one hour after she had her 'Iced Tea'.

Carrie's BAC was 0.09% at the time of the breath test. This number is the probable BAC of an "average" person who weighs 120 pounds.[119]

Retrograde extrapolation requires the expert to add the average elimination rate to the BAC result. The calculation would be: BAC at the time of the test + 0.015 x (number of hours since operation) = BAC at the time of operation.[120]

Because Carrie operated her vehicle only one hour prior to the BAC test, 0.015% would be added to the BAC to compensate for any alcohol elimination. The result of retrograde extrapolation would thus be 0.09% plus 0.015%, or 0.105%. This number represents Carrie's supposed BAC at the time of operation.

Under Vermont law, there are several possible results from this scenario. If the state charged Carrie under the per se offense and if the jury believed the expert, she could be convicted for operating a vehicle with more than a 0.10% BAC.[121] If the state charged Carrie under either of the other DUI offenses,[122] the relation back to 0.105% would give rise to the permissive inference

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119. This estimated BAC result is based in part on an average absorption rate. The theory is that if an individual consumes a certain amount of alcohol, an average amount of that alcohol will be absorbed, and the BAC result will be a particular number in one hour. S. Brent & S. Stiller, *supra* note 9, § 3:10, at 36; R. Erwin, *supra* note 40, § 31.02, at 724; J. Tarantino, *supra* note 67, § 202, at 2-6. These sources contain charts which estimate probable BAC according to body weight and the number of drinks consumed. Such charts are often based on the Widmark Factor R, which determines how much alcohol must be consumed per body weight to reach a certain BAC. *See generally* S. Brent & S. Stiller, *supra* note 9, § 3:10; R. Erwin, *supra* note 40, § 31.02; J. Tarantino, *supra* note 67, § 202. Vermont uses the "Sunshine Factor" instead of the Widmark Factor R, but both methods yield similar results. Stowe Letter, *supra* note 44, at 1.

120. Stowe Letter, *supra* note 44, at 1-2. In some cases, the expert will subtract the alcohol absorption of one drink, if the expert knows that the defendant had a drink within an hour before being stopped for drunk driving. *Id.* at 2.

121. Vt. Stat. Ann. tit. 23, § 1201(a)(1) (1987 & Supp. 1990). *See supra* note 17 (setting forth the text of the statute).

122. *Id.* § 1201(a)(2)-(3).

that Carrie was driving under the influence.[123] Consequently, although Carrie is "presumed innocent," the burden is shifted to Carrie to prove that she was not driving while under the influence.[124]

This result is absurd. Assuming that Carrie falls within the hypothetical average, three ounces of alcohol would yield a BAC result of 0.09% one hour after the alcohol consumption. In this example, Carrie took the test one hour after she consumed the alcohol. The expert, in relating the alcohol back to the time of operation, would testify that her BAC at the time of operation was 0.105%. The irony of this situation is that the expert will testify that Carrie's BAC was a higher amount than possible based on the amount of alcohol she consumed.

This hypothetical demonstrates how retrograde extrapolation can yield an inaccurate BAC result. In order to achieve an accurate BAC result based on retrograde extrapolation, the individual's BAC must have peaked at the time of or prior to vehicle operation.[125] It is virtually impossible to ascertain whether BAC has peaked without knowing the time and the amount of alcohol and food consumed.[126] Furthermore, even if the 0.015% elimination rate is applicable to Carrie, the expert must consider other factors in order to calculate the actual BAC at the time of operation. These factors include Carrie's tolerance to alcohol, how much she drank, how much NAD she had in her liver, and whether she is taking steroid contraceptives.[127]

Consequently, Vermont's requirement for retrograde extrapolation is untrustworthy and should be excluded as irrelevant evidence. The calculations are based upon improper presumptions and facts which have no basis in reality.

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123. *Id.* § 1204 (a).

124. State v. Blake, 151 Vt. 235, 236, 559 A.2d 676, 677 (1989).

125. E. Fitzgerald & D. Hume, Intoxication Test Evidence, *supra* note 9, § 2:30, at 46-48.

126. S. Brent & S. Stiller, *supra* note 9, § 3:1, at 27-29; J. Tarantino, *supra* note 67, § 202, at 2-7 to 2-8; L. Taylor, *supra* note 1, § 6.0.2, at 401-04.

127. *See supra* notes 81-116 and accompanying text. *See generally* S. Brent & S. Stiller, *supra* note 9, § 3:1; J. Tarantino, *supra* note 67, §§ 202-203; L. Taylor, *supra* note 1, §§ 6.0.1-6.0.3.

## IV. Alternatives to Retrograde Extrapolation

> *There are four chief obstacles in grasping truth, which hinder every man, however learned, and scarcely allow any one to win a clear title to learning, namely, submission to faulty and unworthy authority, influence of custom, popular prejudice, and concealment of our own ignorance accompanied by an ostentatious display of our knowledge.*
>
> —Roger Bacon[128]

As the foregoing suggests, the scientific basis of retrograde extrapolation as currently used in the judicial system has not been accepted by various sectors of the scientific community.[129] Vermont Rule of Evidence 703 requires that the opinions expressed in expert testimony must be "of a type reasonably relied on by experts in the particular field."[130] The scientific criticism of retrograde analysis raises serious questions regarding the admissibility of retrograde extrapolation under the Vermont Rules of Evidence. There are several alternatives which either reduce the unreliability of retrograde extrapolation or eliminate retrograde extrapolation.

One alternative is to require the state to administer three BAC tests.[131] Three tests, if conducted at equal intervals, would provide a more reliable indication of whether BAC has peaked. The "three test" system reduces speculation that the BAC was declining at the time of the test.[132]

The three test system has several disadvantages. First, if the three test system indicated that the BAC was rising, retrograde extrapolation would be impossible to calculate, because BAC levels rise inconsistently during absorption.[133] Second, even if the BAC was declining, the three test system fails to account for various biological and individual factors which belie the assumption that alcohol is eliminated at a constant rate of 0.015%.[134]

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128. *Quoted in* L. Taylor, *supra* note 1, § 6.7, at 538-39.

129. Jones, *Problems*, *supra* note 12, at 1; Jones, *Status*, *supra* note 12, at 198; Holford, *supra* note 12, at 273; Lewis, *supra* note 12, at 800; J. Tarantino, *supra* note 67, § 202, at 2-5 to 2-8.

130. Vt. R. Evid. 703.

131. Fitzgerald & Hume, *A Challenge to Admissibility*, *supra* note 40, at 29 (suggesting a two test system).

132. Jones, *Status*, *supra* note 12, at 198-200.

133. *Id.*

134. *See supra* notes 99-116 and accompanying text.

Finally, the three test system would be costly. Currently, it costs the State of Vermont thirty to forty dollars per test. In addition, a state chemist spends approximately 20% of his or her time analyzing samples.[135] Another 30% of the chemist's time is spent preparing for and testifying at trial.[136] The three test system would essentially triple the state's cost in terms of money and time spent analyzing samples. The disadvantages of the three test system appear to outweigh the advantages.

A second alternative is to repeal the per se offense and the inferences which require evidence of retrograde extrapolation.[137] The roadside sobriety test could replace the current system, eliminating the prosecution's reliance on untrustworthy scientific evidence.[138] The costs to both the state and the defendant would be reduced because it would eliminate the need for chemical analysis. Further, this option would reduce the amount of time that the police officer is required to spend with the suspect. Under the current system, the suspect has the right to contact an attorney, is allowed one half hour to decide whether to take the BAC test, and the officer must complete several pages of processing forms.[139] Finally, the elimination of scientific evidence would ensure greater fairness to the poor or indigent defendant, who cannot afford expert testimony to contest the reliability of the evidence.

But economic cost is not the most important factor. The purpose of DUI laws is generally to reduce the number of drivers who are too impaired to operate a vehicle, irrespective of the driver's BAC level.[140] The Alcohol Research Center has concluded that the roadside sobriety test is the more accurate way to determine whether one is too impaired to drive.[141] This approach, however, is highly subjective and juries may give the police officer's testimony undue weight. Such deference may be unwarranted because police officers tend to align themselves with the state to the disadvantage

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135. Letter from Carl G. Tremmel, Alcohol Program Coordinator, Agency of Human Services, State of Vermont Department of Health, to Ellen J. Abbott (Jan. 21, 1991).

136. *Id.*

137. This would involve repealing 23 V.S.A. §§ 1201(a)(1) and 1204.

138. *See* L. Taylor, *supra* note 1, § 6.0.1, at 397.

139. Vt. Stat. Ann. tit 23, § 1202(c) (1987 & Supp. 1990).

140. S. Brent & S. Stiller, *supra* note 1, § 1:1, at 4-6; L. Taylor, *supra* note 9, § 1.0, at 9.

141. L. Taylor, *supra* note 1, § 6.0.1, at 397 (quoting a release from the Alcohol Research Center at the University of Colorado, stating that the roadside sobriety test may be more accurate than scientific evidence in determining driving impairment).

of the defendant.

Another alternative is to enact a statute which defines the crucial element of the DUI offense as the BAC at the time of the test.[142] In other words, it would be unlawful to drive a vehicle after having consumed enough alcohol to reach .08 BAC within one hour of driving. The first advantage to this type of statute is that it eliminates the need for retrograde extrapolation. Second, it would increase convictions because the defense to retrograde extrapolation has been very successful.[143] There are, however, some disadvantages to this alternative. There is some evidence that the BAC tests themselves may be scientifically inaccurate and such a per se statute essentially amounts to "conviction by machine."[144]

## V. Conclusion

> *But will you not agree that the worst of evils for one's own community is injustice?*
>
> —Socrates[145]

Vermont laws regarding DUI do not facilitate a just and proper result. Retrograde extrapolation, as a method to convict drunk drivers, is fraught with assumptions which have not been accepted by many in the scientific community.

Retrograde extrapolation presumes that the BAC has peaked at the time of testing. It is virtually impossible to determine whether the BAC is rising or declining with a single BAC test. Furthermore, the method presumes that both absorption and elimination rates are constant for every individual. Scientific studies have consistently found that neither absorption nor elimination rates remain constant. In addition, there are many variables which effect both elimination and absorption rates. Consequently, retrograde calculations of BAC are highly suspect.

The faulty presumptions which underlie retrograde extrapolation suggest only one conclusion: retrograde extrapolation is inherently untrustworthy and should be inadmissible as a matter of law

142. *See Can the State Prove It?*, *supra* note 93, at 825.

143. Jones, *Status*, *supra* note 12, at 198.

144. J. Tarantino, *supra* note 67, § 132, at 1-18. *See generally id.*, at §§ 220-251 (discussing test procedures in general and some inherent problems of both breath and blood tests).

145. Plato, The Republic 206 (D. Lee trans. 2d ed. 1974).

in its current form. Several alternatives exist which either eliminate or reduce the need to rely upon the scientific evidence. These alternatives insure a greater fairness to the defendant than the current system. There is a need for change and the change must be one of fairness, justice, and truth.