ANPA WEST

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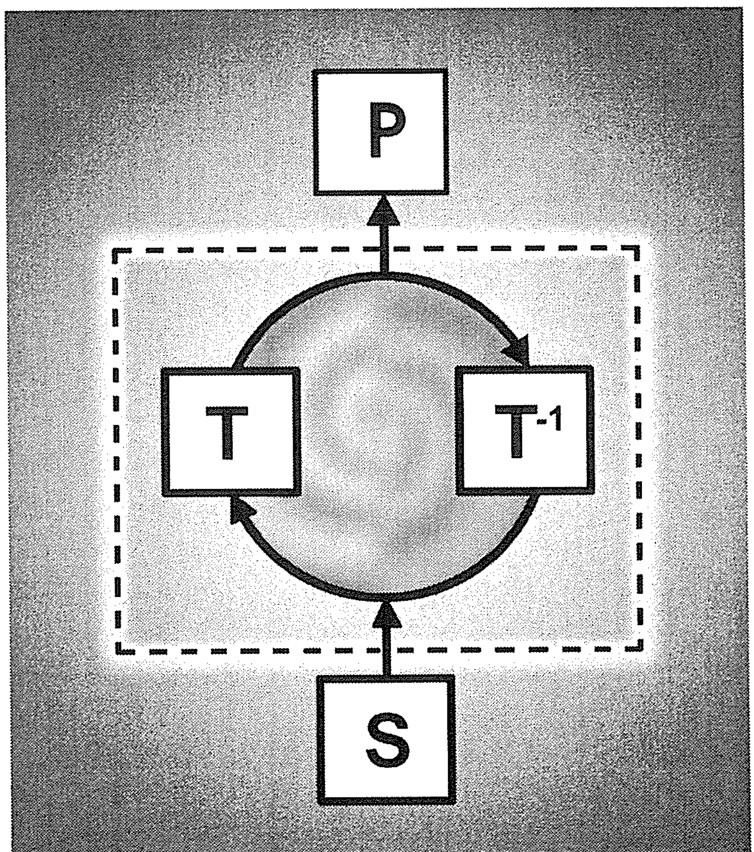

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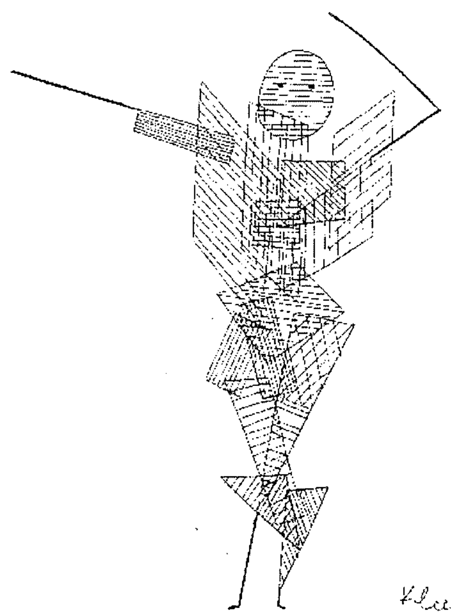
of special note in this issue

ANPA and ANPA West, in past announcements, have perhaps too often used the language of revolution. When one is already caught up in an avalanche of change – which seems to be the case in science today – admonishments to "Get moving!" can ring a bit hollow. Perhaps a better appeal for our time would be to "Look ahead!" This then, is the theme of this winter's Journal.



In This Issue

Our first article is by someone who balances his practice of science with the practice of more traditional disciplines based on an inner approach to reality. The author makes an eloquent case for the possibility of achieving such a balance within a single discipline.

This paper, which was prepared for the PhysComp96 conference on physics and computation, is an exposition of link theory for those more at home with computers than with quantum mechanics. Part I starts with Hilbert space quantum mechanics and ends with diagrams of quantum measurement that exactly match those from link theory. Part II will go the other way, developing quantum theory "from the bottom up."

The author is a psychologist who has for many years studied the synchronization and entrainment of biological rhythms, both in individuals and in groups. This work has led him to novel ideas about the nature of interactivity, which he sees as something fundamental that is irreducible to a back-and forth exchange of information or causal influence. After giving us a survey of many intriguing experimental results, he offers some speculations and warnings on the possibly disrupting effects of new media and channels of communication on the natural rhythms that maintain the social order.

Integral Science

Toward a Comprehensive Science of Inner and Outer Experience

Thomas J. McFarlane

Science without religion is lame, religion without science is blind.
Albert Einstein[1]

Physical science has had a profound impact on both the material and spiritual conditions of life in the West. While on the one hand, physical science has improved the material conditions of life, on the other hand, it has undermined the spiritual traditions which were the foundation of our religious and moral values. As a result, we are materially rich, but spiritually bankrupt. And the consequences of this imbalance are profound. For example, although technology has given us an unprecedented power to change the outer world, we often exercise this power with no guidance from moral or spiritual values. Although we enjoy material comforts today more than ever before, we are no closer to finding enduring happiness. Although we have sophisticated scientific theories that explain subtle phenomena of the outer world, we know precious little about consciousness and its relationship to matter. Our knowledge and understanding of the outer world has developed to such a degree that it has overshadowed, ignored, or even denied knowledge of the inner realities. So there is a great need for a balance between our inner and outer knowledge, for an integration of spiritual wisdom and physical science.

A primary obstacle to the integration of inner and outer approaches to reality is the apparent incompatibility between, on the one hand, the ontology and epistemology of physical science and, on the other hand, those of the religious traditions. As they are commonly conceived, science and religion are indeed incompatible. But if properly understood and appropriately extended, they may be embraced within a framework that is at once true to their differences and yet comprehensive of both. This framework, which I call *integral science*, is based upon a generalization of the scientific method which includes both inner experience and outer experience within its domain. In addition to providing a context for the balancing of inner and outer experience, and for the reconciliation of spiritual traditions and physical science, integral science offers new perspectives on various problems such as the relationship between consciousness and the physical world and the measurement problem of quantum mechanics.

Inner and Outer Ontology

One of the primary points of difference between our common conception of science and that of religion is their claims about external reality. On the one hand, the scientific view of the world has long been dominated by a materialistic philosophy which takes matter as the fundamental reality and regards inner phenomena as mere epiphenomenon. The religious traditions, on the other hand, generally embrace an idealistic philosophy which takes God or spirit as fundamental and regards matter as derivative. In spite of the long history of this polar opposition, however, neither science nor religion can ultimately maintain either of these extremes.

The revolution of modern physics has unquestionably raised profound philosophical challenges to the common conception of science. In particular, quantum theory challenges the assumption that objects have an independent existence. Since mystics throughout the ages have made similar statements, here we have a hint of a deeper level at which physical science and the spiritual traditions may be integrated. Because the denial of the independent existence of objects is very radical, however, such an integration would likely be quite shocking. Indeed, quantum theory and the spiritual traditions have at least this much in common: they are shocking to anyone who really understands them.

> *Those who are not shocked when they first come across quantum theory cannot possibly have understood it.*
>
> -Niels Bohr[1]

The shock is, as it were, a discharge across the large psychological gap between what they say is true about the world and what we normally take to be true. The mystics make the outrageous claim that our belief in a real objective world is a delusion. Take, for example, the following statements by a Western and Eastern mystic, respectively:

> *Everything is of the nature of no thing.*
>
> -Parmenides[2]

> *For the wise, all "things" are wiped away and even the state of imagelessness ceases to exist.*
>
> -Lankavatara Sutra[3]

Since these claims seem to be in blatant contradiction with both our immediate experience and everything most of us were ever taught, our natural response is to dismiss them as ludicrous. For a typical modern Westerner, it is easy to dismiss the radical claims of a few isolated mystics. But it is not so easy to dismiss modern physicists, whose statements are often just as radical. Take, for example, the following words of Niels Bohr and Werner Heisenberg:

> *An independent reality, in the ordinary physical sense, can neither be ascribed to the*

phenomena nor to the agencies of bservation.

-Niels Bohr[4]

If one wants to give an accurate description of the elementary particle. . .the only thing which can be written down as description is a probability function. But then one sees that not even the quality of being. . .belongs to what is described.

-Werner Heisenberg[5]

These statements, like those of the mystics, fly in the face of our common assumption that objects have an independent reality, that they can accurately be described as existing even when we are not looking at them. Not only does this challenge our common sense, but it also challenges the materialist ontology that has dominated science for several hundred years. This radical challenge to our common-sense ideas of an independent objective reality should indeed shock us.

Our resistance to this shock is considerable because our experience, for the most part, conforms to the idea that there really is an objective world. Most of us take thousands of objects to be real every day and find that there is no contradiction with experience at all. Nevertheless, both the mystics and these physicists claim that if we examine our experience closely, we will find that the objective world does not exist the way we think it does.

If our common-sense idea of an objective world is wrong, why does it seem so right? Simply because our common-sense idea of the world is based on our limited experience. For example, the idea that the world is flat is consistent with our common everyday experiences, as is the idea that the sun orbits the earth. These models of reality fit almost all of our experience. It is only when we extend our experience to include subtle astronomical measurements that these world views are found to be false. Although they are valid in limited domains of experience, they are ultimately only useful fictions. So we should expect that as our experience expands, our common sense assumptions of reality will face ever more radical challenges. To quote Bohr and Heisenberg once more,

As our knowledge becomes wider, we must always be prepared. . .to expect alterations in the point of view best suited for the ordering of our experience.

-Niels Bohr[6]

The existing scientific concepts cover always only a very limited part of reality, and the other part that has not yet been understood is infinite. Whenever we proceed from the known into the unknown we may hope to understand, but we may have to learn at the same time a new meaning of the word 'understanding'.

-Werner Heisenberg[7]

We should be very careful, therefore, not to assume that just because our present scientific world view fits our present experience, it will fit all future experience. As physical science expands to include more and more subtle phenomena of outer experience, it will force upon us ever more radical revolutions or paradigm shifts in our conceptions of the world. We may be required to give up even the idea of independent objective existence.

Inner and Outer Epistemology

Even though physical science may continue indefinitely to expand the range of outer experience it comprehends, this expansion still takes place only within a limited domain of experience, namely, the outer sensory domain. Consequently, the corresponding theories are only theories of the outer sensory world. With the epistemological boundaries of science restricted to the outer sensory domain, any claims science may make about inner experience, such as consciousness, are unverifiable. Thus, no matter how far physical science expands into the outer domain of sensory phenomena, no matter how sophisticated or elaborate its theories become, as long as its methods of verification are restricted to the outer sensory domain, it can never answer questions about the inner domain of experience, which includes, among other things, consciousness and the spiritual dimensions of experience. Thus, if there is any hope of attaining genuine verifiable knowledge of this inner domain of experience, we must be willing to extend the scientific method into other domains of experience as well, in particular, into the inner domain.

One of the most fundamental principles of modern science is the method of experimental verification. More specifically, this principle states that scientific propositions are subject to independent experimental verification by a community of trained practitioners. In addition, empirical science requires that the experimental verification take place within the domain of outer sensory experience. Prior to such experimental verification, propositions of science are considered to be merely hypothetical. In contrast to scientific systems, dogmatic systems contain pronouncements that are asserted as true without being subjected to experimental verification. Therefore, insofar as religious doctrines take the form of dogmatic assertions, religion is fundamentally opposed to the most fundamental principle of science. This opposition, however, is based upon the unnecessary restriction of scientific verification to outer sensory experience, and upon an ignorance of the esoteric or mystical aspects of spiritual traditions which question statements and test them against inner experience rather than accepting them on faith alone.

In contrast to the dogmatic religious institutions, the mystics of the spiritual traditions of the world have based their propositions upon direct and immediate inner experience. Moreover, they themselves emphasize that their teachings are not to be taken as dogma, but are to be taken as hypotheses to be verified in an inner experience or realization. As Shankara, the founder of the Advaita Vedanta school of Hindu Philosophy, said, *Erudition, well-articulated speech, a wealth of words, and skill in expounding the scriptures — these things give pleasure to the learned, but they do not bring liberation. Study of the scriptures is fruitless as long as Brahman has not been experienced.*[8]

Like physical scientists, the community of practitioners in various spiritual traditions have developed sophisticated theoretical frameworks and elaborate experimental procedures which may be used to test their claims. Perhaps the purest and most highly developed of these inner sciences is found in the schools of Tibetan Buddhism. These schools have developed over more than a millennium an extensive array of meditative practices and techniques that are designed to lead the practitioner to specific insights. In addition, these experimental techniques are practiced in conjunction with the study and debate of refined theoretical systems.

It is a fundamental epistemological premise of these spiritual traditions that inner experience is a valid basis for obtaining knowledge of reality. This premise is supported both by the intersubjective agreement that is found within specific traditions, as well as by the agreement between traditions. Though their statements are variously inflected by their particular cultural contexts, there is a remarkable agreement among the mystics of different spiritual traditions.

The unanimous witness of the sages and the saints, over the whole surface of the globe and throughout the ages, is a sign or a criterion which no man of good faith can despise.

Frithjof Schuon[9]

Thus, there is good reason to believe that there is a realm of inner experience that may be investigated by methods analogous to those used in the physical sciences. The most convincing and definitive evidence, perhaps, for a science of inner experience is the science of mathematics. Mathematical propositions are not verified or falsified by subjecting them to our outer experience. On the contrary, their truth is tested through the inner examination of their logical coherence by the community of trained mathematicians. The Pythagorean theorem, for example, is and will always be true regardless of any sensory experiences. Its truth depends only on the inner logical coherence of ideas, and anyone who assumes the assumptions and definitions of Euclidean geometry can verify that the Pythagorean theorem is a logical consequence. The existence of mathematics, therefore, demonstrates that at least a portion of inner experience is not necessarily private and that because this portion of inner experience is commonly accessible to a community of practitioners, an inner science is possible.

Since inner experience is not necessarily private experience, the distinction between inner and outer does not coincide with the distinction between private and public. The result is the division of experience into four regions, as shown in the following table.

Both the inner and outer domains of experience contain elements that are personal or private, and elements that are public or interpersonal. For example, our visual perceptions of the outer world are private insofar as the world appears to each of us from entirely different physical points of view. Actually, we all perceive different worlds. Nonetheless, societal conditioning and physical science, by subjecting our experiences to intersubjective agreement, train us to isolate and abstract from these private experiences the universal aspects that are independent of the observer. A similar process of abstraction takes place in the inner domain. In mathematics we are trained to discriminate between logical inferences that are universally true and those that are not. And spiritual practices train us to abstract the universal elements of spiritual experience from the personal elements by determining those that agree with the community of practitioners and those that do not.

	Personal or Private	Interpersonal or Public
Outer Domain	Private Sensory Experience	Outer, Physical Science
Inner Domain	Private Mental and Emotional Experience	Mathematics, Archetypes, Inner Science

Communication of Inner Experience

Mathematics demonstrates also that it is possible to share or communicate inner experience between people. For example, although the insight of the mathematician can only be expressed to others indirectly using symbols and words, if those symbols and words evoke a similar private insight in another person, the knowledge has been shared, and can thus be considered interpersonal rather than personal. Similarly, even though it is an inner experience, spiritual knowledge can be transmitted and passed between spiritual practitioners, each of whom verifies the knowledge in an inner experience.

The communication of inner knowledge is always indirect and evocative rather than direct and descriptive. For example, if a friend has never known the taste of a bran muffin, you can never — no matter how many words you use to describe it — give your friend real knowledge of that taste. What you can do, however, is give your friend a recipe describing how to make muffins. If your friend then follows the recipe, and tastes the muffins, the knowledge will be shared. This is analogous to how mathematical knowledge is shared among mathematicians through instructions to follow the steps of a proof. It is also the way spiritual knowledge is shared through instructions to undertake specific spiritual practices. In fact, if we examine our experience carefully, this is even how knowledge of the physical world is shared.

It is significant that, like mathematical knowledge, the transmission or communication of spiritual knowledge is contingent on the development of certain abilities in the receiver. In fact, many of the spiritual disciplines and practices taught by the mystical traditions of the world are designed specifically to develop these abilities, and anyone who has not undergone such training will not be able to make sense of what many of the mystics say. This situation, however, is no different from the situation in mathematics where one must undergo years of training and mental discipline in order to be able to understand (not to mention verify) certain propositions. Consequently, while the statements of the mystics are not comprehensible to those untrained in spiritual disciplines, one mystic can communicate perfectly with another.

Because a prerequisite for comprehending spiritual knowledge involves extensive training and discipline without any advance certainty that the knowledge is valid, the practitioner must, in the beginning, have faith in the tradition. This faith, however, is not a substitute for knowledge, but a stepping stone to knowledge. It serves this essential role in the mathematical and physical sciences as well. The first step in the training of a physicist is to provisionally accept on faith the teachings of the physicists at the university. Only after years of training in the theories and experimental methods of physics is one capable of actually testing for oneself whether or not the teachings are true. Then faith is replaced by knowledge. The understanding of faith in integral science, therefore, is that any acceptance on faith is provisional only, and the truth of any hypothesis is always subject to experimental verification.

The Fundamentals of Integral Science

In view of the above, let us generalize the principle of scientific verification by relaxing the restriction that verification take place within the limited domain of outer sensory experience. The first fundamental principle of integral science, then, is

1. Propositions are subject to verification in the inner and/or outer domains of experience by a community of trained practitioners.

Since this extension of the epistemological basis of science embraces both the outer domain of physical science and the inner domain of spiritual traditions, it provides the foundation for an integral science that is comprehensive of both inner and outer experience.

Insofar as outer and inner domains of experience are merely two aspects of a single coherent field of experience, integral science is simply a science of experience, both inner and outer. It therefore has at its foundation no bias toward either subjective idealism or objective realism, toward the inner domain or the outer domain. Instead, it provides a common ground for both.

Since there has never been, and never will be, any experience or knowledge outside of consciousness, and since any scientific verification takes place in experience, the foundation of both inner and outer science is consciousness. Indeed, consciousness is the foundation of all knowledge, whether personal or public. Any assertion regarding anything outside of consciousness is, by definition, not accessible to any experience and, therefore, not verifiable. Since an assertion regarding anything outside of consciousness is not verifiable, it can not be a proposition of science. We thus arrive at the second fundamental principle of integral science:

2. Scientific propositions are propositions about experiences within consciousness, i.e. within the pure space of awareness that contains all experience.

It should be emphasized that, although experiences are plural, consciousness is singular: there is only one space of awareness in which all experience arises. The singularity of consciousness, however, does not imply solipsism since consciousness is prior to the distinction between inner and outer, public and private. Since all of experience, objective and subjective alike, is permeated with consciousness, there is no basis for attributing or restricting consciousness to the inner domain while excluding it from the outer domain. Consequently, consciousness is not limited to inner experience any more than to outer, is not limited to private experience any more than to public, and not limited to subjective experience any more than to objective. Since it is the ground of all these types of experience, it is equally present in them all. Consciousness, therefore, is a common ground or context for both the subjective world and the objective world, both the inner world and the outer world.

Within the framework of integral science, both the inner and outer worlds arise as interdependent fields of experience. When we imagine the distinction between inner and outer domains of experience, however, and further imagine that consciousness is restricted to the inner domain, then we are projecting an unconsciousness upon the outer world when it is, in fact, permeated with consciousness. Nevertheless, if we are successful in obscuring or ignoring this fact, then the outer world is experienced as something outside of and other than consciousness. If the outer world were truly other than consciousness, however, it would not be appearing in consciousness. Therefore, because the outer world is in consciousness, consciousness is not actually restricted to the inner world as we imagine.

Insofar as we restrict or obscure consciousness through this trick of the imagination, an outer world appears to us as containing independently existing objects. As both the mystics and quantum physicists tell us, however, this is a delusion. And this delusion arises from an ignorance of the unlimited nature of the space of awareness which contains all experience. In terms of quantum physics, the independent existence of objects arises in association with the projection of the state vector which transforms the system from a state of potentia to a state of actuality. Interestingly, this projection consists precisely in ignoring or obscuring certain components of the vector which were previously known to us. In other words, the state vector is projected not by consciousness (as many people have proposed), but by unconsciousness or ignorance. Moreover, since the obscuration of consciousness that creates the illusion of an objective world is not a real event but an imagination, it follows that the projection of the state vector is not a real event either. Here we have a novel perspective on the measurement problem of quantum mechanics that connects it at a deep level with the very process by which an unconscious objective world appears to arise within consciousness.

The framework of integral science also reveals a surprising and deep relationship between physical and spiritual laws. Because the inner and outer worlds arise in interdependence upon each other, there are, as it were, levels within the psyche that correspond to levels of physical manifestation. The deep levels contain invariants over very large classes of phenomena. At this level are subtle forms and archetypes that are common to all creatures by virtue of our common existence in this same physical universe. Through the act of obscuring consciousness, these inner forms are projected and experienced as objectively existing. At shallower levels within the psyche, there are invariants that correspond to more limited classes of phenomena, e.g., invariants that are shared among all humans, but that humans do not necessarily share with animals, plants, or inanimate forms of manifestation. These levels are also usually unconsciously projected and experienced as objectively existing. Thus we experience a shared human world as objective. Certain invariant forms at this level that are not projected will form the elements of our inner shared world. At even shallower levels are cultural conditionings and paradigms. These also condition our experience and are shared by large groups of people, but they are not common to all humans. Here we begin to enter the realm of what is normally considered personal since, unlike the deeper levels, one can, without extraordinary effort, become conscious of these levels, see their variation among humans, and withdraw the projection. At still shallower levels of the psyche are the more personal habits and conditionings that are often unconscious and projected, but can be made conscious with a little insight. These shallow levels are hardly invariant even in one human.

The levels of the psyche, therefore, get progressively more universal as they deepen, and because the deeper levels are invariant among larger and larger classes of manifestation, they are more difficult to consciously recognize and are consequently projected as being objectively real. So the laws of nature correspond to a deep level in this scheme — much deeper than cultural levels of conditioning. Our conscious understanding or representation of these laws, however, are certainly influenced by our cultural conditioning. That conditioning, however, is merely the form in which the archetypes are represented, like the cultural inflections of the universal archetypes of mythology.

Although it is possible in principle to change the objective world by changing subjective preconditions of experience, this would likely involve extremely profound psychological penetration requiring years of meditative practice. More superficial changes in personal and cultural presuppositions can alter our experience in small ways (e.g. optical illusions) but do not affect physical laws, e.g., the rate of fall of objects. The levels of the psyche that go far deeper than the merely personal or cultural levels of conditioning are the inner correlate to the outer physical laws. If they change, so will the world that is experienced. But this would correspond to very radical psychological transformation, and it would not be accurate to even call such an experience human anymore.

As humans, we are by definition living in this particular world that has arisen in dependence on our characteristically human preconditions of experience. That being given, understanding the world means for us understanding the true nature of this particular world and this particular psyche. Superficial beliefs that are not in harmony with the human mode of existence naturally lead to conflict and confusion. So it is wise for anyone who desires harmony and clarity of understanding to understand the nature of this human world with minimal distortion from the more superficial levels of the mind. But this human mode of existence is not the only way a world can be, and is not the only way conscious experience can be structured. There are thousands of worlds with thousands of beings. The ways of consciousness are infinite, and we see here but a thin sliver of all that is possible.

The Limits of Theoretical Knowledge

Although integral science expands and harmonizes human knowledge, the ultimate truth can not be grasped by a conceptual theory. As the seminal Buddhist philosopher Nagarjuna puts it,

> *The ultimate truth transcends all definitions and descriptions, transcends all comments and disputations, transcends all words.*
>
> -*Nagarjuna* [10]

Any system of thought is limited in some way by the very nature of concepts which distinguish, define, and thereby implicitly limit and exclude. So no conceptual system is an all-inclusive theory of everything. As Gödel's theorem has demonstrated, any sufficiently complex axiomatic system of mathematical symbols can not completely capture mathematical truth. Once we have expressed mathematics in a clear axiomatic system, it falls short of truth. This is not to say, however, that mathematical truth can not be known at all. It is only to say that it can not be completely represented in an axiomatic system. There is still the possibility open, which Gödel recognized, that mathematics can be known in a non-representational insight which is not constrained by the result of his theorem. Similarly, although the ultimate truth of the mystic can not be completely represented in words, this does not imply that it can not be known in a non-conceptual insight. Indeed, the mystics affirm that it can be so known.

By tracing the roots of any world back far enough, and freeing ourselves of the structures that limit us exclusively to one particular world of experience, we may recognize the common formless basis of the worlds that we previously saw as distinct. The ultimate recognition, however, is the recognition that the worlds of form are really no different from the formlessness out of which they arose.

> *At the beginning of the beginning, even nothing did not exist.* -*Chuang-tse* [11]

Worlds can be considered to arise through a process of division and obscuration within consciousness. If we begin with no distinction at all, then we are prior to thought. Indeed, we can not consistently conceive of there being no distinction since in doing so we would be implicitly distinguishing non-distinction from distinction. Thus, at this ineffable point of ultimate simplicity and degeneracy, there is no difference between distinction and non-distinction, between subject and object, or between any opposites whatsoever. This is the true Absolute ground, where there is no difference between emptiness and form, between substance and void, between something and nothing. In the words of the mystics:

> *God dwells in the nothing-at-all that was prior to nothing, in the hidden Godhead of pure gnosis whereof no man durst speak.*
> -*Meister Eckhart*[12]

> *There is not Nirvana except where is Samsara, and no Samsara except where is Nirvana. All duality is falsely imagined.*
> -*Lankavatara Sutra* [13]

> *An understanding of God is not so much an approach towards something as towards nothing; and sacred ignorance teaches me that what seems nothing to the intellect is the incomprehensible Maximum.*
> -*St. Nicholas of Cusa* [14]

Although theoretical models, teachings and scriptures will always fall short of an exhaustive explanation of reality, they may help carry us upward through the levels of understanding toward a recognition of the Absolute ground, just as axiomatic systems of mathematics aid us in attaining non-conceptual insights into mathematics. Although these teachings may be inspired by a perfect recognition of the Absolute, they are nevertheless clothed in words and concepts, and consequently share in the imperfections of relative knowledge. They are pointers beyond themselves, symbolizing and urging us toward that which they can not directly indicate. No matter how refined and subtle a theory or teaching, it inevitably falls short of perfectly reflecting the true Absolute. Nevertheless, they can be of great value so long as their relative status is kept in mind and they are not confused with the Absolute itself.

The levels of understanding and perspectives form a hierarchy graded by the degree to which they are conditioned. Some views near the top of the hierarchy are very subtle and reflect the Absolute with a high degree of purity, while other views are more restricted and give a more distorted reflection of the Absolute. Thus, relatively speaking, the higher levels are endowed with more truth, value, and reality than the lower levels. As conditions and limitations are superimposed upon the Absolute, its true nature is progressively veiled or obscured as one descends down the levels of the hierarchy. The ascent is thus characterized by removing the limitations and conditions to reveal the Absolute in its purity.

Although the gateway to the Absolute is at the top of the hierarchy, the Absolute itself transcends the hierarchy. At the same time, the Absolute is immanent in every level of the hierarchy. Like space, it both transcends the boundaries defined by objects within it and is immanent in all objects. Thus, in the relative view, the path to the Absolute is upward through the hierarchy by purification. Yet the ultimate truth is that the Absolute comprehends the hierarchy in its entirety, Thus, one does not reach the Absolute by rising up the hierarchy, but by realizing that the hierarchy is the Absolute and there is therefore nowhere to go — you already *are* the Absolute. ❋

Footnotes

[1]Werner Heisenberg, *Physics and Beyond*, p. 206

[2]Parmenides, cited in Whitall N. Perry, *A Treasury of Traditional Wisdom*, p. 789

[3]D. Goddard, *A Buddhist Bible*, Beacon Press, 1970, p. 302

[4]Niels Bohr, *The Philosophical Writings of Niels Bohr*, Vol. I, Ox Bow, 1987, p.54

[5]Werner Heisenberg, *Physics and Philosophy*, Harper, 1962, p.70

[6]Niels Bohr, *The Philosophical Writings of Niels Bohr*, p. 1

[7]Werner Heisenberg, *Physics and Philosophy*, p. 201

[8]Shankara, *Crest-Jewel of Discrimination*, Vedanta Press, 1978, p. 41.

[9]Frithjof Schuon, *Logic and Transcendence*, p. 66.

[10]K. Venkata Ramanan, *Nagarjuna's Philosophy*, Motilal Banarsidass, 1966, p. 272

[11]Perry, p. 26

[12]Perry, p. 41

[13]Goddard, p. 292

[14]Perry, p. 72.

How To Take Apart A Wire

Part I: From Waves to Boxes

Tom Etter

Preface: Quantum shape

Quantum mechanics is without question the most successful theory ever, and is steadily becoming more so. But what does it *mean*? I don't see that the march of progress in physics has brought us much closer to an answer. The questions we have the most trouble with seem to belong to a level more fundamental than physics, and we will probably need a whole new science that operates on this more fundamental level to answer them. Perhaps something of this new science can be distilled out of present-day physics, just as geometry was distilled by the ancient Greeks out of the practical arts having to do with space. The present paper is an attempt in this direction.

To push the analogy to geometry in a slightly different direction, one thing I see the need for, and will here present, is a concept of quantum *shape* that is not bound to the details of physics. Of course shape here means something more abstract than physical shape in the usual sense — just what this thing is will be spelled out in detail later. For now let me expand a bit on the general idea of shape.

The ancient world was much concerned with the shape of the Earth, which for them was a live issue, as William James would put it. Sometime around 600 BC the Earth became round, and remained so until the general decline of culture in the 4th and 5th centuries AD. However, even in the Golden Age this roundness had its ups and downs, so-to-speak. The poet Lucretius propounded a relativistic cosmology that is amazingly modern in most respects (it even puts life on other planets), but is conspicuously silent about the shape of the Earth. And well it should be, since, despite its daring relativity concerning position and velocity, it makes up and down into absolutes! We smile at this seeming incongruity, but we should not forget how strongly up and down are "hardwired" into human thought, like past and future. There's a moral in this tale, but I won't labor it.

The hypothesis that the Earth is round was supported, even in ancient times, by very good arguments based on empirical laws about the regularities of diurnal motion in the firmament, the rate at which a ship's mast disappearing over the horizon, etc. Let's refer to these laws collectively as *Earth theory*. Today we have a highly developed and strongly confirmed *quantum theory* which seems to supply very good arguments for the hypothesis that certain things in the world, perhaps all things, have a certain property, a certain "shape", which we could call *quantum.* But just what is this quantum property? The ancients of course knew very well what round is, not only in the ordinary qualitative sense, but in the precise geometric sense. Furthermore, they could contrast roundness with other well-defined shapes very close to round, and the Earth has indeed turned out to be slightly oblate. Nothing like this can be said of quantum.

The present paper will present a concept of "quantum shape" that is as clear and as simple as that of roundness. The analogy to geometry goes farther in that our quantum shape, like roundness, will be set among an infinity of other shapes that are defined in the same general terms. Conspicuous among these other shapes, and conspicuously different from quantum, is a shape I shall call *causal*, which formally captures the essence of our commonsense notion of causality, both deterministic and statistical. Causal shapes will examined at length in Part II.

Notice that a theory of shapes, in itself, does not involve issues of empirical fact; these only arise when we start asking questions like "Are such and such objects round (or quantum, etc.)?" It's then that we consult our empirical theories. Quantum theory in fact resembles Earth theory in that it is closely linked to observation, and is very strongly confirmed; our hypotheses about quantum shapes must definitely take this into account. But within this constraint, we still have a lot of latitude. For instance, we can ask whether only quantum shapes behave in the particular way required by quantum theory, or whether there are other shapes, perhaps causal, or perhaps "oblate" quantum, that could be made to fit quantum theory equally well or better. This is the context in which it makes sense to consider hidden variable theories.

Working with shapes gives us an intellectual mobility that we lack in working with laws alone. Concerning round things, two issues arise: is it round?, and why is it round? Now there can be many reasons for a thing being round. Planets are round because they are too heavy to be anything else; raindrops are round because they are too light to be anything else; basketballs are round because the rules say so; ball bearings are round in order to reduce friction, etc. There is no single "law of roundness." Nor do we feel the need for one. What different occasions of roundness have in common is simply the fact, not the reason. Could something similar be true of quantum? Could quantum arise under many different conditions? Could atoms, superconductors, perhaps even brains, all be quantum, but for different reasons? Perhaps we will someday need many different hidden variable theories.

Quantum does differ greatly from roundness in one respect, which is that it apparently has no place in everyday experience. If someone asks what the word "round" means, we simply point to a basketball and say "There, that's round." Nothing could be farther from the case with quantum. We have a lot of indirect evidence for things being quantum, but just what *is* quantum? Quantum shape provides a partial answer, but there remains the deeper question of how we might *directly experience* quantum. This is where the real questions of interpretation lie. Our new theory of shapes shows that the weirdness of quantum is in fact shared by the vast majority of shapes, and that quantum is actually is a pretty mild case of it. I suspect that this broader weirdness will become one of the main topics of science in the next millennium. In this I'm in good company, notably that of Pauli. Let me end here with a quotation[1] . (First a brief word of clarification: Pauli is following Jung in using the word "synchronicity" for what was then a pretty vague notion of acausal form. I believe that the account of acausal shape in the present paper captures something of his intuition in these matters.)

> "*The quantum mechani*cal situation is naturally not only a degeneration of the more general 'synchronicity' (this is to be understood as a working hypothesis suggested here), but also as a 'rational generalization' of normal deterministic causality (Bohr).... I have no doubts that the quantum mechanical 'statistical correspondence' lies much closer on the side of old determinism than on the side of synchronistic phenomena. Observed from the standpoint of this phenomenon, quantum mechanics must appear to be a very weak generalization of the old causality. And, nevertheless, quantum mechanics seems to me also to have that roadsign towards the other direction, towards the one where it is no longer possible to speak of arbitrary reproducibility at all. To me quantum mechanics seems to occupy a kind of intermediate place."

Section 1. The trouble with Hilbert space

Early quantum mechanics took the *state* of a quantum object to be a wave function. One might suppose that this could give us some notion of quantum shape, since a wave has a definite shape in space and time. However, the concept of wave function has proven to be too narrow for quantum theory in general, and has given way to the concept of a vector in Hilbert space.

This leads to problems. A vector, in itself, has no shape at all. The only shape around is that of the whole space. But this "global" shape is a *featureless* shape; Hilbert space is completely *empty*. It is strange to sometimes hear physicists talk about the quantum state of a macroscopic object as if it contained all of the visible and tangible features we find in ordinary experience. Where could these features have possibly come from? If the whole world is "in" a quantum state, how could the world contain anything at all in particular? Clearly we need a new approach.

In fact the Hilbert space formalism will provide most of what we need for this new approach, but only if we back off from treating it as a "model of reality" and see it more modestly as describing a certain *relationship* between some unspecified quantum domain and the objects and procedures of the laboratory. Here I follow Bohr: The classical world comes first. But then what is classical? This is a question that Bohr and his followers never really touched. The oft-repeated statement that the classical world is Newtonian, though roughly true, completely misses the point, since Newton's laws have nothing at all to do with information, and the essence of the quantum laboratory is that it's a place for the gathering, recording and processing of information. We'll come back to this later.

It's time to get more specific about our new "geometry", which is in fact a branch of relational logic. A shape in this "geometry" is simply a *relation*, any relation, defined in the set-theoretic sense as a set of ordered n-tuples. To get to quantum mechanics we shall actually need a kind of set theory in which membership can be either negative or positive[2], but we'll put this point aside for the moment.

What kind of relation is a quantum shape, then? We now come to a crucial point: The quantum-ness of a quantum relation is not a property of that relation in isolation, but of its situation as a part of some *larger* relation. Our new geometry is really about the part-whole relationship among relations. This is an extremely broad subject, and is arguably coextensive with the mathematical study of parts and wholes in general. Philosophers have a word for the mathematical science of parts and wholes: *mereology*. This paper is about the mereology of the quantum.

In the part 1 we shall start with standard quantum mechanics and go half-way towards its relational shape. We shall end up with a tensor diagram representing orthodox quantum preparation and measurement which precisely matches a certain diagram of relational composition. The fact that these diagrams match means that our logically defined quantum shapes, when their logic is interpreted as that governing our laboratory apparatus, will always generate the observed phenomena of standard quantum mechanics.

We could of course start at the logical end and work our way to quantum mechanics. This is in fact what we do in Part II, and it is actually a much easier progression. However, this approach can leave one with a certain feeling of arbitrariness about the construction, that it is just one more model among many. On the other hand, starting at the quantum end reveals that these relational quantum shapes are already essentially present in standard quantum mechanics, the way geometry is essentially present in the science of surveying. The relational approach, when confined to quantum mechanics itself, is not so much a model as a *distillation*. Its chief appeal is that it gives quantum mechanics a natural place in a much larger context.

We need basically two things from Hilbert space quantum mechanics, 1) the Born probability rule, and 2) the general dynamical rule, the latter being most familiar in the special case of the Schrodinger equation. We'll need these rules stated in the density matrix formalism invented by von Neumann. However, I'll start with them in their more familiar vector form and derive their von Neumann equivalents later. These derivations will serve both as a brief refresher in von Neumann theory and as an introduction to the diagram notation we'll need for the more general theory.

We'll simplify the usual approach in several ways. First of all, we'll only consider finite-dimensional Hilbert spaces. There are a number of reasons for this, not the least of which being that only in such spaces does there always exist the *white* state, by which I mean the mixed state with all weights equal, i.e., the state without information. The white state will play a key role in the results of Chapter 3. The boundedness requirement in infinite-dimensional space, by forbidding states like the white state, acts as a kind of *preparation*, and one which actually pushes us a good way along the path from pure quantum theory to physics, as shown by Deakin[3]. This is all very interesting, but our current aim is not to derive physics but to *disentangle* ourselves from physics in order to better contemplate the pure essence of the quantum.

Second, we'll work with real rather than complex scalars. Mackey[4] showed that we can treat complex quantum mechanics as a special case of real quantum mechanics in which all operators possess a certain symmetry defined by their commuting with a particular square-root of minus the identity. I've discussed this atsome length elsewhere[5]. This symmetry is essential for physics but irrelevant to the quantum puzzles, and does not apply to the non-quantum shapes we'll be studying. The results of the present chapter actually do not depend on the scalars being real, but in the next two chapters we'll only deal with real numbers — integers, in fact!

Third, we'll abandon the coordinate-free methods favored by mathematicians, and treat vectors and operators simply as arrays of numbers. This is not just to keep the computer programmers happy; it also puts us in better touch with the laboratory, where it's the numbers in these arrays, not abstract operators, that correspond to what we actually observe. Most important, it allows room for shapes that break Hilbert space symmetry, room we must have in order to formulate our general concept of shape

Section 2. Notation

Given these simplifications, the Dirac ket vector $|v\rangle$ can be regarded as a finite column of numbers, while the Dirac bra $\langle v|$ is a finite row. Dirac operators are of course matrices. The Dirac notation is wonderfully convenient for many purposes, but it has a limitation that is actually fatal to our present purposes, which is that it can't handle arbitrary number arrays with more than two indices. For now we need only one simple array of this sort, but we need it badly, so we must use a less specialized notation. Standard tensor notation would do, but it has serious drawbacks. Apart from being almost impossible to read, it's also very awkward for word processing, since formatting protocols for subscripts and superscripts — when they exist at all — vary from one editing environment to another.

Let's then adopt the functional notation used by most programming languages, where an array is shown as a numerical function of its index variables; for instance, v(i) is a vector, M(i,j) a matrix etc. It's sometimes useful to divide array indices into two classes, variously called upper and lower indices (tensors), or vertical and horizontal indices (matrices), etc. When we need to distinguish the two kinds of index we'll separate them by a colon; for instance, the array A(i,j:m,n) would have vertical indices i and j, horizontal indices m and n. Since we can write this notation using only ASCII characters, we'll refer to it as ASCII.

We can think of a Dirac ket vector |v> as a vertical vector, or more exactly, as a one-column matrix, written v(i :). A Dirac bra <v| is a one-row matrix, written v(:i). We'll omit the colon when the vector type is clear from the context, or doesn't matter.

The most basic operation on arrays is the *outer product*, sometimes called *tensor product*, written A(..)B(..) for arrays A(..) and B(..). It yields a new array C(..) whose indices are those of A and B together, and whose value, as a function of these indices, is the product of the value of A and B. The outer product of two kets is written |v>|w>, while that of two bras is |v><w|; in our notation these become v(i:)w(j:) and v(i:)w(:j) respectively. Notice that the order of v and w is important in Dirac notation, but not in our notation, since our index places are maintained by the index variables and colons.

Outer products are only allowed in tensor theory between arrays having no indices in common. Notice that there is no such restriction in ordinary algebra, where we are free to multiply any two functions, whatever their variables, for instance (x+y)(y+z). Whether this tensor restriction is really necessary or desirable could be debated, but it is so ingrained in common practice that it would be very confusing to drop it, so we'll keep it.

When an index occurs twice in an array expression, we sum the expression over all of its values; this is called *contraction*. It's forbidden for an index to occur more than twice. Again, we can question whether this is a rule we really want, but again there is no compelling reason to drop it.

Most of the Dirac conventions involve contraction, for instance:

Inner product: <v|w> = v(i:)w(:i)

Triple product: <v|M|w> = v(i:)M(i:j)w(:j)

Matrix product: MN = M(i:j)N(j:k)

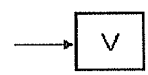
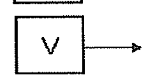
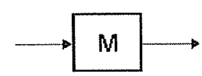
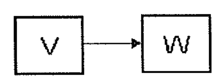
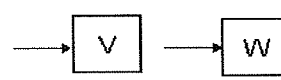
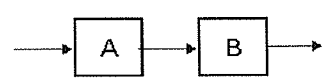
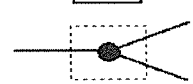
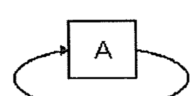
Trace: tr(M) = M(i:i)

ASCII notation is precise and general, but it is far from readable, at least by humans, so we'll do most of our actual work in an equivalent diagrammatic notation consisting of boxes connected by arrows. Not only is this box notation much easier to read, but it often makes it much easier to prove things, and to later understand our proofs. In the next section we'll prove an important theorem by merely rearranging boxes.

The translation between the two notations is straightforward:

Box notation: A box with arrows going in and out represents an array. An out-going arrow is a vertical index. An in-going arrow is a horizontal index. An arrow without a free end is a contraction. Outer multiplication is represented simply by putting unconnected boxes into the same diagram. Arrowheads can be omitted when the index types are irrelevant.

In a perfect world, diagrams are all we would need. In the meantime, while we wait for the world to be perfected, it's useful to think of our ASCII expressions as verbal instructions for drawing diagrams. Dirac, matrix and tensor notation are alas still needed for conversing with physicists. Here is a translation table for a number of common expressions:

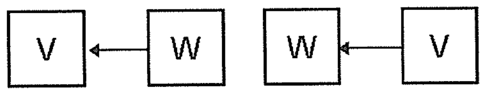
ASCii	Tensor	Dirac	Box
V (i:)	V^i	$\|v\rangle$	
V (:i)	V_i	$\langle v\|$	
M (i:j)	M^i_j	M	
V (i:) W (:j)	$V^i W_j$	$\|v\rangle \langle w\|$	
V (:i) w (i:)	$V_i W^i$	$\langle v \| w\rangle$	
V (i:) w (j:)	$V^i W^j$	$\|v\rangle \|w\rangle$	
A (i:j) B (j:k)	$A^i_j \; B^j$	B A	
K (i,j,k)	$\delta^{i,j,k}$	———	
A(i:i)	$A\,(^i_i)$	trace (A)	

Section 3. Born's rule

The basic rule of quantum observation says that if you prepare a system in state v, the probability of finding it in state w is the square of the absolute value of the inner product of v and w. This rule is essentially due to Born.

Born's rule, version 1: $\text{prob}(w|v) = |\langle v|w\rangle|^2 = \langle v|w\rangle\langle w|v\rangle$

fig. 3.1.



Let's now define two very important matrices, S, defined as $|v\rangle\langle v|$, and P, defined as $|w\rangle\langle w|$. S is called a *density matrix*, or *state matrix*, or simply *state*, while P is called a *proposition*. Both the concepts and terms are due to von Neumann. Here is the crucial theorem about P and S:

Born's rule, version 2: $\text{prob}(w|v) = \text{trace}(PS)$

Proof: Simply redraw the diagram for $\langle v|w\rangle\langle w|v\rangle$ by moving things around and regrouping the vector boxes, thus:

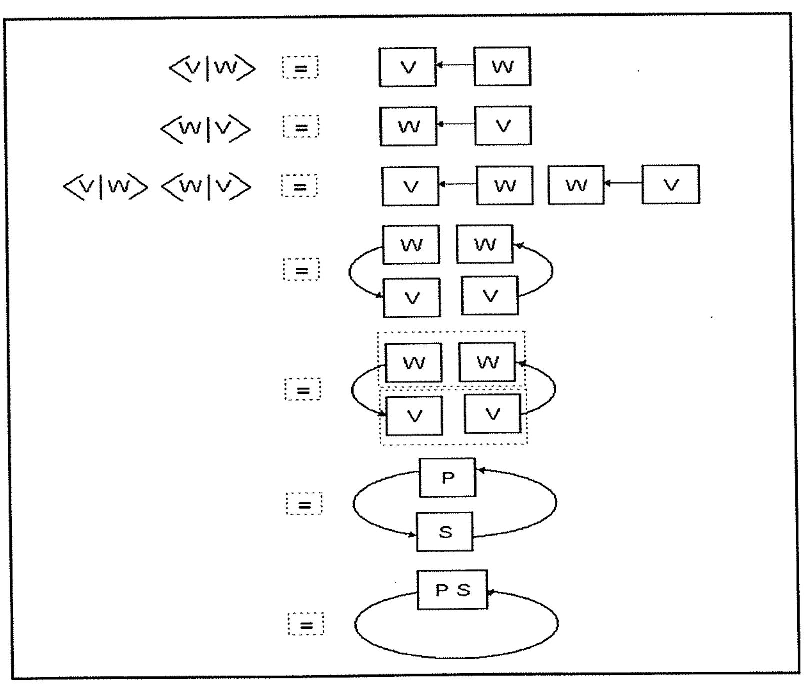


fig 3.2

Von Neumann showed that there is a 1-1 correspondence between propositions about the outcome of measurement and projections, where by a projection is meant an idempotent operator, i.e. P is a projection means PP = P. (Actually they are *orthoprojections*, meaning that their ranges are orthogonal to their null spaces. Note that if we take the state vector w to be normalized, , i.e. if $<w|w> = 1$, then $|w><w|$ is a projection; call it a *ray projection*. Since probabilities add for orthogonal states, and every (ortho) projection is a sum of orthogonal ray projections, it follows from linearity that version 2 of Born's rule gives the probability of any proposition about the outcome of any measurement on state v. An analogous argument from linearity shows that version 2 holds for any density matrix S which is a weighted sum of state matrices of form $|v><v|$ that represents a *mixture* of quantum objects in "pure" states, each given by a vector. To put it simply, version 2 covers every occasion of preparation and measurement. It's the whole story on how the formal objects in quantum theory relate to what we observe.

As we'll see, the greater generality of version 2 extends much further than that. Version 1 is strictly confined to pure states in quantum mechanics. Version 2, on the other hand, turns out to be a general theorem of relational logic, applying to all connections among the components of any compound relation. As we'll see in Chapter 2, it applies even to the wires in a computer. It's curious that this seemingly specialized technical trick for extending Born's rule is what turns out to be the essential feature that quantum mechanics shares with the rest of science. But there it is - let's make the best of it!

Section 4. The dynamical rule

Schrodinger's equation, in coordinate-free language, says merely that Hilbert space rotates uniformly with time. In this respect it is the quantum analogue of Hamilton's classical theorem that Newton's laws define a one-dimensional group of canonical transformations on phase space. Hamilton's theorem was a surprise, since his canonical transformations were originally intended only to capture the notion of a change in the observer's viewpoint. The duality between objective and subjective change which this theorem uncovers is very deep, and certainly deserves a name, which to the best of my knowledge it has never acquired. Let me here propose one: Hamilton's principle.

Hamilton's principle carries over to quantum dynamics as the duality between the Schrodinger representation and the Heisenberg representation, the first being objective, the second subjective. Its chief lesson for us now is to suggest that we should broaden our conception of the basic task of dynamics beyond that of finding the right equations of motion to that of finding the most general "shape" of change. In quantum mechanics, this general shape is simply *unitarity*.

Thus, when we disentangle quantum change from the details of physics, it boils down to just this: A state v changes into a state v' according to the law v' = T(v), where T is a unitary transformation (a matrix T is unitary if its transpose is its inverse, i.e. if $T(i,j)T(k,j) = I(i,k)$, where I is the identity.)

Dynamical rule, version 1: v' = T(v)

Let's see how to express this rule in terms of density matrices. First, let S be the matrix of a pure state, i.e. let $S = |v><v|$. Now a change takes v into T(v), so the changed matrix S' is $|T(v)><T(v)| = T|v><v|T^*$. $= TST^*$ But since T is unitary, $T^* = T^{-1}$, so we have:

Dynamical rule, version 2: $S' = TST^{-1}$

Since a mixed state S is a weighted sum of pure states, it follows from the linearity of T and T^{-1} that version 2 holds for mixed states too. Multiplying both sides of the above equation by T on the right gives:

Dynamical rule, version 3: S'T = TS

For unitary T, versions 2 and 3 are equivalent. However, for matrices in general, version 3 is broader, since it doesn't require that T have an inverse. And it turns out that this broader version 3 joins version 2 of Born's rule in overflowing the boundaries of quantum mechanics into the larger domain of relational logic. As we'll see in Part II, S'T = TS is true of any two-arrow box in the box diagram of a compound relation.

Section 5. Quantum measurement

We'll now put Born's rule and the dynamical rule together to construct a diagram of what happens when we make a preparation followed by a measurement. It's sufficient to consider yes-no measurements, since the theory of these can be shown to lead to the theory of measurements in general[6].

What we are considering is an experiment in which objects like electrons or photons are prepared in a state S, then subjected to a unitary transformation T, and then tested for some property given by a projection P. T can represent a change in S, as when we measure the scattering of electrons that have passed through a slit (Schrodinger), or it can represent a change in our measuring apparatus, as when we prepare photons in a certain state of polarization and then test them at some other angle (Heisenberg), or it can be a combination of both. By Hamilton's principle, we should get the same diagram in all cases, and it turns out that we do.

First, let's make a diagram of the transformed state $S' = TST^{-1}$ in which the vertical axis is time:

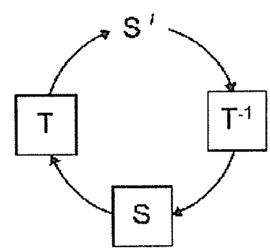


fig. 5.1.

That is, the system is prepared in S at the bottom, undergoes the transformation T, and turns into $S' = TST^{-1}$ at the top.

We have now come to the point where in order to go farther we must introduce a box with three arrows, the so-called *Kronecker box*. We can think of this box as the three-term identity relation, or as the node joining three "wires"; more precisely:

Kronecker box, written K(i,j,k): The three dimensional array which is 1 when i = j = k, otherwise 0.

When you prepare an object in a state S, the matrix representing S is diagonal, when referred to the laboratory. Here is an obvious but very important theorem about diagonal matrices:

The K-theorem: If S(i,j) is diagonal, it can be written in the form K(i,j,k)s(k), where s(k) is the vector of diagonal entries in S. Here is the diagram:

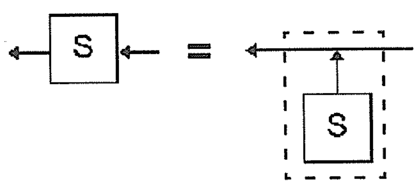


fig 5.2

Let's now use the K- theorem to redraw figure 4 thus:

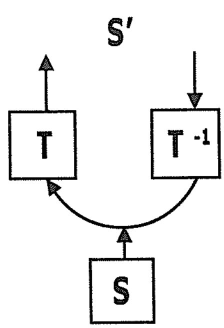


fig 5.3

ASCII for fig. 5.3: S' = T(i,j)K(i,n,k)s(k)T^{-1}(m,n)

The vector s(k) represents the probability distribution on the pure components of the preparation; if S is pure, then s(k) has a single entry which is 1, with the rest being 0. We can think it s(k) more concretely as representing the laboratory device that is doing the preparing, where its outgoing arrow is its "output" to the quantum domain.

By version 2 of the Born rule, the probability that the particle will pass the test P is trace(PS'). Let's draw a diagram of trace(PS') based on that of fig 6:

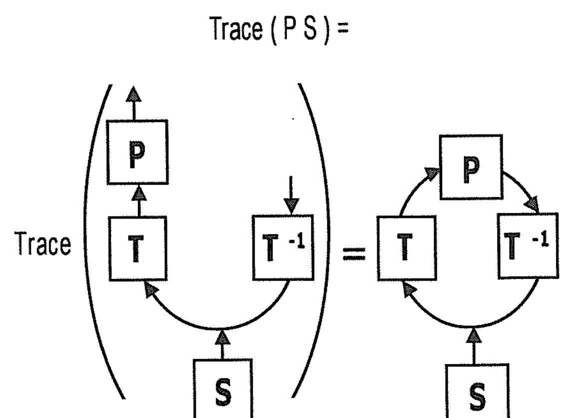


fig !

ASCII for fig. 5.4: trace(PS') = trace(P(j,h)T(i,j)K(i,n,k)s(k)T^{-1}(m,n)) = P(j,m)T(i,j)K(i,n,k)s(k)T^{-1}(m,n)

Since P represents the state of the detector, it too has a diagonal matrix in laboratory coordinates. Thus we can apply the K-theorem again to remove it from the loop:

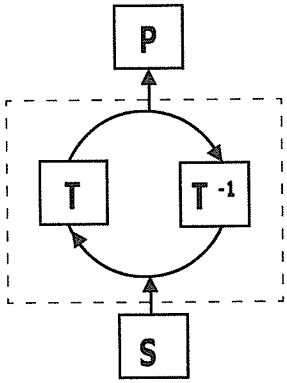


fig 5.5

ASCII for fig 5.5:
$p(d)K(d,j,m)T(i,j)K(i,n,k)s(k)T^{-1}(m,n)$ and
$Q = K(d,j,m)T(i,j)K(i,n,k)\ T^{-1}(m,n)$

Notice that we have now made a neat separation between the laboratory devices, represented by vectors s(i) and p(j), and the quantum domain Q, represented by the inner loop. The preparation s(i) feeds the inner loop through the classical variable i, and the detection p(j) is fed by the loop through the classical variable j.

Fig 5 is the basic structure of preparation and measurement, and as such it reveals a number of interesting things.

First of all, it directly exhibits Hamilton's principle. To see why, we must back-track a bit. In Section 3 it was said that $S' = TST^{-1}$ is the dynamical law, but this is not quite accurate, since it is actually only the Heisenberg form of the dynamical law, the Schrodinger form being $S' = T^{-1}ST$. But it's obvious that the order of T and T^{-1} in fig. 8 is irrelevant, so there would be no way to tell which of the two forms it represents. To put it another way, the difference between Heisenberg and Schrodinger is unobservable. This is not a new result, but it's nice to see it so plainly portrayed.

Second, this same symmetry reveals that Q is symmetrical in time. If S is pure and P is a ray projection, the whole diagram is symmetrical in time. In this case, where do we locate the "collapse of the wavefront" by measurement? Is it collapsed by p, or collapsed backwards in time by s?

Much more interesting is the question of what fig 5 reveals about the quantum domain Q "in itself". Suppose there is no measurement, only a preparation:

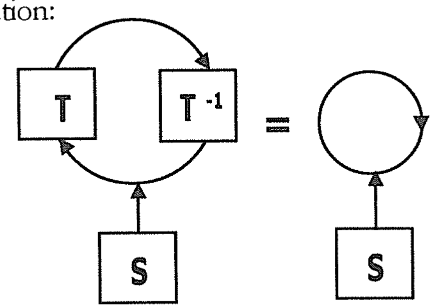


fig 5.6.

ASCII for fig 9: $T(i,j)K(i,n,k)s(k)T^{-1}(j,n) = K(i,i,k)s(k)$, and $Q = K(i,i,k)$

Q is now what? The output of s(k) connected to itself! What sort of thing is that?

Conversely, suppose there is no preparation, only a measurement:

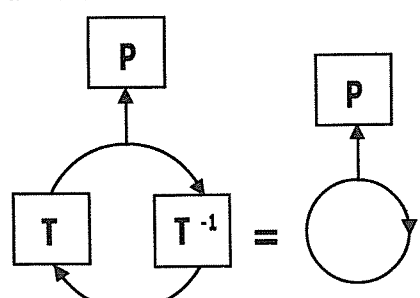


fig 5.7.

ASCII for fig 5.7: $p(d)K(d,j,m)T(i,j)\ T^{-1}(m,j) = p(d)K(d,j,j) = \text{trace}(P)$, and $Q = K(d,j,j)$

What then is being measured? Notice that trace(P) is not a probability, since it's generally greater than 1. That's because by removing s we removed the normalizer 1/n, where n is the dimension of Hilbert space. Putting it back, we find that what we are measuring is the *white* state, i.e., the state without information, which means we could just as well be flipping a coin. The unprepared quantum state has absolutely nothing to say!

At least it has nothing to say to us. But what might it be saying to itself in isolation? Let's see what it looks like when we remove both the preparation and the measurement:

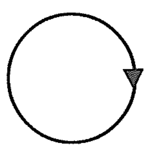


Fig. 5.8

Recall that in section 1 we remarked that Hilbert space is empty. This ultimately simple diagram is another way of saying the same thing. The quantum domain in itself, before it is married to the world of classical events, is literally nothing, but nevertheless, the marriage has proved to be a most fertile one !

Footnotes

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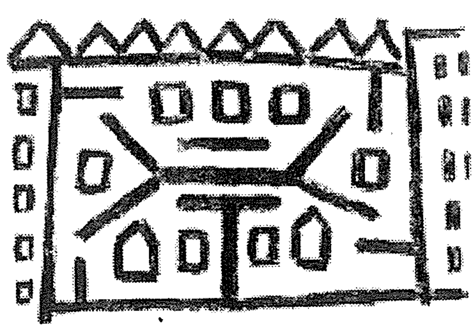


Natural Interactivity

by Helgi-Jón Schweizer

In this paper I would like to introduce you to my view on Interactivity. Interactivity is a concept which has gained in importance over the last decades, especially in connection to the rise of new media. My handling of this topic is determined, to some extent, by my field, namely biology and psychology. In the course of this paper I will try to unearth underneath our everyday experience a fundamental interactivity which guides our conduct with others and our use of media.

The first part will be about research done in my field in the natural sciences. Partly it will cover experiments which I carried out together with my students, and still carry out. This is the first time that these appear in print, in this case though only to illustrate my thoughts on interactivity and media. The goal of my presentation is to gradually sharpen our understanding of the terms Interactivity and Natural Interactivity and to use this understanding for approaching media.

In the second section we will leave the facts somewhat behind and indulge in speculation with an eye to the fascinating topic of Virtual Reality.

And finally I will report to you a project which brings the presentation full circle – very much in the spirit of the loop of Interactivity. This project is about reciprocal virtual reality, or maybe it would be better to call it, real virtuality.

I encountered the issue of interactivity for the first time, as far as I remember, in the context of my dissertation which was an investigation of the *eye-hand feedback loop* in balancing a rod. Actually, one can distinguish two feedback loops coupled together: an outer one and an inner one. When quickly reaching for an object, for example, the inner feedback loop has the function to place the hand- based on a quasi-knowledge of body position, body location and environment in close vicinity to the object (this corresponds to control via feedback from proprioception). The outer feedback loop controls the rest of the movement with the help of the eye, until the hand reaches the target object. These feedback loops happen so smoothly and quickly that we do not ever become conscious of them. What started me thinking back then was not the question about their being conscious or unconscious. Rather it was about the relative movement of rod and hand during balancing and my description of the process which ran approximately like this: "the rod leans away from the vertical position to the right with increasing speed. I perceive this and respond by moving my hand to the right. The rod, consequently, slows down in its falling, reverts the direction of its motion and returns to the vertical position and then may start to lean in the opposite direction . . . "[1]

At some point I asked myself precisely what was happening in this back and forth movement. What was my hand responding to? The leaning of the rod? Was it not really myself who produced what the rod did? was it not my corrections which caused the stick's movement? Was it not my own behavior of just a second ago which I encountered the next moment in the behavior of the rod? And was it not really my own imprecise corrections that I constantly had to correct?

By the way, it is not only the leaning of the rod which one corrects during balancing, but also the rod's and one's own position in space, as, for example, when one comes too close to a wall.

I started to see the "interaction" between myself and the rod also as the interaction between me and myself, an interaction between my past and future decisions.

Since I can assume that you all have some experience with balancing I would like to use the opportunity to point out a couple of things which will become important in the further course of the investigation, and which you might be able to confirm through your own experiences.

1. Balancing is fun; we do it playfully, voluntarily; it is natural

2. When we do it, we are absorbed in the process, in some sense, we become one with the rod.

3. Balancing is one continuous process;

4. We do not know what precisely we do in detail; we do not respond to single individuated stimuli; we act within the flow.

5. Our actions depend upon our expectations and our expectations, in turn, depend upon our actions.

Anybody can confirm what I just stated by balancing at home with the broom stick. But, notice, it works only with something like a broomstick, not with a pencil or a pole of ten yards. This, too, we should keep in mind. The pendulum motion of a broom seems to be especially well-fitted to the natural tempo of our actions.

This first encounter with interactivity within my work on balancing was at first merely perplexing. The situation seemed too entangled and complex to sort out. Then a small incident happened: my second encounter with interactivity which showed me interactivity in a totally different light.

The occasion was a computer fair (I had been working for several years in the field of Artificial Intelligence and computer simulation of neuronal networks) where a representative of a computer company approached me to announce triumphantly that they too had finally developed an intelligent and interactive teaching program.

The program worked basically like this: it showed first a page of the material to be studied. Once the student indicated by pressing a button that he had absorbed the material the program presented a number of questions which the student had to answer, also by pressing buttons. After evaluating the answers the program decided whether to present the first page one more time or whether to move on to the next page. Needless to say, I was not very impressed. It did not seem to me that one could approach interactivity profitably that way. (Which is not to say that developing such programs could not be an interesting and fruitful thing.)

My thoughts were returning to the strange interplay of balanced object and balancing subject that I had noticed in my experiments; to the fluid interlacing of perception and action in one continuous loop.

The close relationship between circular motion, pendulum swing, repetition and rhythm, intrigued me as much as the close relation between repetition, identity and order; the role played by the redundant, regular, familiar and old in opposition to newness, randomness, information, to the unknown.

Harmonic oscillators I found especially fascinating they are the temporal equivalent to the circle, the star exemplar of uniform repetition where even the derivative of the function the change of change, so to speak is again a harmonic oscillation. One could call it with some reason "pure repetition" and "elemental." This fits well with the discovery of Monsieur Jean Babtiste Joseph Baron de Fourier, which was that every periodic process can be described (better: conceived) as the sum (or rather composition) of harmonic oscillations.

With such thoughts in mind I moved my experimental activity to the area of iterative, rhythmic behavior. In the everyday of research work this meant investigating finger tapping (because these tapping events were thought to be clearly identifiable and could be unambiguously registered). Beyond that we investigated also a large spectrum of rhythmic activities, the movement of different extremities, speaking, breathing, even the reversal of gestalt switches and free association. We investigated regular, rhythmic and random tapping, slowing down and speeding up of tapping in different tempi, and so on. Every sequence of tap intervals was recorded and treated to state-of-the-art time series analysis (more precisely: point process analysis).

The results were very interesting, some totally unexpected and unexplainable unless one took them as surface behavior of underlying rhythmic processes of a highly complex and hierarchically organized nature. We found, for example, amazingly stable correlation patterns extending over many intervals, and sequences of ten and more minutes of gradually decreasing (smooth, exponential) or increasing tap intervals.

In a second experimental phase, we studied and with this we approach again our topic interactivity the relation between two simultaneous rhythmic processes of the body: for example, tapping with left and right hand simultaneously, or tapping with hand while listening to series of taps presented to the ear, or even tapping while listening to rhythmic forms of music. The studies confirmed in detail something we all know from our own experience, namely that there exists an irresistible tendency to establish stable rhythmic relations, mostly through synchronization.

Of course, we tried our statistical analysis again cross-correlation this time, but the results were meager compared to the power of the phenomenal experience. At one point or another, everything seems to be rhythmically related to everything else. It was like observing waves at two different points of an enormous body of water a undulating sea of different gradations of rhythmic interdependencies which are also susceptible to external influences and integrate them into the overall pattern.

My phase of experimental activism was followed by a period of sober theoretical consideration coupled with the necessary stepping back to gain an overview.

In this phase, the term "synchronicity" moved more and more on center stage, and with it the issue of *mutual adaptation* or differently put, of interactivity.

We searched for mathematical models to describe mutual adaptation, but what we really had in mind was the interplay or rather the interacting of persons, the way it can be observed, for instance, in dance, or, a more trivial example, when two people try to pass one another on the sidewalk and one steps to the side and runs into the other who did exactly the same.

We learned not much from this search other than that the term adaptation can be meaningfully applied only to processes with different temporal properties, i.e. a rapid, variable process adapting to a slow, inflexible process. But this insight seemed so trivial it hardly deserved the name. It also seemed to ignore something that was basic to all rhythmical biological processes. This something is often abstractly termed "oscillation" and points to what takes place behind the observed rhythmic surface behavior. We see only certain macro-aspects those that are relevant for our actions macro-aspects of a gigantic conglomerate of interdependently networked, and hierarchically self-organizing rhythmic processes (which operate from the highest levels of rhythmic behavior all the way down to the rhythmic activity of single nerve cells, and probably beyond.)

I like to illustrate this with the image of an ant hill on which we place the leaf from a tree. The ants that crawl underneath the leaf can move it only if they all crawl in organized fashion; this means in the majority unidirectional and simultaneous movement. (One could also say: "synchronously" or "coupled"). The movement of the leaf corresponds to a statistical macro-aspect, is an expression of literally the underlying organization.

The problem of mutual adaptation accordingly refers to the interaction of two or more separate systems of such complex internally rhythmic networks which form one system through their synchronizing interaction.

The depressing fate of the (physiological) psychologist seems to be very often to get hopelessly entangled in complexity when traveling from a seemingly simple, formally abstract mathematical model to the corresponding, seemingly equally simple experience of the everyday. And this happens even when the model and object of the model are quite close.

In the above case, even the construction of a convincing mathematical representation turned out to be a relatively difficult enterprise, far beyond our capabilities. The starting point of this undertaking dates back to the 17th century, more precisely, it can be traced back to the winter of 1665. The Dutch physicist Christian Huygens had caught a cold and was forced to stay in bed for a couple of days. Most likely out of boredom he started observing the behavior of two pendulum clocks which he had himself constructed and mounted over his bed. Much to his surprise he found that they both moved in precise synchronicity, and this not only intermittently. Even when he disturbed their synchronicity by stopping one of them they were back to swinging in unison within half an hour. Huygens hypothesized that they influence one another via vibrations of the intervening air or the connecting wall. He found this theory confirmed, for when he mounted them on opposite walls of his room, he found that they gradually fell out of step. With these observation from his sick bed, Christian Huygens became the founder of a new branch of mathematics which lasts to our days, and has even experienced a revival in the last years. I am talking of the theory of coupled oscillators.

The stubborn efforts of mathematicians to capture the regularities of these fundamental phenomena which turn up everywhere, in biology as much as in plasma physics, have been described by Steven Strogatz and Jan Stewart in a very readable article in the Scientific American with the title "Coupled Oscillators and Biological Synchronization."[2] The subtitle of the article reads, "A subtle mathematical thread connects clocks, ambling elephants, brain rhythms and the onset of chaos."

The path covered by these efforts leads from extremely simplified cases (like the case of two identical oscillators) to large assemblies and networks, less identical and discontinuous oscillators (for example, action potentials of nerve cells) with different degrees of coupling. Special considerations are given to *assemblies* of oscillators (*communities of oscillators*) which are also open to external influence. The degree of coupling in a natural network of oscillators varies a great deal. In most cases, neighbors exert the greatest influence on one another or specially connected sub-assemblies of oscillators, as, for example, nerve cells which create special linkages via their long extensions or via special messenger substances and the corresponding receptors. By the way, I tell my students to think of the axonal connections between nerve cells as comparable to telephone and the chemical connections as comparable to radio.

Mathematicians, of course, prefer the case in which each oscillator influences all other ones, a case in which the strength of the coupling rises with the phase difference. For this case, the *interaction* between oscillators that are swinging in phase is minimal.

We will have to look more closely at the central concept of synchronicity, if only to avoid confusing it with simultaneity. For starters, the first has to do with harmonic oscillation, the latter with individual, discrete events.

Synchronicity is a special case of phase-locking in harmonic oscillators; phase locking means that two oscillators are in a stable relation with respect to their phases; this implies that they swing at identical frequencies (i.e. identical recurrence)

Two coupled oscillators have precisely two special cases of phase-locking: a state of minimal phase difference which is called *synchronicity*, and a case of maximal phase difference which is called *anti-synchronicity*. With three and more oscillators there are increasingly more and more complex states of coupling. In this case one talks of standard patterns of phase-locking in groups of coupled oscillators. I will spare you the mathematical background.

Biological oscillator systems, for example nervous systems, normally consist of large numbers of more or less coupled oscillators. Efforts to capture the behavior of such oscillator communities are, despite all abstraction and simplification, still in the infant stage. For our purposes it is enough to state that concepts like coherence, collective rhythms, mutual influence, temporal pattern, harmony, and last, but not least, interactivity play an important role. Examples illustrating the behavior of coupled oscillators are often taken from biology. For example, the gait of four-legged animals has been described (or should one say: explained?) as the natural pattern resulting from the phase-locking of four oscillators. [3]

Especially spectacular is the synchronous blinking of swarms of fire flies on the banks of the tidal rivers of Malaysia which switch whole trees on and off like neon signs. Less exotic, but much more familiar, are the collective and synchronous changes in direction executed by flocks of birds or schools of fish. The popular explanation is that potential predators will perceive, or rather, misperceive, the swarm as one large organism. Even more familiar is the collective behavior of humans when they produce or listen to music, while dancing or marching, or the mysterious synchronous yawning of groups of people.

Those who long for a more philosophical take on synchronicity, could consider the meaning of simultaneity in a network of coupled oscillators. The simultaneity of two events in different parts of the brain, for example, might mean that they are one event for me. We will, however, not give in to the fascination of such pursuits but focus instead on more concrete, more secured facts. To this purpose we go to the already mentioed Scientific American article by Strogatz and Stewart which starts with the question: "Why do gaits resemble the natural patterns of coupled oscillators?"

They state: "The mechanical design of animal limbs is unlikely to be the primary reason . . . the most likely source of this concordance between nature and mathematics is in the architecture of the circuits in the nervous system that control locomotion."[4]

This is precisely what we found in our tapping experiments as, for instance, when we tried to change the mechanical properties of the tapping finger, by attaching a weight to the finger. The connection became especially clear when we studied the relation between perceived rhythms, especially acoustic ones, and generated rhythms. Well, all this is hardly surprising, since the first thing that comes to mind in the context of rhythm is music and dance, and the connection is confirmed also by our experiences.

Music, especially Jazz, is in some ways almost the ideal demonstration of intra- and inter-individual rhythmic relationship. One can speak here of a genuine case of *rhythmic interactivity.* One may equally well think of the dynamics of a rhythm section in terms of a basic pulse and subsequently differentiated phraseology (micro timing) in an orchestra, or of the exact subdividing of an adopted base interval – the key – by a singer.

Instead of speaking more about our own investigations, let me here cite a number of well-known, well confirmed studies which also lend support to the theory of coupled oscillators as "pervasive, fundamental principle of natural order"[5]. I refer in the following largely to the studies of William S. Condon and quote from an article entitled "*Communication: Rhythm and Structure.*"[6] But first I want to quote Condon's own summary of this article, of "a paper seeking to explore forms of rhythmic synchronization by micro-analysis of speaking and listening behavior:"

> "A speaker's body is observed to move in organizations of change which are precisely synchronized with the articulatory structure of his own speech across multiple levels. This is a unified, rhythmic and hierarchic organization of great precision which has been called self-synchrony. Further, and surprisingly, the body of a listener moves in organizations of change which are precisely synchronized with the articulatory structure of a speaker's speech, and often with inanimate sounds as well. This has been called interactional synchrony or entrainment. It appears to be a universal characteristics of normal listener behavior and has been observed in many different cultures. It is also a basic characteristics of infant behavior and has been observed as early as twenty minutes after birth. The same organizational processes which mediate self-synchrony may mediate interactional synchrony. The organization of movement of the listener's body thus is in precise rhythmic synchrony with the rhythmic pattern of the speech of the person he is listening to. This occurs very rapidly i.e. within the first frame following sound onset, which is 42 ms. Similar synchronization with sound has been observed in rhesus monkeys and may exist in most hearing creatures. The hearing creature reflects the structure of the acoustic universe in which it exists."[7]

So far the quote. The whole can, and I think, should, be interpreted in terms of coupled oscillators, even if Condon does not do this in his article. The connection gets even more evident in several other parts of the same article which I want to quote since they also point in the direction of our further inquiry.

> "Thus the movements, gestures and speech that one sees and hears when a person speaks can be interpreted as wave forms which are hierarchically organized. This also suggests that they may be produced by similarly synchronized brain processes [. . .] it is as if there is an ongoing multi-level organizational rhythm hierarchy in terms of which behavior behaves. Both speech and body motion obey this hierarchic rhythm structure and are simultaneously synchronized across these multiple levels in their co-occurring.
>
> Behavior appears phenomenologically to be both discrete-like and continuous simultaneously without contradiction, providing an organizational form where the discrete-like is fused into the continuous. The smaller wave forms get integrated into the larger wave form . . . "[8]

I have deliberately quoted this at such length to counter the impression that I only want to present my own theory and opinions. My own extensive studies on rhythm serve here only as substantial confirmation of the results and interpretation of William Condon's work. Even though we used very different methodological paths, both led in the end as if by force from the synchronization of *intra-individual* processes to that of *inter-individual* processes.

Before turning back to my own experimental work, I will dwell briefly on Condon's results. Beside the already mentioned synchronization of speaker and listener ("there is a precise isomorphism between the flow of the speaker's speech and the body motion of the listener . . .") it is the synchronization of mother and child which was Condon's prime interest. "A normal infant as young as twenty minutes following birth can entrain with adult speech almost as well as an adult. This suggests a biological preparedness for speech and human communication . . . it was as if the organization of the infant's body motion was being generated by the structure of the mother's speech."[9]

Condon's claims have been confirmed, differentiated and completed, in several subsequent research projects. Peery (1980) studied "facial behavior of infants in relation to adult (mother's) speech and movement."[10] Kato and co-workers carried out similar investigations in Japan, and confirmed the earlier work with one very interesting addition. They state that their results suggest not only that the organization of the neonates' motor behavior reacts to and is synchronized with the organized speech behavior of adults in his environment, but that the neonates' movements influence adult speech.[11]

Condon mentions in his summary article also a study of eight adults listening to one speaker. The study showed that they all moved in synchrony with the speaker, and therefore also in synchrony with one another. This leads Condon to remark: "Such group synchrony may create a new out-of-conscious-awareness phenomenon which is absent in dyadic interaction [. . .] this might create a richer participant effect [. . .] some speakers can arouse audiences more than others. Hitler, for example, has been known for his ability to appeal to audiences."[12] Condon says that he once studied a close-up of a film of Hitler during a speech and at one point (and at the same moment) his right eye moved right and his left eye moved left. (!)

In conclusion, it appears that human existence is intricately connected with the ability to synchronize with the universe in which one exists and with other human beings. Communication among humans is grounded in synchronicity, and rhythmic synchrony and rhythm itself are primary aspects of all human behavior.

Having said this much about Condon's work, we turn back to our own work and thoughts. As I stated already, these confirm inasmuch as there is an overlap the results just described in impressive manner. In several interesting aspects we could sharpen Condon's results, as for example, in his observation that both human speech and human movement display a basic periodicity of approximately one second. Our experiments showed that the periodicity mentioned is actually at 800 ms. Not only is the 800 ms interval easily adopted ("learned"), but it is more resilient to interference and can be remembered and reproduced more accurately. The 800 ms interval appears to be something of a basic internal and interactive tempo; maybe one could call it a tempo norm.[13]

Much more exciting than these rather conventional experiments are experiments we designed to explore inter-individual, especially rhythmic, interaction and collaboration.

The experimental setup is extremely simply, almost ridiculously so. It consists in a pendulum which is mounted on the ceiling and ends just above a writing surface. The lower end of the pendulum is a small platform of Plexiglas, about 4 X 4 inches. A pencil inserted at the center of the platform reaches down to the writing surface and records in this way the movement of the platform. The whole looks like a semi-scientific Ouija board and this is really what it is about.

The phenomenon itself has been known for centuries, and has occasionally been demonstrated convincingly; yet there has never been a serious inquiry into the principles. More than one reason could be found for this state of affairs. For one, the phenomenon itself is a bit uncanny. But the decisive reason is probably that the phenomenon can not be reliably produced. This means that the experimental conditions are not precisely repeatable due to the complex psychic makeup of the persons involved. Already the intention to observe in a neutral way can prevent the phenomenon from appearing. There is a very important connection between scientificity and repeatability, a connection which is very interesting in itself, but which is, especially in psychology, not without its drawbacks.

Our research with the interactivity-pendulum has recently received some, at least, moral support from an unexpected corner, namely from the therapy of autism. For our purposes it is enough to know that autistic persons are severely impaired in their ability to communicate. The name itself refers to, and they themselves experience, a state in which the person is locked into him- or herself, isolated from the outside, having difficulty relating to other people. From outside they appear close and inaccessible, even mentally deformed.

There is an old suspicion that autism is somehow connected with rhythm, but it has never been more than a vague intuition, even though this connection seems evident enough when one observes the strange movement and way of speaking of autistic persons.

My immediate impression has always been that of an orchestra which plays off of different and incorrect scores: the composition the hierarchically organized, rhythmically interrelated whole, loses its harmonious flow; it freezes, falls apart.

Condon's research showed that the autistic person's rhythmical entrainment with other people is highly disturbed. Since this would also be true for the relationship to the mother one can safely assume that the autistic person never acquired the ability to integrate into a rhythmical temporal order, an ability which is lacking in all his interaction with other people.

Recent studies on autism discovered the surprising fact that autistic people can express themselves quite clearly if they are "supported" by a certain person. This support looks in most cases like this: the supporter lightly lifts or touches the hand with which the autistic person types on a typewriter. Naively put, it looks as if they are writing together.

And indeed, this phenomenon which has been named facilitated *communication* and enables many autistic persons to break through their isolation and communicate their rich inner life, has gotten a bad reputation because some of the messages produced seem to originate in the supporter; others are of such peculiar, at times even obscene nature that nobody wants to take credit for them.

Another problem with facilitated communication is the lack of reproducibility something we have by now learned to expect: namely, as the result of the complex interrelations of the phenomenon with such evanescent conditions as the mood and the relation of the participants to one another.

These problems as well as the difficulty with interpreting the results make our comparably simple and straightforward experiments with the interactivity-pendulum an interesting alternative for autism research.

It would take too much time to describe the results of our experiments in full; so I will only pick the one which is the most interesting for our discussions on interactivity.

We were interested in decision behavior and designed an experiment in which the subjects had to move the pendulum over a surface with six dots; the dots were arranged in regular intervals, about 6 inches apart, like the sixth face of a dice. The subjects were asked to hit these dots in random sequence as often as possible within a given time period.

They did this alone, in pairs and in groups of more than two people. The surprising result: two or more people operating together can decide as quickly and unambiguously as one. One caveat, though: they can, but they do not always do it, though it happens often. (They do it especially then when they are explicitly asked *not* to let themselves be guided by the other person.) At the moment we are investigating the conditions for these communal decisions and communal actions.

These surprising results paled, however, compared to the comments made by the participants: they said that they had the impression that the pendulum was acting on its own especially when there were three or more persons involved. It "makes its own decisions which are co-executed, co-authored, co-decided by the individual participants in a manner that is hard to describe." One experiences oneself as co-responsibleco-accountable, as operating in a state of consensual participation, without being the single author of the actual events. (Maybe in the way a parent feels responsible for the behavior of his or her children.)

The ominous "Gemeinwesen" (= communal spirit) that takes hold of the pendulum might well be the ghost that has been known to appear in the traditional seances with the Ouija board: I speak metaphorically and jokingly of an "it", of the "third man" or of a "We that is larger than the sum of I's."

Just to prevent hasty conclusions, no, we do not see ghosts. But, despite all commitment to methodological precision, we hesitate to ignore interesting phenomena just because they do not fit very well into our Western individualistic scientific world view. At the moment we still suspend judgment, at least officially. Unofficially we speculate without inhibitions. With respect to experimental work, we approach the phenomena from the side I already mentioned, namely from a theory of rhythmic coupling. To use Condon's words: it is the merging of *individual rhythmic order* in dyads, triads and interacting groups.

We investigated for example, the spreading of rhythmic entrainment in interacting groups, in situations where one participant hears rhythmic music over earphones, or by changing the properties of the pendulum. At the moment we are working in the area of high-frequency interactive coupling, studying processes which happen so fast that they are, so to speak, *above* conscious awareness. Think, for example, of the last phase of the pointing process or rapid saccadic movements of the eye.

By now, I think, we have worked our way long enough through the more or less sedimented results of empirical research. It is time to rise above the stony ground of facts and semi-facts on the wings of fantasy and speculation. In the end, there is nothing else to do if we want to cross the waters that separate these products of exact science from a guided and meaningful application in daily life.

Before all else we need to consider the role of interactivity in our communicating communities in the context of the monumental changes brought about by the rise of new "media."

This explosive development can hardly be conceived as biological evolution in the ordinary sense. All the more important to answer the question in what way it touches upon the biological principles which are responsible for our lives and survival in the long run.

Inter-individual interaction in human or animal communities this we can take as certain has been for most of history a matter of proximity: sensory proximity for which we have terms like "in sight, within reach, within shouting (or smelling) distance, in body contact." We might call this simply "presence." We form a community with those individuals of our species who are permanently close to us in this sense. Community in the sense of *uni*fication, and comm*uni*cation, and in the sense of adaptation to one single order (culture) which we develop and hand on from individual to individual, from generation to generation: which we develop and hand on through interaction via the bridge of a common rhythmic order in time. This fundamental connection, this relation of closeness, of adaptedness, and ongoing adaptation, we experience unless it is so self-evident to escape notice altogether as a feeling of belonging, a sense of acceptance by others and by the community, and as a basic set of values which determines what we agree to or reject, what we pay attention to, think, learn and do. Perhaps we can conceive of this fundamental value-giving as a form of meaning, but then it is a form of meaning which precedes any rational conception of meaning.

Communities whose members interact in permanent bodily presence, in physical proximity are biologically sedimented, that is, developed, tested and proven over millions of years. New media change the communal patterns of interactivity.

We are not even thinking only of the modern electronic, digital media. Already language was a step on the road to increased mediation. Just consider the case in which somebody tells us something that a third person, possibly someone who is already dead, has said. This is already more than the simple communication of a speaker to a listener. Writing can be seen as yet another step in this direction; in this case one can even do without the physical presence and proximity of the speaker.

The step to modern electronic media appears from this perspective almost dizzying: individuals become partially close who are at the same time unreachably far away. The symmetry of the relation of proximity can be changed and manipulated almost at will. Even persons who are long dead speak to us within our own four walls.

Such artificial influencing of the traditional inter-individual fabric of social relations, of the natural interactive order of proximity, opens up new spaces for the development of human society: paths leading to progress but also paths leading to decay. The latter threat we have to counter first by recognizing it as clearly as possibly. Here is my version of it.

By moving closer to distant, dead, or even artificial individuals we move away, at least partially from our natural proximate neighbors. They become indifferent to us and thereby easier to replace. Instead of loving our neighbor, not because, but **by** being close to him or her, we begin to judge them and compare them under the pragmatic aspects of utility. The natural, unifying circle of symmetrical interaction shows cracks, breaks apart. The We falls apart into separate individuals who enter into a contract with one another instead of trusting one another.

The immediate result of such a development is a rising individualism which the person experiences as increasing isolation that forces everyone to live for and by him-or herself and to view others as competitors or even enemies.

The fragmentation of the other into bundles of properties is supported by the new media in an alarming way. Properties which multiply, spread, and sell across media move into the foreground.

One does not need much imagination to recognize the central role rhythm plays in seducing us into this development. It is enough to 'zap' through the channels on radio or TV to make evident that among the most beloved people on this planet are those who produce banal love confessions accompanied by rhythmic shaking of the limbs. The irrationality with which their physical proximity is desired becomes evident in mass events like concerts in which the darling of the audience is to most people as visible as a flea in the flea circus.

Just one indication for the great importance of interactivity can be found in media events, where one can see the enormous effectiveness of the smallest amount of personal feedback in the sense of co-production in which I am aware of my influence on the events, perceive myself in the mirror of the effect of my decisions, and of my presence.

We can judge the effectiveness of even very indirect feedback from those TV programs in which a present, only audible, audience (which I experience as representative of myself) interacts with the events on the floor. This minutely small and only occasionally experienced 'waft' of a feedback is so important because it closes the circle of interactivity and supplements thereby the one-sided and partial proximity of the media events in the direction of natural human closeness.

Another important instance of this effect are the so-called therapy computer programs as, for example, the famous Eliza by Weizenbaum; their efficacy is little diminished by the knowledge of the 'patient' that he is only conversing with a computer program.

At this point we are only a step away from asking what we mean when we call something "real", or in German "wirklich." But before we are going to take this step and start thinking about the connection between interactivity and reality, we should I think deepen the concept of interactivity a bit more.

When I started to think about interactivity I thought first of activity, then of "actio et reactio" and finally of "inter-actio," i.e. interactivity (which was, as far as I know, not known to the Romans).

Interactivity, I imagined at first, as a series of action and reaction: I decide; I act; this means: something starts from me, originates with me. Then some thing approaches me from without, a thing not independent of my decision and my action, rather co-determined by me, which returns to me in this way and influences again my decision and action, and so on. In the case of two 'inter-agents' we need to reverse the sequence for the other, replace actio with reactio, and reactio with actio.

Whether the action moves this way or that is consequently a matter of perspective, depends upon the viewpoint from which I look at it.

At this point I decided to rethink the matter by taking interaction as a unified whole. I view it as a *closed circle* without beginning or end. (In principio erat interactio!) In this image action and reaction represent my own, linguistically reified separating of the circular process into aspects which I discriminate. I create them by putting myself into the circle; thereby I break the circle and linearize it. It seems there are two ways for me to look at it: as a circle and as a line.

This lead me like a vortex down into deep philosophical contemplation. There is not enough time to describe this amazing journey here. Only one insight which I brought back from my excursion I would like to relate to you, namely that it is erroneous to regard the first view, namely viewing it as a circle, as right and the other, viewing it as a line, as wrong; it is even erroneous to put one before the other. Here is where I think we have gone awry: the linear view predominates. We focus too much on what approaches us and on what leaves us. We suppress, however, how much what approaches us is also what leaves us, and how much what leaves us is also what moves toward us. The in and out, the before and hereafter, the if-then predominates: the chicken takes precedence over the egg.

This little expedition into deeper waters may give a premonition of the kind of problems which we can expect once we connect interactivity with reality; it gets even worse when we consider such audacious, if not irresponsible constructions as artificial or virtual reality.

We could, for example, ask ourselves how natural or how artificial (virtual) my interaction with a *virtual* therapist is. Or we could ask ourselves how one should understand a *virtual* interaction with a *real, natural* therapist. Maybe we should ask ourselves whether there is such a thing as reality without interaction, whether the end of interactivity in constituting my end, not also constitutes the end of reality.

The distinction between real/natural reality and artificial/virtual reality can perhaps be made easier with the help of the concept of interactivity: namely, by separating a biologically successful, engulfing, naturally occurring and familiar form of interaction from an interaction which deviates in major aspects from the first. In the end we need to consider that even the concepts of interaction and reality have been developed in the context of interactional processes in which I myself participate along with other I's and We's.

Based on our considerations to date I might summarize our current position as follows: I experience reality

- by experiencing myself as present in the (interactive) feedback, in the effect of my latest decision;
- by experiencing biologically important sensations (for instance, pain or hunger); through behaviors that have proven to be successful for a long time; simply by surviving;
- by experiencing according to expectations – based on the experience of the individual as well as of the community that have been successful so far;
- by taking **my** experience as real, or rather by taking **our** experiencing as real.

One can derive a large number of questions from these statements, as for example, the one about possible discrepancies between the individual and communal reality. (One can think, for example, again about science and repeatability). One can generate another set of questions by simply moving and rearranging concepts, as for example, when asking after the reality of virtuality, irreality, etc.

A third set of questions develops from the opposition of experience and survival. This one tells us, for example, that the experience of reality has little to do with high-fidelity, since even deaf-blind people have an experience of reality. It has rather more to do with survival: with the long-term conditions of our conscious being, those that are innate and those that have been acquired. Virtual survival does sound pretty meaningless, belonging into the same category as virtual food, virtual pain, virtual desire and virtual problems.

These questions all have one thing in common: they lead straightway into bottomless pits and can only be answered through correspondingly fundamental theoretical constructions. Though there is no denying their attraction. But we have, at least this time, more practical things in mind: media, especially the modern interactive, digital media.

Seen from the vista point that our efforts have helped us reach, all media appear as developments of natural, planned and long-tested interactivity.

At present, the problem that is most urgently demanding a solution is how we can goad this development into taking the most desirable course for us. The best way to finding this meaningful course is through a study of the natural, traditional, proven form of interactivity and try to continue in its course. This means also that we have to be able to diagnose quickly when the development has gone awry, that is, to identify early signs of disturbed interactivity – especially in connection to the media.

Any such indication of disturbed interactivity of a general kind and the signs are hard to ignore in our days one should also study with regard to media. I think in this context of two very impressive examples: one is the disappearing unity of giving and taking in ordinary social exchange, literally the disappearing of the "give-and-take." We give in order to take, but we do not take in order to give! We consume by taking away from others, by using **up** when we should be only using. We take from the community (and from nature) without creating a balance through giving. Then we are surprised when we get alienated from our community (and nature), when we experience animosity in the contact, when it *takes* without giving.

The second example concerns the thoughtless manipulation of the preconditions of our social behavior that are naturally given and tested for interactivity: we kill without effort and without confronting the other whose life we are ending either through sight, sound, smell or touch.

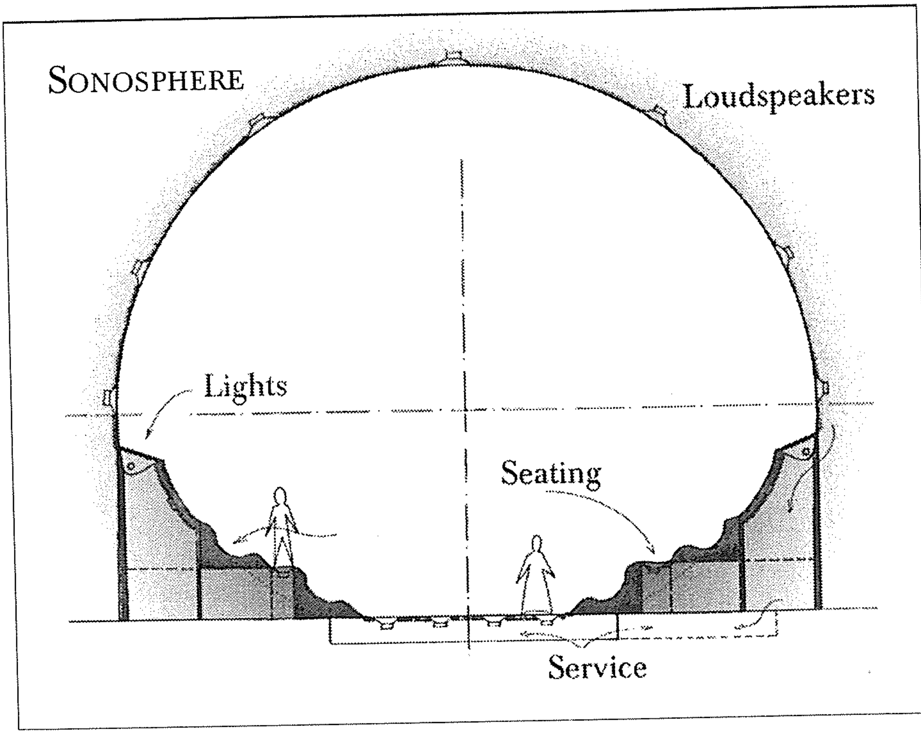
It is not my intention to preach to you. But the warning to caution with regard to media seems indicated. Especially when one is dealing with the media we call interactive. As they are becoming more natural, more real, they also become more effective . . . for good as well as bad.

The meaning of *virtual* worlds, *virtual* experience, lies in *real* life; let us state this even stronger: lies in *developing*, and improving real life. Or are we looking for an electronic paradise for an electronic Ego?

Confronted with the new media I feel a little like a child that has been granted too many wishes: I wished I knew what I wished for; I wish for wishes.

Such meditation probably inspired me to take an old project out of the back drawer: the project "Sonosphere"[14], which I developed years ago for the Residenztheater in Munich. Its precedent had been the multimedia child of the psychedelic age: a spectacle of many coupled film projectors, laser canons and electronic music, projected 180 degrees into a cupola. The audience liked the show, but over the years it lost its splendor. So on the occasion of a new production of the spectacle I was asked to think of a way to revive its old glory.

My proposal was the "Sonosphere" which also involved a cupola-projection, but it this time it was a projection of nothing: We produced a homogeneous illumination almost at the level of daylight in a cupola, which was painted matte white on the inside (called Ulbrich's Globe and also called a "Ganzfeld."). This means that there is no shadow – an effect comparable to snow-blindness. An observer inside this cupola finds him- or herself within a short period of time in a state of wakeful meditation with hallucinogenic, dreamlike experiences. This endogenous experiencing, let's call it a day dream, should be guided and co-determined by electronic mu-



sic. (I say "should" because the project has so far not managed to grow far beyond its pilot installation in which the cupola is 2.5 m in diameter.)

I was conceiving of this production of *guided hallucination* in the way in which a dream can be guided by outside events. I was also thinking of the way in which words and sentences (and pictures) determine inner mental imagery; how they guide fantasy production. They can take us into worlds which one could not have entered without the assistance of the artist and the poet. In this way one gets experiences which one welcomes as enriching, beautiful, pleasant and interesting. . .

The happenings in the Sonosphere follow the reverse course from events in virtual reality. Certain decisions in the flow of my experiencing are handled for me by the program which, in this case, is a piece of music or literature. I make the decisions of the program my own and produce the accompanying sensory events, especially in the form of images.

Virtual reality, or whatever is usually called by that name, goes in the opposite direction: I take certain decisions, the program produces the fitting sensory events – by adjusting the scenery on the computer screen, for example, to my move through a building in cyberspace.

Both methods can function as tools for artistic production and communication. But the most promising form appears to be a balanced combination of both: a configuration which is parallel to the natural circle of reception and production – i.e. interaction. ❋

FOOTNOTES

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[5]ibid.

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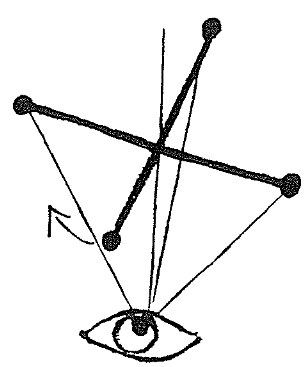

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Outside speakers (so far) Prof. Bruce Rosenblum (UC Santa Cruz) and Prof. Louis H. Kauffman (UI Chicago); local: Etter, Noyes, Young.

Alternative Natural Philosophy Association

Statement of Purpose

1. The primary purpose of the Association is to consider coherent models based on a minimal number of assumptions to bring together areas of thought and experience within a natural philosophy that is alternative to the prevailing scientific attitude. The combinatorial hierarchy, as such a model, will form an initial focus of our discussion.
2. This purpose will be pursued by research, conferences, publications, and any other appropriate means including the foundation of subsidiary organizations and the support of individuals and groups with the some objective.
3. The association will remain open to new ideas and modes of action - however suggested - which might serve the primary purpose.
4. The Association will seek ways to use its knowledge and facilities for the benefit of humanity and will try to prevent such knowledge and facilities being used to the detriment of humanity.