For Thursday March 19, 2015

Read Math Through The Ages – Chapter 21 & Chapter 22

Read 2 Articles in this packet --- Also think about the context at the end -- RED vs. BLUE.

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https://www.maa.org/external_archive/devlin/devlin_11_08.html

Polling, Polling, Polling

One nice thing about waking up on November 5 will be that we'll be spared the daily media bombardment of election opinion polls we've been subjected to for weeks now. Or maybe not. With an entire industry of pollsters, and news media eager for something to report on, a more likely scenario is that only the question will change. "Who will you vote for?" will be replaced by "How do you feel about the result?" Or some such.

Truth is, I find myself sucked in as much as anyone else. I could simply ignore the polls but I don't. The reason is that they actually do tell us something. Not how the election will turn out, of course - no one can do that; rather, they tell us how our fellow citizens say (at the time of the poll) they intend to vote. To the degree that declared intentions indicate subsequent action, and barring unusual circumstances, the former can be inferred from the latter. If this were not the case, surely none of us would pay the opinion polls much, if any, attention.

The fact is, whether we like it or not, opinion polling is now a major part of our life, and has been for many decades. We take for granted the fact that by asking a tiny fraction of the population - perhaps as few as 1,000 Americans - we can obtain a fairly reliable indication of how an entire state will vote. Yet if you stop and think about it for a moment, that is a remarkable fact.

Even more remarkable, to my mind, is the very notion that we can make any prediction about a future event such as an election, or how a roll of two dice will come out, or what might happen to the stocks in our retirement fund. What's that you say? What is remarkable about that? After all, you say, no one is claiming that we can ever know for sure what tomorrow will bring. Rather what polling - and other predictive techniques - do is put numerical values on the various likelihoods of future events. What's the big deal about that? Surely, anyone with even the most basic mathematical training will accept that you can assign probabilities to future events. Right?

True - today. But that's a fairly recent state of affairs. Aristotle - who certainly was no slouch when it came to math - believed, and wrote, that one realm where mathematics could not be applied was the future. The future was unpredictable to man, known only to the gods.

And so everyone believed until 1654, when the great French mathematician Pierre de Fermat solved the problem of the Unfinished Game.

The Unfinished Game

The problem of the unfinished game, also known as the problem of the points, was described in a book on arithmetic and geometry written by the Italian mathematician Luca Pacioli in 1494, though it is known to predate that mention. It asks how the pot should be fairly divided when a multi-round tournament has to be abandoned before it is finished. For instance, suppose two players are rolling a pair of dice and agree to play a best of five rounds tournament. Three rounds are played, leaving one player ahead 2 to 1, at which point they must abandon the game. How should they divide the pot?

Pacioli was unable to solve this problem. So too were a number of other mathematicians (and gamblers) who tried, including Girolamo Cardano, Niccolo Tartaglia, and Lorenzo Forstani. The consensus was that the problem could not be solved.

Then, early in 1654, a gambler by the name of Antoine Gombaud, more often referred to in modern history books by his French nobleman's title of the Chevalier de Mere, asked his friend the mathematician Blaise Pascal. Pascal produced a complicated argument that can be made to work, but was not happy with it, so at a friend's urging he wrote to Fermat about it. Fermat quickly found a simple solution.

There are two rounds left unplayed, argued Fermat. In each round, either player can win, so there are in all four different ways the game could continue to its five-round completion. The player who has won one round to the other's two must win both those final rounds in order to win the contest; in the other three possible endings, the player who is ahead after three rounds will win. Therefore, said Fermat, the player who is ahead when the game is abandoned should take 3/4 of the pot, with the other player taking 1/4.

To anyone who sees this solution today, it seems simple enough. (The solution assumes the tournament is thought of as a "best-of-five" rounds, as opposed to a "first-to-three". You need a slightly more complicated argument in the latter case, but the answer is the same, a 3 to 1 division of the pot.) But no one before Fermat saw it, including Cardano who did work out all of the basic rules we use today to combine probabilities. Moreover, when he did see Fermat's solution, Pascal could not accept it, and nor could various of his colleagues he showed it to. What was their problem?

Since the computation is trivial, indeed no different from the calculation of the odds in any game of chance (and actually much simpler than many), the only thing that could be holding everyone back was the fact that what Fermat was counting were "possible futures." Something that two thousand years of received wisdom said was not possible.

Once word got out about Fermat's breakthrough, however - presumably through the highly mobile network of gambling European noblemen - it did not take long for others to jump into the "future prediction" act. Within a single lifespan, modern future prediction and risk management were in place.

The modern world begins

The speed of developments that followed the solution to the problem of the unfinished game is staggering.

- 1657. Christian Huyghens writes a 16-page paper that lays out pretty well all of modern probability theory, including the notion of expectation, which he introduces.
- 1662. John Graunt, an English haberdasher, publishes an analysis of the London mortality tables, and in so doing establishes the beginnings of modern statistical inference.
- 1669. Huyghens uses his new probability theory to re-compute Graunt's mortality tables with greater precision.
- 1709. Nikolas Bernoulli writes a book describing applications of the new methods in the law. One problem he shows how to solve is how long must elapse after an individual goes missing before the court can declare him dead and allow his estate to be divided among his heirs.
- 1713. Jakob Bernoulli writes a book showing how the new probability theory can be used to predict the future in the everyday world. This is the first time the word "probability" is used in the precise, mathematical sense we use it today. He also proves the law of large numbers, of which more in a moment.
- 1732. The first American insurance company begins in Charleston, S.C., restricted to fire insurance.
- 1732. Edward Lloyd starts the precursor of what in 1734 becomes Lloyd's List, and eventually gives birth to the insurance company Lloyds of London.
- 1733. Abraham de Moivre discovers the bell curve, the icon of modern data collection.
- 1738. Daniel Bernoulli introduces the concept of utility to try to get a better handle on human decision making under uncertainty.
- 1760s. The first life insurance companies begin.

Then came opinion polling.

Enter the pollsters

The mathematical basis for opinion polling is Jakob Bernoulli's law of large numbers. Roughly speaking, this says that if you take a sufficiently large random subcollection of a population, it will be representative of the entire population. The more numerous the random subcollection, the more it will reflect the entire population.

The first known opinion poll was in 1824, when the *Harrisburg Pennsylvanian* newspaper conducted a local poll that showed, incorrectly it turned out, Andrew Jackson was leading John Quincy Adams in the presidential race. (Jackson became president next time round.)

The first national poll was in 1916, when the *Literary Digest* predicted - correctly - that Woodrow Wilson would be elected. Their approach was to mail out millions of postcards and count the returns. This is now recognized as a woefully unreliable method, but the magazine managed to correctly predict the following four presidential elections this way before getting it badly wrong in 1936, when it erroneously predicted that Alf Landon would beat Franklin D. Roosevelt.

The difficult part - or rather, *one* difficult part - of conducting a reliable poll is making sure that the sample is random. The math requires this. Using a non-random sample was a large part of the reason why the 1936 *Digest* poll came unstuck. That same year, George Gallup conducted a much smaller poll based on a properly representative sample and got the right answer.

Another famous case when the pollsters got it wrong was in 1948, when major polls, including Gallup, indicated that Thomas Dewey would defeat Harry S. Truman in the presidential election in a landslide victory. As we know, Truman came out on top, and there is a famous photograph of a smiling Truman holding up a first-edition Chicago newspaper that had a big headline saying "Dewey wins."

The problem that time was that the pollsters relied on telephone interviews, and in those days only wealthier people had phones, and so the sample was heavily biased toward Dewey supporters.

Most people are surprised by how small a random sample can be and yet still yield a reliable result. If you do the math, you find that (provided the sample polled is truly random) 1,000 people will give you a prediction accurate to within a 3% margin of error. You could get the error down to 1% if you polled 10,000, but the more people you poll the more expensive it gets, of course. 1,000 is a number typically used these days.

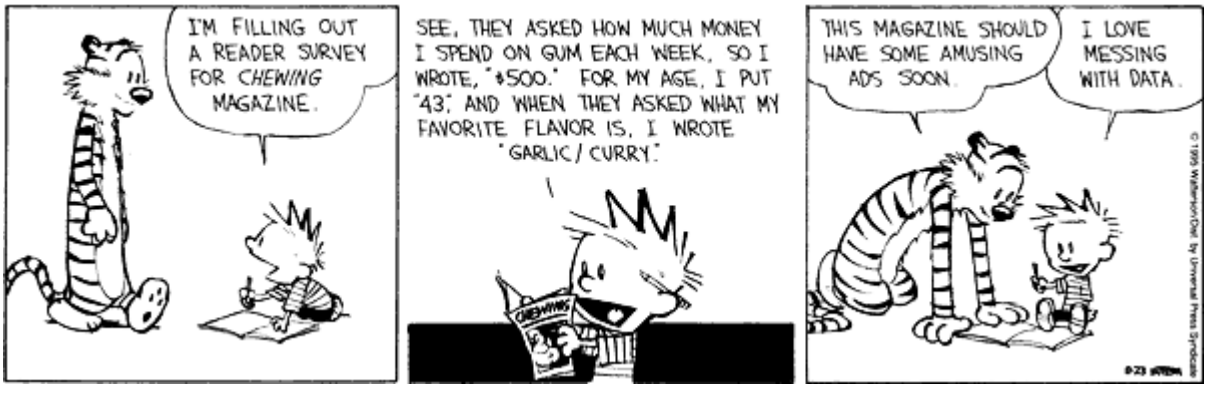
In recent elections, with phones no longer restricted to the more wealthy, phone interviews seem to have done pretty well. But they do leave out people whose only phone is a mobile phone, and as more and more young people get to voting age, that could become a significant factor.

The kinds of polls you see on news organization web sites that ask people to vote on an issue are extremely unreliable, because the population sampled is self-selected. Polling results are reliable only when the sample is chosen in a truly random fashion.

Finally, while on the topic of applying mathematics to predicting elections, I can't pass up the opportunity to point you to what is surely the most cerebral political ad video in this year's campaign. It's titled "The Theorem". I point you to it with no intended or implied endorsement, etc. etc.

http://www.youtube.com/watch?v=-4qwtPxUNJg

Enjoy.



Tea for three

Of infusions and inferences and milk in first

A statistician, an algologist and a biochemist sat down to a nice cup of tea. The algologist would not drink hers. It sounds like the start of a bad joke. It was actually the beginning – the rather romantic beginning – of proper design and analysis of experiments. **Stephen Senn** considers how that time-honoured British institution, the tea-break, inspired R. A. Fisher to an approach which still raises questions today.

Order, order!

Three scientists were taking tea in the common room at an agricultural research station one afternoon in the early 1920s. The male statistician poured milk into a cup, added tea, and, since this was the 1920s and he was a gentleman, offered it to the female algologist. She politely declined it, saying that she preferred to add the milk to the tea. He protested that it made no difference but she reiterated quite firmly that it did. She preferred tea in first, and she could taste the difference. At this point the male biochemist joined in. "Let's test her", he said.

We should perhaps reveal that the male biochemist was in love. He was in love with the female algologist and, very happily, she was in love with him. In fact they were engaged. Whether it was love that made the biochemist propose that the lady's claim be tested, and love that made her agree to the test, we shall never know. What we do know is that the statistician devised an experiment to test her claim and the lady submitted herself to it; the biochemist presumably refereed and ensured fair play. They began the experiment straight away.

The research station was Rothamsted in Harpenden, a little to the north of London, and the statistician was Ronald Aylmer Fisher (1890–1962). In her wonderful biography of her father[1], Joan Fisher Box identifies the algologist – the lady whose study was of algae – as Dr B. Muriel Bristol (see Box 1), who worked in the Mycological Laboratory of Rothamsted's Institute of Plant Pathology; her fiancé was William Roach, who worked in the antiseptics and insecticides lab. This, however, is not the way that most statisticians will have come across this famous story.

The tea-tasting challenge was known to many before the publication of the 1978 biography since Fisher had used it in his book *The Design of Experiments* in 1935. Here is what Fisher had to say:

> A lady declares that by tasting a cup of tea made with milk she can discriminate whether the milk or the tea infusion was first added to the cup… Our experiment consists in mixing eight cups of tea, four in one way and four in the other, and presenting them to the subject in a random order. The subject has been told in advance of what the test will consist, namely that these shall be four of each kind, and that they shall be presented to her in a random order, that is an order not determined arbitrarily by human choice, but by the actual manipulation of the physical apparatus used in games of chance.[2]

Muriel Bristol (1888–1950)

Blanche "Muriel" Bristol was born in Croydon on April 21st, 1888 to Annie Eliza, née Davies, and Alfred Bristol, a commercial traveller. She studied to be a botanist and did a PhD on algae, probably at Birmingham University with Professor George Stephen West (1876–1919) who died in the great post-war Spanish influenza epidemic. Certainly there is a paper of July 1916 with "B. Muriel Bristol, MSc" as author with her address as the Botanical Laboratory, Birmingham University, and Bristol also wrote an obituary of West in 1921, so it seems plausible that she obtained her PhD with him. On 6 June 1923, she married William Roach (born 15 October 1895, the son of a Devon farmer) in the parish church of Saint George, Edgbaston. According to Lund, writing in 1947[4], the species of algae, *C. muriella*, is "named after B. Muriel Bristol Roach." Muriel Roach died in Bristol on 15 March 1950 of ovarian cancer, her age being incorrectly given on the death certificate as 62 (rather than 61). William Roach later remarried and died in 1984.



Dr Blanche Muriel Roach, nee Bristol, from a Rothamsted Research Station staff photograph. With grateful thanks to Rothamsted archivists

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Counting sequences

The argument presented here is slightly different from Fisher's. Consider a possible sequence of the labelled cards, T4, M1, T1, M4, M2, M3, T3, T2, representing the order in which the cards were dealt. How many such sequences are there? We have eight possible choices for the first card. However, once we have dealt the first card we only have seven possibilities for the second and once we have dealt the first two cards only six for the third and so forth. Thus we have $8 \times 7 \times 6 \times 5 \times 4 \times 3 \times 2 \times 1 = 40\,320$ possible sequences. However, consider another sequence, T4, M2, T1, M3, M4, M1, T3, T2. The position of the cards corresponding to the tea-in-first cups is the same but those corresponding to the milk-in-first cups are changed. However, this makes no difference to the positions of the type of cups. The positions of all the cups by type for these two sequences will be identical. This means that each one of the 40 320 sequences can be matched by several in which the milk-in-first cup positions are identical (even though the cards are not). In fact, if we take the positions of the milk-in-first cups as fixed but shuffle the corresponding cards, we will have $4 \times 3 \times 2 \times 1 = 24$ possible arrangements. This means that, as regards milk-in-first positions, the 40 320 sequences can be reduced to 40 320/24=1680. However, we can now use an identical argument for the tea-in-first cups. For any set of fixed positions of the four such cups, there are 24 arrangements of the four cards. Thus we must divide the 1680 sequences further by 24 to get 1680/24=70. Hence there are 70 possible sequences of cups.

Choices, choices

Let us consider how we might perform the experiment. We might, of course, offer her one cup of each kind and see if she could tell them apart. That would hardly be conclusive; she might easily guess the right answer. We might instead offer her 100 cups, 50 of each kind. That experimental design has several flaws. It would take more time and effort – it would strain the capacity of the tea urn, the participants would get bored, and the Rothamsted tea-break would be over long before the test was half-way through.

Fisher, as we have seen, settled for eight cups. We shall shortly see how discriminatory – how certain in its conclusion – such an experiment may be. He stipulated a "random order" as from a game of chance for presenting the cups. How can we achieve that? The lady leaves the room, of course. We could prepare eight identical cards, four of which we mark as T1, T2, T3, T4 to identify those cups which will hold "tea first" brews and four of which we mark M5, M6, M7, M8 to identify those cups that will hold "milk first" infusions. We then shuffle the cards thoroughly and place them one by one face up on the table. We now have a random order of the eight cards. We place a cup behind each card. If the card has a "T" on it we prepare the cup with tea in first. If it has an "M" on it the cup has milk in first. We turn the cards over so that the labels are hidden and invite the lady back in to taste and to try to identify which is which.

Suppose that she identifies correctly in each case how the cup was prepared. Clearly this is something of a personal triumph and vindication for her. "But", we might idly suppose to ourselves, "might she not just have been lucky?" To examine this point we might, like Fisher, calculate the probability that by pure guesswork she might get all cups right.

Fisher argues (see Box 2) that there are 70 equally likely possible sequences of four M cups and four T cups and that a logical strategy for anybody guessing would be to plump for one of them. There would thus be a one in 70 chance of guesswork leading to a correct identification of all cups. If Dr Bristol did indeed correctly identify all eight cups, many people would feel justified in believing that her tastebuds were as sensitive as she claimed.



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Blind chance

There are two important features of Fisher's prescription that are sometimes overlooked. The first is that the sequence of the cups should be chosen at random, and the second that the lady should be informed that this will be so. Let us consider these in turn.

Commentators have sometimes suggested that is sufficient that the sequence be chosen in a way that is "haphazard" rather than random. The problem with this, however, is that it is not clear what "haphazard" means. By "random" Fisher means that the probability of drawing any one of the 70 possible sequences is identical and thus equal to 1/70. Now consider what it means for a sequence to be "haphazard". Either the meaning of "haphazard" is identical to "random", in which case it does not really offer an alternative and the words are just synonyms, or else "haphazard" must mean that there is some other probability with which individual sequences will arise.

"Haphazard" in this sense might mean "what human beings perceive to lack order". We might reject, for example, the arrangement M1, M2, M3, M4, T1, T2, T3, T4 as being ordered rather than haphazard, and we would not arrange the cups that way. That arrangement might not be haphazard, but it could well be random. That is, it could well have arisen by chance, by the shuffling of cards or the throwing of dice. If we allowed our prejudice against that ordering to stand it would invalidate the experiment – because our subject, the lady tasting tea, might share our prejudice and be able to double-guess us.

> If blinding is of the essence we have the problem that our thoughts may be divined. Randomization solves that problem

In a letter to the physicist Harold Jeffreys (1891–1989), with whom he long maintained a cordial disagreement on statistical inference, Fisher put it like this:

> if I want to test the capacity of the human race for telepathically perceiving a playing card, I might choose the Queen of Diamonds, and get thousands of radio listeners to send in guesses. I should then find that considerably more than one in 52 guessed the card right ... Experimentally this sort of thing arises because we are in the habit of making tacit hypotheses,

Milk in first – the theories

The issue may leave Americans cold. The most central position of tea in U.S. national history is the episode in which a large quantity of it was poured into Boston harbour without adding milk at all; but the question of whether milk should go into the cup before or after the tea has divided British afternoon-drinkers since tea arrived on our shores in the middle of the 17th century.

The consensus has been that in polite society the milk goes in first. Various reasons have been advanced for this. One theory is that early teacups were of soft Chinese porcelain, and the sudden influx of recently-boiled water tended to crack them. (Milk for tea is, of course, always cold.)

Milk in first also reduces the amount by which the tannins in tea stain the cup – a well-used teapot is almost black inside. If the milk is particularly creamy and not very cold, as it frequently was in the days before fridges, adding it second could result in globules of fat separating and floating unappetisingly on the surface.

Health reasons have also been advanced. Afternoon tea-parties were a staple of social life in Imperial British India. Received wisdom had it that if the quality of the milk was in doubt, then putting the milk in first was a more effective way of scalding it and killing the bacteria.

George Orwell came down on the other side. In his 1946 essay 'A Nice Cup of Tea' he wrote: 'The Milk First school can bring forward some fairly strong arguments but I maintain that my own argument is unanswerable. This is that, by putting the tea in first and then stirring as one pours, one can exactly regulate the amount of milk, whereas one is liable to put in too much milk the other way round.'

None of the above theories refer to taste. There are those, like Fisher, whose default position (until persuaded otherwise by an experiment disproving the null hypothesis) is that it makes no difference at all. The Royal Society of Chemists intervened in 2008 to provide a reason why it does make a difference that might be detectable: 'If milk is poured into hot tea, individual drops separate from the bulk of the milk, and come into contact with the high temperatures of the tea for enough time for significant denaturation - degradation - to occur. This is much less likely to happen if hot water is added to the milk.' Milk second, in other words, tends to cook the milk more, giving a more boiled taste.

So far we have not mentioned another neglected issue, that of warming the teapot before making the infusion. (Making tea directly in the mug is of course an abomination.) But tea has featured in the history of statistics in another context. The Victorian eccentric Sir Francis Galton shares with Fisher some claim to be the founding father of modern statistics. Galton spent months scientifically determining the best way to brew the perfect cup of tea. Having constructed a special thermometer that allowed him constantly to monitor the temperature of the water inside his teapot, after much rigorous testing Galton concluded that:

> "… the tea was full bodied, full tasted, and in no way bitter or flat…when the water in the teapot had remained between 180° and 190° Fahrenheit, and had stood eight minutes on the leaves … There is no other mystery in the teapot'.
>
> Galton put the milk in first.

e.g. "Good guesses are at random except for a possible telepathic influence". But in reality it appears that red cards are always guessed more frequently than black.[3]

Thus the danger is that if we choose a sequence in a haphazard way – say, relying on our brains to do the randomisation – then a similar thought process may be going on in the brain of the subject being tested. If blinding is of the essence, as it is here, then dealing with the problem that our thoughts may be divined is crucial. Randomisation solves the problem.

Why Fisher insists on telling the lady is more subtle. Suppose that a sequence is chosen at random but we had failed to inform the lady that this is what will happen. In fact the sequence drawn is M T T M M T M T, and the lady guesses all cups correctly. We now notice that, in fact, the cups are arranged in pairs. Suppose that the lady had incorrectly assumed this would *have* to be the case. In other words, she assumed that this was the way we would run the experiment. Given such a false assumption, her chance of guessing correctly given the sequence actually produced would be $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{16}$, since for each pair she would have half a chance of guessing which member was milk in first and which was tea in first. Of course, had a sequence been produced not in pairs – say, M M T M M T T T – then her chance of guessing correctly, given her false assumption, would be 0. In fact there are 16 sequences which can be divided off in pairs and a further 54 that cannot. We could argue that it does not matter what the lady thought since *unconditionally*, that is to say in advance of generating the sequence, her probability of guessing correctly would be (54/70 × 0) + (16/70 × 1/16) = 1/70. However, the advantage of having told the lady is that we do not need to argue this way. The unconditional probability of 1/70 is the one that applies.

Agreement and disagreement

The experiment that Fisher describes and its analysis are an elegant solution to the problem of testing the lady – or, at least, so it has seemed to many, including me. However, the solution has raised controversy from the beginning. The possible results for the experiment can be set out in a so-called 2 × 2 contingency table as shown in Table 1.

Whole forests have been destroyed to provide paper for disputes about Fisher's analysis

The columns represent the actual infusion and the rows represent the conclusion of the lady. Given that the lady knows that there are four cups of each sort, she will presumably designate four cups as milk in first (M) and four as tea in first (T). Now consider the number of milk-in-first cups she correctly chooses. This number has been labelled *a* and is entered in the

Table 1. The tea-tasting table. The general case. M=milk in first, T=tea in first

	Infusion		
Conclusion	*M*	*T*	*Total*
M	*a*	*4 – a*	4
T	*4 – a*	*a*	4
Total	4	4	8

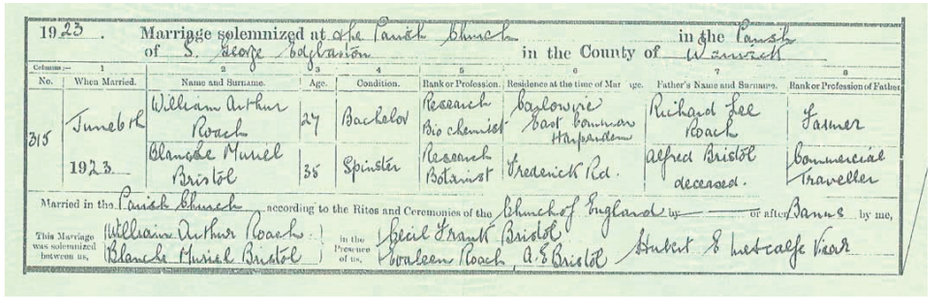
Table 2. The tea-tasting table. A particular case

	Infusion		
Conclusion	*M*	*T*	*Total*
M	*4*	0	4
T	0	*4*	4
Total	4	4	8

top left dark-shaded cell of the table. The actual value of a at the end of the experiment will be 0,1,2,3 or 4. However, as soon as we know the value of a we know the value of the numbers in the other three dark-shaded cells. For example, if she identifies all four milk-in-first cups then she also identifies the four tea-in-first cups. We then have $a = 4$ and the situation will be as in Table 2.

Fisher provided the formula for calculating the probability of any possible such configuration, and the statistical test associated with it is now called *Fisher's exact test*.

There are, however, at least three points of controversy. The first is that the test is often applied in situations where the marginal row and column totals are not fixed as they are here, where it is known in advance that they will be 4. In another context Fisher argued that this did not matter and for cases even where the totals were not fixed in advance the test could be used. The second is that when the most extreme case does not arise – when the lady does not get all eight cups right – the test involves calculating the probability of the most extreme cases and of all the more extreme cases as well. This means that the probability is no longer of something that occurred but is of something that occurred *and* of something that *might* have occurred. This latter makes is problematic for Bayesians. The third occurs when we are interested in departures in the wrong direction also. Suppose that the lady gets things exactly wrong. She might identify every milk-in-first cup as tea-in-first, and vice versa. What should we do then? Should we conclude that she has a fine palate but a poor memory? Or that she cannot taste the difference at all?



1923. Marriage solemnized at the Parish Church of S. George Holfraston in the Parish in the County of Warwick

Columns:— No.	1 When Married.	2 Name and Surname.	3 Age.	4 Condition.	5 Rank or Profession.	6 Residence at the time of Marriage.	7 Father's Name and Surname.	8 Rank or Profession of Father.
315	June 6th 1923	William Arthur Roach	27	Bachelor	Research Bio chemist	Baglowgie East bowman Hampshire	Richard Lee Roach	Farmer
		Blanche Muriel Bristol	35	Spinster	Research Botanist	Frederick Rd.	Alfred Bristol deceased.	Commercial Traveller

Married in the Parish Church according to the Rites and Ceremonies of the Church of England by — or after Banns by me,

This Marriage was solemnized between us, William Arthur Roach, Blanche Muriel Bristol. In the Presence of us, Cecil Frank Bristol, Doreen Roach, A. E. Bristol. Student & Curate Vicar

Marriage certificate of William Roach and Muriel Bristol

Our tea-break is over

We had an apparently simple hypothesis, and an apparently simple experiment; we have found that the inferences we can safely draw are a very long way from being straightforward. Since Fisher's 1935 account, statisticians have caused the destruction of whole forests to provide paper to print their disputes regarding the analysis of 2 × 2 tables. This is not the place to review this literature. Instead, let us raise a cup (of tea) to the memory of a female algologist whose determination to defend her tastes caused one of the greatest scientists of the twentieth century to start a debate that is still running.

And while we sip our restoring brews, we should add that the story has two happy endings. Blanche Muriel Bristol did marry her beloved William Roach – see their marriage certificate above; and the test that Fisher devised, and that she underwent in the Rothamsted common room, showed very conclusively that she could indeed tell the difference between tea with milk in first and tea with milk added after.



Edwardian tea-drinkers: an important afternoon ritual. © iStockphoto.com/Duncan Walker

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RED vs. BLUE

Does uniform color give athletes an advantage over their competitors?

Does uniform color give athletes an advantage over their competitors?
To investigate this question, Hill and Barton (Nature, 2005) examined the records in the 2004 Olympic Games for four combat sports:
boxing, tae kwon do, Greco-Roman wrestling, and freestyle wrestling.

Competitors in these sports were randomly assigned to wear either a red or a blue uniform. The researchers investigated whether competitors wearing one color won significantly more often than those wearing the other color. They analyzed results for a total of 457 matches. The researchers found that the competitor wearing red defeated the competitor wearing blue in 248 matches, and the competitor wearing blue emerged as the winner in 209 matches. The skeptics claim this is ridiculous saying that nothing is going on ... The researchers claim that something is going on …

- What is the thought process of the skeptics? – What is the argument of the skeptics? …

- What is the thought process of the researchers? – What is the argument of the researchers? …

- What is/are the crucial assumption(s) for the skeptics/researchers …