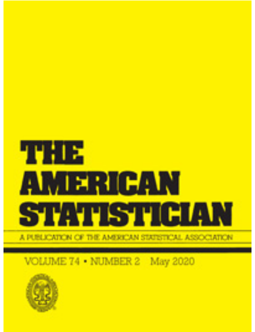

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Lest We Forget: U.S. Selective Service Lotteries, 1917–2019

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ABSTRACT

The United States held 13 draft lotteries between 1917 and 1975, and a contingency procedure is in place for a selective service lottery were there ever to be a return to the draft. In 11 of these instances, the selection procedures spread the risk/harm evenhandedly. In two, whose anniversaries approach, the lotteries were problematic. Fortunately, one (1940) employed a "doubly robust" selection scheme that preserved the overall randomness; the other (1969) did not, and was not even-handed. These 13 lotteries provide examples of sound and unsound statistical planning, statistical acuity, and lessons ignored/learned. Existing and newly assembled raw data are used to describe the randomizations and to statistically measure deviations from randomness. The key statistical principle used in the selection procedures in WW I and WW II, in 1970–1975, and in the current (2019) contingency plan, is that of "double"—or even "quadruple"—robustness. This principle was used in medieval lotteries, such as the (four-month) two-drum lottery of 1569. Its use in the speeded up 2019 version provides a valuable and transparent statistical backstop where "an image of absolute fairness" is the over-riding concern.

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1. Introduction

The draft lottery of 1917 was—in the words of the then US War Department Secretary Newton D. Baker—the "first application of a principle believed by many of us to be thoroughly democratic, equal and fair in selecting soldiers to defend the national honor abroad and at home." New statistical evidence presented below shows that the 1917–1918 lotteries were successful in spreading the risk/harm as evenhandedly as possible: no (identifiable a priori) subgroup bore more of the burden than would be expected.

We are now approaching the 50th anniversary of a December 1969 draft lottery—based on birthdays—that was not fair. The evidence for this is not limited to the statistical trend in the month-of-birth-specific mean *lottery numbers* in the newspaper article a month later (Rosenbaum 1970a) or the more extensive statistical tables and figures reported in a scholarly journal a year later (Fienberg 1971). There is also the direct evidence: the clear upward trend in the column of month-of-birth-specific *casualty numbers* in Table 1 of a report (Sommers 2003) derived from the biographies of the persons listed on The Vietnam Veterans Memorial ("the Wall"). The recent article (Johnson, Dawes, and Conley 2019) in this journal is especially welcome, as it reintroduces the flawed 1969 lottery to the current generation of statisticians, and introduces them to the statisticians behind the 1970 "remedy."

Next year will mark the 80th anniversary of another less well known but more spectacularly flawed draft lottery—the first of the three during World War II. However, unlike the 1969 one, it did not create any unfairness. These two anniversaries are an opportunity to consider the statistical ingredients for a fair process, and to examine the contingency procedure currently in place for a selective service lottery were there to be a return to the draft today.

These lotteries are big-ticket examples of sound and unsound statistical planning, lessons learned/ignored, and the central role of statisticians and statistical analyses. They also provide some interesting teaching perspectives. I begin with the meticulously planned "lower-tech" doubly robust lottery of 1917 and end with the also doubly robust but "high-tech" plan in place as of 2019. In between, I show the high resolution version of the 1940 lottery data, as well as a high-resolution photograph—not widely available in 1940—that helps explain the blatant nonrandomness that these data exhibit. Despite this more extreme lottery result, I argue that the more robust 1940 selection *process* made for a fairer system than the 1969 one. I end by tracing the robustness principle used in the current contingency plan as far back as the—more cumbersome—lotteries held in medieval times.

2. US Selective Service Lotteries, 1917–1975

2.1. *WW I*

These three lotteries (see Table 1) were carried out under the Selective Service Law enacted soon after the US Congress declared war on Germany. Registrations, carried out by 4000 local boards, yielded 10, 0.7, and 13 million men, respectively. Each local board shuffled the registration cards deposited with it, assigned serial numbers without regard to the registrant's

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/r/TAS.

Table 1. WW I and WW II lotteries.

Year	Age/born	Registration day	Millions registered	Lottery date	Numbers drawn, 1–	Duration (hr)
1917	21–30	June 5	10	July 20	10,500	16
1918	21*	June 5	0.7	June 27	1200	2
1918	18–45	September 12	13	September 30	17,000	18
1940	21–30	October 16	16	October 29	9000	14
1941	21*	July 1	0.75	July 17	800	2
1942	20–45	February 14–16	9	March 17	7000	13

*Had reached 21 since previous registration.

name or order of registration, and displayed publicly the list of men and their assigned serial numbers. (In 1917, the largest number registered with any one board was 10,500.) A single Master List, to be developed later and shared by all boards, determined the order in which the boards would call up men.

The list was established using a lottery held in Washington. On July 20, 1917, some 10,500 serial numbers were drawn. These numbers were first stamped on slips of paper and enclosed in small capsules before being placed in a glass bowl and thoroughly mixed with a ladle. They were drawn out publicly by blindfolded male university students. The capsules were stirred at regular intervals. The first 4 numbers drawn were: 258, 2522, 9613, 4532. Thus, in a board with 5000 registrants, the first 3 called were those assigned serial numbers 258, 2522, and 4532; a board continued calling, examining and classifying men until it reached the assigned quota of men it was to supply (Provost Marshal General 1918). The overall (national) quota was 687,000.

In his review, Fienberg (1971) did not have data from 1917; nor could he locate any statistical analysis that tested "whether the selection was indeed fair." Today, digital newspaper archives contain partial lists—typically in the order drawn. Some newspapers, such as the New York Times, provided a way to "immediately find your place in the draft" by publishing an "inverted" list: the orders in which the serial numbers 1 to 4696 ["the largest number registered in a New York City district"] were drawn. However, given the facilities in 1917, it acknowledged that "many errors occurred" and that while "scores of these have been found and corrected, some still remain." However, I was able to locate the official Master List (Selective Service 1918, pp. 322–343) and I extracted the data used in this article from it. To establish the order of call for the second registration, the numbers from 1 to 1200 were drawn—in over just 2 hours, from a smaller glass bowl—in the smaller drawing held on June 27, 1918. I extracted the data from this lottery from the official Master List 2 (Selective Service 1918, pp. 345–348). I was only able to locate a list of the first 100 numbers drawn in the September 1918 lottery, the largest of all of the 13 US lotteries, involving 17,000 numbers drawn over 18 hours. Fortunately, an armistice was signed on November 11 and that lottery list was never used.

Row (A) of Figure 1 plots the newly assembled "raw" data from the first two WW I lotteries, and can be used as a point of departure to ask students for their visual impressions of the patterns in the data.

Rows (B) and (C) are two of the many ways students and teachers might assess departures from randomness. Row (B) hints at a slight "first in, last out" pattern in the very large 1917 lottery. Row (C), using an approach that was applied to the 1940 lottery data (see below) is an attempt to look for "lumpiness" in the data, but finds no evidence of it. The results are a tribute to the extensive mixing. The impression, borne out by where the r and X^2 statistics stand in their respective null sampling distributions, is that the great care taken by Gen. Crowder—attested to by the media—paid off.

2.2. WW II

In the 6-min audio clip (Roosevelt 1940a) from the first of the three WW II lotteries, President Franklin Roosevelt characterized selective service as the "most democratic as well as the most efficient means for the mustering of our manpower." Since each of the steps in the selection plays a vital role, his next words are worth repeating…

> Briefly and in simplest terms, the processes of the selection are these. Each registrant in each of 6500 local areas has been assigned a number at random, assigned to him by a committee or board of his neighbors. Each man's number in each local board area has been officially recorded as pertaining exclusively to him in that area. Those numbers run from 1 to 7836. Opaque capsules, each containing a different number, have been placed in a glass bowl. […] These capsule numbers also run from 1 to 7836 with a few extra higher numbers to allow for late registration. One capsule at a time will be drawn from the bowl until none is left.

Several online video clips (e.g., Roosevelt 1940b), newspaper articles, and Fienberg's (1971) article fill in further details.

Using the digital archives of several newspapers, and other contemporary sources, I have been able to assemble the orders in which the serial numbers were drawn in the lotteries of 1940, 1941, and 1942. These are plotted in row (A) of Figure 2, where the extraordinary pattern in 1940 is revealed by that simplest of statistical procedures, the inter-ocular traumatic test, aided a little by today's statistical graphics.

The outline of that pattern was soon noticed by statistics graduate student P. H. Benson at the University of Chicago (Chicago Tribune 1940). Scanning the list for his own number, he was struck by the preponderance of high serial numbers in the early hours of the drawing. He brought his observation to the attention of University of Chicago statisticians Bartky and Stouffer, who were also struck by the strange order in which the numbers were drawn. "Bartky and Prof. Stouffer were amazed by their findings in a preliminary examination of the lottery list. The statistical staff they assembled put in 185 man hours in studying, charting, and applying formulas of mathematical probabilities to the data presented by the lottery."

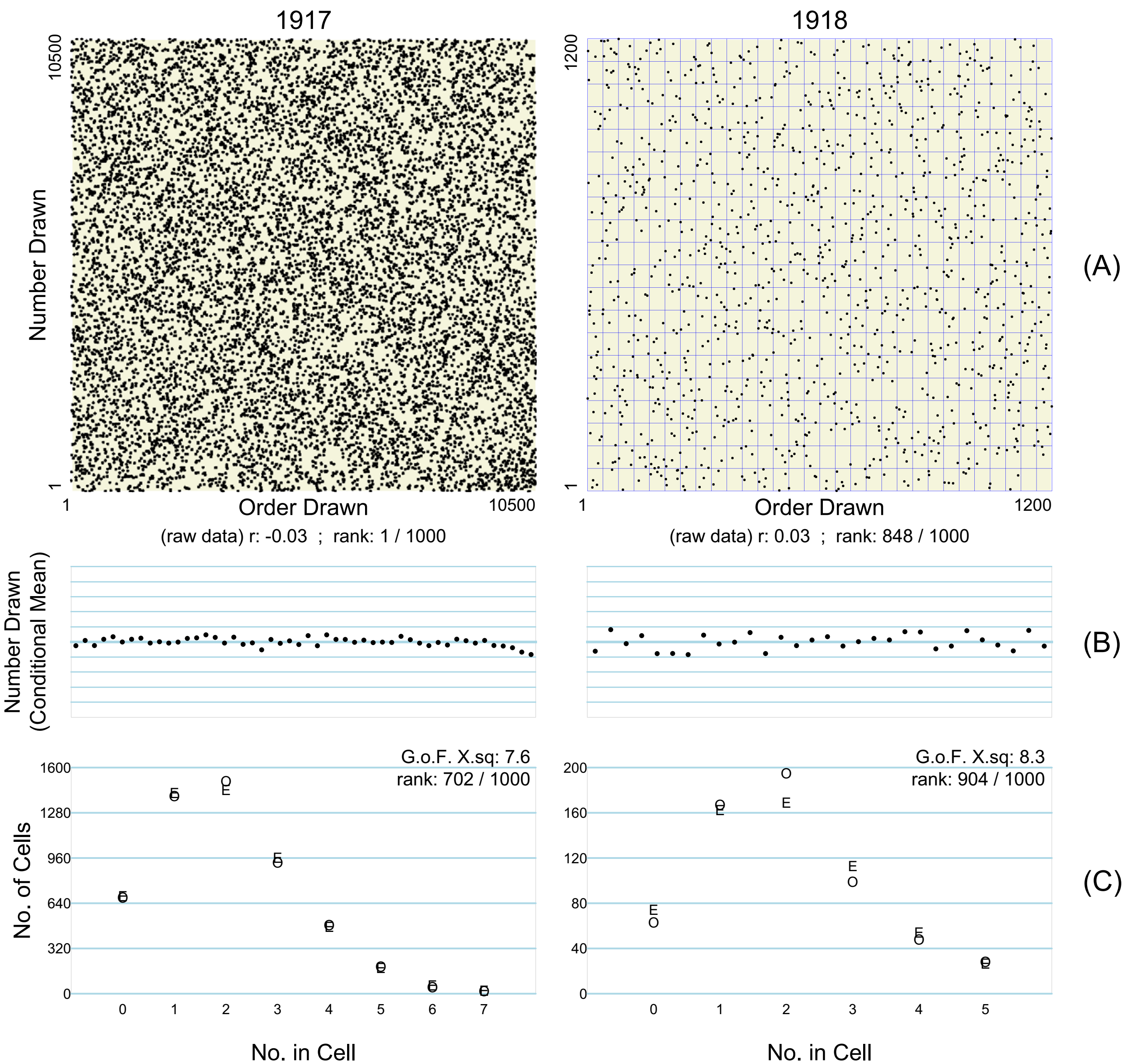

Figure 1. Scatterplots (A), conditional means (B), and observed and expected cell frequencies (C) based on raw data from WW I lotteries. Instead of using them to estimate a *p*-value, the correlations in 1000 simulated lotteries were ranked from smallest (1) to largest (1000), and the reported rank of the observed correlation is its position in this array; thus a "rank" of 0 means that the observed correlation was smaller than all 1000 simulated correlations. The vertical ranges in (B) are the same as in (A), namely 1 to 10,500 and 1 to 1200, and the means are conditional on the "*x*" bins. The 5250 and 600 cells, respectively, used in (C) were formed by binning the *x* and *y* axes in (A) so as to have rectangles ("cells") with a mean of 2 dots per cell (see cells formed using 1918 lottery data). O and E: Observed and expected frequencies, both summing to 5250 or to 600. E's and ranked goodness of fit (G.o.F) statistics are based on the 1000 simulated lotteries.

Their findings were published in the Chicago Tribune on November 2, under the heading "Flaw in Draft Told" that spanned the entire first page, in a column with the heading "Failure to Mix Numbers in Jar Shown by Study: Capsules in Nests within Bowl." On an inside page, under the title "Mathematicians Chart National Lottery and Find Discrepancies in Drawing of Numbers" was a frequency table of 45 rows and 90 columns. At this resolution the expected frequency was 9000 / (45 × 90) = 2.2 per cell. The observed cell frequencies were shown as tallies, for example, |///| |/|, rather than numbers, making it easier to visualize the large variations in "density."

Under the heading "Scientists Tell Study of Draft Lottery Draws: Probabilities Applied to Numbers" Bartky and Stouffer summarized their statistical study of the draft lottery drawings as follows

> The question is: Were the numbers thoroly [sic] mixed in the goldfish bowl in Washington, permitting a random drawing? Or were groups of numbers clustered in nests within the bowl, preventing a random drawing? The answer must be: The odds were astronomically high against the theory that the selection was conducted at random.

They then went on to give examples of these astronomically high odds. They first focused on the finding that numbers did "cluster in nests in such a way that the serial numbers in the groups from 1 to 2400 tended to escape drawing the first 2000

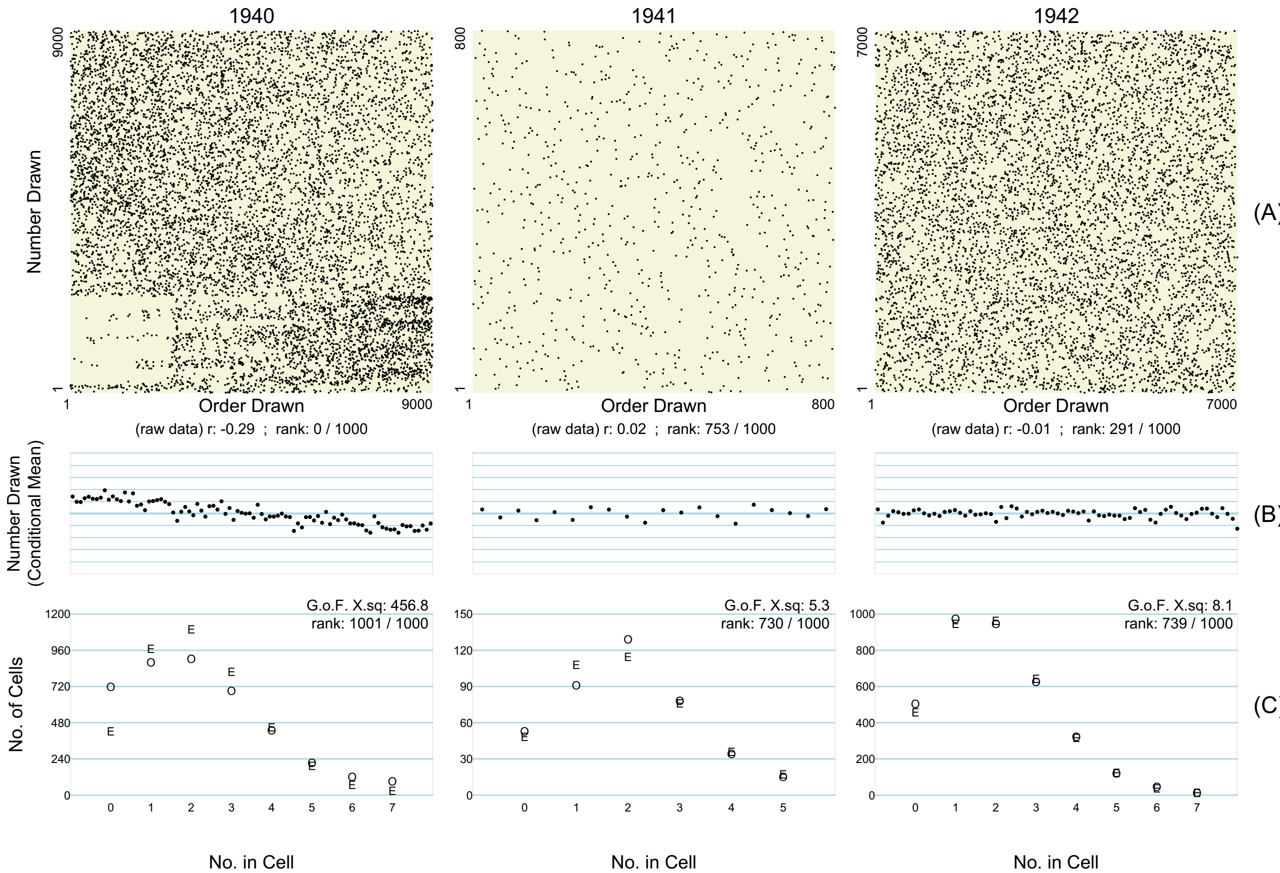

Figure 2. Scatterplots (A), conditional means (B), and observed and expected cell frequencies (C) based on raw data from the WW II lotteries. Explanations as in Figure 1. In (C) a "rank" of 1001 meas that the observed G.o.F statistic was larger than the 1000 simulated G.o.F statistics.

or so draws, with the curious exception of too frequent drawing of serial numbers in the group 101 to 200."

> For example, no serial number between 300 and 600 was drawn in the first 2400 draws. (Note blank A on chart on this page.) By pure chance this would occur less than once in 150,000,000,000,000,000,000,000,000,000,00,000,000,000 times.
>
> Such an improbability can be translated into everyday experience in terms of a bridge game. It is even more than the chances of drawing a hand of 13 spades three times in succession in a bridge game. The same improbability applies to the serial numbers from 901 to 1200 [note Blank B on chart] and an even greater improbability to the numbers 1501 to 1800 (Blank C on chart). The fourth blank, D, represents the absence of numbers from 2101 to 2400. Considering the early drawings as a whole the improbability of the results happening by chance is so great that it would be absurd even to attempt a numerical calculation.

It is left to readers to try to replicate these probabilities. Teachers might ask whether such "post-hoc" probability calculations are legitimate, or examples of a "Texas Sharpshooter" who first fires shots randomly at the side of the barn and *then* draws a bull's-eye around each of the bullet holes. Bartky and Stouffer then took a more omnibus view, by "examining the large table, [where] we can compare the distribution of the actual numbers as a whole with the numbers expected by chance."

> By the probability theory, only 439 entries in this table would have been expected to be blank. Actually, 747 of the entries are blank. Theoretically, only 109 of the entries should have been higher than 5. Actually, 195 of the entries are higher than 5. There should not have been more than one or two cases in the entire table in which as many as four successive blanks occurred in succession, going down a column.
>
> The actual occurrence of four blanks is so frequent that the odds against this happening are obviously too enormous to justify an attempt at exact calculation.

Again, it is left to readers to try to replicate these frequency calculations. As statisticians, Bartky and Stouffer cautioned that "An expert making an analysis such as this, based solely on the theory of probability, can only demonstrate the discrepancies and cannot say why they occurred." The extensive video material now readily available confirms the newspaper accounts that capsules were large and densely packed, mixing during the drawing was difficult, and some capsules broke open. The Director of Selective Service, in his report to the President (Selective Service 1942), did acknowledge the clustering. He attributed it to "the fact that the numbers had been poured [into the bowl] in lots of a hundred each, and the lateral stirring had not effected a complete mixing or redistribution of the numbers." Several photographs, now easily found online, and at higher resolutions than the versions published at the time, give a new clue as to the peculiar pattern: in Figure 3, one can see the plastic "collar" that was used to extend the historic bowl used in 1917 so that

Figure 3. Drawing of the fourth number in the 1940 lottery by the (blindfolded) Secretary of the Navy, Frank Knox, with President Franklin Roosevelt (left) looking on. The image is licensed from *http:www.alamy.com*. The problems caused by the ad-hoc extension to the bowl used in 1917 are easily seen if one looks carefully at the capsules near the bottom of the bowl. Photographs of the drawings of the first and fourth numbers are also available at the Library of Congress: *https://www.loc.gov/item/2012648302/* and *https://www.loc.gov/item/2004671493/*.

it could accommodate the—somewhat fewer but—much larger capsules. It extends down to within a few inches of the bottom of the original bowl, and prevented the capsules at the bottom from being reached.

2.2.1. 1941 and 1942

Only 800 numbers were drawn in the 1941 lottery and so the task was much easier. Nevertheless, the organizers had learned their lesson. Before they were placed in the bowl the capsules had been mixed thoroughly by four men who vigorously shook them in a tarpaulin. For the larger lottery, with 7000 numbers, carried out in March 1942 (NBC Radio 1942), they were even more thorough. Newspaper accounts tell that, and now-readily available online video footage shows that the capsules were premixed in a glass-walled cylindrical tumbler, and then funneled into the extended historical bowl. Figure 2 provides visual and formal statistical evidence of how successful these remedies were.

For those in the last two registrations in WW II, the order of call was based on men's birth dates, oldest first, and alphabetically in the case of ties. The identification of men by their birthdays simplified matters but was to create its own statistical challenges a generation later.

2.3. War in Vietnam

The aims and procedure are well summarized in a recently de-classified memo (Lynn 1969) to the then National Security Advisor soon after the 1969 lottery,

> The basic purpose of the lottery system is to reduce the uncertainty faced by a potential draftee by assigning him a definite rank in the order of call. The means used to assign this rank is a random selection of birthdays (1–366). The induction of individuals follows this order of birthdates. This new system is intended to be different from the old system in three principal respects: it selects persons randomly by age rather than "oldest first"; it assigns a definite rank order of induction to an individual rather than forcing him to guess when he will be called; it also limits the liability of the registrant to one year rather than six years. [...]
>
> The first lottery drawing was held on December 1 [1969] by the Selective Service. [It] placed 366 balls in a jar, stirred them with a paddle, and then selected them one by one to determine the order of call [for] each of the 850,000 eligible registrants in the eligible pool. At that time, the Pentagon stated that the lower two-thirds (1–244) of the draw faced military service while those in the upper third (245–366) would almost certainly not be called.

The drawing was broadcast live by the CBS television network (CBS News 2013); clips from the broadcast can be found online, and in the original Against All Odds series (Annenberg/CPB Project 1988, Program 8).

In Figure 4(A), the x axis gives the order in which the birthdays were drawn out, and y the 366 birthdays. I have presented these 3 scatterplots (with the axes reversed) to several classes of students over the last 40 years, but few notice any nonrandomness, even if I ask them to look specifically at the 1969 plot. The striking exception was the year the class included a radiologist, who instantly noticed "a defect in the upper right quadrant."

Statisticians seldom have enough visual acuity to directly see the signals through the noise. So they use statistical

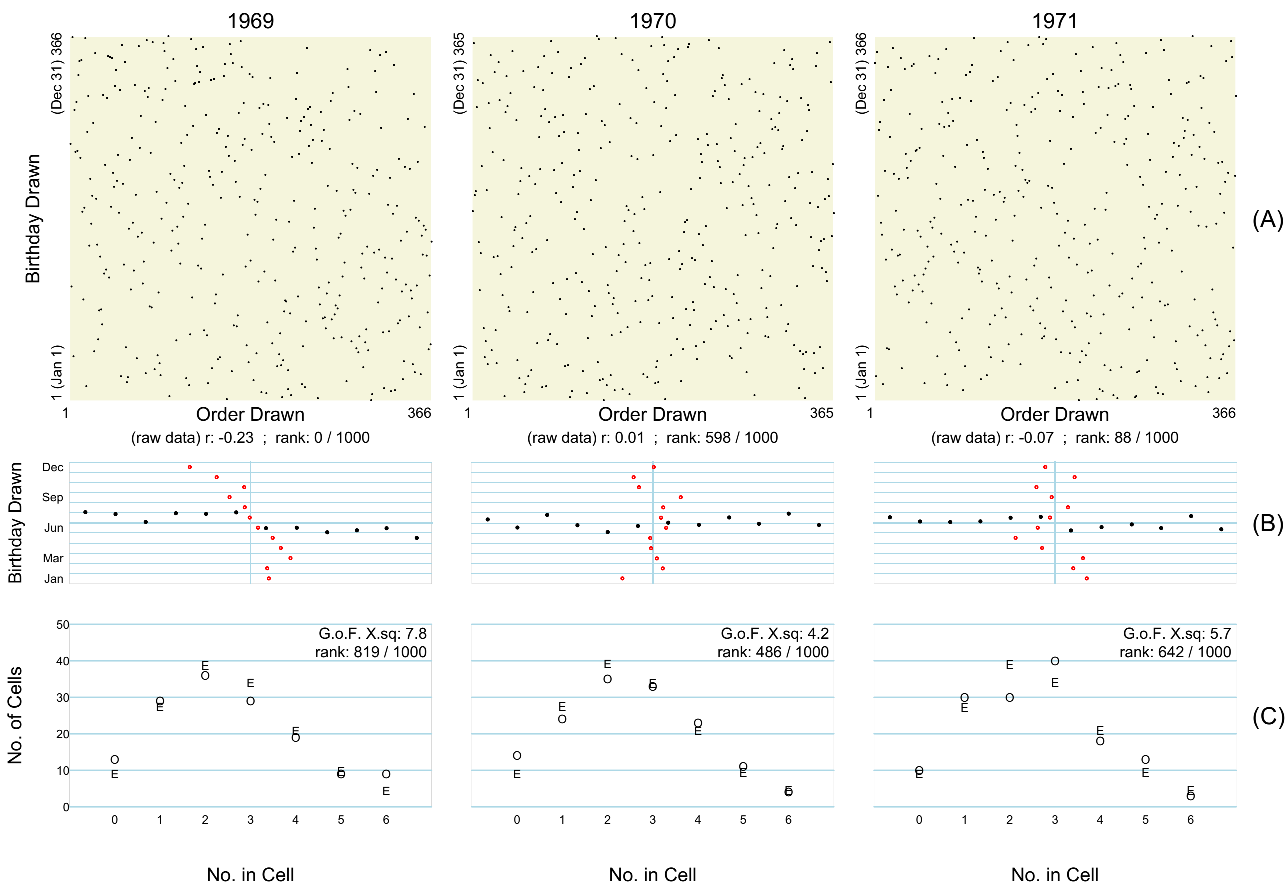

Figure 4. Scatterplots (A), conditional means (B), and observed and expected cell frequencies (C) based on raw data from the first three Vietnam War era lotteries. Explanations as in Figure 1. Each black dot in (B) is a mean($y|x$); each red dot is a mean($x|y$), the more commonly used conditioning in previous analyses of these data. (The 12 red means from the 1969 data were plotted as a bar graph in the New York Times.) The $12 \times 12 = 144$ cells in (C) are formed from the 2-way grid using x- and y-intervals of length 31, 28(29), 30, . . . , 31. Expected numbers and ranks are based on 1000 simulated lotteries. The three datasets are provided in the article by Starr (1997), which also provides a valuable set of primary and secondary print sources.

summaries, such as—in this application—the correlations shown below the scatterplots. They also use various levels and methods of smoothing, such as the conditional means shown in Figure 4(B), or fitted lines (Fienberg 1971, 1973), or a median trace (Annenberg/CPB Project 1988; Moore 1999). Once shown the correlation of −0.23 or the smoothed line, students understand why, in the cartoon (Moore 1979) showing two American soldiers in the Vietnam jungle, one remarks to the other, "So you were born in December too, eh??" The fact that the test for lumpiness gave no indication of a problem can be used to emphasize that are many types of departure from randomness, and that different tools are sensitive to different types. Interestingly, students tended to "see" greater departures from randomness in the 1970 and 1971 lotteries than in the 1969 lottery, even though the various test statistics show otherwise. [The data from the 1969–1971 and the "just in case" 1972–1975 lotteries (Burkardt 2019)—conducted after the transition to an all-volunteer force—but with the 7 years de-identified, would be an interesting test of students' visual and data-analysis skills.]

Given the difficulty of seeing the nonrandomness in the raw data from 1969, one might wonder how quickly it was noticed at the time, and by whom. The earliest written account of "citizen" recognition that I have located appeared on Saturday December 6 (Ann Arbor News 1969) under the title "Draft Lottery Called Statistically Unfair" It reported that

The draft lottery is statistically unfair and will result in twice as many men born in December being drafted as those born in January, Dr. Fred T. Haddock, one of the University's most distinguished scientists said yesterday. Haddock, director of the U-M Radio Astronomy Observatory and an internationally recognized leader in his field, concluded the draft lottery is "not random" after working on the problem with the aid of mathematicians over the past several days.

"The draft lottery is definitely not random. Inspection of the lottery results clearly shows a systematically increasing number of men being drafted as their birth date falls later in the year. The odd against this trend resulting from random selection are over 100,000 to 1. For example, twice as many men with December birth dates will be drafted compared to those having January birth dates.

"This can easily be seen by plotting the average monthly draft number from January through December. The plot gives a nearly linear decrease in average draft number (increasing draft risk) with the date of birth. It is as if the capsules containing the birth dates were placed in the glass bowl in monthly order with January on the bottom and December on top and mixed too little for a random mixture to be obtained.

"The monthly average draft numbers from January to December are approximately: 201, 203, 226, 204, 208, 196,

> 182, 173, 157, 182, 149, and 122. Note that the first six months all have averages above the overall average, of 183.5, and that the last six months averages are all below the overall average. The coefficient of linear correlation between the order number of the lottery drawing and the order of the birthdate from January 1, is −0.222, with a standard deviation of 0.052. If the drawings were random the coefficient would be very near 0. The chance of the coefficient being this far from 0 is less than 1 in 100,000.

Furthermore, Haddock suggested that, in keeping with "the intent and spirit and intent of the lottery, [...] men born in November and December with draft card numbers below 184 should be given a new deal by having their 47 birth dates redrawn from a new lottery which would give them order numbers to be multiplied by 366 divided by 47 and then interlaced with the remaining present numbers."

A December 16 article (Madison Capital Times 1969) carried a report entitled "Draft Lottery Bias on Dates Charged," under the byline "Students Cite Statistics." The students were University of Wisconsin graduate students David Stodolsky and Carol Falender. It reported that

> The bias, according to Stodolsky, is shown to exist with a certainty of 50,000 to 1. The two graduate students point out that of the first 100 birth dates selected, 16 are from the month of December, 6 from January and only one from March. The[ir] letter, thick with statistical explanation, was sent Monday to Wisconsin Sens. William Proxmire and Gaylord Nelson. It asks for an immediate [congressional] investigation. Other students of probability elsewhere in the nation have noted the unusual distribution of birthdates in the pool and have suggested that the bowl was not shaken adequately after the capsules were introduced into it.

In January, as a Federal district judge in Wisconsin agreed to hear a test case on the lottery, a "knowledgeable White House official" said that "discussions that the lottery was nor random are purely speculative" and that there was "no possibility" that there would be another drawing. Moreover, "The Selective Service official who conducted the lottery said, "An effort was made to make the thing as fair as possible." (Rosenbaum 1970a)

The de-classified memorandum to the National Security Advisor confirms that those in the White House knew of the problem for some time, and what caused it. Under the heading "The Randomness of the Lottery," that Dec 13 memorandum (passed on to President Nixon on December 26) continued

> **[T]he random process developed by the Selective Service for use in lottery was not random.**
> [I]t failed to ensure true randomness because (i) the balls were placed in the jar in calendar order (January, February, etc.), not random order (ii) the stirring did not randomize the balls in the jar.
>
> As a result, the lottery first drew the birthdays from those months late in the calendar which had been put into the jar last. The registrants unlucky enough to have been born in December had an average rank order of call of 120 (certain to be drafted) while the registrant born in January had an average rank of 210 (not likely to be called). Standard statistical tests indicate that this sort of distribution of rank order among months was virtually impossible (1 in 16,000) given a truly random selection process.

The 1969 procedures, the results, and the 1970 modifications have been extensively analyzed and reported upon (Rosenbaum 1970a; Fienberg 1971; Rosenblatt and Filliben 1971; Johnson, Dawes, and Conley 2019). The data and graphics have been widely used in the teaching of probability and statistics (Annenberg/CPB Project 1988; Moore 1999; Starr 1997). Thus, I will merely (i) add the four additional p-values (<0.001, 0.02, <0.005, and <0.001) reported by Fienberg to the odds/probabilities already cited above and (ii) suggest that students use the (now more easily accessed and analyzed) data to reconcile Haddock's monthly average draft numbers with the 201, 203, 226, 204, 208, 196, 180, 173, 157, 182, 149, and 122 shown atop the vertical bars in the New York Times graphic, and with the 210 and 120 cited in the December 13 memo.

2.3.1. 1940 Versus 1969: Which Failure Was Worse?

Statistically, the gaffe in 1940 was far bigger, and immediately obvious visually when the raw data are plotted. Yet, despite this glaring nonrandomness, and the large initial headlines, why was it not perceived as unfair? The statistical reason can be found in President Roosevelt's words: the selection *processes* in 1940 involved 6500 separate local randomizations, and 1 central one. The central randomization protected against errors in the local ones, and vice versa. That the independent national lottery failed would have no effect on overall selection randomness unless something was done systematically (doubtful, and likely impossible to know) in assigning serial numbers at the local level. The strange order in which the serial numbers were drawn was merely a statistical embarrassment, but not demonstrably unfair to any particular class of men.

As the White House memo stressed, the *intended* procedure for the 1969 selection involved two independent randomizations, governing the order in which the capsules were (i) loaded and (ii) drawn out. *Each randomization would protect against errors in the other*. The selection process would have been fair if *at least one* of the two were properly carried out. However, *both* stages failed: the later in the year birthdates dates were inadequately mixed with the earlier ones before being poured into the two feet deep bowl. Although it would have been feasible, the 366 small capsules were not stirred (officials remembered that when the capsules were stirred in the 1940 lottery, some of them broke). Each of the 47 people of draft age "drew their seven or eight capsules quickly and efficiently," "generally from the top." The resulting double-failure spread the risk/harm unevenly among the 366 subsets of men.

2.4. 1970–1975

As described the next day (Rosenbaum 1970b), the following year (Fienberg 1971; Rosenblatt et al. 1971) and again recently (Johnson, Dawes, and Conley 2019), the procedure for the July 1, 1970 lottery involved 2 independent rotary drums and 4 independent randomizations. The latter are denoted R_1 to R_4 in the toy example—with $n = 8$ birthdays—in Figure 5. One drum contains n capsules, each containing one birthday, and

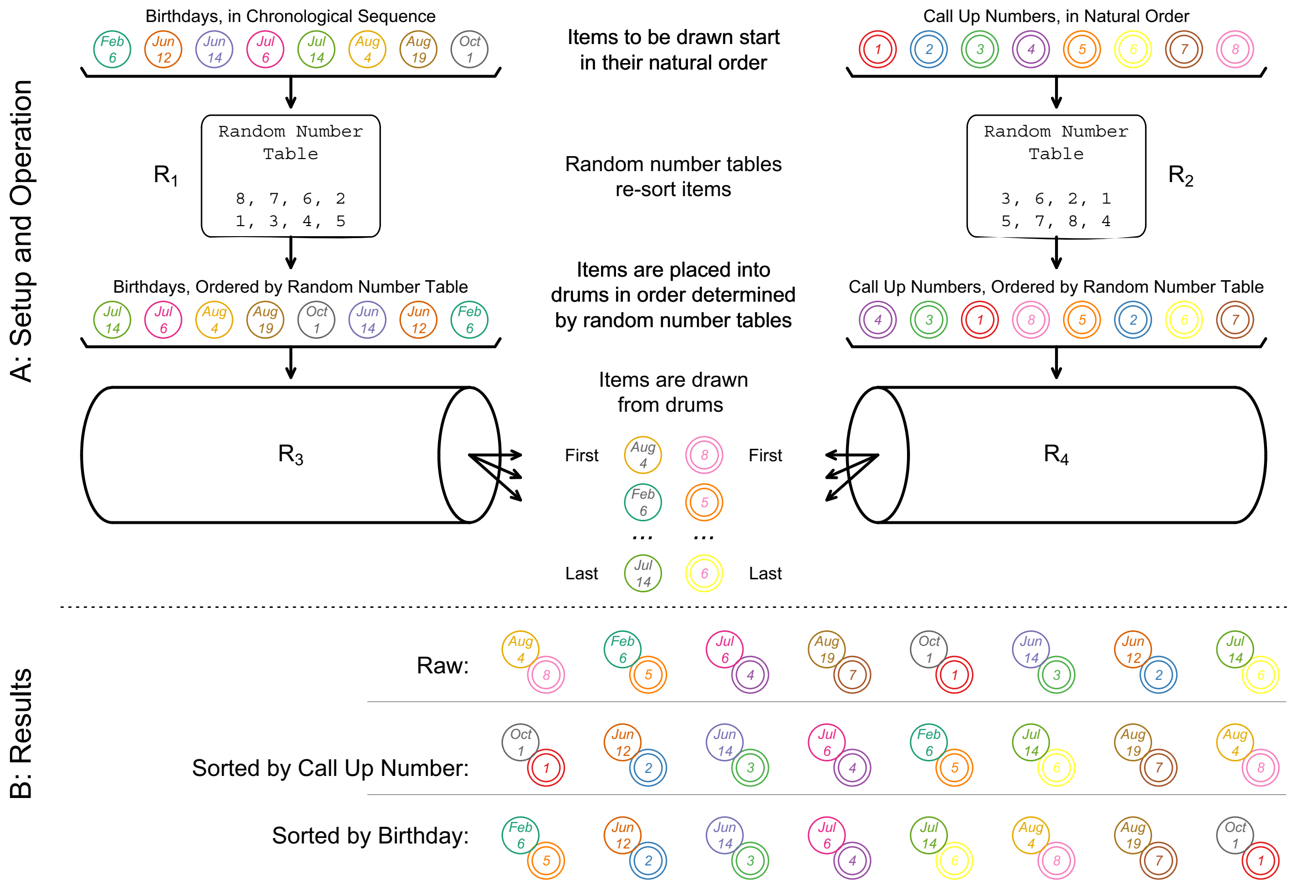

Figure 5. Toy example illustrating the setup of, and a realization from, the "4 randomizations (R_1 to R_4) and 2 drums" procedure used in the 1970–1975 draft lotteries. Randomizations R_1 and R_2 (see text) determined the order in which the birthdays and the call up numbers were placed in the 2 respective drums. Randomizations R_3 and R_4 determined the order in which they were drawn from them. The significance of the 8 birthdays is left for readers to determine.

the other contains n capsules containing the numbers 1 to n. In the toy example, the random permutations R_1 and R_2 were carried out using the `sample` function in R; the real ones were carried out using 2 printed tables of $n = 366$ random numbers selected randomly from several such tables. In the toy example, the random permutations R_3 and R_4 were again carried out in R; in the real one, they were carried out by rotating the two drums for at least 30 min, and having individuals pick out capsules at random. "Each time a red (birth date) capsule was drawn, a green one (number) was picked, and the date and the number were matched. *A man's place in the draft sequence was determined by the number that was matched with his birth date*." There "appeared to be little doubt that the drawing had resulted in a random selection" (Rosenbaum 1970b). The actual results seen in Figure 3 are what one would expect from a system with this number of separate protections against failure.

The New York Times accounts of the 2-drum lotteries of 71.08.05, 72.02.02, 73.03.08, 74.03.20, and 75.03.12 mention the preloading based on tables of random numbers, the shorter lengths of time the drums were rotated, and 1 min rotations after every 20 draws. Students can use the consolidated dataset provided to check the results.

Some years later (Tarr 1981), an academic who led the reform of the Selective Service System and the draft lottery relayed the verdict of a committee of statisticians he asked to review the new system.

> Listening carefully to what we had done, they approved. Later, Al Bowker, my friend from Stanford, [one of the founders of its Department of Statistics] summed it up best: "A clear case of statistical overkill!"

At the time, the Selective Service had to be thorough. "Overkill it was. But it was not the only time that we had to take extreme precautions to insure equitability in the draft; to erase the negative image of the System we had inherited, we had to continually reinforce an image of absolute fairness. This was one of the many lessons we learned in our two years."

3. 1569–2019: Back to the Present

The Selective Service System (2019) now shows on its website *https://www.sss.gov/About/History-And-Records/Selective-Service-Lottery* the contingency plan for the lottery that would be conducted today "if and when the Congress and the President [were to] reinstate a military draft." It retains the two-drum system used in the 1970s, but uses two large *air mix* drums, similar in principle to those used to draw Bingo balls. As Figure 6 shows, the balls have the birthdays and the call-up-sequence numbers written on them. There is no mention of using randomizations R_1 and R_2 to load them into the two "Titan drawing machines" before proceeding to R_3 and R_4. Presumably, the improvements in mixing technology have reduced the need for the statistical overkill of the early 1970s.

Figure 6. In readiness for another Selective Service Lottery, *https://www.sss.gov/About/History-And-Records/Selective-Service-Lottery*. The image is reproduced with the permission of the Selective Service System agency.

Statistical procedures designed to be less sensitive to deviations from the assumptions of conventional statistical procedures have come to be called "robust." The term "*doubly robust*" or "*doubly protected*" estimator emerged more recently (Bickel and Kwon 2001, p. 921) in the context of a pair of models that describe different aspects of nonexperimental data used to estimate causal "effects." *Only one of the two models need be correctly specified* to obtain an unbiased effect estimator. We might apply the same terminology to the draft selection procedures. Those in WW I and II were doubly robust locally, and multiply robust nationally. The 1969 procedure was not at all robust; the 1970–1975 procedures were "quadruply" and the 2019 procedure is "merely doubly" robust.

Although "high-tech," the 2019 procedure employs the "double-drawings" principle used in lotteries in medieval Venice (Schwartz 2006, p. 86). These were created by merchants to get rid of their stale goods or valuable items for which they could not find a purchaser. The procedure was quickly adopted by the Venetian Republic.

> Tickets were not numbered. Instead, each bettor wrote his/her name or personal motto on a slip of paper, which went into one urn. Into the other urn went slips of paper bearing the word "*patientia*," patience, meaning "better luck tomorrow," or *precio*, prize and a description of the prize won. Blindfolded orphans selected winners by simultaneously drawing slips from each urn. The draw, which did not end until all tickets had been pulled and matched, could take as long as eleven days.

This Venetian model was used in England's first lottery (The History Press 2019) held 550 years ago, in 1569, and organized directly on the order of Queen Elizabeth I. Promoted as "A very rich lotterie generall without any blankes," every ticket buyer "won something" and the remaining proceeds were to go to the upkeep of harbors and defenses. The organizers simultaneously drew the names from one receptacle ("wheel"), and the prizes from another. The drawing of the 400,000 pairs took place at the west door of St Paul's Cathedral, ran 24/7, and took almost 4 months to complete.

This cumbersome 2-drum system was gradually replaced by a more efficient Genoese system, the forerunner of today's single-urn "6/49-type" lottery (Bradley 2001). However, now that speed is no longer a limiting factor, the 2-drum lottery continues to provide a valuable and transparent statistical backstop in social affairs where "an image of absolute fairness" is the overriding concern.

Data: The single dataset provided contains not only the consolidated data for the 8 lotteries considered above, but also the (limited) data from the (unused) September 1918 lottery, and the 1972 to 1975 "just in case" lotteries.

Other historical material: Additional newspaper articles, images, audio and video clips are available from the author, and via the link on his homepage, *http://www.biostat.mcgill.ca/hanley*.

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