tistical computer which receives a stream of information about the stimuli, accumulates this information, or some transformation of it, in an "adder," and matches a running total of this accumulated information against some predetermined criterion value. For example, the information might represent dissimilarity of the two stimuli, so that the subject would judge "different" if the running total accumulates beyond the criterion within a certain interval, determined by task requirements of speed and accuracy. In this case, the judgment "same" would occur only if the criterion value for the judgment "different" is not reached within the allotted interval; thus, on the average, "different" judgments would be reached earlier than "same" judgments. The reverse would be true if the information represented similarity of the two stimuli.

Another possibility is that there are two adders, one accumulating dissimilarity information and the other accumulating similarity information. Assuming that, correspondingly, there are also two criteria, the judgment reached would depend upon whether the "different" input accumulates to the level of the "different" criterion before the "same" input accumulates to the level of the "same" criterion, or vice versa. Response latency would then depend upon (i) the input rates of dissimilarity and similarity information—that is, on the relative preponderance of similarities or dissimilarities in the comparison stimuli; and (ii) the stringency of the criterion—that is, the magnitude of the cumulative total an adder must reach before the corresponding judgment would be given. Errors would be a function only of the stringency of the criterion; the greater the stringency the fewer the errors. To account for the longer latencies and greater frequency of error for "same" judgments, it is again sufficient to postulate that the "same" criterion is more stringent than the "different" criterion.

What factors determine the adoption of a more stringent criterion of sameness than of differentness? The significant interaction between judgment and discriminability in experiment 1 suggests that the difficulty of the discrimination may be one such factor; as discrimination difficulty decreases, the stringency of the "same" criterion is lowered relative to that of the "different" criterion. This implies that the latency differences observed in our experiments could be made to disappear, and possibly even reverse, by the use of more discriminable stimuli. Other task conditions, such as payoffs, could also be used to manipulate the relative stringency of the two criteria, and hence the relative latencies of "same" and "different" judgments. A systematic study of these factors should elucidate the nature of the "same–different" judgment.

DALBIR BINDRA
JUDITH A. WILLIAMS
JACK S. WISE
*Department of Psychology, McGill University, Montreal, Canada*

**References and Notes**

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6. This work was supported by research grant 9425-10 from the Defence Research Board of Canada. We benefited from discussions with M. C. Corballis.

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## Square Root Variations of Reciprocal Graphing of Enzyme Kinetic Data

Stutts and Fridovich (*1*) make a general criticism of the mathematical treatment of enzyme kinetic data which we have used extensively in recent years (*2–6*). They point out that it is difficult to distinguish between a reciprocal plot ($1/v \times 1/S$) (*6*) of data fitting the usual Michaelis-Menten formulation and a plot of $1/v^{1/2} \times 1/S$. On these grounds they suggest that the square root variation is limited in usefulness. However, in their treatment of ideal data from the Michaelis-Menten equation they do not show what data would look like if they did not fit the Michaelis-Menten relationship and yet could be made to do so by extraction of the square root.

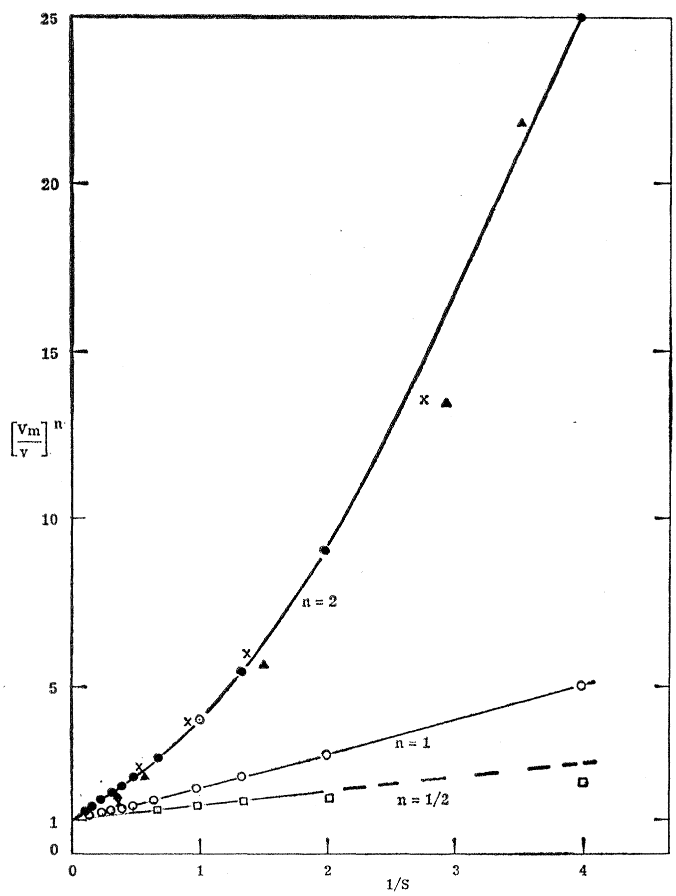
This omission is here corrected. Table 1 and Fig. 1 correspond to table 1 and figure 1 of Stutts and Fridovich (*1*) but provide the additional data and plot of $1/v^2 \times 1/S$ which permit the proper comparison. That is, since the square root of the data had to be extracted to adjust them to the usual curves, the ideal data are here squared for purposes of comparison. The data have also been "normalized" by using $V_m/v$ instead of $1/v$ so that the ordinate intercept is the same in all cases and it is easier to make a direct comparison.

To further clarify the differences between Stutts and Fridovich's ideal data (*1*) and the experimental data obtained by ourselves and collaborators (*2, 5, 6*) some of these experimental data have been recalculated (from the published curves) and plotted as $V_m/v$ in Fig. 1. The recalculation was made by measuring the points on the graphs and squaring to reconvert to "raw" data. The $1/S$ values so obtained were multiplied by the Michaelis constant ($K_m$) determined from the curves, and the $1/v$ values were multiplied by the maximum velocity to convert $V_m$ to 1.0. This is a general method for standardizing enzyme data to a $K_m$ and $V_m$ of 1. All data which can be expressed by a simple Michaelis-Menten relationship will fall on the same line passing through the points 0,1 and 1,2, with a slope of 1.0. If this procedure were always followed, there would never be difficulty in distinguishing between the possible cases shown. The results of these operations, shown in Fig. 1, should leave no doubts as to the internal consistency of the criticized data and as to the usefulness of the square root variation of the Lineweaver-Burk plot when it is properly applicable.

In Fig. 2, which corresponds to figure 2 of Stutts and Fridovich (*1*), a plot is made of the data obtained at sub-

Table 1. Idealized data of Stutts and Fridovich (*1*, table 1) converted to ($V_m/v^n$ to "normalize" the ordinate intercepts.

| $1/S$ | $V_m/v$ | $(V_m/v)^{\frac{1}{2}}$ | $(V_m/v)^2$ |
|---|---|---|---|
| 4.0 | 5.0 | 2.23 | 25.0 |
| 2.0 | 3.0 | 1.74 | 9.0 |
| 1.33 | 2.3 | 1.53 | 5.3 |
| 1.00 | 2.0 | 1.41 | 4.0 |
| 0.667 | 1.67 | 1.29 | 2.79 |
| .500 | 1.49 | 1.22 | 2.22 |
| .400 | 1.40 | 1.18 | 1.96 |
| .333 | 1.33 | 1.15 | 1.77 |
| .250 | 1.25 | 1.11 | 1.56 |
| .167 | 1.16 | 1.08 | 1.34 |
| .125 | 1.12 | 1.06 | 1.25 |



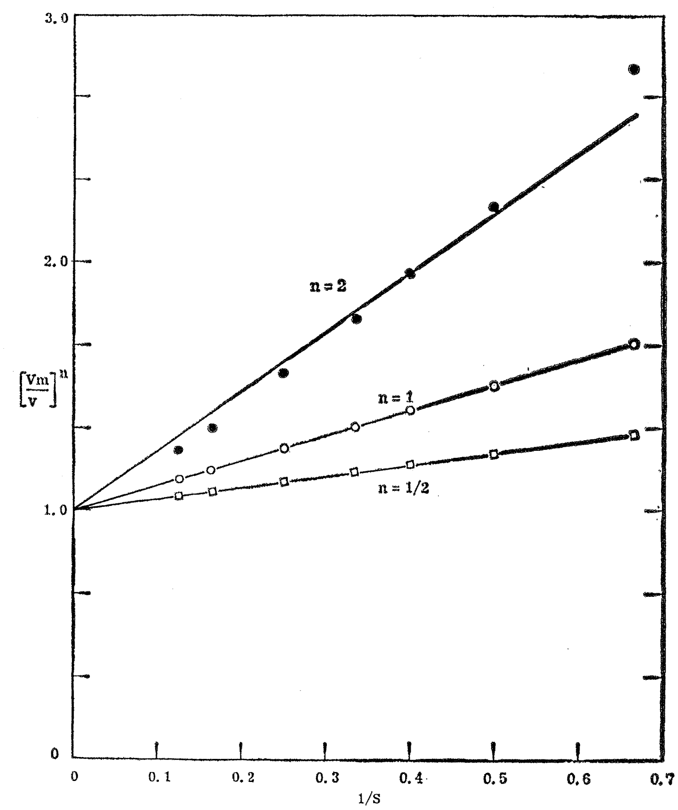




Fig. 1 (left). Data from Table 1 plotted to show the relationship between data which may be adjusted to fit the usual Lineweaver-Burk reciprocal plots by extraction of the square roots—$V_m/v^2$, normal data—$V_m/v$, and normal data which have been treated improperly by extraction of the square root—$V_m/v^{\frac{1}{2}}$. ▲ Recalculated from figure 4 of Totter *et al.* (*4*). **X** Recalculated from figure 6 of Dure and Cormier (*6*). Fig. 2 (right). Similar to Fig. 1 but with data from substrate concentrations above the "true" Michaelis constant ($K_m$).

strate concentrations above the "true" Michaelis constant. It is clear that it is possible to determine that the data are improperly plotted as $1/v$ (the $1/v^2$ curve), even at such high substrate concentrations. Data such as these must have the square root extracted or they will not conform to the expected relationship. As Stutts and Fridovich point out, it is not so easy to distinguish when the data are improperly treated (the $1/v^{1/2}$ curve) by a square root variation and account is not taken of the slope.

The properly prepared $1/v \times 1/S$ plot, whether the square root variation is found necessary or not, is "self-consistent" in that it is readily possible to tell when the substrate concentrations are below the value of $K_m$, since they will appear on the curve at twice the ordinate intercept or above. All of the data cited by Stutts and Fridovich contain points at substrate concentrations well below the value of the $K_m$'s revealed by the curves. There is thus no foundation for the statements in the last two paragraphs of their critique.

Part of their concern (*1*) arose because the Michaelis constants for xanthine oxidase in the cited papers were higher than those found in work at Duke University (*8*). Since the conditions of buffer, ionic strength, *p*H, and in some cases substrates were different in the researches being compared, this difference in recorded $K_m$ does not appear to us to have any important consequences. It is well known that $K_m$'s differ according to these conditions; in fact, Fridovich (*9*) has obtained a $K_m$ for xanthine oxidase–xanthine at *p*H 10.5 of approximately the same value as we have obtained using light measurements (*10*).

In a personal communication Fridovich indicates that he failed in an attempt to reproduce the square root relationship found by Cormier and Dure (*5*) with 5-amino-2,3-phthalazine-1,4-dione (luminol). Luminol obtained from a commercial source was used. Cormier and Dure have also failed to obtain the square root relationship with such unpurified luminol (*11*). Highly purified luminol synthesized in the laboratory, however, gives the relationship found earlier (*6*). It is easily possible to demonstrate radical scavengers in some commercial samples, and it it possible that this difference is due to their presence in the commercial luminol. In addition, it is necessary to use rapid mixing techniques and a fast response recorder to obtain an accurate measure of initial rates in these experiments.


JOHN R. TOTTER

*Division of Biology and Medicine, Atomic Energy Commission, Washington, D.C.*

MILTON J. CORMIER

*Department of Biochemistry, University of Georgia, Athens*

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18 August 1965

## Convection Plumes from Trees

There is nothing in Peterson and Damman's report "Convection plumes from *Ulmus americana* L. [*Science* **148**, 392 (1965)] to show that the plumes they observed were not aggregations of small dipterous insects, which, as has been well-known for centuries, characteristically form under just such conditions as those specified in the report. Indeed, the authors' illustration and detailed description would fit almost exactly many of the recorded instances of crepuscular swarming by mosquitoes and midges. Such observations are widespread and numerous. *The Mosquitoes of North and Central America and the West Indies*, by Howard, Dyar, and Knab (Carnegie Institution of Washington, 1912) contains a rich store of them. There (vol. 1, p. 125) we read of small gnats swarming in a light breeze as the sun set, where "from the top of nearly every tree three or four . . . strange, smokelike columns could be seen standing up in the air, always straight but not always vertical, some of them being inclined at small angles." There, incidentally, we can read also (vol. 1, p. 124) of the "Mückenpeitscher"—the people of Fischhausen who mistakenly gave a fire alarm when they saw gnats swarming above a church steeple!

The likelihood is, then, that the plumes reported by Peterson and Damman ("the precise composition [of which] remains unknown") were aggregations of small Diptera. The authors' summary dismissal of this possibility ("there were no local concentrations of smoke or insects in the air that could have contributed to the phenomenon") cannot be taken seriously by readers familiar with waterside swarms of mosquitoes and midges (which are of course aquatic in their early stages) and familiar also with the practical difficulties of detecting small insects sheltering high in the crowns of trees. Indeed, tree-top swarms often provide the first evidence of the presence of such insects.

Under the circumstances, the only logical course is to assume that the plumes observed were indeed insect swarms—at least until the authors offer factual evidence to the contrary. And let us not speak of a "Peterson-Damman effect" [*Science* **149**, 764 (1965)] until reasonably sure that we have something novel to describe.


PHILIP S. CORBET
J. A. DOWNES
*Entomology Research Institute, Canada Department of Agriculture, Ottawa, Ontario*


22 November 1965

Peterson and Damman's article and the letters by Ward and Beckner, Hackman [*Science* **149**, 764 (1965)], Drapeau [*ibid.* **150**, 509 (1965)], and Rigby (*ibid.* p. 783) prompt me to remark that this phenomenon of plume-like appendages observed near the top of trees and other high objects is well known to students of two-winged flies (*Diptera*) and to offer the following introduction to its literature: J. A. Downes, *Trans. Roy. Entomol. Soc. London* **106**, 213 (1955), and *Proc. Intern. Congr. Entomol. 10th* **2**, 425 (1958); P. A. Glick, *U.S. Dept. Agr. Tech. Bull.* **673** (1939); A. J. Haddow *et al.*, *Trans. Roy. Entomol. Soc. London* **113**, 249 (1961); H. Oldroyd, *The Natural History of Flies* (Norton, New York, 1965).

Oldroyd's book presents an admirable account of swarming in flies, with references to a number of papers, one of which (Haddow *et al.*) includes 6 pages of bibliography referring to occurrences of insects at heights from the ground. Downes, in the later paper, gives a summary and bibliography of the habit in biting flies such as mosquitoes and punkies, and in the earlier paper he includes a figure (very similar to one by Peterson and Damman) of plume-like swarms over a 25-foot spruce tree. Glick gave a lengthy bibliography and showed that insects occur at considerable height.

I have observed the phenomenon several times; the most vivid recollection is of plumes trailing leeward in the wind from tops of tall tamarack trees on the shore of the "eau" at Rondeau Provincial Park, Ontario.


GEORGE STEYSKAL
*Insect Identification and Parasite Introduction Research Branch, U.S. Department of Agriculture, Washington, D.C.*


22 November 1965

## Gegenschein: Photographs

In our report "Gemini V experiments on zodiacal light and gegenschein [*Science* **150**, 53 (1965)], we made the statement, "No previous attempts to photograph the gegenschein have been successful." The statement should have been, "No previous attempts to photograph the gegenschein without airglow contamination have been successful." As a consequence of our original statement, we have received letters directing our attention to a paper by Osterbrock and Sharpless [*Astrophys. J.* **113**, 222 (1951)] and an article by Struve [*Sky and Telescope* **10**, 215 (1951)].

The photograph by Osterbrock and Sharpless shows a diffuse illumination in the gegenschein direction which is probably the counterglow. We have a number of unpublished balloon-camera photographs which also show diffuse illumination in the approximate anti-sun direction. It is our opinion, however, that the presence of the patchy terrestrial airglow above the camera makes it impossible to identify as extraterrestrial any other dim, diffuse phenomenon photographed from below the airglow layer. For example, reports of motion and parallax of the gegenschein [Elvey, *Astrophys. J.* **77**, 56 (1933)] are much more indicative of airglow effects than of the presence of a true extraterrestrial source of light.

It is therefore in identifying the gegenschein as an extraterrestrial illumination that we consider the Gemini V photographs to be unique.


EDWARD P. NEY
WILLIAM F. HUCH
*School of Physics and Astronomy, University of Minnesota, Minneapolis*


26 October 1965