46 S.W.3d 902
Court of Criminal Appeals of Texas,
En Banc.

Raul MATA, Appellant,
v.
The STATE of Texas.

No. 133–00.
|
June 6, 2001.

Synopsis

Defendant was convicted following jury trial in the County Court, Bexar County, Tony Jimenez, J., of driving while intoxicated (DWI). Defendant appealed. The Fourth Court of Appeals affirmed, 13 S.W.3d 1. Granting petition for discretionary review, the Court of Criminal Appeals, Keasler, J., held that: (1) science of **retrograde extrapolation**, as used in DWI cases to estimate a defendant's blood alcohol content (BAC) at time of alleged offense, can be reliable in a given case, depending on factors including expert's ability to explain the science with clarity, timing and number of tests performed, and expert's knowledge of a defendant's personal characteristics; and (2) state failed to make requisite showing by clear and convincing evidence that expert's testimony in present case was reliable.

Remanded.

Keller, P.J., filed a dissenting opinion.

Womack, J., filed a dissenting opinion in which Keller, P.J., joined.

Johnson, J., filed a concurring opinion in which Price, J., joined.

West Headnotes (14)

[1] **Criminal Law** Opinion evidence

Defendant in prosecution for driving while intoxicated (DWI) preserved alleged error with respect to state expert's testimony regarding whether defendant was intoxicated at time of arrest, though written motion to suppress attempted to suppress only the results of breath test administered more than two hours later, where defendant at suppression hearing argued for suppression of expert's testimony on ground that it was not reliable, and trial court denied motion after hearing defendant's argument. Rules of Evid., Rule 702; Rules App.Proc., Rule 33.1(a)(1)(A).

6 Cases that cite this headnote

[2] **Criminal Law** Experiments and Tests; Scientific and Survey Evidence

A trial court's responsibility, under rule governing admission of scientific evidence, is to determine whether proffered scientific evidence is sufficiently reliable and relevant to assist the jury. Rules of Evid., Rule 702.

2 Cases that cite this headnote

[3] **Criminal Law** Experiments and Tests; Scientific and Survey Evidence

Proponent of scientific evidence must demonstrate by clear and convincing evidence that the evidence is reliable by showing the validity of the underlying scientific theory, the validity of the technique applying the theory, and proper application of the technique on the occasion in question. Rules of Evid., Rule 702.

7 Cases that cite this headnote

[4] **Criminal Law** Experiments and Tests; Scientific and Survey Evidence

Factors that may affect reliability of scientific evidence include, but are not limited to: (1) extent to which underlying scientific theory and technique are accepted as valid by relevant scientific community, if such community can be ascertained; (2) testifying expert's qualifications; (3) existence of literature supporting or rejecting underlying scientific theory and technique; (4) technique's potential rate of error; (5) availability of other experts to test and evaluate technique; (6) clarity with which underlying scientific theory and technique can be explained to court; and (7) experience and skill of person who applied technique on occasion in question. Rules of Evid., Rule 702.

7 Cases that cite this headnote

[5] **Criminal Law** Experiments and Tests; Scientific and Survey Evidence

In weeding out so-called "junk" science when ruling on proffered scientific testimony, trial judges are called upon to serve as "gatekeepers." Rules of Evid., Rule 702.

2 Cases that cite this headnote

[6] **Criminal Law** Experiments and Tests; Scientific and Survey Evidence

Proffered scientific testimony must be sufficiently tied to the facts of the case that it will aid the jury in resolving a factual dispute. Rules of Evid., Rule 702.

1 Cases that cite this headnote

[7] **Criminal Law** Competency of evidence

Court of Criminal Appeals will not disturb the trial court's decision to admit scientific evidence absent an abuse of discretion. Rules of Evid., Rule 702.

2 Cases that cite this headnote

[8] **Criminal Law** Physiological facts

Court of Criminal Appeals, in reviewing admissibility of scientific testimony, may take judicial notice of scientific literature not presented by either party at trial or on appeal. Rules of Evid., Rule 702.

5 Cases that cite this headnote

[9] **Criminal Law** Preliminary evidence as to competency

Reliance by Court of Appeals on its opinion in another case as evidence of state expert's qualifications in present prosecution for driving while intoxicated (DWI) was inappropriate. Rules of Evid., Rule 702.

1 Cases that cite this headnote

[10] **Criminal Law** Intoxication

Science of **retrograde extrapolation**, as used by experts in driving while intoxicated (DWI) cases to estimate a defendant's blood alcohol content (BAC) at time of offense based on results of a subsequently administered breath test, can be reliable in a given case, as necessary for admission under rule relating to scientific evidence. Rules of Evid., Rule 702.

47 Cases that cite this headnote

[11] **Criminal Law** Intoxication

In determining reliability of **retrograde extrapolation**, as used in driving while intoxicated (DWI) cases to estimate a defendant's blood alcohol content (BAC) at time of offense, expert's ability to apply the science and explain it with clarity to the court is a paramount consideration; in addition, expert must demonstrate some understanding of difficulties associated with **retrograde extrapolation**, must demonstrate awareness of the subtleties of the science and the risks inherent in any extrapolation, and must be able to clearly and consistently apply the science. Rules of Evid., Rule 702.

84 Cases that cite this headnote

[12] **Criminal Law** Intoxication

In evaluating the reliability of a **retrograde extrapolation**, as used by expert in driving while intoxicated (DWI) case to estimate defendant's blood alcohol content (BAC) at time of offense, court should consider (a) the length of time between the offense and the test(s) administered; (b) the number of tests given and the length of time between each test; and (c) whether, and if so, to what extent, any individual characteristics of the defendant were known to the expert in providing his extrapolation. Rules of Evid., Rule 702.

51 Cases that cite this headnote

[13] **Criminal Law** Intoxication

Characteristics and behaviors that, if known to expert who uses **retrograde extrapolation** to estimate blood alcohol content (BAC) at time of alleged driving while intoxicated (DWI) offense, are relevant to determining reliability of that testimony might include, but are not limited to, defendant's weight and gender, defendant's typical drinking pattern and alcohol tolerance, how much defendant had to drink on day or night in question, what defendant drank, duration of drinking spree, time of last drink, and how much and what defendant had to eat either before, during, or after the drinking. Rules of Evid., Rule 702.

40 Cases that cite this headnote

[14] **Criminal Law** Intoxication

State failed in driving while intoxicated (DWI) prosecution to make required showing by clear and convincing evidence that expert's **retrograde extrapolation** as to defendant's blood alcohol content (BAC) at time of offense was reliable; expert's testimony contained inconsistencies that prevented him

from explaining science of **retrograde extrapolation** with any clarity, only one BAC test was performed and it did not occur until over two hours after alleged offense, and expert had no knowledge of any personal characteristics of defendant. Rules of Evid., Rule 702.

110 Cases that cite this headnote

Attorneys and Law Firms

***904** George Scharmen, San Antonio, for Appellant.

Mary Beth Welsh, Assist. DA, San Antonio, for State.

Before the court en banc.

OPINION

KEASLER, J., delivered the opinion of the Court, in which MEYERS, PRICE, HOLLAND, JOHNSON, and HOLCOMB, JJ., joined.

At Raul Mata's trial for driving while intoxicated, an expert witness testified that Mata's blood alcohol content two hours after his arrest showed that he was intoxicated at the time of his arrest. We must decide whether this expert's testimony met the requirements of *Daubert v. Merrell Dow Pharmaceuticals, Inc.,* [1] and *Kelly v. State.* [2] We conclude that it did not.

Factual Background

Officer Kenneth Thompson pulled Mata over at 3:05 a.m. on May 25, 1992, for a traffic violation. He smelled alcohol on Mata's breath, so he asked Mata to perform some field sobriety tests. After the tests, Officer Thompson arrested Mata for driving while intoxicated. Over two hours later, at 5:14 a.m., Mata took two breath tests in quick succession and registered a blood alcohol content (BAC) of .19.

The State charged Mata with driving while intoxicated both by driving with a BAC in excess of .10 and by driving without the normal use of his mental and physical faculties.

Suppression Hearing

Mata filed a motion to suppress the results of his breath test because, among other reasons, they were obtained "from scientific techniques which have not been shown by clear and convincing evidence to be reliable and relevant." He relied on Rules 403 and 702 of the Texas Rules of Criminal Evidence—the applicable rules at the time of Mata's 1993 trial.

At the suppression hearing, George Allen McDougall, Jr., testified that he was the breath test technical supervisor for Bexar County. He explained that an individual's BAC is reflected by an alcohol concentration curve which begins at the low point when there is no alcohol in the person's blood and rises as the alcohol is absorbed into the bloodstream until it ***905** reaches the peak, that is, the maximum alcohol concentration. Then the curve falls as

the alcohol dissipates from the bloodstream to the low point when there is no alcohol left. McDougall testified that he had "done some calculations like this on his own" and that to draw such a curve for an individual, he would need "more than a couple" of reference points. He would need "a lot of them." McDougall conceded that, although Mata blew into the breathalyzer twice, the readings were only two minutes apart and, for purposes of drawing an alcohol concentration curve, constituted only a single reading. That single reading did not give McDougall enough information to determine whether Mata was in the absorption phase or the elimination phase at the time of the breath test.

McDougall testified that, in order to determine an individual's BAC at the time the individual was driving, he "assume[s] several variables." He testified to several possibilities: the individual could have had a higher BAC at the time he was driving than at the time of the breath test; the individual could have had a lower BAC at the time he was driving than at the time of the breath test; or the individual could have the same BAC at both times. McDougall testified that he determines how high the BAC could have possibly been and how low it could have possibly been. Then "between those two somewhere is where the actual value will be."

McDougall agreed that the alcohol concentration curve of an individual who drank on an empty stomach would rise higher and faster than the curve of an individual who drank on a full stomach. He conceded that without a number of tests, and without knowing an individual's weight and whether he had eaten anything, he could not determine the steepness of that individual's alcohol concentration curve. He testified that, regardless of what the person had in his stomach, "an hour and a half is adequate for a complete absorption of the drinks."[3] He testified that alcohol eliminates at a rate of .02 grams per 210 liters.[4]

When given a hypothetical case based on the facts of this case, McDougall testified that if an individual's breath test registered .19 two hours and nine minutes after that person had been driving, McDougall would say that the person had a higher BAC at the time of the test than at the time of the driving. He also testified that, nevertheless, based on those facts, he would believe the person was intoxicated at the time of the driving.

McDougall testified that, given Mata's BAC of .19 two hours after his arrest, he believed Mata was impaired at the time of driving and had lost the normal use of his mental or physical faculties at the time he was driving. But he emphasized that he was not saying that Mata's BAC at the time of driving was .10—only that it was at least .08. He said Mata's BAC range was between .12 or .13 all the way up to .25. He testified that these figures were based on Mata having an empty stomach. If he had a full stomach, the range would be more narrow—that is, from a low end of .16 up to a high end of .21 or .22. Then, when asked if Mata's BAC could have been less than a .10, McDougall said "there was an 'extreme situation' in which that was possible."[5]

McDougall conceded that he did not know how much Mata weighed, how much Mata had to eat or drink before taking the breath test, or when Mata's last drink was.

***906** Defense counsel argued that McDougall's testimony was unreliable insofar as it attempted to extrapolate Mata's .19 breath test result back to the time of his arrest. The trial court denied the motion to suppress.

Trial

At trial, McDougall testified to his background again. When the prosecutor asked McDougall to give the jury a range for a person's BAC at the time of driving if two hours later his breath test showed a BAC of .19, defense counsel examined McDougall outside the presence of the jury "concerning the underlying facts or data upon

which he relies to render this opinion, so that the Court may determine that the expert has a sufficient basis for his opinion."

During voir dire examination, McDougall testified that, while elimination rates are standard, absorption rates vary from person to person. He testified that the absorption phase does not last more than one hour. He then testified that it could last up to an hour and a half if the person had a full stomach. But he maintained that it was not possible for a person's BAC to peak two hours after he quit drinking. When presented with an exhibit showing a person's BAC peaking two hours after drinking stopped, McDougall testified that that case involved a very small amount of alcohol, which was not the norm. He later testified that he had "tested thousands of individuals" and, "with all of the studies that [he had] read," it was his experience that the BAC will not rise for more than one and a half hours after the first drink, whether the person has a full or empty stomach. [6]

McDougall acknowledged that he did not know when Mata began drinking or when he stopped or when Mata reached his peak BAC. He explained that, without knowing when Mata peaked, he considers all the possible peak points to calculate the BAC range for Mata at the time of the arrest. He testified that the normal or average person eliminates alcohol at a rate of .02 per hour, that he uses the .02 elimination rate, [7] and that he bases his calculations on a "normal drinking pattern." According to McDougall, an individual who "chug-a-lugs" shots of hard liquor in a short period of time is not engaging in a "normal" drinking pattern. He admitted that, if he were to include the chug-a-lug situation in his calculations, there would be "a lot of variability." He conceded that a study by the National Highway Traffic Safety Administration (NHTSA) reflected that a person's BAC can rise 10 points in one hour in the chug-a-lug situation, but he repeated that this was not a "normal" drinking pattern. [8]

At the conclusion of the voir dire, defense counsel argued that McDougall was only qualified to testify about the "average" or "normal" person, but he could not apply his calculations to Mata, because he did not know if Mata engaged in "normal" drinking patterns, and he did not know if Mata had been eating, how much he had been eating, how much he had had to drink, or his weight. The trial court allowed McDougall to offer his opinion before the jury.

Before the jury, McDougall testified that, given a .19 BAC two hours after driving, he would estimate a person's BAC while driving to be between .13 and .23. [9] He also testified that the person's BAC ***907** could be lower than .10 if he chug-a-lugged a lot of hard liquor just before being stopped. [10] He first testified that it would take five shots to increase from a .10 to a .19 in two hours. He later testified that it would take seven to twelve shots. [11]

In performing a hypothetical calculation, McDougall utilized a .02 or .03 elimination rate. He later testified that the elimination rate could range from .018 to .025. [12]

McDougall again testified that he based his calculations and estimates on "normal drinking patterns" and he did not know if Mata followed such patterns. [13] He also testified that he did not believe a person's peak BAC could occur more than an hour and a half after the arrest. [14]

The jury convicted Mata of driving while intoxicated and the court sentenced him to 90 days in jail, probated for two years, and a fine of $400. Mata filed a motion for new trial arguing that the trial court erred in overruling the motion to suppress and in allowing into evidence "the opinion of ... McDougall ... because that opinion was non-scientific and unreliable." After hearing argument, the trial court denied Mata's motion.

Court of Appeals

In his first two points of error on appeal, Mata argued that the trial court erred in overruling his suppression motion because McDougall's testimony was unreliable and because the probative value of the testimony was outweighed by the unfair prejudice. Mata relied in part on *Daubert* and *Kelly.* The court of appeals summarily rejected these claims, quoting a portion of its prior opinion in *Hartman v. State* [15] :

> Given McDougall's impeccable qualifications, including extensive personal observations of the alcohol absorption and elimination process, and the limits which McDougall placed on his opinion, we find the trial court did not abuse its discretion in admitting his testimony. Once the trial court so found, any further doubts as to the veracity of McDougall's opinions were for the trier of fact to weigh in its deliberations. [16]

The appellate court did not discuss the requirements of *Daubert* or *Kelly* and whether those requirements were met in this case. In a lengthy dissent, Justice Cadena concluded that McDougall's testimony was not sufficiently reliable under *Kelly* and that the trial court abused its discretion in admitting it. [17]

We granted Mata's petition for discretionary review to decide whether McDougall's testimony was admissible pursuant to the requirements of *Daubert* and *Kelly.*

Preservation of Error

[1] The State argues that Mata did not preserve error because his written motion to suppress did not attempt to suppress McDougall's testimony. Instead, it attempted to suppress the results of the breath test. The court of appeals found the error preserved. [18]

***908** Appellate Rule 33.1(a)(1)(A) provides that error is preserved if the "complaint was made to the trial court by a timely request, objection, or motion" that states the grounds "with sufficient specificity to make the trial court aware of the complaint." At the suppression hearing, Mata argued for the suppression of McDougall's testimony on the grounds that it was not reliable. The trial court denied the motion to suppress after hearing Mata's argument. We conclude that Mata timely informed the trial court of his grounds with sufficient specificity and, therefore, that he preserved error.

Legal Background

[2] **[3]** **[4]** Evidence Rule 702 provides that an expert witness may testify as to his opinion based on scientific knowledge if it will help the trier of fact understand the evidence or determine a fact in issue. A trial court's responsibility under Rule 702 is to determine whether proffered scientific evidence is sufficiently reliable and relevant to assist the jury. [19] The proponent of the scientific evidence must demonstrate by clear and convincing evidence that the evidence is reliable. [20] This is accomplished by showing the validity of the underlying scientific theory, the validity of the technique applying the theory, and proper application of the technique on the occasion in question. [21] Factors that may affect reliability include, but are not limited to, the following: (1) the extent to which the underlying scientific theory and technique are accepted as valid by the relevant scientific community, if such a community can be ascertained; (2) the testifying expert's qualifications; (3) the existence of literature supporting or rejecting the underlying scientific theory and technique; (4) the technique's potential rate of error;

(5) the availability of other experts to test and evaluate the technique; (6) the clarity with which the underlying scientific theory and technique can be explained to the court; and (7) the experience and skill of the person who applied the technique on the occasion in question. [22]

[5] **[6]** **[7]** While Rule 702 involves the "dual inquiry of relevance and reliability," the "overarching subject of Rule 702 is the scientific validity of the evidence at issue." [23] In weeding out the so-called "junk" science, trial judges are called upon to serve as "gatekeepers." [24] The proffered testimony must be sufficiently tied to the facts of the case that it will aid the jury in resolving a factual dispute. [25] We will not disturb the trial court's decision to admit scientific evidence absent an abuse of discretion. [26]

Analysis

The science which we analyze today is known as "**retrograde extrapolation**." **Retrograde extrapolation** is the computation back in time of the blood-alcohol level—that is, the estimation of the level at ***909** the time of driving based on a test result from some later time. [27]

As alcohol is consumed, it passes from the stomach and intestines into the blood, a process referred to as absorption. [28] When the alcohol reaches the brain and nervous system, the characteristic signs of intoxication begin to show. [29] The length of time necessary for the alcohol to be absorbed depends on a variety of factors, including the presence and type of food in the stomach, [30] the person's gender, [31] the person's weight, [32] the person's age, [33] the person's mental state, [34] the drinking pattern, [35] the type of beverage consumed, [36] the amount consumed, [37] and the time period of alcohol consumption. [38] At some point after drinking has ceased, the person's BAC will reach a peak. After the peak, the BAC will begin to fall as alcohol is eliminated from the person's body. The body eliminates alcohol through the liver at a slow but consistent rate. [39]

In 1932, Swedish chemist E.M.P. Widmark first calculated absorption and elimination rates in the body, and his work still represents the benchmark for other scientists' studies today. Widmark created what we know today as the "BAC curve," which represents the rise and fall of an individual's BAC as his body absorbs and eliminates alcohol. A reading from a single breath test will not reflect where the person is on his BAC curve. In other words, it will not indicate whether the person is in the absorption phase, at his peak, or in the elimination phase. [40]

So if a driver is tested while in the absorption phase, his BAC at the time of the test will be higher than his BAC while driving. If tested while in the elimination phase, his BAC at the time of the test could be lower than while driving, depending on whether he had reached his peak before or after he was stopped. Obviously, the greater the length of time between ***910** the driving and the test, the greater the potential variation between the two BACs.

To clarify, we are not addressing whether **retrograde extrapolation** is necessary in order for the State to prove a defendant guilty in a DWI case. [41] Nor do we address whether test results showing a defendant's BAC at some time after the alleged offense are admissible at trial in the absence of **retrograde extrapolation**. [42] Our only concern today is whether McDougall reliably applied the science of **retrograde extrapolation** in Mata's trial.

Scientific Literature

[8] We may take judicial notice of scientific literature not presented by either party at trial or on appeal.[43] Our research revealed a number of articles on the subject. Mark Montgomery of the College of Public Health at the University of Florida and Mark Reasor of the Department of Pharmacology and Toxicology in West Virginia contend that **retrograde extrapolation** is reliable.[44] They concede that "the scientific community is divided" on this issue.[45] But they believe that extrapolation to a range of BACs can be accomplished reliably, as long as "justifiable assumptions are made that are based on sound principles of pharmacology, toxicology, and physiology."[46] The authors set forth several hypothetical cases in which, given several known factors, they are able to calculate the subject's expected BAC at the time of driving. In each hypothetical case, the known factors include the subject's weight, the length of time in which drinking occurred, and the time at which the drinking stopped.

Other scientists are more cautious in their examination of reliability. Richard Watkins, Assistant Director of the Phoenix Crime Detection Lab, and Eugene Adler, a toxicologist for the Arizona Department of Public Safety Crime Lab, write that **retrograde extrapolation** is somewhat reliable.[47] In their study on the effect of drinking on a full versus an empty stomach, they discovered that "the alcohol elimination rate was lower in the full stomach condition ***911** compared to the empty stomach condition. The difference was statistically significant."[48] They concluded that it was possible to make estimates of BACs at some time removed from the breath test that were "sufficiently reliable."[49] But they nevertheless cautioned that, "[h]owever useful such estimates may be in [DWI] cases, it should be remembered that the process of alcohol absorption is highly variable. The limitations and pitfalls associated with **retrograde extrapolations** are often not appreciated by laymen and the courts."[50] The authors concluded that "[a]ny attempt at **retrograde extrapolation** should be made with caution, and performed by persons able to assess and discuss the applicability of a **retrograde extrapolation** to a particular situation."[51]

Still others are even more wary of the science. Alan Jones, Ph.D., Associate Professor in the Department of Alcohol Toxicology at the University Hospital in Sweden, Kjell Ake Jonsson, M.D. and Ph.D., Clinical Associate at the Department of Clinical Pharmacology and Internal Medicine at the University Hospital, and Aldo Neri, M.D., Research Technician at the Department of Alcohol and Drug Addiction Research at the Karolinska Institute in Stockholm, Sweden, point out the potential for error in the science.[52] They write that **retrograde extrapolation** is a "dubious practice" and that expert testimony on the issue "requires careful consideration of the absorption kinetics of ethanol and the factors influencing this process."[53] They explain that "[t]he absorption profile of ethanol differs widely among individuals, and the peak [BAC] and the time of its occurrence depend on numerous factors. Among other factors, the drinking pattern, the type of beverage consumed, the fed or fasted state, the nature and composition of foodstuff in the stomach, the anatomy of the gastroinstestinal canal, and the mental state of the subject are considered to play a role."[54]

These authors point out the limitations of the Widmark equations. In their study, they found that "rapid consumption of a moderate dose of ethanol on an empty stomach" resulted in a peak BAC that was "higher than would be expected.. according to Widmark calculations."[55] They refer to this as the "overshoot effect ." They explain that after this "early peak" there would be a "diffusion plunge." They state that "[i]f the apparent rate of elimination is calculated from the change in [BAC] between two time points immediately after an overshoot, that is, on a diffusion plunge, the results are abnormally high."[56] Professor Jones and his colleagues conclude that "[t]he status of ethanol absorption in drunk drivers at the time of the offense is a more difficult question to tackle. In practice, this will depend on such circumstances as the previous drinking spree—the duration and quantities consumed—and the time lapse from the end of drinking to the time of arrest or the time an accident occurred."[57]

The authors "highly recommend" that such "speculation" be avoided by states defining the offense of ***912** driving drunk as having a certain BAC at the time of the breath test rather than at the time of the driving. [58]

P.R. Jackson, G.T. Tucker, and H.F. Woods, all of the University of Medicine and Pharmacology at Royal Hallmshire Hospital in Great Britain, agree that **retrograde extrapolation** should be used with caution. [59] They state that the method used should "account for possible variations from several sources." [60] The "major possible source of error," the authors state, is when "continuing absorption is ignored, as this can make a large difference to the shape and position of" the BAC curve. [61] Another source of error "arises from the unique status of the observed subject" because there is "generally no information as to his or her position in the population distribution of the parameters describing ethanol elimination." [62] These authors conclude that, "in the absence of continuing absorption," reasonably reliable BAC estimates can be made. But "when absorption continues after drinking, especially when at a slow rate, backtracking calculations become markedly inaccurate." [63]

Jones and Neri, in another paper, agree that Widmark's method, while it can be "practical and reliable" in some instances, is not reliable "if alcohol is consumed together with a meal" because "the resulting blood-ethanol concentrations are underestimated." [64]

The complicating factors were discussed by Y. Al–Lanqawi of the Department of Pharmacology and Clinical Pharmacology at the University of Dundee Medical School, and his colleagues. [65] He writes that "[i]ndividuals vary with respect to age, sex, body weight and lean body mass, all of which may effect the disposition of ethanol. In addition, the absorption of ethanol into the body may be variable and may continue over a long period of time." [66] He found that **retrograde extrapolations** using the "mean elimination rate" observed in their study resulted in a rate of error of "essentially zero." [67] He nevertheless noted that "the variability in the extrapolation error obtained in individual suspects with the mean elimination rate was considerable." [68]

In particular, Al–Lanqawi discovered that the potential rate of error increased as time went on. Indeed, "this variability was particularly large" when extrapolation back one hour or more was attempted. [69] Finally, Al–Lanqawi and his colleagues found that the mean elimination rate in their study was 25% greater than the "frequently cited population mean rate" of .015. "When the latter slope was used in the back extrapolation procedure, a consistent underestimation in the plasma ethanol ***913** concentration was observed in the majority of the subjects." [70]

Finally, Edward Fitzgerald, a lawyer in Massachusetts, and Dr. David Hume, a professor of analytical chemistry at M.I.T., write that there are "serious questions about the reliability of any later single test as an indicator of an earlier BAC." [71] They explain that most extrapolations are based upon certain assumptions which simply are not true, including the assumption that a person's BAC will decline once drinking has stopped. In fact, they say, in most DWI cases, the person is arrested shortly after his last drink. [72] His stomach has not yet absorbed all the alcohol, and his BAC will continue to rise for some time after arrest, resulting in a tested BAC which is higher than what it was at the time of the driving. Another assumption these authors criticize is the assumption that all people have an alcohol elimination rate of .015. While that is the average rate of elimination, the authors point out that the actual individual range is generally between .01 and .02, with values seen as high as .04 and as low as .006. [73] They conclude that the attempt to engage in **retrograde extrapolation** is "fraught with difficulties." [74]

Other Courts

Few jurisdictions have considered the reliability of **retrograde extrapolations**. One reason for this is that many states have eliminated any need for **retrograde extrapolation** as a matter of law. Their statutes provide for a rebuttable presumption that an individual is guilty of DWI if his BAC at the time of the test is over the legal limit, assuming the test was conducted within a specified or reasonable time from the driving. [75] In these states, a BAC of .10 or more at the time of the breath test would essentially prove the State's case; it is then the defendant's burden to prove that his BAC was lower than the legal limit at the time he was driving. In contrast, at the time of Mata's offense, our statute required the State to prove that the defendant had a BAC of .10 "while operating a motor vehicle." [76]

We found only two courts that have touched upon the reliability of **retrograde extrapolation**. An Arizona appellate court has stated in a footnote, without citation to authority, that the science of **retrograde extrapolation** "has achieved general acceptance in the scientific field." [77] The Alabama Court of Criminal Appeals, on the other hand, appears to disagree. That court, while finding the issue was not preserved for appeal, cautioned that its opinion should not be interpreted as "tacit approval" for the use of **retrograde extrapolations**. [78] Citing a law review article, the Court stated that

> "[c]areful analysis of these studies indicates that **retrograde extrapolation** is an unreliable method of determining a defendant's ***914** 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. These inadequacies render **retrograde extrapolation** inherently untrustworthy and therefore inappropriate for use as evidence to convict drunk drivers." [79]

The Expert

[9] Under *Kelly* we may also examine the clarity with which the expert explained the underlying scientific theory and technique. Initially, we note that McDougall is a popular expert in Bexar County DWI prosecutions. [80] The court of appeals found that he has "impeccable qualifications, including extensive personal observations of the alcohol absorption and elimination process." But we find nothing in the record supporting any "extensive personal observations of the alcohol absorption and elimination process" or any ability to perform **retrograde extrapolations**. It was inappropriate for the court of appeals to rely on its opinion in *Hartman* as evidence of McDougall's qualifications in this case. Nevertheless, Mata conceded at trial that McDougall was qualified to perform **retrograde extrapolations** generally; he complained only that McDougall could not reliably apply the technique to Mata.

In reviewing the testimony, we find that, while McDougall's testimony indicates a general understanding of the BAC curve and the concepts of absorption and elimination, it reflects failure to explain the theory to the court with any clarity. First, McDougall contradicted himself within his testimony. He testified, at various times, that the absorption phase could not last longer than an hour, or an hour and a half, or two hours. [81] He testified that Mata's BAC at the time of driving would have been at least .08, then .12 or .13. He testified that Mata's high-end BAC would have been .25, then .23. [82]

In addition, McDougall seemed unaware of the subtleties inherent in any **retrograde extrapolation** calculation. He initially testified that the average elimination rate was approximately .02, but most of the literature suggests it

is .015, [83] and McDougall did not acknowledge the difference (a difference of 33%) or explain it. He later testified that elimination rates could range from .018 to .025, but he nevertheless stated that he used a .02 or .03 elimination rate in his calculations. McDougall's .03 elimination rate is not only outside his own stated range, it is ***915** twice the generally-accepted elimination rate. The dissent believes McDougall "clearly misspoke" [84] in referring to elimination rates, but we find nothing in the record to indicate this. The dissent also suggests that McDougall's erroneous elimination rate is irrelevant since scientific literature also suggests that the .015 rate is too slow, and "recent literature indicates that anything from .015 to .02 is ... normal." [85] But our focus today is not on what the proper elimination rate is or should be. We merely observe that McDougall's testimony was inconsistent and failed to acknowledge scientific evidence to the contrary. This is just another factor we consider in determining whether McDougall explained the science to the court with clarity.

Moreover, McDougall's math appeared to be in error. At the suppression hearing, McDougall calculated a high-end BAC for Mata as being .25 on an empty stomach and .22 on a full stomach. He testified that he used a .02 elimination rate. But if Mata's BAC was .19 at the time of the test, and McDougall was using the average elimination rate of .02, McDougall should have calculated a high-end BAC of .23 at the time of the offense, which was two hours before the test. McDougall did not explain the difference in the numbers. At trial, he corrected his math and calculated a high-end BAC for Mata as being .23. McDougall's changing his calculations from the pretrial hearing to the trial is a factor we can consider in determining the reliability of his testimony.

McDougall's inconsistent statements did not stop here. Regarding the number of drinks required to increase from below a .10 to a .19 in two hours, McDougall first testified that five drinks would be sufficient, then changed his testimony to seven to twelve drinks. [86]

Finally, McDougall conceded that his calculations were based on a "normal drinking pattern." He acknowledged that the "chug-a-lug" situation was not a normal drinking pattern, and he also acknowledged that he had no idea how much Mata had had to drink, what he had had to drink, or how long Mata had been drinking. As a result, McDougall essentially conceded that all of his calculations as to Mata were speculative. [87]

Conclusion

Our study of **retrograde extrapolation** leads us to several conclusions. Initially, we recognize that even those who believe **retrograde extrapolation** is a reliable technique have utilized it only if certain factors are known, such as the length of the drinking spree, the time of the last drink, and the person's weight. [88] McDougall knew none of those factors, or any other individual characteristics of Mata, for that matter. In addition, there appears to be general disagreement on some of the fundamental aspects of the theory, such as the accuracy of Widmark's formulas, [89] ***916** whether a standard elimination rate can be reliably applied to a given subject, [90] and the effect that food in the stomach has on alcohol absorption. [91] Nevertheless, given the studies, other concepts seem indisputable, including that multiple tests will increase the ability to plot a subject's BAC curve, a test nearer in time to the time of the alleged offense increases the ability to determine the subject's offense-time BAC, and the more personal information known about the subject increases the reliability of an extrapolation.

[10] **[11]** We believe that the science of **retrograde extrapolation** can be reliable in a given case. The expert's ability to apply the science and explain it with clarity to the court is a paramount consideration. In addition, the expert must demonstrate some understanding of the difficulties associated with a **retrograde extrapolation**. He must demonstrate an awareness of the subtleties of the science and the risks inherent in any extrapolation. Finally, he must be able to clearly and consistently apply the science.

[12] **[13]** The court evaluating the reliability of a **retrograde extrapolation** should also consider (a) the length of time between the offense and the test(s) administered; (b) the number of tests given and the length of time between each test; and (c) whether, and if so, to what extent, any individual characteristics of the defendant were known to the expert in providing his extrapolation. These characteristics and behaviors might include, but are not limited to, the person's weight and gender, the person's typical drinking pattern and tolerance for alcohol, how much the person had to drink on the day or night in question, what the person drank, the duration of the drinking spree, the time of the last drink, and how much and what the person had to eat either before, during, or after the drinking.

Obviously, not every single personal fact about the defendant must be known to the expert in order to produce an extrapolation with the appropriate level of reliability. As the Kentucky Supreme Court has recognized, if this were the case, no valid extrapolation could ever occur without the defendant's cooperation, since a number of facts known only to the defendant are essential to the process.[92] If the State had more than one test, each test a reasonable length of time apart, and the first test were conducted within a reasonable time from the time of the offense, then an expert could potentially create a reliable estimate of the defendant's BAC with limited knowledge of personal characteristics and behaviors. In contrast, a single test conducted some time after the offense could result in a reliable extrapolation only if the expert had knowledge of many personal characteristics and behaviors of the defendant. Somewhere in the middle might fall a case in which there was a single test a reasonable length of time from the driving, and two or three personal characteristics ***917** of the defendant were known to the expert. We cannot and should not determine today the exact blueprint for reliability in every case. Suffice it to say that the factors must be balanced.

Application

[14] In this case, the inconsistencies in McDougall's testimony prevented him from explaining the science to the court with any clarity. Regarding the other factors, there was only one test of Mata's BAC, and it occurred over two hours after the alleged offense. This is a significant length of time and seriously affects the reliability of any extrapolation. Add to that the fact that McDougall did not know one single personal characteristic of Mata—he did not know whether Mata had eaten anything that night and if so, how much; how much Mata had had to drink; what Mata had been drinking; when Mata's last drink was; the length of Mata's drinking spree; or even Mata's weight.

We find that the factors in this case weigh against a finding of reliability. Even the scientists who find **retrograde extrapolations** reliable would require more known quantities than what McDougall had in this case. Given McDougall's inconsistent testimony, along with the single breath test conducted over two hours after the driving, we conclude that, in this case, the State failed to prove by clear and convincing evidence that McDougall's **retrograde extrapolation** was reliable.

Judgment

We conclude the trial court abused its discretion in admitting that part of McDougall's testimony pertaining to the extrapolation of Mata's BAC. We remand this cause to the court of appeals for a determination of harm under Appellate Rule 44.2.

KELLER, P.J., filed a dissenting opinion.

WOMACK, J., filed a dissenting opinion.

JOHNSON, J., filed a concurring opinion in which PRICE, J., joined.

HERVEY, J., did not participate.

APPENDIX A

Testimony Regarding Length of Absorption Phase

Suppression Hearing

Q: And is it conceivable then that over a period of two hours, if a person had a very full stomach, that it is going to take awhile for them to reach their peak of alcohol concentration?

A: Yes.

Q: Regardless of how much they have had to drink, if they have a full stomach, you know, lots of meat and potatoes, it is just going to take some time for it to get up there?

A: Yes.

Q: Two hours maybe?

A: I think *an hour and a half is adequate for a complete absorption* of the drinks. *It doesn't take two hours* to digest a stomach full of food. So all of the alcohol would be absorbed in the hour and a half.

Q: An hour and a half?

A: Yes, and it would be less than that if it were not a full stomach.

Voir Dire

Q: Consequently, if all you have is the test result and you have the arrest time, the only angle that [you] can draw, nothing [*sic*] that the peak occurred after the test, is the angle from zero, at the time of ***918** arrest, to the point of the chart on the test?

A: No, I don't agree with that.

Q: Okay. Tell me why you disagree with that?

A: *I don't know of any situation where a person would be in the absorption phase after an hour.* So let's assume that he was arrested and he drank just before he was arrested. He could be rising for an hour and then he would peak. *I don't know of any instance where he would peak two hours later.*

Q: Okay. Are you saying that an individual who has a full stomach on him, a meal of potatoes, would not peak more than two hours?

A: *If the person had an empty stomach he would peak in about half an hour to 45 minutes. And if he is on a full stomach it would be somewhere around an hour to an hour and a half at the very most.*

Q: *So are you saying that it is not possible?*

A: *For him the peak two hours later, no. He has to peak before two hours. He has to peak in about an hour.*

Q: Well, I am just going to show you this chart that we have gone over. I know you have seen it. *This is that chart* based upon the U.S. Department of Transportation, Alcohol and Safety study and we referred to this. And you will note that the second or the lower of the two was based upon, you know, the same amount of alcohol with an individual immediately after eating a meal of potatoes *and it shows that this person is peaking right at about two hours, doesn't it?*

A: *Yes, it does.*

Q: Now, would you say you would disagree with that?

A: Here is the problem. On this particular chart our peak is at a .04. That is a very limited alcohol concentration.

Q: It is lower.

A: So it is a very small amount of alcohol in the amount of potatoes. It varies greatly with more alcohol. It would not be delayed as much for a greater amount of alcohol. Potatoes can't dilute the alcohol any more than potatoes can dilute the alcohol.

Q: I agree, but what it does is it slows down the system and it slows down the alcohol getting into the gut, basically?

A: Yes, but that is also dependent upon the concentration of the alcohol and the amount of the alcohol. This is a limited amount of alcohol. This is just two ounces.

Q: Well, here it says two ounces of pure alcohol and 8 ounces of water, equivalent to 5 ounces of 80 proof Vodka. Would you agree with that?

A: Yes, sir.

* * *

Q: This is an extreme. Okay. I agree with you that that is extreme on one end. But would you agree with me that there is also an extreme on the other end that in some individuals, that they could have been drinking for a long period of time and had achieved a high level of alcohol in their system, perhaps several hours before this, and *then continued to rise for a period of time?*

A: *For an hour to an hour and a half. That is the most.*

Q: Yes.

A: *Anything more than that I don't believe.* It has not been my experience and I have tested thousands of individuals and *it has not been my experience that their* ***919** *alcohol concentration rises more than an hour and a half after their last drink.*

Q: Even though this survey might suggest otherwise?

A: That is not a survey. That is an experiment done with a gulp of five ounces on potatoes and then you measure the alcohol concentration.

Q: Right. And one was done on a full stomach and one was done on an empty stomach and there was a variability. You will agree with that?

A: *I am not going to accept the two hours as an absolute, no.* In my experience with all of the studies that I have read *it is between half an hour to an hour and a half to reach a peak,* after drinking on a full or empty stomach.

Within the limitations of that graph they could have been [talking] about an hour and a half and it looks like two hours. It is not very significant.

Trial

Q: What would [it be] if the peak in this situation came after the test? How would that change your range?

A: I don't believe it would have occurred more than an hour and a half after the arrest. I don't know of an instance, in my own experience, *I don't know of anybody that has reached a peak more than an hour and a half after the last drink.*

Q: You have not come across that situation?

A: No, but *I must admit that I have not tested a chug-a-lugger.*

APPENDIX B

Testimony Regarding Elimination Rates

Suppression Hearing

Q: And for the alcohol to be metabolized and processed out of the system, we are talking about—that is when we talk about this absorption/elimination. In other words, it is going to rise fairly rapidly in terms of absorption and *then it will dissipate or eliminate at .02 percent grams per 210 liters, is that correct?*

A: *Yes.*

Q: Approximately?

A: Yes, sir.

Voir Dire

Q: Now, *alcohol ... eliminates at about a .02 per hour, something like that?*

A: *Yes, sir.*

* * *

Q: What you are saying then as I understand it is, that you take the time of the test, and *following the .02 elimination rate,* you would draw a chart up to, say the time of the arrest and past it to a potential peak, is that right?

A: Yes, sir.

* * *

Q: Now, the reason we can testify about this range right here, or you can, is that you have two knowns. You have the known breath test and you have *the known standard elimination rate which is pretty standard among all persons. Will you agree with me?*

A: *Yes, sir.*

Trial

Q: Could you draw for the jury a graph in the form of an XY axis, showing us that range?

A: By XY, do you mean alcohol concentration versus time?

Q: Right.

A: I guess I can.

Q: Your Honor, may the witness step down to the diagram?

***920** Court: Yes.

A: This is time and this would be alcohol concentration. The only time that I really have is the time of the test. And this is the only real test and I will put that at .19 up here, a .193 and the time of the test. Alcohol is eliminated at the rate of one drink per hour. Two hours before it could have been as high as a .23. And then, *let's say it was at a .02 or .03 elimination per hour,* it would make it at .06 less than this—a .13. His alcohol concentration would have been somewhere in that range (indicating on the chart).

* * *

Q: Now, let's talk about the elimination rates. Is that a fairly standard number in all persons' elimination rate?

A: *.02 per hour of alcohol concentration for a 150 pound person is pretty stable. It ranges from [.018 to a .025]. A .02 is very close to normal.*

Q: So we are not going to see any large shift in elimination rates over a period of time. It is going to be right around a .02?

A: If all he is doing is eliminating and if he has completed absorption.

Q: And that will probably be pretty close to the same for the average person throughout?

A: Yes, sir.

Q: So given an elimination rate of .02, if we assume, based upon your chart, that the individual peaked prior to the test then you can draw sort of a line back showing, you know, on this chart a rise of .02 per hour?

A: If he peaked two hours before or if he peaked prior to that.

Q: Right. And that is what this line would represent because these are known things, right? We know that we have a breath test score of a .193 or whatever it was and we know about a .02 elimination rate, over time. Now, what about absorption rates?

A: They vary more because of the amount of food in the stomach and also the amount of the concentration of the alcohol being consumed.

APPENDIX C

Testimony Regarding BAC Range

Suppression Hearing

Q: You are not testifying, today, about what his conditions were while he was in actual, physical control of a motor vehicle, are you?

A: Yes, I believe I was.

Q: What are you saying about his condition when he was in actual, physical control of a motor vehicle?

A: That he was impaired and that he had lost the normal use of his mental or physical faculties at the time that he was in control of a motor vehicle.

Q: You are not saying that he had a breath alcohol content of .10 or higher, are you?

A: No, *I am saying that he had an alcohol concentration of at least a .08 or higher.*

Q: So you will state that in your opinion, at a .08, it means an individual has lost the normal use of their mental or physical faculties?

A: Yes.

Q: If that is the result of ingesting alcohol?

A: Yes.

Q: Now, however, you will agree that the State, in terms of the breath alcohol testing program, the State minimum is a .10?

A: Yes, I will.

***921** Q: All right. But based upon the information that you have, you just really can't give us a figure for this individual based upon that test taken two hours later, can you?

A: I can't give you an individual number. I can give you a range, but not a number.

Q: And they will ask—so I am going to ask you, what is that range?

A: I think it is possible for the person to be as much as a .06 less than a .19, two hours and ten minutes earlier. *It could have been as low as a .12 or a .13.*

Q: I am sorry, a what?

A: *A .12 to a .13 at the low end,* and somewhere about a .25 at the high end, somewhere in between there.

Q: So we are talking about a range here of .13?

A: To a .25, yes, two hours previous.

Q: A range then including 12 points?

A: Yes.

Q: So it is a 12 point range that you will testify to?

A: Yes.

Q: Are you saying that there is not a possibility that it could be lower than 10, a .10?

A: No. *There is an extreme situation where it is possible that it could be less than a .10.*

* * *

A: He could have been as low as maybe a .16 on a full stomach and not quite as high [as] a .25, maybe a .21 or .22.

Trial

Q: A male blows a .193 two hours after they were stopped, two hours after we know at least that they had stopped drinking two hours prior. Can you give us a range as to what his alcohol concentration would have been at the time he was stopped?

A: I believe the high side would have been somewhere around a .04 higher than that, which would be a .23 and then his body would have eliminated the equivalent of two drinks during those two hours. On the low side, his body could have absorbed two or three drinks and as much as a .04 or a .06, reached a peak and either maintained that level or decreased a little bit until the time of arrest, which would make him, I guess, at the low side of a .13. So I would say *somewhere between a .13 and a .23.*

* * *

Q: Mr. McDougall, *can you conceive of any factuall* [sic] *facts that would support an alcohol concentration below a .10 at the time that he was stopped?*

A: *Yes.*

Q: Okay. What would that be?

A: If just before he was stopped if he chug-a-lugged a lot of hard liquor, hard alcohol.

* * *

Q: Now, in this particular case you have testified that you thought there was a range of .13 to .23?

A: Yes, sir.

Q: However, you previously testified that the range could have been from a point .12 to a point .25. Is that correct?

A: That is very possible. I don't know if we used the same assumptions.

Q: I don't want to put words in your mouth and that is why I marked this and I want to make sure that you are the same George Allen McDougall that testified in this case back in June of 1993. There is ***922** no other George Allen McDougall, is there, testifying?

A: Well, my father, but he is not testifying.

Q: Okay. Then I will submit to you that this was your testimony in response to my questions.

A: It could have been as low as a .12 or a .13. That is what I testified to here, and to a .25, yes. Yes, what did I say previously, a .23? It is possible I could have testified to that.

APPENDIX D

Testimony Regarding Normal Drinking Patterns

Voir Dire

Q: Let's assume that we do have a .19, and we have that .19 an hour and 55 minutes, tested, after the arrest. And that is all the information that you have?

A: That is correct.

Q: Now, not nothing [*sic*] when that peak occurs, before or after, why is that figure any different in factoring your theoretical analysis of range than the figure that we are dealing with here?

A: Because you are assuming that he chug-a-lugged twice as much alcohol to get to that level.

Q: Perhaps. See, I am not assuming that. I think that you have to assume that. You have to assume many different variables is what I am saying?

A: I don't think that I have to assume that. *I think that I can assume a normal drinking pattern.* And if you want to raise the issue of the possibility of a chug-a-lug, then we can talk about it. But I don't assume that as normal. I am sorry, but *I don't assume that chug-a-lugging alcohol is normal. In my drinking experience that is very unusual.*

Q: Well, that is true?

A: I am not going to give you an example based on a very unusual situation.

Q: But you will agree with me, won't you, that there are persons that drink that much?

A: Who drink that much, yes, but not chug-a-lug. But yes, there are people that drink that much. Yes, I will agree with you.

Q: Mr. McDougall, the point I am trying to make is that you don't know anything about Mr. Mata or his drinking habits and what he had to drink on that night, so you cannot factor in any of these variables to determine the angle, you know, back which we can recreate this range.

A: No, but I can state the parameters under which I am making my hypothetical answer and you can live with that or you can illustrate the limitations of my parameters. But I think my parameters are very well within the bounds of what you are going to find.

Q: *But what you are saying is you are basing your parameters on some hypothetical individual?*

A: *Yes, on a normal drinking individual.*

Q: But that may mean something totally different to this jury than it does to you because you are a breath test supervisor?

A: But I am not adverse to explaining what my parameters are and they can assume those parameters and they can understand the parameters I am using. I am not using any magic.

Q: No, and I agree with that, but wouldn't you agree that your experience with drinking and with the capacities of individuals and the vari [e]ties within the population, that your experience is far different than these people on this jury. You have a much broader range of information.

***923** A: And with that knowledge a chug-a-lug is even more exceptional. To state that a chug-a-lug—which is the only possibility that we are talking about here, is that he actually gulped down a quart of liquor just before the arrest and then he went driving.

Q: Right, that is one of the possibilities that you have to consider?

A: *That is one that would not be considered normal. I am sorry.*

Q: Well, you say normal but you have to apply that opinion to Mr. Mata. Are you saying to this court that you would limit your testimony not to Mr. Mata but to a hypothetical individual who is not him?

A: No, I would explain what is normal and if you were to bring up other parameters then I will tell you what those other parameters will do to an individual. I will explain it and lay it all out.

Trial

Q: You say when he could have peaked within a normal drinking pattern—is that what you just said?

A: Yes.

Q: But you don't know what the drinking pattern is of Mr. Mata?

A: That is correct.

Q: So that range is based upon an assumption that doesn't apply to Mr. Mata, is that correct?

A: It may not, yes, sir.

Q: So that range that we have there may not be his range?

A: That is possible, yes.

Q: This is a hypothetical based upon your person, the average person?

A: Yes.

APPENDIX E

Trial Testimony Regarding Amount of Liquor Required to Increase BAC by 10 Points

Q: Mr. McDougall, can you conceive of any factuall [*sic*] facts that would support an alcohol concentration below a .10 at the time that he was stopped?

A: Yes.

Q: Okay. What would that be?

A: If just before he was stopped if he chug-a-lugged a lot of hard liquor, hard alcohol.

Q: About how much? Can you tell us at this point about how much he would have to chug-a-lug to blow a .10 and up to a .19?

A: Again I need to know his body weight. If we are talking about a 150 pound person then that is *five extra drinks, from a .10 to a .19.* He would have to consume at least five shots of alcohol for 150 pounds and proportionally more if he weighs more than 150 pounds.

Q: So a 150 pound person, it would be about five shots?

A: Five shots of hard liquor.

Q: And how many ounces constitute the shot?

A: An ounce and a quarter.

Q: And that would be right before the person was stopped?

A: That would be so that the person had consumed the alcohol but it hadn't had a chance to get into his blood stream yet, which means very close to the time that he was arrested. He would have to very quickly be drinking and be very quickly arrested thereafter.

Q: Are you assuming in this fact situation as in a .09, or are you assuming he is a .00 at the time that he had the five shots?

***924** A: No, he would be at five shots in addition to a .10. *Let's assume that he is at .10 and to reach a .19 he would have to consume at least five shots* if he weighed 150 pounds.

Q: If the person was stone, cold sober and had not a drop to drink at the time that they were stopped, they would have to drink significantly more than the five shots?

A: He would have to consume about 12 shots, from .00 to .19. Yes, 12 shots of hard liquor.

* * *

Q: Based upon the factual hypothetical that we talked about earlier, what are you considering the abnormal drinking pattern?

A: Chug-a-lugging a bottle of hard liquor and gulping it down as fast and as much as you can in a short period of time.

Q: And this hypothetical that we talked about, him going from a [.10 to a .19] [93] , that it had to take him five shots just before he got arrested, do you agree with that?

A: *No.* Those aren't the same. Chug-a-lugging is drinking much more than that. *It would be seven, eight, nine, ten, or eleven or twelve drinks consumed very quickly.*

Q: *For him to come from below a .10 up to a .19?*

A: *Yes,* he would have to have much more than that.

Q: And an individual from that fact situation, this person that blows a .19, two hours after arrest, they have above a .10 at the time that they are stopped?

A: I believe so, yes.

KELLER, P.J., filed a dissenting opinion.
The Court acknowledges that "**retrograde extrapolation**" testimony constitutes reliable evidence under Rule 702 [1] if the principles of the theory are applied correctly. However, the Court contends that the **retrograde extrapolation** analysis in this case was improperly conducted. I respectfully disagree.

The Court first contends that McDougall's testimony reflects a failure to explain the theory with any clarity. In support of this contention, the Court points to what it believes are various contradictions in McDougall's testimony. The Court finds that McDougall contradicted himself in testifying that absorption could last no longer than an hour, an hour and a half, or two hours. My reading of the testimony reveals no contradiction. McDougall testified that *usually* absorption would take no longer than an hour, and *at most* it would take an hour and a half. McDougall acknowledged a study that showed absorption ***925** taking two hours, but McDougall cautioned that the study involved relatively small amounts of alcohol (well below the legal limit) that were diluted by food. McDougall maintained that larger volumes of alcohol were not so easily diluted and were absorbed within the hour and a half time frame.

The Court also contends that McDougall contradicted himself by testifying that Mata's BAC at the time of driving would have been at least .08, then .12 or .13. But an examination of the testimony shows no contradiction. McDougall set .12 or .13 as the low end but acknowledged an "extreme situation" that could result in a lower BAC of .08.

Citing Widmark's research and other literature suggesting that the average elimination rate is .015 per hour, the Court finds fault with McDougall's testimony that the average elimination rate is .02. But earlier in its opinion the Court cites other literature that says Widmark's average is too slow. [2] Moreover, recent literature indicates that anything from .015 to .020 is accepted as "normal." [3] "Disagreements between experts about the variables and correct elimination rates to be applied go to the weight of the evidence as do the differences in the experts' credentials." [4] The Court faults McDougall for failing to acknowledge contrary opinions in the literature, but McDougall was not asked about contrary opinions. He was simply asked for his own opinions on the elimination rate. As a qualified expert, McDougall could base his opinion on what he believed to be the most accurate literature on the subject and what accords most with his experience, which, according to his testimony, included the testing of two thousand individuals. If McDougall had been questioned about the contrary literature and had failed to acknowledge it, that might be cause for concern, but such was not the case here.

The Court further argues that McDougall committed a math error by giving a high-end range of .25, when the high-end should have been a .23 given a test result of .19 and using an elimination rate of .02 per hour for two hours. But, the supposed math error seems to be eliminated if one considers that the .25 estimate was made at the motion to suppress hearing, where McDougall used the .196 base test result. McDougall testified at trial that the average elimination rate ranged from .018 to .025, although .02 was considered "normal." Adding a .025 elimination rate to .196 over two hours would yield a .246—or .25 if one rounds up. At trial, the prosecution used the other sample as the basis for comparison, giving a base test result of .193. McDougall then calculated the high end as .23, which is consistent with the testified elimination rate of .02.

The Court also contends that McDougall assumed an elimination rate of .03 in his testimony, thereby going beyond his own stated range of elimination rates. A close examination of the testimony, however, shows that McDougall was referring to the low end of the alcohol concentration range—which is produced by measuring *absorption* rates, not elimination rates. McDougall clearly misspoke here when he used the word "elimination" instead of "absorption." That slip of the tongue does ***926** not mean McDougall was unable to explain **retrograde extrapolation** with any clarity; it simply means that McDougall is human and can be expected to make a mistake

now and then. If the parties had thought it to be important, they could have corrected this slip of the tongue through questioning. And in fact, in other testimony at trial, McDougall expressly stated that a total absorption of .04 or .06 could be expected over a two hour period, which is consistent with the ".02 to .03" per hour rate given in the testimony of which the Court complains. [5]

The Court finally contends that McDougall contradicted himself when he first testified that five drinks would be required to increase from below a .10 to a .19 in two hours but later testified that seven to twelve drinks would be required. But the record shows the latter testimony was in response to a hypothetical assuming a BAC "from .01 to .09." The Court contends that this range was either a stenographic error or a misstatement by the prosecutor but that the witness clearly understood the prosecutor's question to refer to the previous hypothetical involving a range of .10 to .19. It may be, however, that the prosecutor misspoke, and in so doing, confused the witness. McDougall's earlier testimony involved two hypotheticals: (1) five drinks (shots of hard liquor) to raise someone from a .10 to a .19, and (2) twelve drinks to raise someone from a .00 to a .19. McDougall may have believed that the prosecutor was referencing the latter hypothetical in giving his answer. At any rate, after McDougall's seven to twelve drink answer, the prosecutor clarified the hypothetical as coming from "*below* a .10 up to a .19." Such a hypothetical could include a base level of .00 through .09 with .19 as the end result—which would make McDougall's range of seven to twelve drinks consistent with his previous testimony. Moreover, if there was a contradiction, no one bothered to question McDougall about it. Had someone done so, perhaps McDougall would have supplied an explanation for the apparent disparity or explained whether he had misheard or misunderstood the hypothetical. The trial court could have easily concluded from the evidence before it that McDougall could explain the theory of **retrograde extrapolation** with sufficient clarity.

The Court next contends that there were insufficient facts in the present case from which to conduct a proper **retrograde extrapolation** analysis. The Court lists the following non-exclusive characteristics to consider: weight, sex, typical drinking pattern, tolerance for alcohol, how much the person had to drink on the occasion, what the person drank, duration of the drinking spree, time of the last drink, and how much the person had to eat. McDougall knew that appellant was a man. Although he did not know appellant's weight, McDougall testified that his calculations had taken weight into account. Perhaps McDougall was referring to the hypothetical of a person weighing 150 pounds that was given to him at trial. If appellant's weight varied greatly from 150 pounds, he could have brought that out through cross-examination and posed a hypothetical that included his actual weight.

Moreover, McDougall testified that his figures assumed a normal drinking pattern, but he was willing to explain how the estimates would change for a chug-a-lug situation. Further, McDougall testified to the top and bottom ends of the range of possible intoxication based upon the breath ***927** result of .19. His figures assumed an empty stomach because the figures for a full stomach would be closer to the tested value, and hence, within the range given. Finally, while he did not know whether appellant was in the absorption phase or elimination phase, McDougall gave figures that took both of these possibilities into account.

While McDougall's knowledge of appellant's personal characteristics was sparse, he did not attempt to arbitrarily estimate a single value for appellant's BAC. If he had done so, the Court's criticism would be well-taken. But McDougall was a very thoughtful witness. He set up a rather large range of BAC values and explained the assumptions upon which that range was based. In doing so, McDougall took into account the universe of likely factors based upon the information given. If appellant believed that McDougall had neglected to consider a particular factor or set of factors, appellant was free to pose the appropriate hypothetical and obtain a corresponding opinion. In fact, McDougall plainly said that a variety of factors could influence a person's BAC.

McDougall testified to a BAC range that, regardless of the factors involved, showed appellant was almost certainly above the legal limit. In that regard, the testimony was both reliable and helpful to the jury.

I respectfully dissent.

WOMACK, J., filed a dissenting opinion, in which KELLER, P.J., joined.

In this case the material fact was the concentration of alcohol in the appellant's body at the time he was arrested while driving, which was 3:05 a.m. [1] About two hours later the defendant gave two samples of his breath, a few minutes apart, for testing. [2] The testing instrument reported his alcohol concentration as being 0.196 in the first sample and 0.193 in the second. [3] George McDougall was asked what the range of alcohol concentration of "a male" would have been when he was arrested if he had stopped drinking at least two hours earlier. [4] McDougall answered:

> I believe that the high side would have been somewhere around a .04 higher than that, which would be a 0.23 and then his body would have eliminated the equivalent of two drinks during those two hours. On the low side, his body could have absorbed two or three drinks and as much as a .04 or a .06, reached a peak and either maintained that level or decreased a little bit until the time of arrest, which would make him, I guess, at the low side of a .13. So I would say somewhere between a .13 and a .23. [5]

He explained that "he would need to know his body weight" to know how much alcohol was in the male's system when he was tested. He said he could conceive that the male could have had an alcohol concentration below 0.10 at the time he was stopped ***928** if "just before he was stopped he chug-a-lugged a lot of hard liquor, hard alcohol." To say how much alcohol, he would need to know the male's body weight. [6]

On cross-examination he agreed that, because he lacked several pieces of information, the breath test in this case did not tell the defendant's alcohol level at the time he was driving. [7] He did not observe the defendant's driving or his drinking or whether he had had anything to eat, and he did not know the defendant's weight. [8] He agreed that he did not know when "the peak of the [defendant's] blood alcohol absorption/elimination occurred," that he could give a better answer if he knew that fact, and that his opinion was "based upon some assumptions about absorption and elimination rates," which varied among individuals. [9] He also admitted that his opinion was based on "a normal drinking pattern," and that he did not know the defendant's drinking pattern . [10]

> Q. So that range is based upon an assumption that doesn't apply to Mr. Mata, is that correct?
>
> A. It may not, yes, sir.
>
> Q. So that range that we have there may not be his range?
>
> A. That is possible, yes.
>
> Q. *This is a hypothetical* based upon your person, the average person?
>
> A. Yes. [11]

All of the testimony that I have mentioned was given to the jury. It also should be noted that, outside the presence of the jury when the district court was considering the admissibility of McDougall's testimony, the defense counsel asked similar questions, concluding with these:

> Q. So your *hypothetical* has to deal with an average person or a reasonable person and not specifically with my client?

A. With a reasonable possibility of drinking, yes.

Q. What you consider are the reasonable possibilities of drinking?

A. Exactly. [12]

I have set forth these details because, in my view, they determine the outcome of this case, in which the witness's qualifications are not challenged and in which his testimony clearly referred to a hypothetical or average person. I do not think the trial court abused its discretion in finding that such general testimony would "assist the trier of fact to understand the evidence or to determine a fact in issue," Tex.R. Evid. 702. The jury was given general information about alcohol concentration's varying over time as alcohol is introduced, absorbed, metabolized, and eliminated; about the usual speed with which this may happen in an average person; and about the fact that these processes vary among individuals and in response to the behaviors that accompany the drinking.

The case might be different if the witness had expressed an opinion about the defendant's blood alcohol, or if his qualifications had been challenged. Of course I express no view about such questions.

I would affirm the judgments below.

***929** JOHNSON, J., joined by PRICE, J., concurring.

Rates for alcohol absorption and burn-off are an appropriate matter of inquiry and exposition in a trial for driving while intoxicated. However, using such rates to establish that the defendant was driving while intoxicated may be a problem because Texas law is stated in terms of concentration of alcohol in the blood (BAC) at time of driving rather than time of testing. Extrapolation back from the BAC at the time of testing to the BAC at the time of driving is an endeavor fraught with the danger of inappropriately bamboozling the jury into thinking that such an extrapolation can be anything close to accurate. The information which is usually available to the expert doing the extrapolation is woefully inadequate to make even an educated guess about a range of possible BACs.

According to Nichols and Whited,

> The intoxication of an individual depends on the absorption, distribution, and elimination of alcohol through the body. The rate of absorption, distribution and elimination varies greatly between individuals, and can have a substantial effect on an individual's intoxication and chemical test results. Despite the substantial variability of these factors, the chemical tests used to determine the intoxication of an individual are based on the "average" person under constant conditions. The "average" person is created using a number of assumptions that do not take into account the substantial individual variation.

DONALD H. NICHOLS & FLEM K. WHITED, III, DRINKING/DRIVING LITIGATION: CIVIL AND CRIMINAL 14–2 (2d ed.1998).(DDL). Add to this the reality that elimination begins as soon as the first alcohol reaches the liver. EDWARD F. FITZGERALD, INTOXICATION TEST EVIDENCE 2–14 (2d ed.2000).(ITE). Thus absorption and elimination occur simultaneously until all of the ingested alcohol has been absorbed. TEXAS BREATH ALCOHOL TESTING PROGRAM OPERATOR MANUAL 5–10 (1996).(OM).

The original work in the area of absorption and burn-off rates was done in the 1930s by E.M.P. Widmark. Unfortunately, his work has been subjected to "gross simplification." ITE at 3–8. All of Widmark's work was done

on subjects who drank a metered amount of alcohol on an empty stomach. *Id. at* 3–2 et seq. In the original test group of 30 subjects, only 3(10%) tested in the absorption range of 0.65 and 0.70, 19(63%) tested under 0.65 and 8(27%) tested over 0.65. The subjects' elimination rates varied from 0.006 to 0.04 with most being widely distributed between 0.010 and 0.020. Widmark and later researchers established that both absorption and elimination rates vary widely and are dependent on a large number of factors, including gender. Today, however, "experts" take the averages rate for males and apply them to everyone. They then testify authoritatively that "the average person" absorbs and eliminates alcohol at fixed, known rates, generally claimed to be 0.68 for absorption and .015 for elimination, and make no mention of the myriad variables known to have marked effect on those rates.

Absorption and burn-off rates are highly variable, even in a single individual. The generally accepted rate of burn-off is about one beer per hour, based on the "average man." However, the "average man," like the "average family" with 2.4 children, doesn't exist; the only rates which have relevance are the rates of the person on trial. Absorption and elimination rates are affected by a myriad of factors, including most commonly, weight, gender, physical condition, metabolic rate, time of day, when, what, and how much ***930** the defendant last ate, when, what, and how much and how the defendant drank, medications taken or not taken, point in a woman's menstrual cycle, emotional state, and whether the defendant is an alcoholic. We can extrapolate in regard to which way each known factor, in isolation, will affect absorption and burn-off, but prediction becomes more complicated each time another factor is added to the equation. Very quickly, accurate extrapolation becomes impossible. The impossibility is highlighted when the values of only a few of these many variables are known to the extrapolator. *See generally,* ITE, Chapter 11.

The first inquiry must be into where on the absorption/elimination curve the BAC sample falls. *Id.* at 2–1. Given the procedures mandated by police policy, that inquiry can almost never be accurately answered; determination by law enforcement of BAC via breath or blood is usually the result of a single sample. At least two, and preferably three, samples taken over time are absolutely necessary. *Id. at* 4–11—19. After drinking begins, the BAC will rise to some peak value, then decrease until all alcohol has been metabolized. If, at the time of testing, a person is in the absorption phase, in which the BAC is increasing, the BAC at time of driving would be lower than the tested value. The opposite is true if at the time of testing the person is in the elimination phase, in which the BAC is decreasing. Without knowing even the sample's general location on the BAC curve, all other calculations are specious sophistry. A single high reading can be useful as an indication of intoxication, e.g. when the BAC is 0.20 one hour after driving, but even then is not helpful in determining what the actual BAC was at the time of driving. *Id.* at 4–15—16. Even if the position on the BAC curve at the time of testing can be determined, the task of determining BAC at the time of driving gets no easier.

According to the TEXAS BREATH ALCOHOL TESTING PROGRAM OPERATOR MANUAL (1996), the manual for breath-test operators published by the Texas Department of Public Safety (OM), a "200 lb. man must consume twice as much alcohol as a 100 lb. man to attain the same alcohol concentration." *Id. at* 5–7. Even that statement is a generalization; alcohol is distributed through the body dissolved in the water contained in the body. OM at 5–5. For the above statement to be true, we must assume that the two men have identical levels of tissue water, for instance, 70%. The equation changes again if the individual is a woman; women tend to have less water and more body fat than men. *Id. at* 5–8. A woman is therefore likely to have a higher blood-alcohol level than a man of equal weight after consuming the same quantity of alcohol. *Id.*

Even that may not be true if the man is obese and the woman has extremely low body fat. ITE at 2–6. Generally, the better the person's physical condition (high muscle, low body fat), the lower the peak BAC will be. *Id.* The rate at which a person metabolizes alcohol is affected by the health of that person, especially the health of the person's liver. *Id. at* 2–13. Size, shape, and capacity of the liver affect the rate of elimination. *Id. at* 4–40. At least seventeen shapes are considered "normal," *id.,* and liver size is related to body weight, DDL at 14–139. If the person is an active alcoholic, the rate will be even more unpredictable; alcoholics tend to metabolize ethanol

more rapidly (DDL at 14–149—53, OM at 5–5) and at least partially by a different chemical process than non-alcoholics (ITE at 4–5).

One of the major influences on how quickly and how high BAC rises is whether ingestion of alcohol is accompanied by ingestion of food. As noted above, the ***931** original research into BAC was done only on subjects drinking on an empty stomach, yet the rates derived from that research are now applied indiscriminately to all scenarios. The presence of food in the stomach slows the rate of gastric emptying, and that rate is known to have a dramatic effect in how much and how quickly alcohol gets into the small intestine, where the vast majority of alcohol is absorbed. *Id. at* 2–3. Absorption in the small intestine is quick. *Id. at* 2–3. DDL at 14–47 et seq. Absorption in the stomach is generally slow and inefficient, so the longer alcohol stays in the stomach, the longer it will take to reach peak BAC. *Id. at* 2–2. DDL at 14–70. Also, when alcohol stays in the stomach, the digestive process breaks down some of the ethanol into smaller pieces which do not cause intoxication when absorbed by the body, and so the peak BAC is lower than if the alcohol were consumed on an empty stomach. DDL at 14–52, 14–70, ITE at 14–115.

A number of factors affect gastric emptying. Protein slows emptying more than sugars, which slow emptying more than carbohydrates, which slow emptying more than fats. DDL at 14–63. Large meals slow emptying more than small ones. *Id. at* 55. Size, shape, and position of the stomach also affect emptying, and at least nine positions and nineteen shapes are recognized as "normal." ITE at 4–2, 4–39. Because gastric emptying is controlled by the nervous system, emotions affect the rate; fear decreases it, while excitement tends to accelerate it. DDL at 14–70. Trauma may shut down emptying altogether. ITE at 2–10—11. The alcohol itself can alter the rate; alcohol ingested in large quantities causes the pyloric sphincter to close, preventing emptying. *Id. at* 14–37, 14–68—69, OM at 5–5. Carbonated beverages mixed with alcohol accelerate emptying. ITE at 14–69, OM at 5–5. Surgery such as stapling also alters the rate of emptying, ITE at 14–73—74, as does gravity, *id. at* 14–73, some kinds of drugs, such as Tagamet, *id. at* 14–73, and some diseases (*id. at* 14–74). [1]

Which kind of alcoholic beverage was ingested and in what quantity and manner also affect BAC. Distilled liquors produce a higher BAC than beer or wine for a given amount of alcohol. DDL at 14–38 *et seq.* Large quantities increase the time needed to reach peak BAC. *Id. at* 14–44 et seq. Chugging produces a higher, quicker peak BAC than an equal amount of alcohol consumed over a longer period of time. DDL at 14–88—89.

Other factors which may affect peak BAC and rates of absorption and elimination include altitude, DDL at 14–33, point in menstrual cycle, *id. at* 14–79, 14–159 *et seq.,* oral contraceptives, *id. at* 14–84, ITE at 4–7, drugs, especially if they act on the stomach or circulation or are metabolized by the liver, ITE at 2–13, body temperature, DDL at 14–139—40, and time of day, DDL at 14–85—86, 14–164—66. Add in physiological differences, such as inherited or developed tolerances or sensitivities, and accurate prediction becomes even more problematic.

To make accurate prediction even more improbable, recent research has shown that two of the basic assumptions used in extrapolating to the time of driving, a smooth BAC curve and linear elimination rates, are not in fact true. The BAC curve is not smooth, as it is usually presumed to be, but rather is irregular and contains unpredictable spikes. DDL at 14–171. ***932** Other research has shown that elimination rates are non-linear and vary over time. The importance of such a finding is that "if elimination is nonlinear, then it is impossible to estimate someone's blood alcohol concentration at a time earlier or later than when the blood alcohol measurement is made...." *Id. at* 14–166.

A simple mathematical formula for the number of possible combinations of variables is 2 to the power equal to the number of variables, e.g., 5 variables indicates 2^5, producing 32 possible results. Noted above are at least twenty variables. The number of possible results is thus 2^{20}, or 1,048,576. However, this simple equation assumes that each variable has only two values and does not consider any possible interactions between variables.

The general equation is the number of possible values, "m," raised to the power of the number of variables, "n," or m^n. Assuming an average of 5 values per variable and twenty variables, the number of possible results, 5^{20}, is 24,414,062. Each variable in the BAC calculation has many possible values. Many of the variables have a possibility of interacting with each other and further complicating the matter. Even assuming a relatively small number of possible values, the number of possible results increases exponentially and quickly becomes mind-boggling.

In most cases, the expert who is attempting to extrapolate BAC to the time of driving has little information about the defendant or the circumstances surrounding the ingestion of alcohol beyond the single BAC reading, the gender of the driver, and perhaps an approximate weight. Even with full information, the complexity of the interaction of the variables makes the accuracy of any claimed BAC value, or range of values, suspect. "For all these reasons the actual BAC curve which will result from the ingestion of a given amount of alcohol on a given occasion by a particular person is, at best, highly unpredictable, although many experts testify as though they can, in fact, predict 'the' BAC which **will** result on a given occasion." ITE at 2–7 (emphasis in original). The majority chooses not to go so far as to call attempted extrapolation from a single BAC sample back to the time of driving "junk science." I do not feel so constrained, and junk science has no place in a courtroom where the standard of proof is beyond a reasonable doubt.

With these comments, I join the majority.

All Citations

46 S.W.3d 902

Footnotes

1 509 U.S. 579, 113 S.Ct. 2786, 125 L.Ed.2d 469 (1993).
2 824 S.W.2d 568 (Tex.Crim.App.1992).
3 *See* Appendix A.
4 *See* Appendix B.
5 *See* Appendix C.
6 *See* Appendix A.
7 *See* Appendix B.
8 *See* Appendix D.
9 *See* Appendix C.
10 *See* Appendix C.
11 *See* Appendix E.
12 *See* Appendix B.
13 *See* Appendix D.
14 *See* Appendix A.
15 2 S.W.3d 490 (Tex.App.—San Antonio 1999, pet. ref'd) (en banc).
16 *Mata v. State,* 13 S.W.3d 1, 2 (Tex.App.—San Antonio 1999) (*quoting Hartman,* 2 S.W.3d at 493–94).
17 *Id.* at 4–37 (Cadena, J., dissenting).
18 *Id.* at 2 n. 1.
19 *Jackson v. State,* 17 S.W.3d 664, 670 (Tex.Crim.App.2000); *Jordan v. State,* 928 S.W.2d 550, 554–55 (Tex.Crim.App.1996).
20 *Jackson,* 17 S.W.3d at 670.
21 *Kelly,* 824 S.W.2d at 573.
22 *Ibid.*

23 *Jordan,* 928 S.W.2d at 554–55, *quoting Daubert,* 509 U.S. at 593–95, 113 S.Ct. at 2797.

24 *Id.* at 555.

25 *Ibid.*

26 *Hinojosa v. State,* 4 S.W.3d 240, 250–51(Tex.Crim.App.1999); *Griffith v. State,* 983 S.W.2d 282, 287 (Tex.Crim.App.1998).

27 *See* Lawrence Taylor, DRUNK DRIVING DEFENSE § 5.2 (5th ed.) (2000).

28 NAT'L INST. ON ALCOHOL ABUSE & ALCOHOLISM, ALCOHOL ALERT, "Alcohol Metabolism," No. 35 (Jan.1997).

29 Jennifer Pariser, *Note: In Vino Veritas: The Truth About Blood Alcohol Presumptions in State Drunk Driving Law,* 64 N.Y.U.L.REV. 141, 146 (1989), *citing* S. Brent & S. Stiller, HANDLING DRUNK DRIVING CASES, § 4:2 (1985); Edward Fitzgerald & Dr. David Hume, *The Single Chemical Test for Intoxication: A Challenge to Admissibility,* 66 MASS. L.REV. 23, 28 (1981).

30 Pariser, 64 N.Y.U.L. REV. at 147, *citing* 2 R. Erwin, DEFENSE OF DRUNK DRIVING CASES CRIMINAL/CIVIL § 15.04[1][b][i], at 15 (3d ed.1988); Rodney Gullberg, *Variation in Blood Alcohol Concentration Following the Last Drink,* 10 J. OF POLICE SCIENCE & ADMIN. 289 (1982); Alan Jones *et al., Peak Blood Ethanol Concentration and the Time of Its Occurrence After Rapid Drinking on an Empty Stomach,* 36 J. OF FORENSIC SCIENCE 376, 381 (1991).

31 NIAAA ALCOHOL ALERT, "Alcohol Metabolism," No. 35 (Jan.1997).

32 Y. Al–Lanqawi *et al., Ethanol Kinetics: Extent of Error in Back Extrapolation Procedures,* 34 BRITISH J. OF CLINICAL PHARMACOLOGY 316, 320 (1992).

33 *Ibid.*

34 Jones *et al.,* 36 J. OF FORENSIC SCIENCE at 381.

35 *Ibid.*

36 *Ibid.*

37 Gullberg, 10 J. OF POLICE SCIENCE & ADMIN. at 289.

38 *Ibid.*

39 Pariser, 64 N.Y.U.L. REV. at 149.

40 Pariser, 64 N.Y.U.L. REV. at 152, *citing* W. Frajola, DEFENDING DRINKING DRIVERS 16.1 (1985).

41 *Compare, e.g., McCafferty v. State,* 748 S.W.2d 489 (Tex.App.—Houston [1st Dist.] 1988, no pet.) (evidence insufficient without **retrograde extrapolation**); *State v. Ladwig,* 434 N.W.2d 594 (S.D.1989) (same); *Desmond v. Superior Court,* 161 Ariz. 522, 779 P.2d 1261 (Ariz.1989) (same); *Allman v. State,* 728 N.E.2d 230 (Ind.Ct.App.2000) (same); *State v. Rollins,* 141 Vt. 105, 444 A.2d 884 (Vt.1982) (same); *State v. Geisler,* 22 Conn.App. 142, 576 A.2d 1283 (Conn.App.1990) (same), *appeal denied,* 215 Conn. 819, 576 A.2d 547 (Conn.1990), *vacated on other grounds,* 498 U.S. 1019, 111 S.Ct. 663, 112 L.Ed.2d 657 (1991); *with Haas v. State,* 597 So.2d 770 (Fla.1992) (evidence sufficient without **retrograde extrapolation**); *Sullivan v. State,* 517 N.E.2d 1251 (Ind.Ct.App.1988) (same); *People v. Mertz,* 68 N.Y.2d 136, 497 N.E.2d 657, 506 N.Y.S.2d 290 (N.Y.1986) (same); *Commonwealth v. Slingerland,* 358 Pa.Super. 531, 518 A.2d 266 (Pa.Super.Ct.1986) (same); *Comm. v. Wirth,* 936 S.W.2d 78, 84 (Ky.1996) (same); *State v. Kubik,* 235 Neb. 612, 456 N.W.2d 487 (1990) (same).

42 *See, e.g., Mireles v. Dep't of Public Safety,* 9 S.W.3d 128 (Tex.1999) (test results admissible without **retrograde extrapolation**); *State v. Barber,* 42 Conn.App. 589, 681 A.2d 348 (Conn.Ct.App.1996) (same); *Desmond, supra* (same).

43 *Emerson v. State,* 880 S.W.2d 759, 764–65 and 765 n. 1. (Tex.Crim.App.1994).

44 Mark Montgomery & Mark Reasor, ***Retrograde Extrapolation*** *of Blood Alcohol Data: An Applied Approach,* 36 J. OF TOXICOLOGY AND ENVTL. HEALTH H 281–292 (1992).

45 *Id.* at 282.

46 *Id.* at 288.

47 Richard Watkins & Eugene Adler, *The Effect of Food on Alcohol Absorption and Elimination Patterns,* 38 J. OF FORENSIC SCIENCE 285–291 (1993).

48 *Id.* at 288.

49 *Id.* at 290.

50 *Ibid.*

51 *Ibid.*

52 Jones *et al.,* 36 J. OF FORENSIC SCIENCE 376–385 (1991).
53 *Id.* at 377.
54 *Id.* at 381.
55 *Ibid.*
56 *Id.* at 381–83.
57 *Id.* at 384.
58 *Ibid.*
59 P.R. Jackson *et al., Back-tracking Booze with Bayes—the Retrospective Interpretation of Blood Alcohol Data,* 31 BRITISH J. OF CLINICAL PHARMACOLOGY 55–63 (1991).
60 *Id.* at 61.
61 *Id.* at 61–62.
62 *Id.* at 62.
63 *Ibid.*
64 A.W. Jones & A. Neri, *Reinvestigation of Widmark's Method for Quantitative Evaluation of Blood–Ethanol Profiles: Influence of Alcohol Dose and Mode of Drinking,* 33 CLINICAL CHEMISTRY 1469 (1987).
65 Al Lanqawi *et al.,* 34 BRITISH J. OF CLINICAL PHARMACOLOGY at 321.
66 *Id.* at 320.
67 *Ibid.*
68 *Ibid.*
69 *Ibid.*
70 *Ibid.*
71 Fitzgerald & Hume, 66 MASS. L.REV. at 28 (1981).
72 *Id.* at 31.
73 *Id.* at 31.
74 *Id.* at 32.
75 *See, e.g.,* CAL. VEH.CODE § 23152(b); NEV. REV. STAT . § 484.381(1); IND.CODE ANN. § 9–11–4–15; IOWA CODE ANN. § 321J.2(7); MINN.STAT. §§ 169.121 subd. 2.
76 Former TEX.REV.CIV. STAT. ART.. 6701*l*–1 (repealed 1995), now located at TEX. PENAL CODE § 49.04.
77 *Ring v. Taylor,* 141 Ariz. 56, 69 n. 6, 685 P.2d 121, 134 n. 6 (Ariz.Ct.App.1984).
78 *Smith v. Tuscaloosa,* 601 So.2d 1136, 1140 (Ala.Crim.App.1992).
79 *Ibid., quoting* E. Abbott, *"One for the Road"—The Reliability of* ***Retrograde*** ***Extrapolation*** *and the Implications for Vermont Statutes,* 16 VT.L.REV. 395, 397 (1991).
80 *See Coward v. State,* 993 S.W.2d 307 (Tex.App.—San Antonio 1999, no pet.); *Mireles v. Texas Department of Public Safety,* 993 S.W.2d 426 (Tex.App.—San Antonio 1999), *aff'd,* 9 S.W.3d 128 (Tex.1999); *State v. Reed,* 888 S.W.2d 117 (Tex.App.—San Antonio 1994, no pet.); *Kapuscinski v. State,* 878 S.W.2d 248 (Tex.App.—San Antonio 1994, pet. ref'd); *State v. Krager,* 810 S.W.2d 450 (Tex.App.—San Antonio 1991, pet. ref'd); *State v. Kost,* 785 S.W.2d 936 (Tex.App.—San Antonio 1990, pet. ref'd); *Douthit v. State,* 739 S.W.2d 94 (Tex.App.—San Antonio 1987, no pet.); *Harrell v. State,* 725 S.W.2d 208 (Tex.Crim.App.1986).
81 *See* Appendix A.
82 *See* Appendix C.
83 *See* Fitzgerald & Hume, 66 MASS. L.REV. at 31 (average elimination rate is .015); Pariser, 64 N.Y.U.L.Rev. at 152 n. 76, citing Watson & Batt, *Prediction of Blood Alcohol Concentrations in Human Subjects: Updating the Widmark Equation,* 42 J. STUD. ALCHOLL 547 (1981); Taylor, DRUNK DRIVING DEFENSE § 5.2.3 (Widmark's research indicates average elimination rate of .015).
84 *Post,* op. at 905 (Keller, P.J., dissenting).
85 *Id.,* op. at 905.
86 *See* Appendix E.
87 *See* Appendix D.
88 Montgomery & Reasor, 36 J. OF TOXICOLOGY AND ENVTL. HEALTHH at 287–88.
89 *Compare* Jones *et al.,* 36 J. OF FORENSIC SCIENCE at 381 (consumption of alcohol on empty stomach results in rates different from Widmark equations); Jones & Neri, 33 CLINICAL CHEMISTRY at 1469 (consumption of alcohol on

full stomach results in rates different from Widmark equations); *with* Montgomery & Reasor, 36 J. OF TOXICOLOGY AND ENVTL. HEALTH H at 282 (finding **retrograde extrapolations** generally reliable).

90 *Compare* Watkins & Adler, 38 J. OF FORENSIC SCIENCE at 288 (standard elimination rate cannot apply because elimination rates vary depending on full or empty stomach, and variation is statistically significant); Pariser, 64 N.Y.U.L.REV. at 152 n. 76 (individuals will have higher or lower elimination rates than standard elimination rates); *with* Montgomery & Reasor, 36 J. OF TOXICOLOGY AND ENVIRONMENTAL HEALTH at 282 (finding **retrograde extrapolations** generally reliable).

91 *Compare* Watkins & Adler, 38 J. OF FORENSIC SCIENCE at 288 (food does not affect the time it takes to reach peak BAC); *with* Jones *et al.,* 36 J. OF FORENSIC SCIENCE at 381 (food does affect the time it takes to reach peak BAC).

92 *Wirth,* 936 S.W.2d at 84.

93 The reporter's record actually states ".01 to a .09" at this point. But nowhere in the "hypothetical ... talked about earlier" did these numbers occur. Instead, the "hypothetical talked about earlier" concerned increasing from a .10, the legal limit, to a .19, Mata's BAC. Moreover, in the prosecutor's very next two questions, the reporter's record reflects the numbers .10 and .19. The reference to ".01 to a .09" is either a typographical error or a misstatement by the prosecutor. Either way, the record indicates that both the prosecutor and McDougall understood the hypothetical as referring to the numbers .10 and .19.

1 Texas Rule of Evidence 702 provides:

> If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education may testify thereto in the form of an opinion or otherwise.

2 Court's opinion at 20 (citing Y. Al–Lanqawi *et al., Ethano Kinetics: Extent of Error in Back Extrapolation Procedures,* 34 BRITISH J. OF CLINICAL PHARMACOLOGY 316, 320 (1992)).

3 J. Nicholas Bostic, *Alcohol–Related Offenses: **Retrograde Extrapolation** after Wager,* 79 MICHIGAN BAR J. 668, conclusion section (June 2000).

4 *Id.*

5 *See* Court's opinion, Appendix C. Consistent with his one and a half hour time frame for absorption, McDougall indicated that the peak could have been maintained or reduced a little before arrest.

1 *See* Testimony of Kenneth Wayne Thompson, 3 Reporter's Record (hereinafter "RR") at 146, 189.

2 *See* Testimony of Arnold Santos, 3 RR192, 195, 196.

3 Testimony of George Allen McDougal, Jr., 233. Alcohol concentration is "the number of grams of ethyl alcohol that are found in 210 liters of the vapor being analyzed." *Id.* at 232.

4 "A male blows a .193 two hours after they were stopped, two hours after we know at least that they had stopped drinking two hours prior. Can you give us a range as to what his alcohol concentration would have been at the time he was stopped?" *Id.* at 257.

5 *Ibid.*

6 *Ibid.*

7 *Id.* at 264.

8 *Ibid.*

9 *Id.* at 270.

10 *Id.* at 295.

11 *Id.* at 296.

12 *Id.* at 252.

1 Gastric ulcers and diabetes decrease gastric emptying rates, while duodenal ulcers increase them. DDL at 14–74—75.

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