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

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Tryon's (1996) primary thesis and four corollary points are restated. Seven of Löker's primary criticisms are identified and rebutted. It is concluded that measurement units are theoretical entities because they concern the quanta being measured and that these entities can be combined in various ways to generate new theoretical concepts.

Tryon (1996) in this Journal made the following points: (a) measurement units are theoretical concepts because measurement presumes theoretical definition of the quanta being measured, (b) new theoretical concepts can be constructed through the algebraic combination, usually multiplication or division, of previously defined measurement units, (c) physics developed such a knowledge hierarchy along with discovery of natural laws, (d) the current lack of emphasis on measurement units in psychology precludes a similar development in psychology, and (e) psychology has long used time as a fundamental unit which means that we only need to create a second unit to begin this process. Löker (1999) criticized Tryon (1996) on the following grounds: (a) only some mathematical relations in physics are definitions; others express natural law, (b) Newton only defined acceleration and not force which was discovered as a natural law, (c) scientific laws have been ignored including how they are discovered, (d) Tryon appears to consider such laws as unscientific, (e) measurements only serve to determine characteristic properties of substances. Löker further charges that Tryon: (f) "reflects most strikingly the incorrigible inclination of 'scientific' psychologists to abstain from theory construction and the study of unconscious" (p. 277), and (g) "Tryon attempts to reduce theory to measurement, and psychology to behaviorism by using

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physics as a model for psychology and ignoring Freud's work completely" (p. 277). The remainder of the present article considers these "criticisms" and shows that none of them invalidates Tryon's fundamental thesis that measurement units are theoretical concepts because they define the quanta being measured or his other four points.

Löker (1999) distinguishes between equations that are definitional and equations that reflect empirically discovered natural law [his point (a)]. Instead of giving a clear example of an equivalence statement that is definitional and one that reflects natural law, Löker asserts that the formula for density (d) in terms of mass (m) per unit volume (v) [d = m/v] "represents a 'law of nature'" (p. 278) and criticizes me for not explaining how this relationship was discovered. He treats Newton's equation of force with accelerated mass [f = ma] in the same manner. While our understanding of both density and force undoubtedly had its origins in experience with the physical world long before these concepts were expressed in terms of equivalence statements, this fact does not negate Tryon's points (a) through (e) as Löker implies. Formulas *formulate* and this is a theoretical act that applies equally to our idealizations of natural law as to definitional statements. That formulas formulate is not dependent upon the degree of experience or experimentation prior to mathematical formulation nor does it depend on how one went about obtaining the data upon which the formulation was based.

It is worth noting that Newton could not have empirically discovered that f = ma as Löker maintains because this would require independent measurements of force, mass, and acceleration at a time when no unit of force was defined. Newton's contribution was to give specific meaning to the previously vague idea of force by *formulating* it in terms of accelerated mass. Newton thereby defined a new measurement unit, the kilogram meter per second per second. His contribution was formally recognized by defining the force necessary to accelerate a 1 kg mass to 1 m/s/s as 1 Newton. Moreover, and central to Tryon's point about constructing a knowledge hierarchy, Newton's equivalence statement added to the knowledge hierarchy in physics by combining previously accepted units of measure. Physics now had an additional well formulated concept of force with which to understand physical phenomena.

Once an equation between, or among, variables has been asserted on theoretical (definitional) or empirical grounds, the laws of algebra allow us to place each variable to the left of the equal sign and thereby understand, formulate, it in terms of the units of measure (quanta) represented by the variables on the right side of the equal sign. For example, the theoretical assertion, expressed in mathematical form, that f = ma carries with it the following two corollary assertions: (a) m = f/a, (b) a = f/m. It may be true that Newton did not initially have the two corollary statements in mind when he

formulated force in terms of accelerated mass but that does not change the fact that asserting f = ma necessarily entails two additional corollary equivalence statements. Any lack of awareness on Newton's part of these corollary assertions does not alter or invalidate their theoretical status.

I did not discuss scientific laws and how they were discovered [Löker's point (c)] because, as stated above, the methods used to collect data have no bearing on the thesis that measurement units are theoretical entities because they define the quanta being measured and that new concepts can be defined through algebraic combinations of previously defined measurement units. This position does not make me hostile to the laws of nature which is why I never said that they are unscientific as Löker charges [point (d)].

Löker's incorrectly asserts that Tryon ". . . believes that measurements serve only to determine the characteristic properties of substances" (p. 277, abstract) [his point (e)]. My point is that characteristic properties like density, solubility, specific heat, and specific gravity entail ratios of measurement units and take their meaning from the definitions of these units of measure. Said otherwise, the concept of characteristic property could have been given verbally by physicists. This could have resulted in different concepts expressed in various ways much like personality constructs are. Physicists could have then debated the merits of each assertion and conducted experiments in an attempt to decide which formulation is best. Instead, they restricted themselves to previously defined units of measure and formulated characteristic properties in terms of algebraic combinations of these measurement units. This resulted in new well-defined concepts such as density, solubility, specific head, and specific gravity. Their meaning was clear and their utility readily appreciated. Each new definition was an important addition to the knowledge hierarchy in physics. I suggested that psychologists might benefit from considering how this approach to theory construction could be applied to psychology. We already accept the unit of time in seconds. Introduction of a second measurement unit would enable it to be combined with time to create a third construct. Adding further measurement units would substantially augment this process.

Löker wrongly characterizes scientific psychologists as incorrigibly disinterested in theory construction issues [the first part of his point (f)]. I expect that nearly all psychologists who publish in scientific journals see their work as theoretically relevant. He also incorrectly maintains that scientific psychologists have avoided unconscious processes [the second part of his point (f)]. This is simply not true. For example, subliminal reaction time is based on standard units of time, milliseconds, and has been used to investigate unconscious processes (cf., Bornstein, 1992; Weinberger, 1992). Moreover, this research is heavily informed by Freudian theory. Emphasis on objective measurement does not preclude the study of unconscious processes as Löker

implies. There is no necessary incompatibility between objective measurement units and Freudian theory or any other theory. Löker further criticizes Tryon for completely ignoring Freud's work [the second part of his point (g)]. Freud's work was ignored because it does not discuss units of measure or their role in formulating theoretical concepts — and therefore is irrelevant to the present discussion.

The first part of Löker's point (g) accuses me of attempting to reduce all theory to measurement and all psychology to behaviorism. Tryon's (1996) points are summarized at the beginning of this article and do not even come close to making either of the two claims Löker charges. It appears that Löker has greatly over-generalized my recommendation that behavioral assessment, one approach to client evaluation, be extended to include behavioral physics which obtains data exclusively from instruments and therefore is systematically based on standard units of measure. For example, there are many clinical and research applications that benefit from having objective measures of activity level (cf., Tryon, 1991; Tryon and Williams, 1996).

Löker's section on "Theory Construction in Physics" presents his views on this subject but does not fault Tryon's point that units of measure are theoretical entities or that measurement units can be combined algebraically to define new concepts thereby forming a knowledge hierarchy. Löker's sections on "The 'Mechanism' of Mental Causation, or Mental Response" and "Functionality in Freud's Theories" are independent statements of the author's views rather than a reply to my original article as his main title indicates and are therefore beyond the scope of this response.

In conclusion, measurement units are theoretical entities because they define what is being quantified. It is possible to define new concepts in terms of algebraic combinations of two or more of these units. This approach has led to a knowledge hierarchy within physics. It is therefore suggested that psychologists begin to consider how they might develop an analogous knowledge hierarchy in psychology.

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