



Panel discussions

In which we meet a group of Operators, and discover something of the Calculus that governs their interactions.

Robert B. Leighton

Recently at a meeting of a scientific society I found myself listening to a panel discussion ostensibly devoted to give-and-take discussion of a certain topic dear to my heart. I have attended—and participated in—several such discussions, and have usually found them less helpful than one would wish. I had never understood the reason for this, but, as I listened, something said by one of the panelists struck a responsive chord inside me. I soon recognized the deep truth of what he said, and a whole host of previous panel experiences were thereby illuminated.

This man recounted *another* panel discussion he had recently attended, at which many startling new experimental results in his field were supposed to be placed in perspective by the panelists. He bemoaned the fact that, rather than rising to this challenge, each panelist in turn spent most of his time trying to show how the new results lent definite support, however small, to some idea the panelist had suggested several years earlier. He then went on

to remark that the various panelists didn't seem to listen to each other, and that after hearing the panel discussion and the papers that followed, one wouldn't have guessed that anything had fundamentally changed as a result of the new data.

Perhaps it was this last observation that set my mind to work, for as I listened to the other members of this panel, it became quite clear that these people didn't hear each other either. Recalling still other panel discussions of the recent past, I realized that the same had been true of them! Here, then, was an important new phenomenon to be examined.

I mulled it over both consciously and otherwise during most of the night, and as a result became convinced that this was indeed a fact, new at least to me, and one which, furthermore, was but one facet of an even broader structure that gradually clarified itself in my mind.

No doubt it is premature, if not presumptuous, to dignify this broad structure by giving it a name—I call it a "Calculus of Retroactive Argument Presentation"—and I freely admit that it is as yet in a most schematic, even descriptive, form. But true understanding often begins with systematic description (witness Darwin's experience), and I am sure that time will but

solidify and broaden the rather faltering steps I have so far taken.

Therefore, in the hope of avoiding unnecessary prolongation of the anguish many feel with panel discussions as they are now constituted, I shall describe this new Thing and suggest how panel meetings and symposia might be streamlined so as more nearly to fulfill their intended purpose of Enlightened Give-and-Take Discussion, leading to New Ideas.

The Calculus

Fundamental to the Calculus of Retroactive Argument Presentation—or simply the "Calculus" for short (I haven't been able to think of a more suitable abbreviation)—is this notion: *Every theoretical idea and every experimental fact—or putative fact—may be likened to a vector in a multidimensional, inhomogeneous space.* Such a scheme, once visualized, provides a powerful framework for further understanding, as we shall see.

Let us call the vector for a theoretical idea ψ . We could, of course, have used θ (for theory) or φ (for phantasy), but these do not properly describe a very important aspect of any theory vector, namely, its almost unique relationship to the *psyche* of the operator that created it.

Similarly, we adopt ξ as a generic

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s there any hope?

symbol for any particular experimental fact. Here the choice of symbol is not so important, for a fact is supposed to be invariant with respect to psyches, although counter examples have been known to occur.

It must be realized at once that any ψ may be complex, and that, measured in any frame but that of its own creation operator, most ψ 's seem very complex indeed. In fact, some psyches, purposely or otherwise, appear to create ψ 's with very large imaginary components in all other frames.

Now what about the ξ 's? At first it seems that all these must be purely real, but experience has shown many ξ 's to have had significant imaginary parts also when measured again at a later time. Examples from astrophysics, lunar and planetary physics, and the weak interactions come readily to my mind, and you must surely know of others. In addition, imaginary components are sometimes purposely *attributed* to some ξ 's, as will be described later.

Next we must consider the relationship between the ψ and ξ manifolds. To assert that these are in any sense in a one-to-one relationship is clearly tautological and useless. The rule for creating a ψ , rather, is to choose some subset of ξ 's and to try to match this entire subset—specifically, its vector

sum $\mathbf{X}$ —with a single ψ . This is difficult to do well, but fun to try.

Thus for any given scientific field at any given time we may imagine a certain set of ξ vectors whose resultant $\mathbf{X}$ seems to point off in some direction, and a cloud of ψ vectors (various theories) pointing every which way. (For some purposes it is useful also to think of the set of ψ vectors associated with a *given creation operator* rather than the set of theories associated with *different operators* but the same ξ set. Some operators are thus found to bristle with ψ 's, even approaching the appearance of a porcupine in shock.) The whole structure is of course rather ghostly and indistinct because of all the imaginary components involved, and the assemblage takes on grossly different appearances when viewed from different angles.

The quantitative definition of a "match" between theory and experiment is easily seen to be that the projection $\psi^* \mathbf{X}$ be mostly *real*, with the real part *positive* and as large as possible. Just here is where much of the anguish that gives trouble in panel discussions arises, as we might guess.

How it works

Before applying all this to practical situations, we must consider briefly the dynamics of the ψ and ξ operators. This is best done through the study of

their creation operators, to which we have already referred above.

Let T or $\bar{T}$ be Theoretical Operators. (We avoid the use of the symbol Θ here because, while most of the vectors they *produce* are Greek, few of the Operators themselves have this characteristic.) The presence of an accent (as in the second form above) recognizes that Operators have different national origins for their reference frames, and this may affect the projection of their ψ vectors into other reference frames, either enhancing or diminishing their receptivity. (Did you ever notice how much more sensible a theory sounds if it is presented with a slight British accent?) Superficially, it also appears that accented Operators commute more regularly than unaccented ones.

The properties of Theoretical Operators appear to be as follows:

1. A ψ vector is created by the reaction of a T or $\bar{T}$ operator to a set of vectors

$$\psi_i(t) = T_i \mathbf{X}$$

where $\mathbf{X}$ denotes the vector sum of the ξ set, i defines a particular Operator, and t is the time.

2. If T_i and T_j are two Independent Operators (either or both may be accented), and ψ_i and ψ_j are the ψ vectors resulting from their reaction to the same set of ξ 's, the projection $\psi_i^* \psi_j$ is found to be zero or negative. This is called

"Essential Orthogonality of Independent Operators," and is one of the most direct causes of failure of panel sessions.

3. Occasionally one does find Dependent (or Collaborative) Theoretical Operators. These usually occur in commuting pairs, seldom as triples, practically never as higher associations. Their special peculiarity appears to lie in the breakdown of Essential Orthogonality for vectors created within the group. Practically, one may treat Dependent Operators as equivalent single, Independent Operators so long as only one at a time is associated with a given panel. (Commentator Operators or Dependent Operators in different panel roles present special problems.)

4. So far we have discussed the effects of T operators upon ξ sets only. How do they operate upon ψ 's? Here we find the simple rule

$$T_i\psi_j = \begin{cases} \text{real and } \gg 1 & \text{if } i = j \\ \text{imaginary or zero} & \text{if } i \neq j \end{cases}$$

If the result is actually zero, T_i has effectively acted as an Annihilation Operator. When this does not occur, it is usually not through lack of effort.

5. Actually, the above rule for $i = j$ is strictly true only at the time of creation, and for short times thereafter. More exactly, if $T(t)$ acts upon one of its own ψ 's formed at an earlier time (taken as $t = 0$), one finds

$$T_i(t)\psi_i(0) = A \exp(-t/\tau_i)$$

This is called the "Equation of Recollective Decay." Some people believe this to be an entirely involuntary effect. Everyone finds it convenient.

6. Two more dynamical equations remain. These describe the reactions of various Operators upon the product ψ^*X , which represents the match of a theory to experiment. Here the result

depends upon whether or not a given Operator has itself created a ψ in reaction to the ξ set in question.

We have

$$T_i(\psi_j^*X) = \begin{cases} A_{ij}(X) & \psi_j \text{ NO} \\ \begin{cases} |P_i|^2 & i = j \\ -|P_i|^2 & i \neq j \end{cases} & \psi_j \text{ YES} \end{cases}$$

where A_{ij} is an Objective Analysis Coefficient that may be complex, and P_i is an Inverse Modesty Index or Promotion Index.

7. The last dynamical equation is similar to the above except that the Operator is taken to be an Experimental Operator E, and we distinguish explicitly the individual ξ components of X :

$$E_i(\psi_j^*\xi_k) = \begin{cases} B_{ijk}(\xi) & k \neq i \\ \text{indeterminate} & k = i \end{cases}$$

where the meanings should be obvious from the preceding discussion. Note that the important case of combined E and T operators is not included in the present form of the Calculus, even though some of my best friends fall in this category. I make the unwarranted assumption of separability.

8. The rule for evaluation of any given theory ψ_j is to form the asymptotic sum

$$C_j = \sum_{i=1}^n \frac{[A_{ij} + B_{ijk}]}{n|X|^2} \quad (i \neq j \text{ or } k)$$

and thus find the magnitude of the Credibility C_j .

C_j may be regarded roughly as the probability that the theory is true, except that if C_j is negative or non-convergent for large n , Indirect or Conflicting Interest of one or more Operators is indicated, or else the ξ set possesses an unrecognized large imaginary component.

In the last instance, wherein a certain ξ set is suddenly found (by new measurement) to have had a large imaginary component, interesting dynamical effects occur. This is usually just the situation that calls for a Panel Discussion, so we must understand it clearly.

Imaginary component

Immediately upon the establishment of the new ξ set X_{NLT} (the subscripts stand for "New Local Truth"), every T_i that has ever produced a ψ_i in reaction to the original X is impelled to evaluate $T_i(\psi_i^*X_{NLT})$, sometimes using electronic or video aids if these are available. Needless to say, the magnitude of the Promotion Index plays a critical role here, and may lead to enhanced repulsion and even nonzero divergence if many T_i 's are grouped together.

What is not generally recognized by Panel Organizers is that, under these conditions, two important effects are present. One is that a given ψ is never immediately changed in response to sudden experimental impulses of this kind, although a certain precession and slow relaxation toward the new X_{NLT} may occur. The other is that, in forming $\psi_i^*X_{NLT}$, the value of a given ψ_i is severely limited by Recollective Decay if t is more than a year or two, which tends to produce gross overestimates of the real part of the product. The first of these effects is called "Cultural Lag" or "Mental Inertia," although some Operators prefer to call it "Mental Momentum."

Actually, many Operators seem able to create ψ 's having a certain flexibility, which is found useful in these circumstances. (It is the later exploitation of this flexibility that accounts for the name given the Calculus.)

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Some of the ways of doing this are as follows:

Parameterization is self-descriptive.

Use of large imaginary components. The imaginary part of a ψ is usually regarded as constant, more or less characteristic of the particular T operator. But comparison of successive readouts of some ψ 's shows that the imaginary part may vary with time. This is like the precession described earlier, except that it carries the ψ in a random walk that seldom approaches any fixed value, and often leaves the ψ without any value whatever. Alternatively, a large imaginary component is sometimes purposefully attributed to the ξ set to which a theory is related, in an attempt to maximize the real part of ψ^*X . Of course it usually turns out that the assumed imaginary part of X and the characteristic imaginary part of ψ lead to a negative real product.

Infinite series of ψ 's. This is similar to the preceding method, except that the former is more or less tied to a single ξ set, while the infinite series involves shifts in definition of the ξ set also. The idea, of course, is not at all that the series should converge; it is, rather, that a sufficient amount of ψ space be spanned that any later $X_{N+1,T}$ may be matched by some combination of the ψ series. That this usually fails is recognized by everybody but the practitioners of the method.

Use of Collaborator Operators. T Operators whose characteristic symbols fall late in an alphabetical ordering but high in a hierarchical ordering sometimes create ψ 's collaboratively in large numbers, following a strategy like that of the infinite series. How much of a

ψ is to be ascribed to each of the (generally two) collaborative T's is retroactively allocated by the hierarchically greater T operator on the basis of the value of the Credibility Coefficient that ψ eventually attains. Needless to say, the Recollective Decay Time τ_r plays a significant role here. The alphabetical ordering is usually taken to govern in cases of low C_j value.

Singular Operators. This is not a technique but simply recognition of a fact: Some Operators defy rational description as to their properties or modes of operation, and yet seem to produce ψ 's that extract much time and energy from other Operators. The ψ 's of a Singular Operator are usually stochastic in direction, magnitude, and effect, which may partly explain the ready amplification they tend to undergo via electronic, video, and graphic readout. They are sometimes even created on a null ξ set, particularly in such fields as cosmology and high-energy astrophysics. (This has been likened to a doctor inventing a cure for which there is no known disease.) On the other hand, nonsingular Operators are said occasionally to be productively excited to create mutant forms of some of these ψ 's, which then attain nonzero C values, but I can't think of a good example right now.

From the above list, incomplete as it may be, we can easily understand the reasons why Panel Discussions (and even Symposia) are so difficult and hazardous to organize, for we have all undoubtedly observed the various techniques in actual use—by others. Needless to say, the problems are world wide. Strong foci of such activity

are to be found not only up and down the two coasts of the US, in the Southwest, Midwest and upper New York State, but also in England, Europe including the Scandinavian countries, eastern Europe, and of course the USSR. Milder but significant forms have been recognized elsewhere in the world.

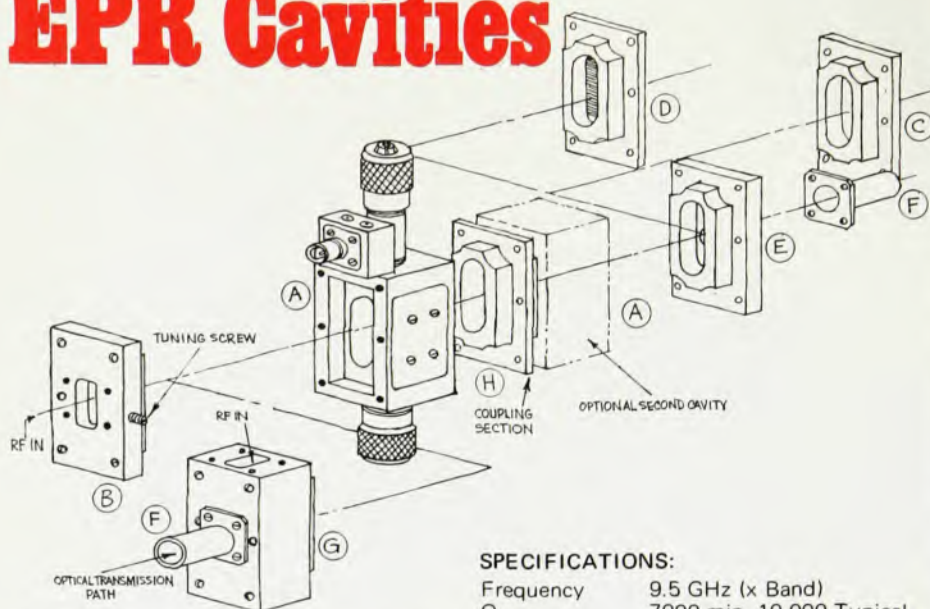
Possible solutions

Now, what can be done about the situation? How, in the face of such facts, can sensible, peaceful, productive Panel Discussions be carried on? Several important ideas suggest themselves.

First, in choosing the panelists the organizer naturally tries to select well known experts who are sharp, informed and open minded. As we have seen, these requirements are hopelessly contradictory, although as many as three of the attributes sometimes are found in one candidate. The next best thing is clearly to select Operators whose Promotion Indices are nonzero (as they all are) *but not too large*. Unfortunately, this would appear to eliminate all Singular Operators, but this loss might be made up for in other ways and one is sure to hear from them in any case.

Second, the time wasted in hearing panelists describe their estimates of $T_i(\psi_i^*X_{N+1,T})$ might largely be saved by adopting the rule that any ψ (or ξ) for which t is greater than three or four years be referred to by number only. This could even be formalized by distilling all old ψ 's and ξ 's into a concentrated form and listing them, by number and author, in an easy reference form like *Aesop's Fables* or *Joe Miller's*

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Joke Book. Indeed, looking back over the history of science, the analogy is seen to be not altogether inappropriate. Each panelist could, in a few seconds, place in the record his own selection of ψ 's and ξ 's and use the remaining time for more creative contributions. If it were absolutely necessary to go beyond the simple mention of a number and author (sometimes the author alone might suffice), the reference might be limited to the "punch line" alone. Among audiences interested in planetary physics, I know that the mere mention of "85 millibars" will immediately evoke a reaction. (For those unfamiliar with this story, "85 millibars" refers to the surface pressure of Mars's atmosphere, which is about 6 millibars.)

I can not close without calling attention to one other factor that appears to operate not only in many Panel Discussions but in a broad range of other human activities, notably in politics and religion. I shall describe it only as it applies to our present topic, and leave the possible extensions to you. It may be called the Problem of Induction from $N - 1$ to N , and it operates whenever the variety of opinion about some subject equals (or exceeds) the number N of Panelists, as it almost always does. In this case each Panelist finds each of the $N - 1$ other Panelists' opinions unacceptable, that is, incorrect. (This can easily be stated symbolically in the same notation as our earlier discussion—it is related to the Principle of Essential Orthogonality). The situation is obvious. If N is small, say 2, it is in fact possible that one Panelist is correct. Of course, that isn't a Panel, but a Debate. For $N = 3$ or even $N = 4$, it sometimes happens that one opinion proves actually to be correct. Clearly, as N increases this becomes less and less likely. Yet for no value of N has a Panelist ever been known to suggest that all N members, rather than only $n - 1$, are wrong! As a statistical truth, the conclusion is obvious but never recognized.

In the face of this formidable barrier (and I haven't even mentioned the effect of the audience towards increasing N , the accentuated conflicts when disparate groups called "Schools of Thought" are involved, and so on) is it possible to make progress? Perhaps, but only if we tighten up the discipline and become more professional in our approach, in the manner of our colleagues the Lawyers, or perhaps the Group Therapists. That is, if Panelists were not simply invited to participate but each were required to defend *someone else's* point of view, I'm sure they would start to listen to one another.

When I hear Panelist A say, "Considering the new evidence, I feel that B has been right all along and I have been wrong," that'll be the day! □