sedimentary petrologist, confronted in his quarry with the solitary pebble embedded in fine silt, or the rare particle locally so abundant, will most heartily concur in Prof. Gaddum's advocacy of the merits of the geometric mean.

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Nov. 5.

[1] *Nature*, **156**, 463 (1945).
[2] *J. Sed. Petrol.*, **4**, 65 (1934).
[3] *J. Sed. Petrol.*, **6**, 35 (1936).
[4] *Neues Jahrb. f. Min.*, etc., **73**, 137 (1937).
[5] "Manual of Sedimentary Petrography" (New York, 1938).
[6] *J. Sed. Petrol.*, in the press.
[7] Bartlett, M. S., *Proc. Roy. Soc.*, A, **160**, 268 (1937).
[8] Bartlett, M. S., *J. Roy. Statist. Soc.*, Suppl., **4**, 158 (1937).

PROF. J. H. GADDUM has dealt[1] comprehensively with the subject of logarithmic transformations, including $X = \log (x + 1)$. The use of this transformation was first advocated by Williams[2] on the grounds that it approximated to the logarithmic transformation for large values of x, and avoided the difficulty of a non-finite value of X when x was zero ; but this argument is rather arbitrary, since the same might be said of any function of the form, $\log (kx+1)$. Also, the existence of zeros implies usually that many of the values of x will be small and lie in the range where $\log (x + 1)$ behaves like a square-root transformation. Consequently, some further investigation of the properties of this function seems to be called for.

Since there are several instances[3,4] where a good correction for discontinuity has been found by adding $\frac{1}{2}$ to the variate, it appears possible that the transformation, $X = \log (2x + 1)$, would have the advantages of $X = \log (x + 1)$ and would also correct the ordinary logarithmic transformation for discontinuity.

Two trials have recently been carried out to investigate empirically the properties of these two transformations. Each was concerned with the numbers of fruits on apple trees. In the first there were four randomized blocks of seven treatments with seven trees to a plot. It was thus possible to compute a variance within plots with 24 degrees of freedom for each treatment, and to compare the seven variances thus obtained by evaluating the ratio of their geometric and arithmetic means. This quantity, known as L_1, has been tabulated by Nayer[5]. Using the $\sqrt{x + \frac{1}{2}}$ transformation, L_1 was $0{\cdot}863$; for $\log (x + 1)$ it was $0{\cdot}980$; and for $\log (2x + 1)$ it was $0{\cdot}982$. The first of these values indicates a significant departure ($P < 0{\cdot}01$) from uniformity in the variances; but it will be seen that both the logarithmic transformations were successful in equalizing them. The mean numbers of fruits per tree for the different treatments varied from 1·3 to 10·0, so the values of the variate largely lay in the range where discontinuity is serious and where $\log (x + 1)$ most closely approximates to $\frac{1}{3}\sqrt{x}$. In the second trial there were 64 pairs of trees of which 32 had been starved of potash while the rest had received adequate fertilizer, the treatment means being respectively 8·3 and 12·5 fruits per tree and the ranges within which the data lay being respectively 0–35 and 0–67 fruits. Variances with 32 degrees of freedom were worked out between trees within pairs within treatments. Using the transformations $\sqrt{x}$, $\sqrt{x + \frac{1}{2}}$, $\log (x + 1)$ and $\log (2x + 1)$, the values of L_1 were 0·968, 0·952, 0·9987 and 0·9998 respectively. Of these the second approaches the 5 per cent significance point, while the last two represent unusually good agreement between the variances. Indeed, such good agreement must be considered as partly fortuitous.

It would be rash to base much on the results of two small trials. However, there is reason to think that the transformation, $X = \log (x + 1)$, may be useful in dealing with small integral values despite the arbitrary element in its original selection, and despite its approximating sometimes to a square root and sometimes to a logarithmic transformation. It seems, also, that $X = \log (2x + 1)$ has at least an equal claim to be considered when such data are dealt with. It is to be hoped that this matter will engage the attention of some mathematical statistician, for it has obvious importance in the interpretation of a large class of data.

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[1] *Nature*, **156**, 463 (1945).
[2] Williams, C. B., *Ann. Appl. Biol.*, **24**, 404 (1937).
[3] Yates, F., *J. Roy. Statist. Soc.*, Suppl., **1**, 217 (1934).
[4] Bartlett, M. S., *J. Roy. Statist. Soc.*, Suppl., **3**, 68 (1936).
[5] Nayer, P. P. N., *Statist. Res. Mem.*, **1**, 38 (1936).

DR. ALLEN's letter is welcome because it emphasizes the fact that no simple transformation can act as a panacea. The choice of the appropriate technique for any given problem must always be based, if possible, on direct evidence of its suitability. Another type of distribution has been discovered by Bagnold[1], who studied the distributions of the sizes of particles of sand deposited by wind. They were not lognormal, but when the logarithm of the diameter was plotted against the logarithm of the frequency, the observations were closely fitted by two straight lines. This fact presumably depends on the physical factors governing the deposition of particles from moving air, and may have many applications in geology. Such distributions can be normalized, but no simple general formula can be given since the slopes of the two lines may vary independently, and it is doubtful whether normalization would serve any good purpose. The logarithmic transformation is a useful tool; but, as Dr. Allen has emphasized, it must be used with care.

I should be glad to hear of more examples of lognormal distributions.

J. H. GADDUM.

[1] Bagnold, R. A., "The Physics of Blown Sand and Desert Dunes" (London : Methuen, 1941).

Kinematical Relativity

MY attention has been directed to Prof. H. Dingle's recent letter in *Nature*[1]. His supposed refutation of kinematical relativity is on a par with Dr. Samuel Johnson's refutation of metaphysics ; my failure to reply to him directly is due to my reluctance to engage in such trivialities. I have already given him all the answer he needs by referring him to my