A story of "Cooked Lists" and "Permutation Races."

The Torah Codes: Puzzle and Solution

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In 1994, Statistical Science *published astonishing statistical evidence proving the existence of a hidden code in the Book of Genesis relating to future events. New research deprives this evidence of its import by proving that the same code can be found in the Hebrew translation of* War and Peace.

The Bible Code

On Thursday, May 28, 1997, Simon & Schuster took out a full page ad in *The New York Times*, announcing a new book with the following caption: "In all of history, few books have completely changed the way we view the world. The Bible was one. *The Bible Code* is another." Within a week, the book had been featured on CNN and in *The New York Times*, *TIME* magazine, and *Newsweek* (in the Religion section). In quick succession, it was featured in the leading U.S. newspapers and on the *Today Show* and the *Oprah* show. It was translated into many languages and topped bestseller lists all over the world for weeks. Warner Brothers bought the movie rights.

The claims made for the book were of *National Inquirer* quality: "For three thousand years a code in the Bible has remained hidden. Now it has been unlocked by computer—and it may reveal our future." Using this code, the author, a self-described "skeptical secular reporter" named Michael Drosnin, discovered what he took to be a prediction of the assassination of the late Yitzhak Rabin, then prime minister of Israel. Lest skeptics dismiss this claim out of hand, readers were told, "The code was broken by an Israeli mathematician, who presented the proof in a major science journal, and it has been confirmed by famous mathematicians around the world" and "In a few dramatic cases [Rabin's assassination being one of them] detailed predictions were found in advance—and the events then happened exactly as predicted" (all quotes are from the book jacket). Astonishingly, these assertions are actually more or less truthful: Evidence for the so-called Torah code was published in 1994 in the respectable peer-reviewed journal *Statistical Science* (Witztum, Rips and Rosenberg 1994, hereafter WRR), it received a degree of endorsement from several famous Jewish Orthodox mathematicians from Harvard, Yale, and The Hebrew University, and reliable witnesses confirm that Drosnin took pains to warn Rabin of the danger to his life a full year before the assassination.

What is this Torah Code, and What are We to Make of It?

The Torah Code

Take the Book of Genesis in Hebrew. If you start from the very first (Hebrew equivalent of the letter) *T* and skip 49 letters, the 50th letter is an *O*. Skipping over another 49 letters brings you to an *R*, and a final 49-letter skip brings you to *H*, thus spelling the Hebrew word for Bible, or Torah, in the form of an equal-letter-skip, or ELS for short. This ELS, and some others like it, were discovered several decades ago by the late Rabbi Weissmandel.

How remarkable is this discovery? An easy combinatorial argument shows that if a word is not too long (say, up to six letters), or its letters not too rare, then the chances of finding it as an ELS in a text as long as Genesis—78,064 Hebrew letters long—is excellent. Indeed, based on the letter frequencies in Genesis, the expected number of appearances of the word TORH in Genesis as an ELS with any given skip size is 3. In fact, TORH appears 56,769 times in Genesis as an ELS. In that respect, the discovery, appearance

notwithstanding, is unamazing. How remarkable is it, though, that one of these should start, of all places, at the very first T in Genesis, and have a skip size of 49, a significant number in Judaism? The problem with putting a number on the remarkableness of this detail is, of course, that it is ad hoc.

What Weissmandel saw with the unaided eye can nowadays be sought with the aid of computers, spanning much longer text segments, and much larger letter skips. In the mid 80s Ilya Rips, a professor of mathematics at The Hebrew University, and Doron Witztum, who, like Rips, is an Orthodox Jew, used the computer to search for all kinds of words and word combinations in Genesis. Witztum had an idea—to write Genesis as a single, extended page consisting only of letters (no spaces and no punctuation marks). This huge page could have various dimensions. For example, the 78,064 letters could be written as a page of 78 rows, each 1,000 letters wide, or as a page of 780 rows, each 100 letters wide, and so on. In this rectangular letter array, ELS words are allowed to be read horizontally, vertically, or diagonally, and in any direction—left to right or right to left, top down or bottom up. This enables the presentation of ELS words in a visually ready manner even though in the original text the letters constituting an ELS might be separated by hundreds, if not by thousands, of other letters.

Witztum and Rips were struck by the occasional discovery of thematically related ELS's in proximity—namely, in a relatively compact rectangle of letters. Such a rectangle can be thought of as a small "window" cut out of some gigantic Genesis page. An example is the famous array on the cover of Michael Drosnin's book, *The Bible Code* (Drosnin 1997), containing Rabin's full name in Hebrew and the words: "A murderer who murders." These words appear as plain text in Deuteronomy, chapter 4, verse 42; The Jerusalem Bible translates them to "a man ... who had killed his fellow;" Drosnin translates them as: "an assassin who will assassinate;" the skip in Rabin's name is of almost 5,000 letters. Striking as these arrays may seem to the naive reader, the unsystematic nature of the search methodology makes the calculation of a responsible number for the probability of any particular discovery impossible to do analytically (although irresponsible calculations abound).

Table 1—Alternative Date Choices and Proximity Measures in Genesis

	First List	Second List
†Only death dates	144	4
†Only conventional form for 15, 16 of the month	107	20
b'alef b'Tishrey date form	301,391	521,298
alef l'Tishrey date form	930,257	274,167
b'alef l'Tishrey date form	637,082	749,344
alef shel Tishrey date form	869,341	105,694
b'alef shel Tishrey date form	617,047	225,328
Dates and forms of Margalioth	288,779	360,472
Distance measured by minimal area of enclosing rectangle	5,547	63
Distance measured by minimal diagonal of enclosing rectangle	24,554	425
Distance measured by minimal perimeter of enclosing rectangle	22,160	434
Distance between the closest two letters	47,965	617
Distance between the farthest two letters	21,398	510

† **Note:** Only a small number of dates were removed in this check.
The number in the table gives the rank of the correctly paired rabbis' list in a race against 999,999 competing permutations. The race was run with respect to the P2 statistic of WRR, in the Book of Genesis. The numbers are, of course, subject to minor sampling errors.

The Rabbis Test

Concerned over the possibility that in any text of sufficient length it is possible to find ELS clusters like those found in Genesis, Witztum and Rips decided to run a kind of statistical test and calculate the significance—statistical and otherwise—of their discoveries. In selecting a sample, they set themselves a goal of "uniformity and objectivity with regard to the choice of the pairs" (WRR, p. 431). *The Encyclopedia of Great Men of Israel* (1961) contains short biographies of Jewish Rabbis who lived between the 8th and the 19th centuries. A minority of the biographies contain a death date or a birth date (Hebrew dates are written using letters only. Numbers are represented by letters in a systematic way, with the first 10 letters of the alphabet representing the numbers 1 to 10, etc.) Witztum and Rips drew up a list of those rabbis to which the *Encyclopedia* devotes three columns and more of text and mentions a date of death or birth. They found 34 such rabbis (actually, they erred slightly in composing the list, including in it one rabbi who didn't have a long enough entry and missing one rabbi who did), searched for their names and dates as ELS's in Genesis, and computed a kind of distance function between the name of a rabbi and his date. The exact manner in which Witztum and Rips computed the distance is technically complicated and will not be described here. Suffice it to say that proximity between a pair of ELS's was not measured by the size of the letter array enclosing them.

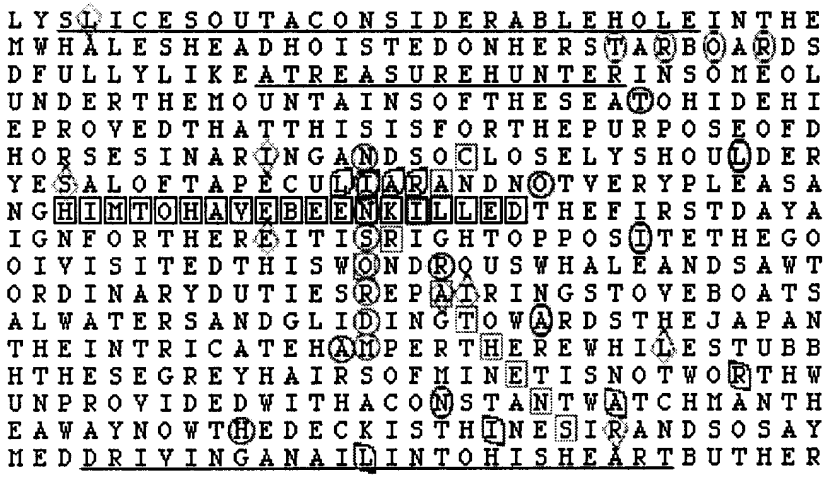

Figure 1. A sample of the Torah Code being decoded.

A list of numbers was obtained that describes the "distance" between the name of a rabbi and his date (in some cases, no ELS was found for a rabbi or his date, and then, of course, no distance was computed). Here and there some rabbi was particularly close to his own date. At the same time, most of the rabbis were actually closer to some other rabbi's date. To test if there was an extraordinary closeness in Genesis between the rabbis' names and dates, some statistical significance test was required. The original method whereby Witztum and Rips attempted to compute the statistical significance of their results made no mathematical sense and will not be described here. Professor Persi Diaconis, then of Harvard University, proposed an alternative method, whose central idea was to compare the distances in the rabbis list to a large number of alternative control lists.

Imagine that each rabbi is paired not with his own date of death but rather with some other date, sampled at random from the list of dates. It is possible, of course, to compute the distance between the rabbis' names and such random dates. If there is anything special in the Book of Genesis and the rabbis' names really appear exceptionally close to their dates of death, then the distances between correct name-date pairs should be, on average, closer than between random name–date pairs. Diaconis suggested running a kind of "race" in which 999,999 permutations of the 34 rabbis were chosen at random. In every permutation, each rabbi was paired with the date against which the permutation pitted him. For each of the 999,999 permutations, the distances between the rabbis' names and the date they happened to be paired with in that permutation were computed. The original, correct, list of distances was compared to 999,999 lists of distances in which each rabbi was paired with a random date, and its proximity rank was taken to be its statistical significance. Lo, the correct pairing achieved one of the first places in this "permutation race!" Of course, if there were nothing special in this list or in the Book of Genesis, there would be no a priori reason for it to excel like that.

The preceding account is an oversimplification in several respects (for example, Witztum and Rips used only ELS's with a near-minimal skip). The actual details are somewhat more complex than we described them, but the simplification smooths the story line. Our account also pretends, contrary to historical fact but for narrative clarity, that the published method was the one used all along. We did not describe how a list of distances was reduced to a single number expressing the proximity of the entire list. It is noteworthy, however, that the method reported in *Statistical Science* is an inferior variation of Diaconis's proposal, and yields results that are hundreds of times more "significant" than Diaconis's original suggestion would have yielded. In addition, although the popular press regards Rips, a reputable mathematician, as the central figure in ELS research, we shall talk of Witztum and Rips, in the order in which they chose to author their papers. The third author, Rosenberg, only did the programming for them and will not be mentioned further.

Reactions to the Rabbis Test

Although a proper significance test obviates the need to test the rabbis list on other texts (since it answers the question, "What is the chance of finding this kind of result by chance alone?"), skeptical referees asked that "control texts" (i.e., texts that ought to yield a significant result) be subjected to the same procedure. Of several control texts used, one, at the explicit request of one of the referees, was Tolstoy's *War and Peace* (first 78,064 letters of the Hebrew translation). Another control text was the book of Isaiah, although Drosnin (p. 36) reported on codes he found in Isaiah and claimed (p. 185) that Rips "agrees that other parts of the Old Testament, like Daniel and Isaiah, might also be encoded." The rabbis list did not excel in the permutation race in any of the control texts. Genesis was clearly special. In addition to the "control texts," Diaconis also asked for a cross-validation, or replication (i.e., a new sample, which is expected to yield a significant result). If a control text is a prudent check for artifacts in the statistical method, a replication is prudent "[i]n order to avoid any conceivable appearance of having fitted the tests to the data" (WRR, p. 431).

WRR's new sample consisted of those rabbis to whom Margalioth's *Encyclopedia* devoted between 1.5 and 3 columns of text, and contained a date of death or birth, "without changing anything else" (WRR, p. 431). The second list, consisting of 32 rabbis (there were some errors of inclusion again), was subjected to the exact same procedure as the first. Again, it arrived almost first in a race among one million contestants. Following these additional tests, the article was finally accepted for publication in *Statistical Science*.

WRR's only conclusion from their extraordinary results is that "the proximity of ELS's with related meanings in the Book of Genesis is not due to

chance" (WRR, p. 434). Their conclusion is more noteworthy for what it does not say (but everyone understands) than for what it does: Since the rabbis were born and died decades after the Torah was written, only a clairvoyant could have coded them into it. If you will, Witztum and Rips had discovered a statistical proof of the divine, or at least supernatural, origin of the Book of Genesis. Professor Robert Kass, then editor of *Statistical Science*, prefaced the article with the words, "Our referees were baffled: Their prior beliefs made them think the Book of Genesis could not possibly contain meaningful references to modern-day individuals ... The paper is thus offered ... as a challenging puzzle" (p. 306). Kass later reacted strongly against claims that the paper had convinced him, telling a reporter "I'd be very surprised to see any statistician believe any of this."

Reactions to Drosnin's Book

The puzzle did not attract much attention, until Drosnin's book appeared to instant best-sellerdom and directed some publicity to WRR's work. Drosnin's book was panned not only by skeptics but even by Witztum and Rips themselves. One stated reason was Drosnin's attempts to use codes to predict future events, which Witztum and Rips claimed to be impossible (though it is not clear why). Another was its lack of rigor. Obviously, "messages" such as those Drosnin found supposedly "encoded" in the Bible could be found in any text. Indeed, the triviality of Drosnin's discoveries is highlighted in the following anecdote. In a *Newsweek* interview, Drosnin had stated: "When my critics find a message about the assassination of a prime minister encrypted in *Moby Dick*, I'll believe them" (Begley 1997, p. 51). McKay promptly found a slew of letter arrays in *Moby Dick*, encoding a series of famous assassinations, including, in addition to Rabin's, those of Kennedy, Martin Luther King, Trotsky, and even a tongue-in-cheek "prediction" of the murder of Drosnin himself, in a format closely mimicking Drosnin's own Rabin assassination array (see Fig. 1). Those impressed by the fact that Drosnin apparently predicted Rabin's assassination before it actually took place should note that his actual warning to Rabin only said: "I believe you are in real danger, but that danger can be averted" (Drosnin, p. 187). That much, however, was a common perception at the time. And of course, this prediction would have been confirmed whether Rabin had been assassinated or not.

Whereas Drosnin's findings, as well as Witztum and Rips's earlier word clusters, are mere anecdotes, the rabbis list is much harder to shrug off. The work described previously has an appearance of scientific rigor. Its faults escaped detection by a bevy of sophisticated referees. It is far and away the strongest evidence for the existence of codes in the Torah. It was time for some statistical sleuthing.

A Closer Look at the Rabbis List

It is difficult for a non-Hebrew speaker to appreciate the details of the rabbis list as they appear, in Hebrew, in WRR. If hitherto our description imparted the impression that each rabbi was represented by a single name and one or two dates, this turns out not to be so. The rabbis were known by many names and appellations, and they entered the list with many names and appellations—as many as 11 in one case! By way of illustration, the current president of the United States can be called, Mr. President, Mr. Clinton, Bill, Bill Clinton, Clinton, and so on. Dates also appear in more than one form, up to six in one case. By way of analogy, consider various date writing forms in English: January first, the first of January, on January first, on the first of January, January one, on January one, New Year's day, on New Year's day, and so on. (In Hebrew, names and dates form much shorter letter sequences than in English, and prepositions such as "on" and "of" are single-letter prefixes.)

Casual observation reveals that the date forms do not exhaust all the different ways in which the dates could have been written, and careful research of the rabbinical literature shows that the names and appellations are not an exhaustive list, either. What was the protocol whereby Witztum and Rips chose the particular names and date forms in their lists? Their article is mum on this question. It states only that "we used three fixed variations of the format of the Hebrew date", and that "The list of appellations ... was provided by Prof. S. Z. Havlin" (WRR, p. 436). Written and oral exchanges of the present authors with Witztum and Rips give a more comprehensive—and startling—answer, however. There was NO protocol! The official line is that the list of names and appellations merely reflects Havlin's judgment, and the choice of date forms is credited to the late Dr. Y. Orbach.

It is also not quite clear who is responsible for the fact that many of the dates mentioned in Margalioth's *Encyclopedia* were altered, corrected, discarded, exchanged, or added to, a fact that is not explicitly mentioned by WRR (though it is mentioned in earlier preprints). The odd fact is that although it was necessary for a rabbi's encyclopedic entry to contain a date for him to be included, the date mentioned was not binding on the authors. They used whichever date they considered most authoritative. Be that as it may, whoever was responsible for the choices made, the end result is that in spite of Witztum and Rips's declared intention of "uniformity and objectivity with regard to the choice of pairs" (WRR, p. 431), the list they actually compiled was neither uniform nor objective: It necessitated the discretionary judgment of experts—judgment which, we shall show, is arguable. Moreover, we shall also show how the fact that the list of names and date forms was a subset of all names and date forms left room for the very "fitting of tests to the data" that the second list was designed to prevent. It is in the multitude of possibilities for writing names and dates, and the even greater multitude of possibilities for choosing among these possibilities, that the key to the Torah codes puzzle lies.

Degrees of Freedom in the Rabbis List

On the face of it, the second list answered the concerns raised by both

the lack of objectivity and the suspicion of a lack of a priority of the first list. Whatever degrees of freedom were exploited in the choice of appellations and date forms in the first list had been exhausted, and the second list was bound to the choices made in the first list. In requesting a new sample, Diaconis had hoped that the constraints set by the first sample would guarantee the objectivity of the new one, and this objectivity was supposed to make it more credible that it was also a priori. But in fact, the rules and constraints laid down by the first list left sufficient room for maneuvering in the second list, allowing for the "cooking" of a second list that would be no less successful than the first list.

Where did any degrees of freedom remain in the transition between the first list and the second? In regard to the date forms, the second list did indeed follow the first list. But in writing names and appellations, there aren't rules as strict and binding as there are for date writing. Different people, even if given the same name at birth, may come to be called differently in the course of their life time (a Robert can be Bob, Bobby, Rob, Robby, Bert, Bertie, etc.). If one Robert is also called Bob and another is not, this is not an inconsistency in choosing appellations—rather, it reflects reality. And the facts of the matter regarding names and appellations cannot be derived from rules; they must be historically known. Hence, allowing nicknames and appellations makes it difficult to specify an "objective" list of names governed by strict rules. The appellations are included because the person who draws the list thinks they should be included. It is a matter of discretionary judgment. Indeed, Havlin, in a written description of his considerations when constructing the lists of names and appellations, admitted explicitly that he used a great deal of judgment when constructing the list. It follows, therefore, that the second list did not solve the problem it was intended to solve, namely—guaranteeing that the second list could not be fiddled with and "cooked" to success.

The reader might wonder at this point: Is it really possible to "cook" a second list, following exactly the rules set by the first list so that it would be as successful as Witztum and Rips's second list is in fact? Many of those who readily see that the appearance of words and of word combinations as ELS's, even in proximity, is possible in any text find it hard to believe that, under the heavy constraints set by the first list of rabbis, Witztum and Rips's results (namely, outstanding performance in a permutation race) can also be replicated in any text. But recently, this too has been unambiguously demonstrated.

The Rabbis List in *War and Peace*

Bar-Natan and McKay undertook the following challenge: To take some text of the length of Genesis and cook the second rabbis list so that it would excel in a race of permuted lists run on this text, yet follow the guidelines governing Witztum and Rips's first list just as closely as their own second list did. The text chosen for this purpose was *War and Peace* (the first 78,064 letters) because of its earlier role in WRR. Bar-Natan and McKay's list was constructed as follows:

1. The list of rabbis was chosen by Witztum and Rips's criterion—namely, rabbis to whom the *Encyclopedia* allotted between 1.5 and 3 columns of text and whose entry included a date of death or birth. One rabbi, who was included in Witztum and Rips's list by mistake, was removed. A missing one was added.
2. The dates, including their form, were identical letter by letter to those used by Witztum and Rips.
3. The computational details were the same as those used by Witztum and Rips, with the following exception: Witztum and Rips included two rabbis even though they had discarded the dates given them by the encyclopedia, thus leaving them unpaired in the correct list. Bar-Natan and McKay's list discarded these rabbis, who necessarily contributed only noise to the computation, altogether.
4. The "cooking" was confined to the list of names and appellations. Out of close to 90 names and appellations in Witztum and Rips's list, 20 were dropped, and 30 were added. For example, the name "Oppenheim" spelled with a single Hebrew letter yod (corresponding roughly to I) was exchanged for that name with a double yod spelling. The deletions and additions were all based on research, and were governed by principles and consistency considerations to the same extent as Witztum and Rips's list was. Menahem Cohen, a colleague of Havlin's from the Faculty of Jewish Studies at Bar-Ilan University, has stated in writing that "The list prepared by Prof. Havlin, ... has, in my humble opinion, no scientific basis. ... I see no essential difference between the two lists for the purpose of using them for ELS experiments." We note that the cooked list is not claimed to be perfect but only as error-free and self-consistent as Witztum and Rips's list, or better. Additional detail can be found on McKay's Web site http://cs.anu.edu.au/~bdm/dilugim/torah.html.

In a race of ten million permutations, the modified list finished in 12th place! It is possible to summarize matters thus: Within the boundaries of mostly trivial changes, all of which are justifiable, consistent, and legitimate no less than Witztum and Rips's, the astonishing result from Genesis can be replicated in *War and Peace*.

Of course, from the fact that a list could be, and was, cooked for *War and Peace*, it does not follow that Witztum and Rips cooked their list for Genesis. They persist in claiming that their list, unlike Bar-Natan and McKay's, was a priori, that it was chosen in good faith, and that the choices were blind with respect to their success probability. Because none of the critics and skeptics were present when the list was drawn up, the decision whether or not to believe the claim that the second list was a priori remains as much an act of faith as it was with regard to the first one. Nonetheless, we performed other analyses, also statistical in nature, which indicate that if Witztum and Rips's list was not cooked then its creators enjoyed a fantastic streak of luck, to say the least. These findings, to be described in the next section, seriously

question the claims of a prioricity. But we shall leave it to the readers to draw their own conclusions.

Choices, Choices

Every researcher in every research must make many methodological and substantial choices. So too, Witztum and Rips, or their consultants, faced many choices and decisions in implementing their selection of a sample of word pairs and in their determination of "distance." The choices that existed with regard to the matter of dates provide some convenient examples.

1. One date, or two? Only four of the 34 rabbis in the first list and one in the second had valid birth dates in the *Encyclopedia*. All but one of them also had death dates. Hence, Witztum and Rips could have settled for dates of death only (they would have lost but one rabbi out of 66), or they could have taken dates of birth as well as dates of death (just birthdates would have been impractical, as there are not enough of them). Thus the choice was between death date or both dates.
2. Conventional forms, or unconventional ones, too? "The 15th and 16th of any Hebrew month can be denoted [two ways]. We used both," said Witztum and Rips (WRR, p. 436). What they did not say is that one of these is conventional and the other, though it used to exist, no longer does. Use of the conventional form only is unlikely to have been questioned, because few people are even aware that there is an alternative. In any case, they were not compelled to use it—they chose to.
3. "In designating dates, we used three fixed variations of the format of the Hebrew date" (WRR p. 436). In fact, there are as many as eight standard ways of writing a Hebrew date, and for some dates (particularly holidays), even more. The choice of three particular forms is arbitrary: It is possible to choose any one form, pair of forms, triplet of forms, etc.

The distance metric also provided a fertile ground for choices. Proximity between word pairs could have been measured any number of ways—area of the minimal rectangle enclosing the pair; diagonal of the minimal rectangle enclosing the pair; circumference of the minimal rectangle enclosing the pair; Euclidean distance between the two farthest letters in the pair; Euclidean distance between the two nearest letters in the pair, and so on and on. How to measure distance was a choice.

Finally, we describe one of the purely technical choices made. If a word is expected (on the basis of the letters in it and their frequency in Genesis) to have more than 10 ELS's in Genesis, Witztum and Rips put a limit on the size of the skip so as to reduce the expected number of ELS's to 10. This is an arbitrary number, the stated reason for which was just to save computation time. It is thus not inherently better than aiming for any other expected value.

These are just a sample of the many choices Witztum and Rips faced. Suppose, now, that all these choices were made, as claimed, in an a priori fashion—namely, without knowing how the choice would affect the outcome. It stands to reason that where a choice could have been realized in one way or another, it would turn out a posteriori that the blind choice was fortunate (i.e., improved the ranking in the race) about as often as it was unfortunate (i.e., hurt the ranking). So it is possible to set up a null hypothesis of blind choice (blind with respect to its implications for the success of the list in the permutation race), according to which the proportion of fortuitous choices is expected to be no higher than 50%. Wonder of wonders, however, it turns out that almost always (though not quite always) the allegedly blind choices paid off: Just about anything that could have been done differently from how it was actually done would have been detrimental to the list's ranking in the race.

In particular, all the choices listed in the present section were fortunate for Witztum and Rips. Had any of them been different, the ranking of the lists in the permutation race would have gone down. Sometimes by a small amount, sometimes by an order of magnitude, but always down. Some might claim that it is not "fair" that the choices were tested with respect to their effect on the permutation race rank, because this statistic had not yet been developed when the choices were made. We are not claiming, however, that choices were made in a deliberate process vis-à-vis any particular statistic. We are merely claiming that blind choice is expected to have yielded different results than those our analyses actually found. Table 1 lists some of the tests we did and their results.

By the way, the rationale that Witztum and Rips gave for not having used a single date form is that they couldn't know in advance which form was the one used in the code. We now know, however, that no single date form is "best." In other words, use of a combination of date forms (and also using both forms of the 15th and 16th of the month) is superior to any single date form. Moreover, the triplet of date forms used by WRR is superior to any of the other 14 choices that could have

Table 2—Replications

	WRR Original Lists	
The text:	List 1	List 2
Genesis	38	2
Exodus	23,888	189,486
Leviticus	698,915	947,860
Numbers	4,573	916,271
Deuteronomy	135,101	760,645

Note: The number in the table gives the rank of the correctly paired rabbis list in a race against 999,999 competing permutations. The race was run with respect to the P2 statistic of WRR, in the Book of Genesis. The numbers are, of course, subject to minor sampling errors.

been made from the power set of the possibilities: alef Tishrey, b'alef Tishrey, alef b' Tishrey, b'alef b' Tishrey. As to how the list would have ranked in the permutation race had some other values been set for the expected number of ELS's rather than 10, the ranks for the choice of 2, 5, 15, 20, 25, or 50 are, respectively, 210, 55, 3, 10, 20, 159. The rank for the original choice of 10 is 2, smaller than for any of these alternative choices.

Of course, the probability of blindly choosing so felicitously again and again and again diminishes rapidly with the number of such choices. By the same statistical logic that gave power to the WRR results, the results of the present analysis suggest that the chance of drawing up such a successful list blindly is very remote.

Lest there be a misunderstanding, we hasten to repeat that the fact that a particular choice made by Witztum and Rips turned out to be better than its alternative by no means implies that both were checked and the superior one was chosen. The method whereby the *War and Peace* list is cooked did not involve any of these choices, because they were imposed already. All choices were limited to which names and appellations to include and how to spell them. Nonetheless, our list would have fared similarly to theirs under the same checks. If a list of names is cooked to optimize some statistic given some choices, the choices look as if they were cooked to optimize the statistic given the list of names.

Replication

Recall that the *Statistical Science* article reported several control tests and only one replication test—the second list. The fact that the second list had too much slack raises the question of whether a replication could be performed that would be completely tight. We believe that the answer is yes—and that we have done some such replications. The (failed) goal of the replication reported by WRR, recall, was "to avoid any conceivable appearance of having fitted the tests to the data" (p. 431). Rather than change the list, one could, of course, change the text within the legitimate category of texts. Running Witztum and Rips's two lists letter for letter on the other four books of the Pentatuech provides eight such replication opportunities. They all failed (see Table 2).

Witztum and Rips are often asked why they didn't check the other books themselves. The standard answer is, "We are only making claims for the Book of Genesis." By the same token, of course, they could have refused to run any new sample, with the excuse that they are "only making claims for the first list."

Another replication attempt is to use the list of names and appellations letter for letter but use a different date form—any single, uniform date form, that would disallow any data fitting. The forms that were not chosen by WRR provide several such replication opportunities. These replications also failed (Table 1). (We do not wish to argue the distinction between a replication, and a mere "what if" check. Roughly speaking, if the check affects all or most of the rabbi pairs, it is probably fair to call it a replication, if it affects just a few—not. A replication should, in principle, allow the computed rank to be anywhere, whereas the checks are often predestined to be not very far from the rank of the original list.)

Over the years, Witztum, Rips, and Rosenberg carried out their own replications, reporting additional positive results with a few similar experiments on different topics. All of them, however, suffer from the same problem as the one that plagues the *Statistical Science* samples: they are not tight enough, leaving too much room for data fitting. They all involve pair lists that could easily be different from what they are and still remain within the stated criteria. Additional information can be found at McKay's Web site. A partial rely by Witztum, with which we very strongly disagree, can be found at his Web site www.torahcodes.co.il.

Conclusion

This analysis completes the critique of the seemingly astounding statistical results that were published by WRR. A list was presented there which performed most surprisingly and impressively in Genesis. That list performed quite poorly in *War and Peace*, and in several other control texts (though we now know that it also performs poorly in Exodus, Numbers, Leviticus, and Deuteronomy). Another list, however, consistent and correct to roughly the same degree as the original list, did achieve in *War and Peace* a measure of success as impressive as that of Witztum and Rips's list. So it is not the Book of Genesis that is remarkable; it is Havlin's lists, which seem made-to-order for Genesis.

What then remains of the "scientific" experiment and the statistical significance testing? We are back to square 1. We started by showing that single words in ELS form can be found not only in Genesis but also in any other sufficiently long text. Now we see that even a list of rabbis and their dates can be found in remarkable proximity not only in Genesis but also in any other sufficiently long text. To be sure, "the proximity of ELS's with related meanings in the Book of Genesis is not due to chance" (p. 434). It must therefore be due to design. The design, however, may well be human, not divine.

[The *Chance* article is loosely based on a Herbrew article (Bar-Hillel, Bar-Natan, and McKay 1997), insofar as both tell essentially the same story, but this article is expanded and more statistically sophisticated.]

References and Further Reading

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