pest as *A. composticola*, however, because of its slower rate of reproduction in mushroom beds.

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PSYCHOLOGY

Speech Communication in Very Noisy Environments

We have conducted experiments on speech communication in extremely noisy environments; one of our findings is particularly surprising, and may be of value to understanding situations in which intense noise is inherently present.

The speech signals used consisted of readings (male voice) from various forms of literature, including newspapers and technical matter, and the aim was to assess communication, rather than intelligibility of single words or sounds. The speech was recorded on tape and passed through a filter of bandwidth 350–800 cycles/sec. This provided a "control" signal which indicated, substantially, only the instants of the vowel sounds (together with some high-energy consonant elements). This narrow band signal was then used to gate the original speech signal. An amplitude-limiter was applied so that only those sounds of high energy were passed. The result then consisted of a staccato sequence of only the high energy voiced speech sounds, which have extremely low intelligibility, even with running speech.

If, however, white noise alone is added in the gaps of this signal and steadily increased, there comes a certain amplitude at which almost full intelligibility of the speech is restored. Nothing is added but white noise. We have found that the amplitude of noise necessary is fairly critical for any individual listener, but that it varies considerably (over 40 dB) between different listeners. All listeners were of the English culture. An average increase in the intelligibility would be, for example, from 20 per cent (no noise added) to at least 70 per cent (noise added).

This general result was expected on the hypothesis that speech consists essentially of accurate time patterning of sounds; it is essentially a rhythmic activity and the precision of timing is very important. The extent of the result, however, was quite unexpected. What remnants of speech have been held unchanged in this processed signal possess the most important factor of syllabic rhythm. The noise bursts, in themselves having no information content, are nevertheless positioned accurately in the rhythmic stream of speech sound elements, and the listener hears a human being speaking. This experiment stresses the vital importance of the temporal patterning of speech to perception. Our intention now is to investigate conversation in similar conditions.

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GENERAL

Unusual Prime Number Sequences

Certain quadratic series abound in prime numbers[1]. Take, for example, the following sequence in which the consecutive differences are 2, 4, 6, 8, etc.

11 13 17 23 31 41 53 67 83 101

These are all prime numbers; the next term in this series is no longer a prime but equal to the square of the first term. The longest series of this kind known at present consists of forty prime numbers. It begins with 41, 43, 47, 53 . . . and ends with . . . 1373, 1447, 1523, 1601, a truly extraordinary sequence. The series starting 101, 103, 170 contains sixty-eight primes and thirty-two non-primes.

We shall throw some light on the mystery of the abundance of prime numbers in these series. When an arbitrary number is divided by a prime number q, the remainder can have any one of q values from 0 to $(q-1)$. In series of the kind considered here, however, one finds only $\frac{1}{2}(q+1)$ different remainders. Only the first $\frac{1}{2}(q+1)$ terms of the series need to be tested for divisibility by q, because after that the remainders repeat. There is a chance of about $\frac{1}{2}$ that none of these $\frac{1}{2}(q+1)$ remainders is 0. Therefore, when not too many prime factors need to be tested, there is a fair chance that none yields a remainder zero and that all the numbers tested are prime. This is the basic reason for the abundance of prime numbers in these series.

An additional favourable circumstance is the following observation. If the series starts with the prime number p and the first few terms are prime, the whole sequence of $(p-1)$ terms contains only prime numbers. More precisely, the series is represented by

$$g(n) = p + n(n-1), \quad 1 \leqslant n \leqslant (p-1) \tag{1}$$

If the terms up to $n = \frac{1}{2} + \sqrt{(1/3\ p)}$ are prime, all $(p-1)$ terms are prime. For example, because in the series starting with forty-one the first four terms are prime numbers, the other thirty-six are also prime numbers. The known sequences with only prime numbers are those starting with p = 5, 11, 17 and 41.

The following relation is also remarkable. When the sequence $g(n)$ contains only prime numbers, there exists a related sequence of half as many terms, which also contains only primes, namely,

$$g_1(k) = 4p - 1 + 4k^2, \quad 0 \leqslant k \leqslant \tfrac{1}{2}(p-3) \tag{2}$$

For example, for $p = 41$, the sequence starting 163, 167, 179 . . . and ending . . . 1319, 1459, 1607, consists of twenty primes.

We shall next indicate the proofs of these statements. Because the remainders repeat, the largest term to be tested for divisibility by a prime factor q is the one with $n = \frac{1}{2}(q+1)$, namely,

$$g(n) = p + \tfrac{1}{4}(q^2 - 1) \tag{3}$$

If $g(n)$ is not prime it must have a prime factor q equal to or less than $\sqrt{g(n)}$. This yields an upper limit for the values of q needed for the divisibility tests, namely, $q \leqslant 2\sqrt{(1/3\ p)}$ and this in turn gives the upper limit for n, given already, beyond which testing is superfluous.

In equation 1 we substitute $n = \frac{1}{2}(q+1) - k$, where q is any prime number less than p. If all the terms in equation 1 are prime, they are not divisible by q. If, after the substitution, we delete from the expression for $g(n)$ that part which is obviously divisible by q, formula 2 for $g_1(k)$ is left over.

There are other quadratic expressions with similar properties. We believe that our considerations have removed the mystery from these prime number sequences and reduced them to a mere curiosity.

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