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Theory in Psychology: A Reply to Tryon's "Measurement Units and Theory Construction"

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Tryon advises psychologists to construct theories as physicists do, and claims that a theory of physics is a system of algebraic relations which constitute the definitions of new concepts and their units of measurement in terms of existing ones, at least two basic units being initially adopted. He says that these algebraic relations create a knowledge hierarchy, which he considers a theory. In reality, only some of the mathematical relations of physics are definitions, which introduce new tools, while the rest of them express the "laws of nature," the discovery of which is the primary objective of science. Tryon also says that these algebraic relations express quantitative, logical, and conceptual equivalences. He is wrong again, because only the relations that constitute definitions express conceptual equivalences, while the laws of nature are discovered either by making measurements or by constructing theories. Tryon says nothing about the discovery of the laws of nature either way, and appears to consider the concept of "law of nature" as unscientific. He also believes that measurements serve only to determine the characteristic properties of substances. In this article, the usefulness of the concept of "law of nature" is illustrated, and more importantly, the method of theory construction used in physics and the way in which it can be adapted to psychology are explained.

Tryon's article "Measurement Units and Theory Construction" (1996) reflects most strikingly the incorrigible inclination of "scientific" psychologists to abstain from theory construction and the study of the unconscious. Tryon attempts to reduce theory to measurement, and psychology to behaviorism, by using physics as a model for psychology and ignoring Freud's work completely. Accordingly, a physical theory is constructed as follows: (1) at least two fundamental units of measurement are adopted; (2) these basic units are combined algebraically in various ways to define derived concepts

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and units of measurement, and then all units are further combined in several successive steps to create a knowledge hierarchy, which constitutes a theory; (3) measurements that are reliable, valid, and accurate are made using the basic and the derived units; and (4) the characteristic properties of substances are thus determined.

Definitions, Laws, and the Units of Measurement

One of Tryon's examples of algebraic relations used in physics to define derived concepts and derived units of measurement is the equation that defines density in terms of mass and volume: d=m/V, or m=d.V. Tryon does not explain how this relation was found, although he advises psychologists to create such relations in their science. The truth is that this algebraic relation represents a "law of nature" that can be verbally expressed as follows: "The mass of a pure element or chemical compound is uniformly distributed over its volume at macro dimensions, and this is true also about sufficiently homogeneous mixtures. In mathematical terms, the mass of such s substance is proportional to its volume, and the constant of proportionality is a characteristic property of the substance on which the measurements are made, called the density of that substance."

The law about the distribution of mass was undoubtedly derived initially from ordinary experience in rough quantitative form, without having a clear concept of mass, and using weight as a measure of mass. Later, this law was expressed mathematically, made more and more accurate through measurement, and the concept of mass was given a clear scientific meaning. Thus, the concept of density and its unit of measurement were defined on the basis of the "empirical law" of mass distribution.

Another one of Tryon's examples of algebraic relations used in physics to define derived concepts and units is the equation f=m.a, which was formulated by Newton as the final law of motion. Tryon says that Newton "derived" the concept of force from this algebraic relation, as the product of mass times acceleration. Newton *defined* only acceleration as the time rate of change of the speed, or the first order derivative of the speed with respect to time, represented by the equation a=dv/dt. Tryon considers the law of motion, f=m.a, a quantitative, logical, and conceptual equivalence. He does not say how Newton discovered, or conceived of, this relation, although he advises psychologists to create such relations in their science too. His interpretation of this law of motion contains several mistakes, as explained below.

Newton did not derive the concept of force from anywhere. This concept can be considered as old as the human race, because it is an anthropomorphic concept derived from experiencing weight, inertia, friction, elasticity, impact, and the muscular force of other persons and animals, long before clear ideas about the nature of these phenomena were acquired. Countless philosophers used the concept of force in vague forms that correspond to various modern concepts such as energy, potential, power, and even concepts such as ability, free will, authority, divinity, and so forth. Consequently, force was considered the cause of existence, life, action, motion, and so on. Newton introduced this old concept of force into physics in a precise, quantitative form through the relation f=m.a, but not as a definition, as explained below.

Before Newton and Galileo, the prevailing belief about the causation of motion was that the continuous action of an agent, or force, for example muscular force, was necessary to keep a terrestrial body moving, celestial bodies being assumed to move in circles by themselves. Galileo discovered that this continuous effort, or force, was made necessary by friction, which slowed down moving bodies; he maintained that a moving body, if left alone, would conserve the direction and the magnitude of its speed. Later, Newton called this rule the "first law of motion." Galileo further claimed that the direction or the magnitude of the speed of a body could be altered only by the action of a force, in conformity with the above first rule. Newton called this second rule the "second law of motion," and by making use of the existing concept of force and the new concept of acceleration which was defined by him, he gave it a mathematical form and thus created the final law of motion. Galileo derived his two rules of motion from his experiments on the motion of bodies on the inclined plane and from his studies of the parabolic trajectories of projectiles. He even expressed the changes in speed numerically, without using a mathematical relation as Newton did, because he lacked the concept of acceleration which was later defined by Newton using differential calculus (also invented by him). Thus, Newton defined only the concept of acceleration mathematically, whereas the relation f=m.a is the mathematical expression of a "law of nature" which was derived from experiment by Galileo, first in a non-quantitative form concerned only with the existence or non-existence of any change in speed, and then in rough quantitative form not expressed by a mathematical relation. To repeat, Newton *defined the concept of acceleration* using differential calculus, which he had invented, and *defined the unit of force* using the existing concept of force and the empirical law of motion discovered by Galileo. Moreover, it is highly probable that Newton was led to the concept of *differential* by Galileo's numerical discoveries about the changes in the speed of falling bodies. But *he did not derive the concept of force or define the law of motion*.

But, the definition of acceleration by Newton, the second rule of motion discovered empirically by Galileo, and the existing anthropomorphic concept of force are not sufficient to formulate Newton's final law of motion, because this law contains also the concept of mass. Galileo's numerical discovery about the motion of falling bodies and projectiles means no more than that they all fall with the same acceleration. Newton may have discovered the mathematical relation between force and acceleration as a result of a thought like this: "Two horses can impart to a load twice the acceleration one horse can impart to the same load," or, "when the load pulled by a horse is doubled, the acceleration imparted to it is reduced to half" (Omnès, 1973). Thus, mass appears to be a characteristic property of matter that resists acceleration, which is called the "inertial mass." Without an experiment like this, actually carried out or only thought of, it is not possible to say that the acceleration is proportional to the force, mass being the constant of proportionality in this mathematical relation. All this means that the relation f=m.a or m=f/a can very well be considered the definition of mass, instead of the definition of force. In fact, we will see that this is necessary in some systems of units, and that moreover, even the form of the law of motion can change, and it can be variously interpreted, depending on the units used. These possibilities further prove that the law of motion is derived from experiment no matter what form it is given and how it is interpreted.

The international units of length and time, the meter and the second, were defined in 1791 and were later redefined in a more accurate and reliable way. Together with the meter, a unit of weight, called the kilogram, was introduced and was originally defined as the weight of a cubic decimeter of water at 4°C. Then a prototype body was manufactured to represent this unit of weight. But because weight was known to be a force, this prototype body was considered to represent the unit of force, called the kilogram-force, by its weight at the place where it was kept, in Sèvres, near Paris. It is necessary to specify the location, because the weight of a body changes with latitude. The same prototype body was considered to represent the unit of mass by its mass, called the kilogram-mass, or simply kilogram.

In the mks system, meter, kilogram, and second are the basic units. In the cgs system, centimeter, gram, and second are the basic units. In the mk(force)s system, meter, kilogram-force, and second are the basic units. As a general rule, every equation expressing a law of nature contains a constant, or factor, of proportionality, of which the numerical value depends on the chosen units of measurement, and which serves to make the equation hold numerically. Accordingly, the general form of the law of motion is f=C.m.a, where C is the constant, or factor, of proportionality (Sena, 1972, p. 23).

In the mks system, C is arbitrarily taken as unity for simplicity, and the unit of force is defined as the force required to impart an acceleration of 1 meter per sec per sec, or 1 m/s^2, to a mass of 1 kg, as Tryon mentions. This unit of force is called the Newton. In the cgs system, the constant of proportionality is again taken as unity, and the unit of force is defined as the force required to impart an acceleration of 1 cm/s^2 to a mass of 1 gr. This unit of force is called the dyne.

But in the mk(force)s system, the unit of force is already defined as a basic unit, whereas the unit of mass is not defined. Therefore the equation $f=C.m.a$ is used to define the unit of mass, instead of the unit of force, by again taking C as unity. The unit of mass thus defined, which has not been given a name, is the mass of a body which acquires an acceleration of 1 m/s^2 when a force of 1 kg(force) acts upon it. Thus, in the mk(force)s system, the relation $f=m.a$, or $m=f/a$, defines the concept and the unit of mass, instead of force. This means that the choice of units is arbitrary, as Tryon implies, but the mathematical relations that connect the values of the physical quantities measured in these units are the laws of nature even when the constant of proportionality is arbitrarily eliminated from them, excepting of course the relations that really express definitions, such as $a=dv/dt$.

The constant of proportionality cannot be eliminated from Newton's law of universal gravitation in any of the above unit systems, because the units of all the quantities that appear in it are already defined as explained above. Therefore this law has the form $f=G.m.m'/r^2$, which Newton verbally expressed as follows: "Every body attracts every other with a force directly proportional to the product of their masses and inversely proportional to the square of the distance between them" (cited in Russell, 1961, p. 521). G is the constant of proportionality, called the gravitational constant, which is required to make this equation hold numerically, and of which the numerical value is $G=6.67(10)^{-11}$ $m^3/kg.s^2$ in the mks system.

Tryon did not include in his article the above equation which expresses the law of gravitation and did not qualify it as a logical, conceptual equivalence, evidently because the units of all the quantities that appear in it are already defined and therefore it contains the constant of proportionality G. But despite this fact, the law of gravitation in the form $G=f.r^2/m.m'$ can be considered a logical, conceptual equivalence defining a characteristic property of the universe, namely, the gravitational constant G. But this interpretation does not alter the fact that this mathematical relation expresses a law of nature just like the laws of motion and mass distribution. We will see how it was discovered by Newton.

Now, the law of gravitation in its general form $f=C.m.m'/r^2$ can be used to define the concept and the unit of force in a new mks system (Sena, 1972, p. 27), instead of the law of motion as in the usual mks system. In this new mks system, the constant of proportionality C can be taken as unity, and the unit of force can thereby be defined as the gravitational force of attraction between two masses of 1 kg each, situated at a distance of 1 m from each other. This "gravitational unit of force" is sometimes used in astronomy. In this new mks system, the constant of proportionality in the law of motion $f=C.m.a$ cannot be taken as unity because the units of all the quantities that appear in it are already defined. Therefore C, the "inertial constant," has to be measured, or calculated as shown below.

The same quantities being measured in the two mks systems:

In the usual mks system: $f=m.a$ and $f=G.m.m'/r^2$

In the new mks system: $f'=C.m.a$ and $f'=m.m'/r^2$

By dividing respectively: $f/f'=1/C$ and $f/f'=G$ hence $C=1/G$

Thus, the inertial constant C has the value: $[6.67(10)^{-11}m^3/kg.s^2]^{-1}$, or $1.5(10)^{10}$ $kg.s^2/m^3$, and the final law of motion in this new mks system is $f=1.5(10)^{10}.\ m.a$ (Sena, 1972, p. 28). This equation does not express a logical, conceptual equivalence in the way f=m.a does; but again, this law of motion f=C.m.a, or C=f/m.a, can be viewed as a logical, conceptual equivalence defining a characteristic property of the universe, namely, the inertial constant C. This interpretation too does not alter the fact that the law of motion was derived from experiment.

It is also possible to adopt only two basic units, for example meter and second, and define the unit of mass by using an appropriate law of nature (Sena, 1972, p. 51). Alternatively, four basic units, instead of two or three, can be adopted, for example meter, kilogram, kilogram-force, and second. It is evident that as the number of the basic units increases, the chance of eliminating the constant of proportionality from the laws of nature diminishes, because the chance of using these laws to define new units diminishes; and therefore the possibility of giving the appearance of definition to the laws of nature diminishes.

Concerning Newton's final law of motion f=m.a, Sena (1972, p. 24) says: "It should be remembered, however, that actually the factor of proportionality is 'invisibly' present in every such formula. Forgetting this often leads to misunderstandings and serious errors." This is the mistake made by Tryon. On the other hand, as Sena (1972, p. 25) points out, the division of relationships into "definitions" and "laws" is not absolute but depends on the point of view. For example, the concept of force, defined on the basis of any physical phenomenon, can be considered a theoretical tool that does not correspond to any physical reality, but exists only through a definition, as pointed out by Russell (1961, p. 24): "The modern physicist, therefore, merely states formulae which determine accelerations, and avoids the word 'force' altogether. 'Force' was the faint ghost of the vitalist view as to the causes of motion, and gradually the ghost has been exorcised." Relativists refer to the gravitational force as the "monster of gravitation." The concept of mass too can be derived, for example, from the concepts of length and time, as mentioned above, and can be considered to exist only in the human mind. Einstein even said that all theories of physics are mental constructs that do not correspond to anything in the physical world. And relativists tried to reduce physics, with all its concepts, to geometry, giving the name of "geometrodynamics" to this new science. But this new science has not been viable, and the concepts of force, mass, and so forth are still used in all areas of physics most profitably. It appears that Tryon wishes to give to psychology an ultramodern outlook which has not yet been achieved even in physics, and he has wrong ideas about how this can be realized. Even the most modern theories of physics were not constructed using arbitrary definitions, measurements, and mathematics, as he believes. Only some of the mathematical relations used in physics are definitions that introduce new concepts as tools, such as the definition of acceleration; others express the laws of nature which are discovered either by making measurements or by constructing theories as explained below.

Theory Construction in Physics

We have seen that the law of mass distribution was initially derived from ordinary experience in rough quantitative form and was then made accurate through measurement; and the final law of motion was formulated by Newton on the basis of the results of the experiments and observations made by Galileo, who began by enunciating a non-quantitative rule about motion and finally discovered a numerical rule about the motion of falling bodies, namely, the constancy of the acceleration. But the formulation of the law of gravitation by Newton necessitated much more theoretical thinking than the discovery of the two laws mentioned above.

Tryon's explanation of the origin of the law of gravitation, which he says was "proposed" by Newton, amounts to saying that Newton arrived at this law by generalizing the fact that falling bodies have a constant acceleration. This explanation is evidently insufficient, because the acceleration of the planets is not constant, and a complex relation such as $f=G.m.m'/r^2$ cannot be arrived at by making a simple generalization. Moreover, the use of a mental operation such as generalization, which yields only hypothetical knowledge, does not fit Tryon's scientific method of making use of only measurements and mathematics. It appears that, because Newton used generalization in arriving at the law of gravitation, and also because his celestial theory is replaced by Einstein's theory, Tryon considers the law of gravitation as "proposed," not as a scientific discovery. In any case, we need to know how Newton arrived at this law if we wish to understand how theories are constructed.

On the basis of Tycho Brahe's records of the results of his observations on the motion of the planets, Kepler discovered that the planets move on elliptical orbits, and deduced numerical rules about these orbits, which are called "semi-empirical laws." Newton, using differential calculus, found that each planet had an acceleration toward the Sun, of which the magnitude was inversely proportional to the square of the planet's distance from the Sun, but was independent from its mass. This much was certain knowledge based on measurement and mathematical deduction. After this, Newton could make a generalization from terrestrial motion to celestial motion and assume that just as the constant acceleration of a falling body is caused by the constant force which is its weight, so the acceleration of a planet toward the Sun, which is inversely proportional to the square of its distance from the Sun, must be caused by a force inversely proportional to the square of its distance from the Sun. But, this argument does not disclose the cause and the nature of the force acting on the planet, and is not sufficient to yield the complete law of gravitation.

Evidently, it is not possible to know precisely the generalizations and the mathematical deductions that Newton really made, because what seems to us like a generalization may have been deduced mathematically by Newton from the result of another generalization that he really made; and moreover, what looks obvious to us may have looked improbable to him. But the result he obtained can be considered today to involve several interconnected hypotheses, such as: (1) forces can act from distance; (2) weight has the same origin as gravitation; (3) the terrestrial, anthropomorphic concept of force is valid also in celestial mechanics; (4) the terrestrial law of motion is valid in celestial mechanics as well; and (5) the inertial mass which appears in the terrestrial law of motion is identical with the gravitational mass that appears in the law of gravitation. This identity of the two concepts of mass plays an important part in the general theory of relativity as a fact, but as far as Newton's theory is concerned, physicists consider it an hypothesis.

It is known that Newton was bothered by at least some of the hypotheses he used in constructing his theory of terrestrial and celestial mechanics. For example, he thought that a medium should exist that could transmit the action of the gravitational force (Russell, 1961, p. 524), but no such medium was known. He published a booklet titled, *Can Gravitational Attraction Make Bodies Fall?* (see Boslough, 1995, p. 22). This shows that Newton had the idea of gravitational attraction before he saw that weight was caused by gravitation, contrary to the popular belief reflected by the anecdote of the falling apple, which is probably the source of Tryon's idea of the generalization made by Newton. But despite all his scientific scepticism, Newton went ahead and completed his theory of terrestrial and celestial mechanics which contains both the law of motion and the law of gravitation. The profound basis of Newton's conviction that "every body attracts every other" can be found in his life experiences[1] (see Löker, 1987, 1993a, in press). It appears that Newton conceived of the laws of motion and gravitation in rough quantitative forms by perceiving analogies between his predecessors' empirical findings and some

[1] When Isaac Newton was five years old, his mother left home and settled in a nearby village. She never visited her son. It is evident that Isaac experienced the warmth and attraction of his mother from a fixed distance all through his childhood. Inevitably, he later saw the analogy between his childhood relationship with his mother, of whom he was born, and

events (and even emotions) of his childhood, and then gave to these laws mathematical forms by integrating them with those empirical findings. But evidently, this theory needed to be tested empirically, because several generalizations were used in its construction. Moreover, both the final mathematical, numerical formulation of the theory and its empirical testing necessitated much quantitative knowledge about terrestrial and celestial dimensions and masses. Newton had to wait for twenty-five years for the correct estimation of the circumference of the Earth by others, based on measurement, to test his theory definitively. He used for this test the tide of the oceans caused by the gravitational attraction of the Moon and the Sun, because this is the most direct way of testing the hypothesis of gravitational attraction.

All theories of physics were constructed by using, basically, the above described method, which can be formulated in general terms as follows: a theory is constructed by integrating at least one hypothesis with known facts (Löker, 1987, 1993a, in press), as is very well known by physicists today. In practice, a fact is either a characteristic property of an object, substance, or event, expressed by a number, or a causal relationship expressed by a mathematical relation, not counting the relations that are definitions of tools. As science progresses, the characteristic properties of objects, substances, and events are theoretically explained and calculated by means of equations that express causal relations. An hypothesis too is a fact in the above sense, but one that cannot be empirically tested or deduced from an existing theory at the time the new theory is constructed. Additionally, a usable hypothesis has the potentiality of being integrated with known facts, or rather, this possibility of integration makes the hypothesis usable and constitutes its preliminary testing. The operation of integration makes the hypothesis compatible with known facts mathematically, numerically. The theory thus constructed is tested as a whole by comparing some of its mathematically, deductively reached consequences with known or newly discovered facts that have not been used in its construction. The hypothesis that the theory contains is thus tested together with the whole theory. A theory serves to explain, predict, and control facts. In reality, each new application of a theory is a new test of it, and when facts that do not fit the theory are encountered, a more general theory becomes necessary. But the old theory does not become totally invalid, unscientific; it remains in use within its limits of validity, because it

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the relationship between the Earth and the Sun, the former being "born" of the latter and being warmed by it, and therefore attracted by it in accordance with this analogy. We also see that the identity of the gravitational and the inertial masses, the former causing acceleration, or motion, and the latter opposing it, is analogous to the ambivalence in Newton's emotions toward his mother. Moreover, this ambivalence has undoubtedly helped him to conceive of the final law of motion too, because this law says that a force of any origin causes acceleration, or motion, but the body on which it acts resists being accelerated, or moved, due to a quality of its own.

is usually easier to use than the more general theory. Moreover, just like the hypotheses used by Newton, all hypotheses of physics have been conceived of as results of mental operations called analogy, generalization, and induction, often in a rough quantitative form, and then given a mathematical, numerical form through integration with known facts; and these three mental operations can be considered to be basically the same operation (Löker, 1987, 1993a, in press). For example, the above mentioned facts about scientific progress through the conception of hypotheses and the construction of theories are also expressed by Russell (1961) in his book *History of Western Philosophy:*

> Scientific method . . . seeks to reach principles inductively from observed facts. (p. 58)
>
> An induction has less cogency than a deduction, and yields only a probability, not a certainty; but on the other hand it gives *new* knowledge, which deduction does not. All the important inferences outside logic and pure mathematics are inductive, not deductive. (p. 209)
>
> Induction is an independent logical principle, incapable of being inferred either from experience or from other logical principles, and . . . without this principle science is impossible. (p. 647)
>
> The men who . . . founded modern science had two merits which are not necessarily found together: immense patience in observation and great boldness in framing hypotheses . . . . The test of scientific truth is patient collection of facts, combined with bold guessing as to laws binding the facts together. (p. 514)
>
> As a rule, the framing of hypotheses is the most difficult part of scientific work, and the part where great ability is indispensable. So far, no method has been found which would make it possible to invent hypotheses by rule . . . . When a hypothesis has to be tested, there is a long deductive journey from the hypothesis to some consequence that can be tested by observation. (p. 529)
>
> The thing that is achieved by the theoretical organization of science is the collection of all subordinate inductions into a few that are very comprehensive — perhaps only one. (p. 530)

When a theory is built around an hypothesis, it is often the theory as a whole that is tested, because the hypothesis cannot be tested in isolation from the rest of the theory — the precise reason it is called an hypothesis. Although Russell does not seem to be concerned with the practice of theory construction and therefore does not explicitly say that hypotheses are conceived of inductively and are integrated with known facts to construct theories which are tested deductively and empirically, his statements imply this process. The attitude of physicists toward the great theories of physics more than suggests that these theories were not deduced mathematically from measurements and logical definitions, as Tryon wants us to believe.

As mentioned, Newton did not publish his theory for twenty-five years, because he waited for the empirical data by experimental physicists. When Maxwell constructed his theory of electromagnetism, he did not publish it, because he tried to deduce it mathematically from existing knowledge, using old concepts such as vortices. But after writing voluminously, Maxwell realized that he was attempting the impossible as well as the unnecessary. He therefore deleted much of what he had written, and published his theory as it was proved through its consequences such as the calculation of the speed of light in terms of other constants. Even this calculation was hypothetical at that time. Planck provided the concept of quantum and produced a theory that explained the peculiarities of black body radiation, but he hesitated a whole year before he published it and only then upon the insistence of his son. He spent the rest of his life trying to reduce the idea of quantum to classical concepts. For many years, physicists did not know where to put the theory of relativity, and some of them rejected it forcefully. Einstein, of course, contributed to the development of the quantum theory, but never accepted it as the final solution of the problems it treated. These great thinkers would not hesitate to publish their theories and to subscribe to the theories of others if theories were constructed using logical equivalencies, measurements, and mathematics, but involved no *uncertain* hypotheses.

Tryon appears to consider the law of gravitation unscientific because it contains a constant of proportionality, because it is "proposed" by Newton upon making a generalization, and also because it is replaced by the equations of the theory of relativity. Ignored by Tryon is that Einstein too, like Newton, conceived of the hypotheses he used in his theories by generalizing some events of his childhood and youth (Löker, 1987, 1993a, in press). At that time, it was thought that the Earth was moving and light was propagating in a medium with very peculiar characteristics, called *ether*, and that therefore an *ether wind* should exist around the Earth and should influence the speed of light with respect to the Earth. Michelson and Morley performed an experiment designed to detect a difference between the speed of light in the direction of the motion of the Earth and its speed in an orthogonal direction. No such difference was observed. Generalizing this result, as written in textbooks, but also generalizing some events of his life, as mentioned above, Einstein hypothesized that the speed of light in vacuum was a universal constant. This hypothesis became the mathematical basis of the restricted theory of relativity, the basic equations of which express the relativity of the measurements of space and time, in conformity with the rough idea of relativity which Einstein had also derived from his life experiences through analogy, or generalization. And the very name of the general theory of relativity exposes the fact that it is a product of a generalization related to the hypothesis of relativity.

Theory Construction in Psychology

What Can Be Learned From Physics?

Based upon his conception of theory construction in physics, Tryon advises psychologists to construct theories by adopting the mks system of units, using mathematics, defining derived units, and making measurements. We know that this is not how theories are constructed in physics. Moreover, the general use of mathematics and measurements is not achieved in psychology yet, despite the efforts of many psychologists. Besides, what Tryon hopes to achieve is the creation of a "behavioral physics," which means returning to behaviorism and denying the status of science to the study of mental phenomena.

We see that Tryon wishes to transfer to psychology some particular features, or methods, of physics, such as the use of mathematics and measurements, instead of the general method of theory construction, which he ignores. This is in fact the mentality of all "scientific" psychologists today. In reality, it is the most general methods and concepts of a discipline that can be expected to be useful also in other disciplines of science. Consequently, the general method of theory construction used in physics, as described, can be used in psychology too — but first the method needs to be adapted to psychology. The concept of "laws of nature" too can be used in psychology in the form of "laws of mental phenomena" or "laws of psychology," because the primary objective of science is the discovery of the laws of nature as constituents of theories.

In the absence of the mathematical language, the use of verbal language can continue in psychology; and the mathematical, numerical logic used in physics can be replaced in psychology by verbal, non-quantitative or rough quantitative logic. In this way, the integration of the facts and the hypotheses, and the deduction of consequences, can be realized in constructing and testing theories. Even non-quantitative knowledge, meaning knowledge about the existence or non-existence of a psychological condition, or phenomenon, is much needed. But rough quantitative concepts, such as mild versus intense fear, can also be used.

Another important physical concept, or tool, namely, force, needs to be replaced in psychology by another concept, because the concept of force cannot be used in relation to mental phenomena. In physics, the interactions of diverse phenomena such as falling bodies, vibrating springs, frictions, impacts, pressures, and so forth, are described and explained as interactions of forces of various origins. Thus, all these phenomena are conceptually integrated in the theories of physics using the concept of force. But because the unifying concept of force cannot be used in psychology and is not replaced by another concept, psychologists are unable to construct theories, and they therefore study mental phenomena only experimentally by isolating them from each other, instead of integrating them conceptually as physicists do. In reality, the method of studying phenomena by isolating them from each other is more suited to physics than to psychology, because many a physical phenomenon is often causally independent from other phenomena. For example, the orbit of a planet is totally independent from its mass, volume, shape, chemical composition, and the phenomena that occur on it or in it. This simplicity does not exist in psychology. Mental phenomena are influenced by each other and by the physiological and environmental conditions because they have functions related to each other and to the needs of the organism as a whole. Despite this, physicists integrate various types of phenomena conceptually in their theories, whereas psychologists study the phenomena only experimentally by isolating them from each other by selecting the samples very carefully and using control groups. Some types of valuable knowledge can of course be obtained in this way, but the exclusive use of this method prevents the understanding of the integrated functioning of the human mind, and makes psychology a fragmented science. Many psychologists are bothered by this situation, as voiced by Sarason (1989, p. 263) in this journal: "As a broad, sprawling field, American psychology has become increasingly molecular, making it inordinately difficult to discover an overarching conception that would counter the centrifugal forces that make psychology a conglomeration of interests for which there is no organizing center."

Evidently, a unifying concept is needed in psychology that can be used to explain the interactions of various types of phenomena, just like the concept of force is used in physics for the same purpose. Additionally, at least one hypothesis is needed that can make the logical integration of facts possible by making use of the unifying concept, for creating a theory.

The "Mechanism" of Mental Causation, or Mental Response

The unifying, or "organizing," concept and hypothesis needed in psychology can be found only by noticing a crucial difference that exists between the laws of physics and the laws of psychology. The physical universe is evolving, but the laws of physics remain unchanged as far as we know. In opposition to this, the very laws of psychology evolve in a way that secures survival and adaptation to the environment more and more effectively. Thus, the laws of human psychology are not the same as the laws of bird psychology or bee psychology. Moreover, even some of the secondary laws of human psychology can be expected to be influenced by physiological and environmental conditions, in conformity with the basic laws determined by evolution.

Because the laws of psychology, or mental causation, are determined by evolution functionally, they cannot be discovered and explained without considering their functions. Perhaps in the future all mental phenomena can be explained in terms of brain processes, and these can be explained mechanistically; but today, mental causation, or response, can be explained only functionally, and trying to explain it mechanistically looks absurd. Functionality is the reason why mental phenomena are naturally integrated, or interrelated, having functions related to each other and to the needs of the *human being as a whole*. Thus, functionality is the *unifying fact* of the mental world, and hence it has to be the *unifying concept* to be used in psychological theorizing.

A mental phenomenon can be explained mechanistically only in terms of a physical/physiological agent that is known to be its direct cause. For example, aphasia due to a clogged blood vessel in the brain is such a phenomenon, or condition. But, this illness is not a mental reaction caused mentally in accordance with the laws of the mental world, or the laws of human psychology. In opposition to this, psychogenic aphasia, or aphasia caused mentally, has a knowable function. In fact, all symptoms of mental disorder that are not directly caused by physical/physiological agents have precise adaptive functions (Löker, 1976, 1987, 1989a, 1989b, 1993a, 1993b, in press). Mental causation, or response, in the absence of organic defects is always functional, the ultimate function being successful adaptation and survival.

But this does not mean that a function has to be invented, or guessed, for every mental phenomenon. Psychologists know very well that guesses made on the basis of functionality often turn out to be wrong, and research is necessary to discover the truth. This is so, evidently because a guess, or hypothesis, or inductive thought, yields uncertain knowledge that needs to be tested empirically. What is needed is not to invent an hypothetical function for every particular mental phenomenon, but to frame a general hypothesis based on the reality of evolution and to integrate it functionally and logically with known facts to create a theory, which will be tested as a whole empirically. As Russell (1961, p. 530) said, "the thing that is achieved by the theoretical organization of science is the collection of all subordinate inductions into a few that are very comprehensive — perhaps one . . . . Such comprehensive inductions are confirmed by so many instances . . . ."

"Scientific" psychologists do not trust hypotheses because they consider them as preconceived ideas. They nevertheless use an hypothesis as a starting point of research, because as Russell (1961, p. 529) maintained, "usually some hypothesis is a necessary preliminary to the collection of facts, since the selection of facts demands some way of determining relevance. Without something of this kind, the mere multiplicity of facts is baffling." However, experimental psychologists usually do not disclose that they started with an hypothesis, because they wish to make their work look perfectly scientific. In reality, hypotheses, which are inductively produced, are necessary not only in scientific work but also in daily life. Surviving the dangers of daily life for very long is impossible without making hypotheses and testing them quickly, because waiting for sure scientific knowledge without any hypothetical anticipation can be a fatal mistake. This is the mistake made in psychology today in relation to theory construction.

Thus, an hypothesis that is framed in daily life or in scientific work to explain a particular event needs to be directly tested empirically, whereas a scientific hypothesis that is framed to construct a theory is first integrated with a sufficient number of known facts of various types, and then the theory is tested as a whole. The possibility of integrating an hypothesis with known facts is already an indication of its validity. A psychological theory constructed in this way will serve to explain, predict, and control not a particular phenomenon, but all phenomena, known or new, within its field of validity, including research results and clinical facts.

Like the unifying concept of function, an hypothesis to be used in psychology has to be based on the reality of evolution. The hypothesis can be initially conceived of in a vague form, and can later be given a clear, precise form through integration with known facts, as this happened in the case of the hypothesis of gravitational attraction. The concepts of functionality, rationality, the satisfaction of the needs of the human being, adaptation to the environment, success, and survival are all related to evolution and can therefore be used to frame an hypothesis.

Functionality in Freud's Theories

Freud is the only psychologist who produced a wide-scope theory which in fact became a *Weltanschauung;* therefore valuable examples can be found in his work. Freud introduced the concept of "blind wish" to replace the physical concept of "blind force." He maintained that the *id* and the *superego* produced only blind wishes. He was thus able to use the mechanistic point of view in psychology. He allowed only the *ego* to be rational — and hence capable of producing adaptive, functional responses, we can say. The hypothesis that he used was that a perpetual conflict exists between the various *domains* of the mind, which resulted in the drive–defense model.

Thus, Freud introduced into psychology the mechanistic point of view through the concept of blind wish, and the functional point of view through the rationality of the ego. Although he preferred mechanistic explanations, he payed more attention to the mind's functionality in his late life than he did earlier, as exemplified by his explanations of anxiety considered below.

What Freud maintained for decades about the generation of anxiety amounts to saying that the failure to complete sexual behavior satisfactorily causes the direct transformation of the sexual excitation into anxiety through an unknown physiological process. This is evidently a mechanistic explanation of anxiety. But in his late life, Freud claimed that anxiety was a danger signal, and explained the danger as follows: "We have become convinced also that instinctual demands often become an (internal) danger only because of the fact that their gratification would bring about an external danger" (1925/1936, p. 116). This is of course a rational and functional explanation of the causation of anxiety. Freud qualified his mechanistic and functional explanations of anxiety as "phenomenological" and "metapsychological," respectively (p. 19).

What should be noticed is that the mechanistic explanation of the generation of anxiety ends by postulating an unknown physiological process, whereas its functional explanation is self-sufficient as far as psychology is concerned. In fact, the "metapsychological" explanation of anxiety can be used to explain its "phenomenological" explanation *functionally*, as shown below — although this was not done by Freud.

Not only the failure to complete the sexual act satisfactorily, but all extreme failures cause anxiety, or fear, because failure generates the anticipation of dangers, and therefore a danger signal becomes necessary for securing readiness to cope with the expected dangers. Thus, extreme failure to recognize and understand causes the fear of the unknown; extreme mastery failure causes the fear of destruction and death; failure to give to the society what is required by the social and moral sense causes the fear of punishment; and failure to receive from the society what is necessitated by the social instinct causes the fear of discrimination, alienation, and loneliness. And when the failure and the dangers it creates are repressed, fear turns to anxiety, because anxiety is a response to dangers of unknown origin, as stated by Freud. These processes seem to be hard-wired into the brain by evolution, and their above presented unified conception illustrates the integrating power of the functionality concept.

The mechanistic conception of mental, behavioral, and psychosomatic phenomena inevitably leads to postulating physiological causes, and physiology cannot supply all the answers, because the interaction between physiological and mental phenomena is a two way process. This situation hinders progress in psychology and, in particular, transposes mental disorders into the sphere of medicine and makes the cure impossible, because mental disorders deserving this name are not caused physically by organic defects. The adoption of the functional point of view in the explanation of psychological, psychosomatic, and behavioral phenomena will eliminate the necessity of referring them to unknown physiological processes and will make psychology a mature science standing on its own feet. In this mature psychology, Freud's theories will not need to be discarded as totally unscientific, because much can still be learned from them by assessing their limits of validity correctly. Psychoanalysis reached stagnation because Freud's successors did not follow all the pathways opened by him.

Freud viewed his "phenomenological" and "metapsychological" explanations of anxiety as describing an id process and an ego process, respectively. He avoided the mechanistic point of view and made use of the mind's rationality and functionality which he considered as belonging to the ego only.

Freud learned by experience that a psychological theory has to have a very wide scope. For four years, he failed to develop his theory of dreams beyond the idea of wish fulfillment, and succeeded only in the fifth year, after he enlarged the scope of his investigations to cover also repression, neuroses, primary and secondary processes, conflict, the Oedipus complex, etc. He stated this in his letter to Fliess, on January 3, 1899: "The key to hysteria lies in dreams. I now also understand why in spite of all my efforts I was unable to finish my dream book . . . . I shall be able to present the psychic process in dreams in such a way that it also includes the process in the formation of hysterical symptoms" (Masson, 1985, p. 338). A psychological theory has to have a wide scope that covers many phenomena of different types, both conscious and unconscious. This means that, for example, it is not possible to understand schizophrenia by studying schizophrenia alone.

Conclusion

Contrary to Tryon's advice, psychology cannot progress by returning to behaviorism and neglecting the study of mental phenomena reaching the depths of the unconscious. *Mind and behavior* have to be studied together, making the appropriate *interdisciplinary* transfers of methods and concepts, and keeping *functionality* in view.

Substantial progress in psychology can be realized at the present time by adopting the general method of theory construction used in physics, as explained above, but replacing mathematics by verbal language and logic, and replacing the mechanistic point of view by functionality, and by constructing wide-scope theories that cover unconscious phenomena too, as Freud did by perceiving the mind's functionality better and better through his career. Research and clinical observation have already yielded an enormous amount of empirical knowledge that can be integrated to construct such a theory, by making use of the hypothesis that the human mind is an extremely integrated cognitive–cybernetic organization enabled by evolution to seek rationally to achieve success and survival through the concurrence of *conscious* and *unconscious* processes (Löker, 1976, 1987, 1989a, 1989b, 1993a, 1993b, in press).

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