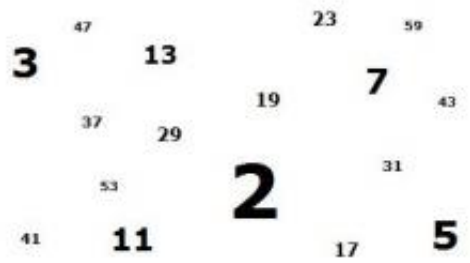
# Mathematician pair find prime numbers aren't as random as thought

March 15 2016, by Bob Yirka




Prime Numbers

(Phys.org)—A pair of mathematicians with Stanford University has found that the distribution of the last digit of prime numbers are not as random as has been thought, which suggests prime's themselves are not. In their paper uploaded to the preprint server *arXiv*, Robert Lemke Oliver and Kannan Soundararajan describe their study of the last digit in prime numbers, how they found it to be less than random, and what they believe is a possible explanation for their findings.

Though the idea behind prime numbers is very simple, they still are not fully understood—they cannot be predicted, for example and finding each new one grows increasingly difficult. Also, they have, at least until now, been believed to be completely random. In this new effort, the researchers have found that the last digit of prime number does not

repeat randomly. Primes can only end in the numbers 1, 3,7 or 9 (apart from 2 and 5 of course), thus if a given prime number ends in a 1, there should be a 25 percent chance that the next one ends in a 1 as well—but, that is not the case the researchers found. In looking at all the prime numbers up to several trillion, they made some odd discoveries.

For the first several million, for example, prime numbers ending in 1 were followed by another prime ending in 1 just 18.5 percent of the time. Primes ending in a 3 or a 7 were followed by a 1, 30 percent of the time and primes ending in 9 were followed by a 1, 22 percent of the time . These numbers show that the distribution of the final digit of prime numbers is clearly not random, which suggests that prime numbers are not actually random. On the other hand, they also found that the more distant prime numbers became the more random the distribution of their last digit became.

The researchers cannot say for sure why the last digit in prime numbers is not random, but they suspect it has do with how often pairs of primes, triples and even larger grouping of primes appear—as predicted by as the k-tuple conjecture, which frustratingly, has yet to be proven.

**More information:** Unexpected biases in the distribution of consecutive primes, arXiv:1603.03720 [math.NT]
arxiv.org/abs/1603.03720

**Abstract**
While the sequence of primes is very well distributed in the reduced residue classes (mod q), the distribution of pairs of consecutive primes among the permissible $\phi(q)2$ pairs of reduced residue classes (mod q) is surprisingly erratic. This paper proposes a conjectural explanation for this phenomenon, based on the Hardy-Littlewood conjectures. The conjectures are then compared to numerical data, and the observed fit is very good.