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Illegitimate concept equating in the partial fusion of construct validation theory and latent variable modeling

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A B S T R A C T

There has come to exist a partial fusion of construct validation theory and latent variable modeling at the center of which is located a practice of equating concepts such as *construct*, *factor*, *latent variable*, *concept*, *unobservable*, *unmeasurable*, *underlying*, *hypothetical variable*, *theoretical term*, *theoretical variable*, *intervening variable*, *cause*, *abstractive property*, *functional unity*, and *measured property*. In the current paper we: a) provide a structural explanation of this concept equating; b) provide arguments to the effect that it is illegitimate; c) suggest that the singular reason for the presence of *construct* in the literature of the social and behavioral sciences is to mark an allowance taken by the social and behavioral scientist to obliterate the *concept*/*referent* distinction that is foundational of sound science.

A latent variable model is a statistical model whose special character resides in the fact that its defining equations make reference to two types of variables, *manifest* random variables and *latent* random variables. The manifest variables are said to be *observable* or *measurable* and the latent variables are said to be *unobservable* or *unmeasurable*. Whatever else is captured by the observable/unobservable dichotomy, it is a fact that prior to the employment of a latent variable model, it is only the manifest variables on which realizations are taken, the consequence being that the data to be analyzed in a latent variable analysis come only from these variables. Let θ stand for a set of k latent random variables, $\mathbf{X}$ stand for an arbitrary set of $p > k$ manifest random variables, f_θ be the marginal density of θ, and $f_{\mathbf{X}|\theta}$ be the density of $\mathbf{X}$ conditional on θ. Then a latent variable model is *specified* as the intersection $\cap_{i=1}^{k} t_i$ of k properties t_i, each t_i a property of either $f_{\mathbf{X}|\theta}$ or f_θ.

The first authentic latent variable model was the linear factor model, the unidimensional variety of which was invented by Charles Spearman in 1904. Since then, there have been invented many other latent variable models, prominent examples being the latent class and latent profile models (e.g., Heinen, 1993; Lazarsfeld, 1950), the non-linear factor models (e.g., McDonald, 1967), the classical item response models (e.g., Lord & Novick, 1968), and the structural equation models (e.g., Joreskog, 1973). In contrast to the vast majority of statistical procedures of comparable sophistication, researchers were quick to come to employ latent variable models in their researches. In discussing the history of structural equation modeling, Bentler (1986, p. 35), for example, notes that "Unlike many other developments in theoretical psychometrics, this methodology spread from the methodology laboratory into the research laboratory with unusual rapidity." McDonald's (1977, p. 165) claim that the "…common factor model is probably the most widely employed device for the statistical analysis of multivariate data" does not seem unreasonable. To engage in a latent variable modeling exercise is to employ a latent variable model in research. Within the social and behavioral sciences, latent variable modeling (LVM) exercises are variably undertaken in the hopes of analyzing the association structures of sets of variables, supporting causal conjectures, and investigating measurement claims.

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Construct Validation Theory (CVT) is an approach to the adjudication of the performance of a test. It was invented by Cronbach and Meehl (1955) in response to dissatisfactions with extant conceptions of test validity. In contradistinction to the content and criterion senses of validity that had previously been dominant in test theory, a test's *construct validity*, it was claimed by Cronbach and Meehl, the relevant sense of validity when the test "… is to be interpreted as a measure of some attribute or quality which is not 'operationally defined'" (Cronbach & Meehl, 1955, p. 281) or, alternatively, when "… the tester has no definite criterion measure of the quality with which he is concerned, and must use indirect measures. Here the trait or quality underlying the test is of central importance, rather than either the test behavior or the scores on the criteria" (Cronbach & Meehl, 1955, p. 281). According to Cronbach and Meehl, the general aim in carrying out construct validation research into a given test is to "…determine what psychological constructs account for test performance…" (Cronbach & Meehl, 1955, p. 281), or, equivalently, to establish "What constructs account for variance in test performance?" (Cronbach & Meehl, 1955, p. 281). The specific aim is to accumulate evidence relevant to determining the truth status of the presumptive hypothesis that the construct that the test items were *designed* to measure is the dominant cause of the manner in which individuals' respond to these items.

Because CVT is an approach to the adjudication of a test's performance, and LVM is the practice of employing in research latent variable models, there would appear to be no prima facie basis for a close relationship between CVT and LVM. Yet, almost immediately upon the creation of CVT, linkages between it and LVM were established, and these linkages have turned out to be compelling enough to have brought about a partial fusion of CVT and LVM. The primary points of contact between CVT and LVM are a) the belief that latent variable models are uniquely well suited to the role of generator of evidence relevant to the issue of a test's construct validity and b) the endemic equating of the concepts *latent variable* and *construct* in both the technical and applied literatures.

However, the literatures on CVT and LVM happen to be conceptually rich, and, in particular, feature a large number of concepts that are related in one way or another to the concepts *latent variable* and *construct*. Consequently, the equating of the concepts *latent variable* and *construct* turns out to be merely the epicenter of a thick web of concept equatings (hereafter, WCE) that involves terms such as *construct, factor*, *latent variable, concept*, *unobservable*, *unmeasurable*, *underlying*, *hypothetical variable*, *theoretical term, theoretical variable*, *intervening variable*, *cause*, *abstractive property*, *functional unity*, and *measured property*. Elements of the WCE are manifested in Cureton's and D'Agostino's (1983) tacit equating of *factor*, *latent variable*, *hypothetical construct*, and *explanatory construct*:

> We use the term "factors" to designate *latent variables*; the term "variable" (or "test") will *always* designate a manifest variable. The factors are actually *hypothetical* or *explanatory constructs* (p. 3; emphases added).

In discussing the employments of latent variable models in social research, Everitt (1984) reveals parts of the WCE in his tacit equating of *psychological term*, *psychological concept*, *latent variable*, *not directly observable*, and *hypothetical construct*:

> Certain concepts in the social and behavioral sciences are not well defined and there are many discussions over the real meaning of terms such as *social class*, *public opinion* or *extrovert personality*. Such *concepts* are often referred to as *latent variables*, since they are not directly observable even in the population; they are essentially *hypothetical constructs* invented by a scientist for the purpose of understanding some research area of interest, and for which there exists no operational method for direct measurement (Everitt, 1984, p. 2; emphases added).

We have chosen to focus our attention on the WCE because, contrary to popular belief, language *does* play a profound role in the doing of science, and the linguistic structure that is the WCE plays a profound role in the doing of psychological science. In particular, the concept equatings of which the WCE is comprised point the psychological scientific enterprise in particular directions. If, for example, *construct* and *latent variable* can be legitimately equated, and constructs are, as is commonly believed, existing constituents of natural reality possessing of causal powers, then it may well appear to be the case that latent variable models *do* have legitimate employments as detectors of *explanatory constructs*. And if *concept* and *construct* can be legitimately equated, and it is true that constructs are existing constituents of natural reality, then the psychologist might well be within his rights to deny the existence of a strict distinction between the empirical and conceptual facets of scientific inquiry, and accept, as CVT urges him to do, that empirical investigation will deliver knowledge of both the meanings of concepts and the properties of the phenomena that they denote.

In writing the current paper, we have two objectives. The first objective is to provide an explanation of the WCE; in other words, an explanation of *why* it is that the concepts that are equated in the WCE are, in fact, equated. When people equate two or more concepts, legitimately or illegitimately, they do so because they believe these concepts to be *linked* in certain ways. A given set of concepts may, in fact, be equated on the basis of a subtle, weakly grasped, network of grammatical, historical, and thematic linkages. Our explanation of the WCE rests on the identification of the bases of linkage at root of the WCE. In particular, we identify six connected bases of linkage, represent them as a schematic, and employ this schematic to explain individual instances of the concept equatings of which the WCE are comprised. Our second objective is to adjudicate the *legitimacy* of the WCE, a task that will turn out to boil down to an adjudication of the legitimacy of the bases of linkage themselves.

1. Connected Bases of Linkage Generative of the WCE

The six connected bases of linkage that are generative of the WCE are represented in the scheme of Fig. 1 as five

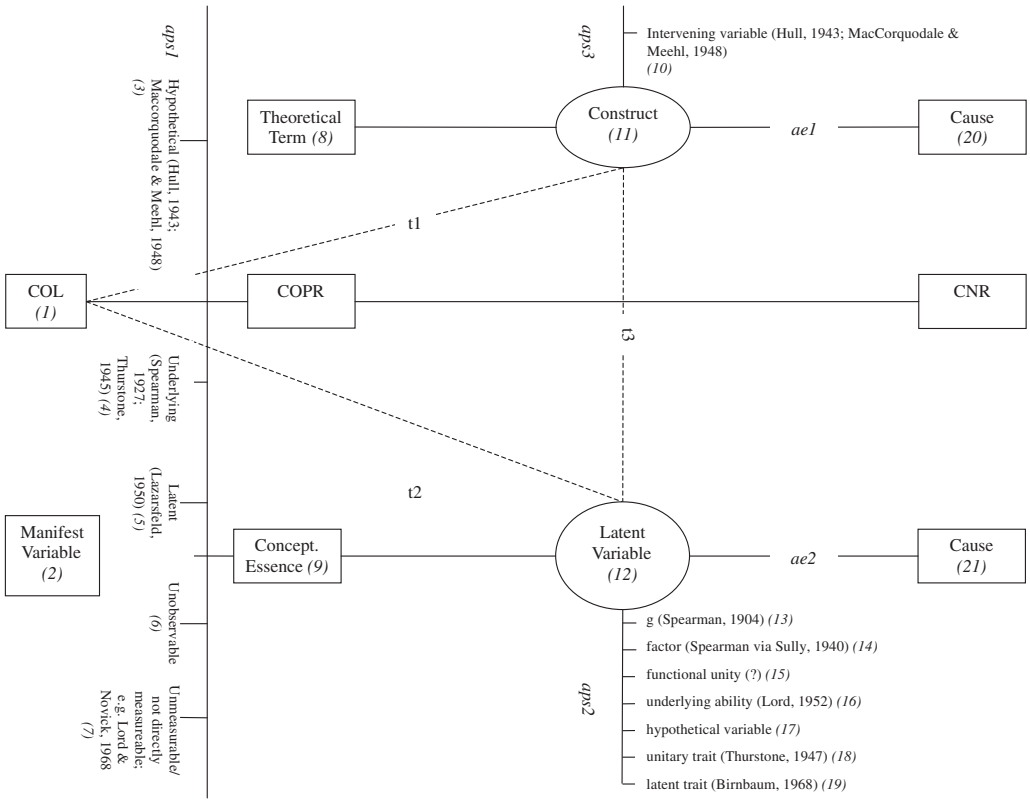

Fig. 1. Six connected bases of linkage of the WCE.

axes and one triangle. The nature of two of these bases of linkage (axes *ae1* and *ae2*) is that of conceptual equivocation and the nature of four of them (axes *aps1*, *aps2*, and *aps3*; triangle t_1–t_2–t_3) is that of perceived synonymy. Under each of *ae1* and *ae2* a set of concepts $\{c_1, c_2, c_3, \ldots,\}$ is linked according to the following mechanism: a) at most one of $\{c_1, c_2, c_3, \ldots,\}$ can be legitimately employed as a modifier of a target concept *z*; b) it has been left unclear which (if any) is the legitimate modifier; c) as a result of (b) it is taken to be allowable that any of the elements of $\{c_1, c_2, c_3, \ldots,\}$ can be ascribed to *z*. Under each of *aps1*, *aps2*, *aps3*, and t_1–t_2–t_3, a set of concepts $\{c_1, c_2, c_3, \ldots,\}$ is linked through the belief, correct or otherwise, that they are synonymous and, hence, can be employed interchangeably in linguistic expressions.

In the next section, we will demonstrate that instances of concept equating that belong to the WCE can usefully be understood as arising from sequences of equivocations and perceived synonymies, and, hence, as sets of *movements* over *ae1*, *ae2*, *aps1*, *aps2*, *aps3*, and t_1–t_2–t_3. Before doing so, we will consider, in turn, the nature of each of *ae1*, *ae2*, *aps1*, *aps2*, *aps3*, and t_1–t_2–t_3.

1.1. *Axes of Equivocation (*ae1 *and* ae2*)*

Both CVT and the modern conception of LVM are offspring of mid 1950s empirical realist philosophy (cf. Feigl, 1953; Hempel, 1958; Sellars, 1956; Tuomela, 1973; Rozeboom, 1984).[1] Authors such as Meehl, Lord, Novick, Green, Royce, and Lazarsfeld, all significant contributors to the literatures of CVT and LVM, reveal in their writings the profound influence that empirical realism had on the formation of their ideas about CVT and LVM (cf. Maraun, 2003). Empirical realism was both seen as providing an explanation of the need for CVT and LVM, and as providing the outline for the interpretive stories that came to accompany each of CVT and LVM (cf. Maraun, 2003).

The core tenets of empirical realist philosophy (cf. Tuomela, 1973) can be outlined as follows (Maraun, Slaney, & Gabriel, 2009, p. 150):

[1] It has been claimed by some (e.g., Norris, 1983) that CVT is a mixture of empirical realist and logical positivist philosophy, but the traces of logical positivism that appear in Cronbach and Meehl (1955) do not cohere with the essential features of their account and their inclusion appears to be, for the most part, accidental. In an age in which sloppy analysis frequently eventuates in logical positivism being blamed for all manner of Psychology's ills, Borsboom, Mellenburgh, and van Heerden (2004) go so far as to blame it for the appearance of the nomological network in the theory of test validity. But they are confused: the nomological network was invented by Feigl (1950, 1956), an empirical realist philosopher whose influence upon the social sciences has been profound, and its role in the doing of psychological science is unmistakably empirical realist in nature (cf. Rozeboom, 1984, p. 214).

1) Natural reality is comprised of observable phenomena and the unobservable causes of these phenomena;

2) These phenomena and causes exist independently of human capacities to perceive them;

3) Scientific concepts can be categorized as either theoretical or observational terms. Because they designate observable phenomena, observational terms are defined in the data language (i.e., in terms of observables), and, hence, are semantically unproblematic. Theoretical terms such as *electron*, *phlogiston*, and *neutrino*, are, on the other hand, introduced by scientific theories and designate unobservable causes of observable phenomena. This makes them both essential to what scientific theories claim about natural reality and, because they cannot be defined on the basis of observables, semantically problematic[2];

4) Because a theoretical term cannot be defined in terms of observables, it must be implicitly, and incompletely, defined by the system of laws and core presumptive hypotheses of which the theory in which it is embedded is comprised. This makes it an *open concept*;

5) While a given theoretical term is implicitly defined by its embedding theory, if the theory is correct, the theoretical term does, in fact, *name* the causal entity to which it refers.

It is unfortunate for the discipline of Psychology that the importation of empirical realist philosophy into CVT and LVM lacked fidelity to the original. In particular, empirical realist philosophy draws a distinction between a theoretical term and its referents. As with any term, a theoretical term is a constituent of language (COL). The referents of a theoretical term are, on the other hand, unobservable causes of phenomena hypothesized to exist and, hence, if they do in fact exist, are constituents of natural reality (CNR). The scholars who chose to found CVT and LVM on empirical realism, however, annihilated the distinction between *concept* and *referent* and, in so doing, granted to those who thereafter would employ the term *construct* (*latent variable*) an allowance to alternate chaotically between taking constructs (latent variables) to be COL, on the one hand, and CNR on the other. The annihilation of the *concept/referent* distinction and the allowance it brought into play is directly responsible for the emergence of the confused belief that empirical investigation yields both knowledge as to the meaning of a concept and as to the properties of the concept's referents. This belief is, in turn, responsible for the devastating extinction of definitional work as a precursory step in empirical investigations.

[2] To the logical positivist, a theoretical term is, at best, a "useful fiction" which may be employed in the statement of a theory (Norris, 1983). If it has a meaning, the meaning of a theoretical term is reducible to statements that involve only observables.

We represent the COL/CNR equivocation that attends the employment of each of the terms *construct* and *latent variable* as axes of equivocation, *ae1* for *construct* and *ae2* for *latent variable*. The poles of *ae1* are:

CNR → construct is a constituent of natural reality possessing of causal powers.
COL → construct is a synonym for theoretical term.

The poles of *ae2* are:

CNR → latent variable is a constituent of natural reality possessing of causal powers.
COL → latent variable is a property/attribute.

*1.2. Axis of perceived synonymy (*aps1*: {*underlying, hypothetical, latent, not directly measurable/unmeasurable, unobservable*})*

Being as both CVT and the modern conception of LVM are offspring of empirical realist philosophy, they are tied in fundamental ways to the distinction between that which is *observable* and that which is *unobservable*. Empirical realism, however, is only the most recent of the philosophies of science that were invented in response to concerns about unobservables. Its predecessor, logical positivism, for example, sought to ban unobservables from admission into scientific discourse by arguing that references to unobservables were, in fact, reduceable to "…data-language constructions…" (cf. Rozeboom, 1984). It is not unreasonable to suggest that, within the social sciences, there has been a longstanding preoccupation with the issue of unobservability. What is unarguable is that many terms have been invented that are now variably employed as synonyms of the concept *unobservable*, the most prominent of these being, in approximate chronological order of entry into the literature, the terms *underlying*, *hypothetical*, *latent*, and *not directly measurable/unmeasurable*. We represent the equating of these terms as axis of perceived synonymy *aps1*. Before turning to an explanation of the role that *aps1* plays in the structuring of the WCE, we will provide a brief discussion of each of its constituent terms.

underlying: This term was first employed by two of the fathers of linear factor analysis, Charles Spearman and L. L. Thurstone. Unlike the concepts *latent* and *unobservable*, the concept *underlying* does not have a contrast term (antonym). This is reflective of the fact that *underlying* is meant to refer not merely to the class of unobservables, but to the class of unobservables possessing of causal powers ("…another-theoretically far more valuable-property may conceivably attach to one among the possible systems of values expressing the correlation; this is, that a measure might be afforded of the hidden underlying cause of the variations" (Spearman, 1927, p. 74)).

hypothetical: This term entered the literature as part of the pre-history of CVT. Hull (1943) discussed the notions of *symbolic construct*, *intervening variable*, and *hypothetical entity*. MacCorquodale and Meehl (1948), responding to comments made about Hull's work by Tolman, in his APA

presidential address, urged that psychologists distinguish between the concepts *intervening variable* and *hypothetical construct*. While stopping short of equating the terms *unobservable* and *hypothetical*, MacCorquodale and Meehl (1948, p. 1) imply that such an equating is acceptable by placing both terms in a category contrastive to the situation in which "direct colligation of observable data" is possible: "…one can still observe among 'tough-minded' psychologists the use of words such as 'unobservable' and 'hypothetical' in an essentially derogatory manner, and an almost compulsive fear of passing beyond the direct colligation of observable data."

latent: The *manifest*/*latent* dichotomy that is nowadays taken to be equivalent to the *observable*/*unobservable* dichotomy was invented by sociologist Paul Lazarsfeld and introduced to scholars in his 1950 paper on latent structure analysis (an LVM technique that he also invented), a work steeped in empirical realist thinking. Lazarsfeld explains the *manifest/latent* dichotomy as follows: "Because the 'response patterns' of the people are obtained from actual experiments, we shall call them *manifest data*; all the information inferred as to the nature of the continuum or the position of people thereon we shall call *latent*. Nothing more is implied in this terminology than the distinction between information obtained by direct observation and information obtained by using additional assumptions and/or by making inferences from the original data" (Lazarsfeld, 1950, pp. 363–364).

Not directly measurable/unmeasurable: The *not directly measurable*, *not directly observable*, *unmeasurable* line originated in Lord's (1952) *A Theory of Test Scores* ("The ability itself is not a directly observable variable," p. 1) and was popularized in Lord's and Novick's (1968) landmark work on test theory, *Statistical Theories of Mental Test Scores*. As with Lazarsfeld's text on latent structure analysis, Lord's and Novick's tome was, essentially, applied empirical realism.

unobservable: As has already been noted, the concept *unobservable* was present in the early pre-history of CVT (cf. MacCorquodale & Meehl, 1948). As for LVM, McDonald stated in a 1972 article that "…most accounts of the fundamental factor model use the non-mathematical qualifier 'unobservable' to describe the common factor scores" (p. 18), and, in a 1974 article, attempted to define *observable (unobservable) random variable*. It would appear that the concept *unobservable* came to prominence within the LVM literature in the 1960s, chiefly through writers such as Lord and Novick (e.g., "The classical test theory models deal with two kinds of random variables, manifest or observable variables and latent or unobservable variables (1968, p. 530)).

The *aps1* plays two roles in the structuring of the WCE. First, *aps1* captures the existing state of affairs in which, because they are taken to be synonymous, the terms *underlying*, *hypothetical*, *latent*, *not directly measurable/unmeasurable*, and *unobservable* are employed interchangeably. Second, by way of a second infidelity in the importation of empirical realist philosophy into CVT and LVM, *aps1* interacts with each of *ae1* and *ae2* to transform the COL poles of the latter two axes.

The nature of this second infidelity and the transformation of COL it brings about can be described as follows:

a) It was widely considered to be the case that certain scientific terms (*intelligence*, *phlogiston*, *neutrino*, *electron*; cf. Rozeboom, 1984) denote unobservables hypothesized to exist. That they did so was seen as rendering them semantically problematic;
b) The philosophy of empirical realism attempted to offer remedy to this semantical problem by enforcing a distinction between *meaning* and *reference*. In particular, on the empirical realist account, theoretical terms "…get their meanings from the data-language contexts in which they are used [but] semantically designate…causal features of natural reality generally concealed from perception but knowable through their data consequences" (Rozeboom, 1984, p. 212);
c) While, on the empirical realist account, it is the unobservability of the *referents* of theoretical terms that causes problems for the semantics of the terms themselves, this particularity was abandoned in the importation of empirical realist thinking into CVT and LVM, the result being that the adjective *unobservable* (and, soon thereafter, its accepted equivalents *hypothetical*, *underlying*, *latent*, *not directly measurable*, and *unmeasurable*) came to be routinely ascribed to *both* CNR and COL;
d) The ascription of the term *unobservable* to COL yields conceptual platonism, or the position that there exists in nature unobservable, *true*, conceptual essences. Thus, *aps1* transforms the COL poles of *ae1* and *ae2* into COPR (*constituent of platonic reality*) poles.

Essential to an understanding of the WCE, then, is an appreciation of the fact that quantitative specialists and applied researchers alike view it to be perfectly reasonable to ascribe the adjective *unobservable* (and its accepted equivalents) to both CNR *and* COL. This is exemplified in the following markers of the CNR and COPR poles of each of *ae1* and *ae2*.

1.3. *COPR pole of* ae1

When Cronbach and Meehl (1955, p. 3) claim that "A construct is some postulated attribute of people", they are asserting a conceptual platonistic claim that the range of attributes that people can possess cannot be known by simply examining language, but, instead, must be postulated. Strauss, too, invokes conceptual platonism in his claim that concepts such as *anxiety* and *extraversion* are unobservables whose natures must be described as a matter of empirical science: "One major concern in psychology is to define and describe psychological constructs such as a person's anxiety, extraversion, intelligence, or goal orientation. However, such psychological constructs cannot be observed directly" (1999, p. 19).

1.4. *COPR pole of* ae2

Markers of the COPR pole of ***ae1*** rest on the portrayal of latent variables as pure conceptual essences, a portrayal that is a special case of the *truth + error* metaphor that features in the central interpretive story of LVM (cf. Maraun, 2003). Statements of the following sorts are

markers of the COPR pole of ***ae1***: "Latent random variables represent unidimensional concepts in their purest form" (Bollen, 1989, p. 11); "These factors, generally based on two or more observed variables (called indicators) are thought to represent "purified" versions of the concepts under study" (Steiger, 2001, p. 332).

1.5. *CNR pole of* ae1

The CNR poles of both *ae1* and *ae2* are marked by assertions to the effect that constructs (latent variables) are causes, the portrayal of constructs (latent variables) as having indicators, the portrayal of indicators as bases for *tapping into* constructs (latent variables), and the portrayal of constructs (latent variables) as possessing of variance explanatory powers. In claiming that the general aim in carrying out a construct validation study of a given test is to "…determine what psychological constructs account for test performance…", or, equivalently, to establish "What constructs account for variance in test performance?" (1955, p. 281), Cronbach and Meehl mark the CNR pole of *ae1*.[3] So too does Lubinski (2000, p. 10) in his portrayal of constructs as unobservable CNR whose presence must be detected: "The discipline of psychometrics has developed instruments for dealing with psychological phenomena remote from personal experience. Psychological constructs are 'removed' from experience because they co-occur with other phenomena. Multiple behavioral episodes are necessary to detect them."

1.6. *CNR pole of* ae2

Markers of the CNR pole of *ae2* are commonplace. While Cattell (1952) was perhaps the most zealous popularizer of the CNR characterization of latent variables, Thurstone (himself, prone to vacillate unpredictably between the CNR and COPR poles of *ae2* in his attempts to explain what a factor is) invokes the CNR pole of *ae2* in his claim that factors may be "…postulated as primary causes of individual differences in overt accomplishment…" (1947, p. 52). Vincent's (1953, p. 107) explanation that factor analytic techniques are "Techniques, developed mainly by psychologists for dealing with their problems, which, by analyzing the inter-correlations between sets of measurements, attempt to identify the causes that are operating to produce the variance within each set, and to evaluate the contribution due to each cause" clearly depends upon the CNR pole of *ae2*.

1.7. *Triangle of perceived synonymy (*t1, t2, and t3*: {*concept, construct, latent variable*})*

The equating of the concepts *concept*, *construct*, and *latent variable* is the central structural feature of the WCE and is, therefore, the essential prop in the partial fusion of CVT and LVM. It can be usefully schematized as a triangle of perceived synonymy, the nature of which can be explained through a description of each of its three sides.

1.7.1. t1*: {Concept, construct}*

Social scientists seamlessly and unthinkingly equate the terms *concept* and *construct* by simply proclaiming *every* particular psychological concept to be a construct. This practice originated with Cronbach and Meehl themselves, their 1955 manifesto declaring that *latent hostility*, *variable in mood*, *ability to plan experiments*, *compulsive rigidity*, and *hunger*, among other concepts, were all examples of constructs. Strauss's matter-of-fact explanation that "One major concern in psychology is to define and describe psychological constructs such as a person's anxiety, extraversion, intelligence, or goal orientation" (Strauss, 1999, p. 19) exemplifies just how well enshrined this practice has become.

1.7.2. t2*: {Concept, latent variable}*

The equating of *concept* and *latent variable* is ubiquitous within the literatures of the social sciences and would appear to be an unavoidable consequence of a set of linked beliefs and conclusions that can be spelled out as follows.

a) *Belief 1: The meanings of concepts are intractably unclear.* This belief was the motivating force behind Spearman's invention of linear factor analysis, he believing that the only way to overcome the murkiness inherent to the concept *general intelligence*, and provide it with an "objective definition", was through the employment of a mathematical model (cf. Hart & Spearman, 1912, p. 67; Spearman, 1927, pp. 4–7). More recent expressions of this belief are provided by Lazarsfeld and Green: "There are various reasons why the social scientists' language has so many of these terms, which at first sight seem to be ill defined and even at their best are 'fuzzy at the fringe.' In some cases we can, by the nature of the concept, only observe symptoms, behind which we assume a more permanent reality" (Lazarsfeld, 1950, p. 477); "To obtain a more precise definition of attitude, we need a mathematical model that relates the responses, or observed variables, to the latent variable" (Green, 1954, p. 725).
b) *Belief 2: Unclarity in the meanings of concepts is a result of their unobservability.* That unclarity in the meanings of psychological concepts is a consequence of the inability of humans to *see* or *recognize* or *directly observe* these

[3] Borsboom et al. (2004) are fabricating wildly in portraying Cronbach's and Meehl's conception of CVT as at odds with the "causal view of measurement" (to wit, that a test T is a measure of an attribute ζ in a population P only if "variations in" ζ "causally produce" variations in T (within population P)). The badly misguided causal view of measurement was, in fact, precisely what was at root of Cronbach's and Meehl's conception of construct validity (cf. "…determine what psychological constructs account for test performance…"; "What constructs account for variance in test performance?" (Cronbach & Meehl, 1955, p. 281). Moreover, Cronbach and Meehl conceived of the role of the nomological net in starkly empirical realist terms; to wit, as the basis for making inferences about the *identities* of the attributes causally responsible for variations in *T*. The meaning/reference difficulty over which Borsboom et al. (2004) fulminate has nothing to do with the nomoligical net, but is, rather, the product of Cronbach's and Meehl's sloppy reading of empirical realism, a reading that led them to conflate the terms *concept* (concepts having meanings) and *referent* (the referents of concepts being CNR that can be conjectured to exist and, through their causal potencies, "produce variations").

concepts is bred in the bone of the social scientist. It is given expression in the following comments from Lubinski and Borsboom: "'Horsepower' is a postulated attribute, you can't 'see' horsepower, but you can construct indicators that covary with meaningful criteria that reflect our concept of horsepower and make it a conceptually powerful and useful concept." (Lubinski, 2000, p. 7); "Age is not observable in the sense that concrete objects like rocks are but is itself a rather abstract dimensional concept" (Borsboom, 2008, p. 28).

c) *Belief 3: Concepts are variables*: Examples of the expression of this belief are the following: "…factor analysis is a method for identifying important variables, but it does not, in and of itself, provide rational equations for linking said concepts" (Royce, 1963, p. 526); "Examples of variables a psychologist might study include cognitive task performance, noise level, spatial density, intelligence, gender, reaction time, rate of forgetting, aggression, speaker credibility, stress, and self- esteem" (Cozby, 1993, p. 28); "…variables that, in statistical analyses, are commonly conceptualized as observed variables, such as sex or age" (Borsboom, 2008, p. 28).

d) *Belief 4: Variables are CNR that are the targets of social and behavioral research*. The social scientist does not speak of studying phenomena, but rather of studying variables. This is because he takes variables to be CNR: "*This* variable (perhaps one points to it) in the world stands in the same relationship to the observed variables as does a common factor to the observed variables of this factor analysis" (Mulaik, 1990, p. 56)).

e) *Conclusion 1*. A concept is an unobservable (latent) variable the investigation of whose properties is a central aim of empirical research: e.g., "…an attitude is a latent variable" (Green, 1954, p. 727); "…general intelligence is a latent variable…" (Borsboom, 2008, p. 27); "…there are many discussions over the real meaning of terms such as *social class*, *public opinion* or *extrovert personality*. Such *concepts* are often referred to as *latent variables*, since they are not directly observable even in the population" (Everitt, 1984, p. 2).

f) *Conclusion 2*. Because concepts are latent variables, they must be detected and identified, and latent variable modeling is uniquely well suited to these tasks: e.g., "Factor analysis or some similar objective process had to be brought into the *search for the unitary traits of personality* [italics added]" (Guilford, 1954, p. 470); "…I need to infer the relevant property (e.g., *being male*) from the data just as well" (Borsboom, 2008, p. 29).

1.7.3. t3*: {Construct, latent variable}*

Given the commonplace equating of *concept* and *construct*, on the one hand, and *concept* and *latent variable*, on the other, it is anything but surprising that social and behavioral scientists complete a "triangle of perceived synonymy" by equating *construct* and *latent variable*. The following are examples of expressions that mark the *t3* side of the triangle of perceived synonymy: "It is clear that factors here function as constructs" (Guilford, 1954); "Each postulates constructs that are not directly measurable and each observes phenomena that manifest these latent constructs but that also exhibit fluctuation due to other factors…" (Lord & Novick, 1968, p. 14).

*1.8. Axis of perceived synonymy (aps2: {*g, factor, functional unity, unitary trait, hypothetical variable, latent variable, latent trait*})*

In his 1947 monument on linear factor analysis, Thurstone stated that "The factors may be called by different names, such as causes, faculties, parameters, functional unities, abilities, independent measurements, experimentally independent effects" (1947, p. 189). This comment captures superbly the laissez-faire attitude of the social scientist regarding the generation of putative synonyms of the concept *factor* as it arises in LVM. Indeed, there have been invented a great number of terms that are now linked in perceived synonymy by their each having a place in the chronologically ordered sequence of terms that begins with *g*, the label Spearman assigned in the early 1900s to both the concept *general intelligence* and to the common factors he extracted in his experimental work. Prominent elements of this sequence are the terms *factor* (co-opted by Spearman (1927) from Burt (1940), his predecessor at University College; cf. Burt, 1940), *unitary trait* (Thurstone, 1931), *functional unity* (a concept that pre-dates Thurstone (1947), for he refers to it), *latent variable* (Lazarsfeld, 1950), *underlying ability* (Lord, 1952), *underlying trait* (Lord, 1953), *hypothetical variable* (e.g., Green, 1954, p. 725), and *latent trait* (Birnbaum, 1968).

*1.9. Axis of perceived synonymy (aps3: {*construct, intervening variable*})*

As mentioned earlier in the paper, in their 1948 paper, MacCorquodale and Meehl drew a sharp distinction between the terms *construct* and *intervening variable*. This fact seems largely to have been forgotten, for, nowadays, the terms *construct* and *intervening variable* are more than occasionally employed as synonyms.

2. A structural explanation of the WCE

We have described six connected bases of linkage that we believe to be generative of the WCE, and have represented these bases of linkage as the schematic of Fig. 1. We will now demonstrate that instances of concept equating that belong to the WCE can usefully be understood as arising from particular sequences of equivocations and perceived synonymies, and, hence, as sets of *movements* over *ae1*, *ae2*, *aps1*, *aps2*, *aps3*, and t_1–t_2–t_3. We will begin by considering the quotes from Cureton and D'Agostino and Everitt that were presented in the introduction of the paper, before classifying a selection of other instances drawn from the WCE.

Recall that Cureton and D'Agostino (1983, p. 3) made the following claim: "We use the term 'factors' to designate *latent variables*; the term 'variable' (or 'test') will always designate a manifest variable. The factors are actually hypothetical or explanatory constructs." On what basis did

Cureton and D'Agostino come to equate the terms *factor*, *latent variable*, *hypothetical construct*, and *explanatory construct*? They came to equate these terms by taking for granted the perceived synonymies and conceptual equivocations represented in schema 1: a) *aps2* grants an allowance to equate the terms *factor* and *latent variable*; b) *t3* grants an allowance to equate the terms *latent variable* and *construct*; c) both poles of *ae1* are viewed as being legitimately predicated by any of the elements of *aps1*, including the term *hypothetical* that Cureton and D'Agostino chose; finally, d) *ae1* grants an allowance to slide from the COPR conception of constructs to the CNR conception of constructs as possessing of *causal* or *explanatory* powers. We represent this set of concept equatings symbolically as $14 \underset{aps2}{\rightarrow} 12 \underset{t3}{\rightarrow} 11 \cap 3 \underset{ae1}{\rightarrow} 20$.

Everitt (1984, p. 2), it will be recalled, was responsible for the following quote: "Certain concepts in the social and behavioral sciences are not well defined and there are many discussions over the real meaning of terms such as social class, public opinion or extrovert personality. Such concepts are often referred to as latent variables, since they are not directly observable even in the population; they are essentially hypothetical constructs invented by a scientist for the purpose of understanding some research area of interest, and for which there exists no operational method for direct measurement." On what basis did he come to equate the terms *psychological term*, *psychological concept*, *latent variable*, *not directly observable*, and *hypothetical construct*? This set of equatings can be described as follows: a) via *t2*, the concepts *social class*, *public opinion*, and *extrovert personality* are proclaimed to be *latent variables*; b) both polls of *ae2* are viewed as being legitimately predicated by any of the elements of *aps1*, including *unobservable* (*not directly observable*); c) via *t3*, *latent variable* and *construct* are taken to be synonymous; d) both poles of *ae1* are viewed as being legitimately predicated by any of the elements of *aps1*, including the term *hypothetical*. We represent this set of equatings symbolically as $1 \underset{t2}{\rightarrow} 12 \cap 6 \underset{t3}{\rightarrow} 11 \cap 3$.

2.1. Classification of a selection of equatings drawn from the WCE

Jost and Gustafson (1998, p. 474): "A goal of empirical investigation is to determine how each theoretical term interacts with others… with external conditions and whatever other variables…"

$$8 \underset{ae1}{\rightarrow} 20 \underset{t3}{\rightarrow} 12$$

Strauss (1999, p. 19): "One major concern in psychology is to define and describe psychological constructs such as a person's anxiety, extraversion, intelligence, or goal orientation. However, such psychological constructs cannot be observed directly."

$$11 \underset{t1}{\rightarrow} 1 \underset{t1}{\rightarrow} 11 \cap 6$$

Lord and Novick (1968): "Each postulates constructs that are not directly measurable and each observes phenomena that manifest these latent constructs but that also exhibit fluctuation due to other factors…" (p. 14). Latent constructs, not directly measurable, are also called "hypothetical" (p. 14) or "theoretical" (p. 15).

$$11 \cap 7 \underset{aps1}{\rightarrow} 11 \cap 5 \underset{t3,aps2}{\rightarrow} 14 \underset{aps2,t3}{\rightarrow} 11 \cap 5 \cap 7 \underset{aps1}{\rightarrow} 11 \cap 3 \underset{ae1}{\rightarrow} 8$$

Borsboom (2008, p. 28): "…observed variables… such as sex or age…These are theoretical constructs."

$$2 \rightarrow 1 \underset{t1}{\rightarrow} 11 \cap 8$$

Borsboom (2008, p. 29): "cannot be defended by referring to the surplus meaning of latent variables as theoretical constructs, for observed variables carry such surplus meaning just as well. Moreover, in both cases it is necessary to make an inference from an observed data pattern to an *underlying* property."

$$12 \underset{t3}{\rightarrow} 11 \cap 8 \cap 4$$

Royce (1963): "…by a factor we shall mean a true variable, a process or determinant which accounts for covariation in a specified domain of observation" (p. 523); "…factors are *O* variables intermediate between *S* and *R* variables. We infer functional unities which are determinants of the covarying response pattern. These mediating variables may be either intervening variables or hypothetical constructs, depending on their depth of penetration into the nomological net" (p. 525).

$$14 \underset{ae2}{\rightarrow} 21 \underset{ae2,aps2}{\rightarrow} 15 \underset{aps2,t3,aps3}{\rightarrow} 10 \underset{aps3}{\rightarrow} 11 \cap 3, 14 \underset{aps2}{\rightarrow} [\textit{true variable}]$$

Harman (1960, p. 14): "It is the object of factor analysis to represent a variable z_j in terms of several underlying *factors*, or hypothetical constructs.

$$14 \cap 4 \underset{t3}{\rightarrow} 11 \cap 3$$

Bentler (1980, p. 420): "…a latent variable is a variable that an investigator has not measured and, in fact, typically cannot measure. Latent variables are hypothetical constructs invented by a scientist for the purpose of understanding a research area; generally there exists no operational method for directly measuring these constructs."

$$12 \cap 7 \underset{t3}{\rightarrow} 11 \cap 3$$

Bartholomew (1980, p. 295): "The latent variable is not "real" meaning that it could not be measured directly, even in principle. It is a mental construct used to facilitate economy of thought. Attitudes and abilities largely come into this category."

$$12 \underset{t3}{\rightarrow} 11 \underset{t1}{\rightarrow} 1$$

Gorsuch (1983): "The present approach is to consider factors as constructs that will, hopefully, aid in theory development. Constructs are always abstractions from data and never observed" (p. 259); factors are "undefined theoretical scores" (p. 258); "The smaller set of variables [factors] can be used as operational representatives of the constructs underlying the complete set of variables" (p. 4).

$$14 \underset{t3}{\rightarrow} 11\cap 6,\ 14 \underset{aps2}{\rightarrow} [und.the.scores] \underset{aps2,t3}{\rightarrow} 11\cap 4$$

Green (1954): Psychological concepts are "hypothetical variables" (p. 75) that have "…been called *traits*, *intervening variables*…, *latent variables*…, *genotypes*…, and *factors*…"

$$1 \underset{t2,aps2}{\rightarrow} 16 \underset{aps2,t2}{\rightarrow} 1 \underset{t1,aps3}{\rightarrow} 10 \underset{t3}{\rightarrow} 12 \underset{aps2}{\rightarrow} 14 \underset{aps2}{\rightarrow} [genotype]$$

Hayduk (1987, p. 88): "If a concept is directly caused or influenced by any of the other concepts, it is classified as endogenous…"

$$1 \underset{t1,t2}{\rightarrow} 20, 21$$

Bollen (1989, p. 11): "Since all latent variables correspond to concepts, they are hypothetical variables. Concepts and latent variables, however, vary in their degree of abstractness. Intelligence, social class, power, and expectations are highly abstract latent variables that are central to many social science theories. Also important, but less abstract, are variables such as income, education, population size, and age. The latter type of latent variables are directly measurable, whereas the former are capable of being only indirectly measured."

$$12 \underset{t2}{\rightarrow} 1 \underset{t2,aps2}{\rightarrow} 16 \underset{aps2}{\rightarrow} 11\cap 7$$

Green (1954): *attitude* is "…a hypothetical or latent variable, rather than an immediately observable variable."

$$1 \underset{t2,aps2}{\rightarrow} 16 \underset{aps2}{\rightarrow} 12$$

3. The Illegitimacy of the WCE

The concept equatings of which the WCE is comprised are illegitimate. They are illegitimate because the connected bases of linkage that grant the allowances for these equatings are illegitimate. That these bases of linkage have come to be taken for granted is a direct consequence of the social and behavioral scientist's misunderstandings over the natures of, and relationships among, the essential components of scientific investigation. Because it is the essential prop in the fusion of CVT and LVM, we will restrict our efforts to establishing the illegitimacy of the triangle of perceived synonymy. This will require that we remind our readers of the place of concepts and variables in scientific practice.

To begin, concepts are constituents of language (COL) and, because language is a human creation, so too are concepts human creations. A given concept's meaning is manifested in its range of correct employments, and, hence, is fixed by the linguistic rules that fix its range of correct employments. Some, but by no means all, concepts denote constituents of natural reality (CNR). Concept "ϕ" denotes certain, particular CNR only if the rules of language grant its ascription to these certain, particular CNR. The certain, particular CNR to which a concept "ϕ" that denotes can be correctly ascribed are called its *referents*. While a concept is a COL (hence, is not a CNR), the referents of a concept are CNR (hence, are not COL). Thus, for example, the concept *bachelor* is a COL. The concept-word "bachelor" appears in spoken and written linguistic expressions. It is employed correctly in such expressions just in the case in which these employments square with the rules of language. It is a violation of the rules of language to ascribe the concept *bachelor* to a horse or to a woman or to an unmarried child, or to anything else save for an adult, unmarried man. The referents of the concept *bachelor* are, then, those living, breathing, existing humans who just happen to be adult, unmarried men. If there were no such men in existence, then there would be no bachelors in existence (even though the concept *bachelor* would remain an existing part of language).

If the referents of particular concept "ϕ" happen to be *existing* CNR (meaning that there is in existence at least one CNR to which the rules of language grant ascription of "ϕ"), then the natures of these existing referents of "ϕ" (but not, of course, concept "ϕ" itself) can be scientifically investigated. To scientifically investigate bachelors is to scientifically investigate the referents of the concept *bachelor*; i.e., those living, breathing, existing humans who just happen to be adult, unmarried men. To conduct a scientific investigation into the dispositional dominances of women is to investigate, in the sub-population of women, those behaviors of these women that the rules of language fix to be instantiators of the concept *dominant* in its dispositional sense.

Scientific investigations have, then, both conceptual and empirical components. The chief conceptual component is the *specification* of the CNR that will be the targets of investigation. This is a conceptual component because the *specification* of the CNR that will be the targets of investigation is identical to the explication of the meaning of (and, in particular, the rules for ascribing) the concept whose referents are just these CNR. Thus, a physicist whose aim it is to investigate alpha particles has the aim of investigating the referents of the concept *alpha particle*, and the rules of language fix that the concept *alpha particle* can be legitimately ascribed to just those CNR that happen to be positively charged nuclear particles consisting of two protons bound to two neutrons. The empirical components of investigation have as their aim the generation of knowledge about the CNR specified as being the targets of investigation.

Contrary to the beliefs of the social and behavioral scientists, it is only to *particular* classes of CNR (paradigmatically, the class of material entities) that the adjective *unobservable* can coherently be ascribed. Equivalently, the referents of only a relatively small subset of concepts (*neutrino*, *virus*, *alpha particle*, etc.) are, in certain particular senses, perceptually unobservable CNR.[4] The perceptual unobservability of a particular class of interesting CNR poses problems for the scientist, chief among them the problem of having to invent tools that can be used to reliably detect these unobservable CNR (cf. Maraun, 2003, chap. VIII; Maraun, 2009).

[4] Psychological concepts do not have unobservable CNR as referents (cf. Maraun, 2003, chap. XII) but are, rather, instantiated in the third person mode on the basis of a different class of CNR, criterial behaviors (cf. Bennett and Hacker, 2003).

A variable is a function or map. When employed in the service of the scientific enterprise, the chief use of variables is to represent empirical phenomena (properties of CNR) numerically. When individuals belonging to a population *P* are scored on the WISC-R, aspects of their test-taking behavior are mapped onto the real line. That is to say, a variable is created. Because the created variable assigns a real number to each member of population *P*, it has a distribution over *P*. Functions, including those that happen to be variables: a) are not CNR; b) are not discoverable; c) are not the targets of scientific investigations (the proper targets of investigation being the properties of existing CNR); and d) do not possess causal powers (the possessors of causal powers being particular classes of existing CNR).

Concepts are constituents of language. Variables are functions. Variables have distributions over populations of entities under study. Concepts do not. The correct employments of concepts are fixed by the constitutive rules of language. The employments of variables in scientific investigations are not. It is clearly nonsensical to equate the concepts *concept* and *variable*. That is to say, pathway *t2* is illegitimate. Thus, when Borsboom (2008, p. 27), for example, offers up the cliche that "general intelligence is a latent variable", he has strayed from sound scholarship into the sloppy, ungrounded mythologizing (cf. Maraun, 2003, for a detailed analysis of this particular mythology) that militates against the doing of sound psychological science.

Moreover, as neither concepts, nor variables, are constituents of natural reality, they are not the right kinds of things to have ascribed to them any of the elements of *aps1* (***underlying, hypothetical, latent, not directly measurable/unmeasurable, unobservable***). The ascription of the concept-words of *aps1* to the concepts *concept* and *variable* is part of a widespread mythology (cf. Maraun, 2003) that has had the effect of excusing the psychologist from resolving the conceptual issues whose resolutions are precursors to his carrying out fruitful empirical research. The meanings of psychological concepts are, indeed, difficult to explicate, but this is not because these concepts are unobservable, but, rather, because their grammars are notoriously complicated.

Consider, now, the concept *construct* which occupies the remaining side of the triangle of perceived synonymy. Ponder for a moment on what it says about the discipline of Psychology that there is even the need to devote a special issue to the question of what is meant by this concept, surely one of the discipline's central props. In all but the social and behavioral sciences, the concept/referent distinction is implicitly grasped and enshrined as the foundation of fruitful empirical investigation. To empirically investigate a particular class of CNR known as γ-*things* is to empirically investigate just those CNR to which concept γ can be correctly ascribed. Thus the targets of investigation are the *referents* of concept γ, and the referents of concept γ are specified in a definition of concept γ.

On the other hand, the distinctive characteristic of the concept *construct* is that it marks a tacit *equivocation* over the concept/referent distinction, the chief negative consequence of this equivocation being the institutionalized confounding of the conceptual and empirical components of scientific investigation (as manifested in Cronbach's and Meehl's famous claim that "We currently don't know what anxiety means. We are engaged in scientific work to answer this question" (1955, p. 20)). Because *construct* simply marks an allowance taken by the social and behavioral scientist to alternate between the two elements of the *concept*/*referent* relationship on an as-needed basis, there do not exist linguistic rules that fix its correct employments. A putative concept absent of a meaning cannot be synonymous with anything; accordingly, there are no grounds for taking *construct* to be synonymous with either of the concepts *concept* and *variable*. That is to say, pathways *t1* and *t3* are illegitimate.

In our opinion, there is no reason that is not antithetical to the doing of sound science for the employment of *construct* in the work of social and behavioral scientists. Some will no doubt fear that the elimination of *construct* from the discourse of the social and behavioral scientist would somehow do damage to his ability to discuss unobservables and formulate causal conjectures. This fear, however, is wholly unfounded. Perceptual unobservability and causal potency are potential properties of CNR, and, hence, potential properties of the *referents* of particular *concepts*. The properties of existing referents of concepts can be discussed, speculated on, and discovered without reference to constructs.

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