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Richard C. Heyser
Douglas R Jones, Ed., *Columbia College Chicago*

CHAPTER 4

INTRODUCTION

I have been accused, quite justly, of being a technologist. Nothing wrong with that. But, as a technologist I stand a bit apart from my fellows because I am convinced of the significance of subjective perception in audio. I don't laugh at those who stubbornly claim to hear something that they believe is wrong in an audio reproduction, even if our measurements do not show anything wrong. I happen to believe that a major purpose of technical audio measurements is to assist in creating better subjective perception, and if that's not happening, then we are getting nowhere with the objective measurement.

My personal views on present testing methods and on the technical laziness of most technologists is well known. We depend upon linear theory to analyze nonlinear distortion, for example, because genuine nonlinear theory is too tough to handle. And we treat humans and their subjective perceptions as linear time invariant systems, which operate under Markov statistics.

Well, I don't happen to think that humans are linear time invariant systems. I do think that the problem of attempting to analyze the mysteries of human perception is so great that in order to even begin to approach that problem, we must re-examine our conventional technical tools, including its topology based mathematics. That re-examination is what I am outlining in these brief articles. I assume total responsibility for what is presented because, after all, it is a summary of a part of my own research dating back nearly two decades and still continuing. It's my research and my conclusions, and if it is wrong then I am to blame.

We have reached a benchmark in the analysis that I am presenting. I have made a rather strong claim that:

(1) ongoing analysis, as represented by that chapter of mathematics called functional analysis, is correct but is based on a hidden paradigm of preserving the frame of reference, and

(2) recognizing this, and motivated by the sketchy details of what we know about subjective perceptual spaces, I proposed a new paradigm of alternatives, which keeps the results of the present paradigm intact but expands our analysis capability beyond that point. It is now time for me to put up or shut up.

PREDICTIONS OF A PARADIGM

How do you know if you're dealing with a new paradigm? It seems to me that there are two major tests that can be applied to see if a problem solving model is really a new paradigm. First, the new paradigm must include everything that the ongoing paradigm does. If, for example, the ongoing paradigm predicts that the result of A and B is C, and a physical observation of A and B producing C is a verified consequence, then the new paradigm must predict the same result. If it predicts almost everything, then I do not regard it as a new paradigm, only a poorly trained contender for the title.

Second, the new paradigm must predict results which are verified in nature, and which cannot be explained by the ongoing paradigm. Einstein's theory of relativity is acknowledged as a replacement for classic theory based on successful predictions that could not be explained by classic theory. This second test of a proposed paradigm is a real toughie.

The paradigm of alternatives passes the first test because it keeps everything we now do as a totally intact subset. None of the math is changed, and none of the concepts are changed, provided that we stay in the contemporary frames of reference.

But what about the second test - coming up with predictions which cannot be explained within the ongoing paradigm? The simple electrical network which we discussed is one such test. Our equations and measurements show the precise partitioning of energy, but there is nothing in our philosophy which can explain why it should occur.

I have developed several other "new paradigm" predictions, and would like to present two of them here, since they are significant in TDS and, of all places, quantum mechanics.

The two predictions of this new theory, which I will now discuss, are as follows:

(1) the procedures of map and operator cannot commute.

(2) operators cannot commute if they are alternatives under some map.

The term "commute" refers to a particular property of procedures that are to be considered two at a time. When one term acting on a second term is equal to the second term acting on the first, then the two terms are said to commute. Commuting is one of the basic rules of common arithmetic. Thus, five times six is the same as six times five.

Not all things commute. Turning right and walking 100 feet does not get you to the same spot as walking 100 feet and then turning right. Commuting is a special type of symmetry, and symmetry is a very important property.

We'll now discuss these two predictions, tests, if you will, of the new paradigm which we are presenting in these articles in AUDIO.

A DEFINITION OF TERMS

Functional analysis deals with the sorts of things we need to handle in signal theory. But functional analysis, as I pointed out earlier, is based on concepts of topology, and dimension is a topological invariant. So it is not surprising that in modern analysis the terms FUNCTION, MAP, TRANSFORM and OPERATOR are considered synonymous. There is nothing, for example, to prevent us from referring to the Fourier transform as a Fourier operator. In fact, this is occasionally done, and the integral transform with weighting kernel, which I gave as equations 6 and 7 in our first article are sometimes referred to as operators.

That's OK, as long as we never knew that there were alternative frames of reference. But once we postulate the existence of complete alternative representations, we must recognize a fundamental fact. There must be a distinction between those procedures which do something to alter form within a particular frame of reference, and those procedures which change from one frame of reference to an alternative frame of reference.

Henceforth, I will use the term OPERATOR to mean that single procedure which does something such that the initial and final states reside in the same frame of reference.

Pushing a pencil on a desktop, a procedure called translation, is an operator. So is taking a derivative.

Henceforth, I will use the terms MAP or TRANSFORM to mean that procedure, the result of whose application resides in alternative frames of reference. The Fourier transform is an example of this.

Once we accept the concept that there is more than one legitimate way of describing the same thing, then this result (that operator and map cannot commute) immediately falls out. A person who measures an audio signal with a spectrum analyzer "sees" that signal in a particular frame of reference. Another person might measure the same audio signal using an oscilloscope; he "sees" the signal in an alternative frame of reference.

If the signal is passed through an "operator" before being seen by the two viewers, then they will not see the same thing happening in their alternative views. For example, if the "operator" is a single sideband up converter, then the spectrum analyzer viewer will see everything shifted to the right by a constant amount, while the oscilloscope viewer will see no such shift in time offset. Without resorting to the math, it seems quite apparent that "shifting" all frequencies up by 100 Hz and then moving over to the time domain to see what happens, is not the same thing as first going over to the time domain and then "shifting" all time upward by any fixed amount. The procedures of going between domains (map or transform) and of doing something to a signal within a domain (operator) cannot commute.

In math parlance, if R is an operator, M is a map, and f is a function, then the relationship in (20) holds.

$$RM(f) \neq MR(f) \quad (20)$$

-or- $[R, M] \neq 0$

In words, acting first with procedure M and then with procedure R on any function f, will not produce the same result as acting first with procedure R and then with procedure M. The Fourier transform of the derivative of an audio signal is not the same thing as the derivative of the Fourier transform of that signal. This is a most surprising result, although readily demonstrated, if you believe in the contemporary definition that map and operator are synonymous.

What about the word FUNCTION? Is it like an operator, like a map, or something altogether different? I consider the concept of function as representing something different. A function is a (Lebesgue) measurable distribution of density which is expressed in terms of the coordinates of a frame of reference. In order to use this concept we should refer to the terminology of that branch of mathematics called generalized functions (also called theory of distributions). Considering a function as a distribution is not too abstract for audio, rather it is what we need to use when we get ready to consider multi-dimensional subjective perception.

A DIAGRAM

The demonstration that R and M cannot commute is straightforward, using the symbolism of the new paradigm. In figure (4) I symbolize two alternative frames of reference, which I have called A and B. If M is a map that converts a(x) in alternative A to c(y) in alternative B, then operator R in system A has the M-transform equivalent of some other operator S in system B. Operator R acting on a(x) produces Ra(x) in system A, which is some new function b(x). A subsequent map M results in the same form in system B as if we had started with mapping a(x) to its alternative form in system B and then applied the alternative operator S. First R then M is not the same as M then R.

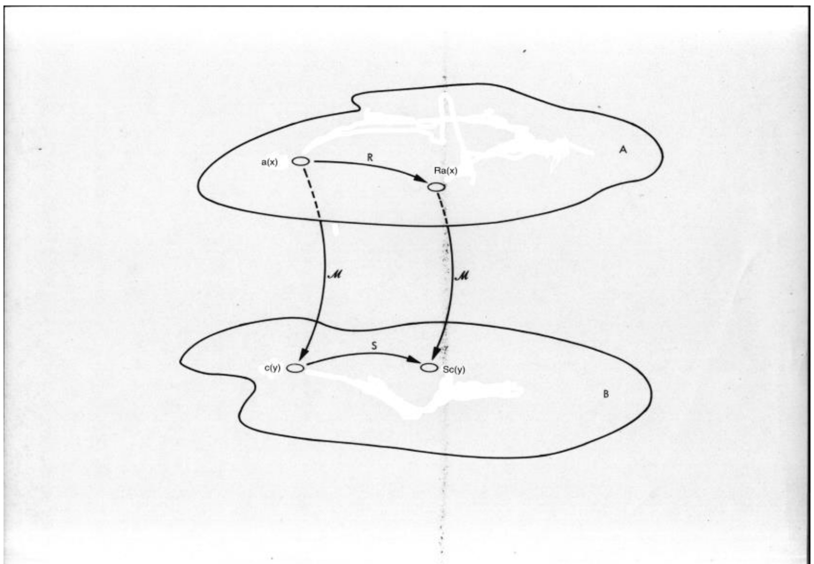

Figure 4

As a side issue, do you know why operational amplifiers, sometimes called op amps, are called operational amplifiers? It's because in the early days of analog computers it was possible to construct certain mathematical operators, such as integration, multiplication and differentiation, by the use of passive components in the feedback configuration of high amplification gain inverting amplifies. Differential equations could then be solved with the use of such mathematical operators which modified the electrical signals passing through them. Also, a simple topological transformation can be used to show that every operational circuit using an infinite gain inverting amplifier has a dual which uses a unity gain non-inverting amplifier. You might think of that the next time you use an "op amp".

In our next discussion, we will begin to consider that most important of all predictions of this new paradigm: the reason why two operators, such as taking a derivative and multiplying by the coordinate, cannot commute; while other combinations of operators, such as taking a derivative and performing a convolution, will commute.

END OF CHAPTER 4