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Review

The dimensionality of the hare psychopathy checklist-revised, revisited: Its purported multidimensionality might well be artifactual

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ABSTRACT

Investigation into the structure of Hare's Psychopathy Checklist-Revised (PCL-R) has consistently shown it to be multidimensional. The implications of multidimensionality for the scale are nontrivial. In the first place, because the construct of psychopathy has traditionally been considered to be dimensional and unitary, results seeming to show that the PCL-R is multidimensional could be taken as calling into question the construct validity of the scale as a measure of psychopathy. In the second, unidimensionality is the sole psychometric justification for employing a composite of test items to scale individuals. Herein, we argue that the purported multidimensionality might, in actuality, be an artifact of the grounding of dimensionality assessment on species of dimensionality- those specific to principal component and linear factor analysis- which are incongruous with the scale. A reconsideration of the scale's theoretical structure singles out the unidimensional monotone latent variable (UMLV) brand of unidimensionality as the one appropriate to the role of grounding dimensionality assessments of the PCL-R. Empirical support for this position is provided by a small-scale dimensionality analysis informed by the UMLV sense of unidimensionality.

1. Introduction

The Hare Psychopathy Checklist-Revised (PCL-R; Hare, 1991, 2003) is a 20-item expert observer rating scale of psychopathic (antisocial, dissocial) personality disorder. Since an account of the development of the original version was first published in a journal article >35 years ago (Hare, 1980), the scale has come to be employed widely in both clinical and research settings. Facilitated by authorized translations into dozens of different languages, it has been adopted for use by correctional and forensic psychiatric agencies around the world. International surveys of forensic mental health professionals indicate that the PCL-R is among the tests most commonly used to assess violence risk. From a test standards perspective, it is somewhat difficult to reconcile this widespread employment with the contentiousness surrounding current understanding of the PCL-R's psychometric behaviour. Test analytic work on the scale has spawned not only multifarious conclusions about its structure, but, also, as a byproduct, long-standing and, at times, acrimonious disputation on the issue. Employing, almost exclusively, variants of linear factor- and principal component- analytic methodology (exploratory and confirmatory; hierarchical, correlated factor, and bifactor; with and without testlets or parceling, etc.), psychopathy researchers have proposed, to date, a considerable diversity of structures, estimated at 11 or more (Pérez, Herrero, Velasco, and Rodriguez-Díaz, 2015). It seems the only thing upon which there is agreement is that the PCL-R does not have a *unidimensional* structure.

It is apparent that, in the estimation of many, the major difficulty posed by this state of affairs is simply the absence of a consensus on an issue central to an accounting of the PCL-R's psychometric characteristics. However, for two reasons, it is the putative multidimensionality which should be most concerning. In the first place, the construct of psychopathy has traditionally been considered to be dimensional and unitary (e.g., Neumann, Hare, and Newman, 2007a). Empirical results seeming to show that the items of the PCL-R are multidimensional could be entertained as calling into question the construct validity of the scale as a measure of psychopathy. The choice researchers have consistently made to interpret the multidimensional findings as novel insights into the nature of the construct, rather than as bearing on the construct validity of the scale, is an arbitrary one, and in no way constitutes a scientific setting to rest of concerns over the latter issue. In the second place, though the scale has a variety of employments, one being as input into structured and semi-structured clinical assessments, its primary employment- certainly in research- is as an

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instrument of scaling. The scaling of individuals on the basis of the items of a test is effected through the formation of an item composite. Unidimensionality is the sole psychometric justification for compositing a set of items[1] (see, e.g., Thissen, Steinberg, Pyszczynski, and Greenberg, 1983; McDonald, 1981).

According to the *Standards for Educational and Psychological Testing* (AERA, 2014), a test must be validated with respect to *each* of its intended employments. It follows, then, that if the PCL-R were multidimensional, it would have to be disqualified from employment as an instrument of scaling. There has been a movement, of recent, to attempt circumnavigation of this implication by setting forth the claim that a single superordinate factor underlies the multidimensionality. It is believed that if the PCL-R were to have such a hierarchical structure, this would constitute "… support for using total scores from the PCL instruments to study groups of individuals…" (Hare and Neumann, 2008, p.234). Later in the paper, we will endeavour to show that this belief is mistaken. The sole psychometric justification for compositing a set of items is that the items *themselves* are unidimensional, and the quintessence of a hierarchical structure is that the items are multidimensional. If they were not so, there wouldn't *be* a set of first-order factors to factor analyze. From both a construct validity and psychometric perspective, the putative multidimensionality of the PCL-R is by no means a trivial matter.

Given the sheer number of quality investigations on which is based the received account that the PCL-R is multidimensional, it might strike the reader as foolishly argumentative to suggest anything to the contrary. Yet, in our view, there is a sound, and solidly technical, basis for disputing the claim. The case we will set forth is that the received account might well be an artifact of the grounding of dimensionality assessment on species of dimensionality- those specific to principal component, and linear factor, analysis- which are incongruous with the scale's nomological embedding theory, and, in consequence, inappropriate as a basis for the assessment of its dimensionality. It is our opinion that the improper selection of dimensionality type is by no means restricted to the particular case under consideration in the present work; that, to the contrary, it is endemic to the social sciences, and, indeed, invalidates a considerable proportion of published test analytic work. It is a predictable consequence of an overly loose appreciation of a technical notion- that of dimensionality-, one feature of which is an obliviousness to the fact that there exists, not a single unitary mathematical sense of the concept, but, rather, a multiplicity of distinct senses.

Any given test will have manifold dimensionalities. An arbitrary test T could, for example, be 4 dimensional in the linear factor analytic sense, 10 dimensional in the principal component analytic sense, 2 dimensional in the sense of non-metric multidimensional scaling, and have a fractal dimensionality of 3.3. However, only a very small subset of the dimensionalities a test has will be logically congruent with its theoretical structure. These latter are the dimensionalities which are *relevant* to the test's evaluation. The species of unidimensionality defined under both principal component, and linear factor, analysis are inconsonant with what the theoretical structure of the PCL-R asserts about the relation between PCL-R items and the construct of psychopathy. If our arguments are accepted as reasonable, past dimensionality claims about the PCL-R must, then, be seen, not as wrong, *per se*, but, rather, as *irrelevant* to the scale's assessment.

We aim, in fact, to reconcile this past work with the focal issue of whether or not the PCL-R is unidimensional, by demonstrating that it is entirely possible for the PCL-R to be *both* multidimensional in the irrelevant senses of dimensionality, to date, employed, and unidimensional in a sense consonant with its theoretical structure. To this end, we will suggest that a careful elucidation of the PCL-R's theoretical structure singles out the monotone latent variable (UMLV) variety of unidimensionality (see Holland and Rosenbaum, 1986) as the one relevant to the scale's assessment. With the aim of grounding our analytically derived recommendation in application, we undertake a small-scale dimensionality assessment of the PCL-R underpinned by this *relevant* variety of unidimensionality.

[1] "Along with an explicit definition, unidimensionality is a logical prerequisite for 'measuring' anything, including 'intelligence'. If it were 2-dimensional, for example, it would no longer make sense to say 'person A is more intelligent than B', because A may be more intelligent than B on intelligence X, but less intelligent than B on intelligence Y." (Schoneman, 1997).

2. The manifold species of unidimensionality

The case we will, herein, set forth, is that the widely-accepted verdict that the PCL-R is multidimensional, might, in fact, be an artifact of the grounding of dimensionality assessment on species of dimensionality which are logically incongruous with the scale. In this section, we elucidate the central technical concept of *test dimensionality*, on which our case depends, focusing on the special case of unidimensionality. In view of the general relevance, and fundamental importance, of the technical points raised, to scientific praxis within the social sciences, we keep the discussion, here, general. The conclusions reached are applied to the case of the PCL-R in a later section. The concept of dimensionality is, of course, of a mathematical nature. To maintain readability, we state the case in words, and place supporting mathematical expressions and proofs in an appendix. Consider a test T comprised of s items, $X = (X_1, X_2, \ldots, X_s)$, the latter of which were constructed to scale individuals with respect to a focal construct φ. The individuals belonging to a population P, in which T is employed, are scored on the items. We note, to begin, that T's dimensionality is an empirical property of the joint distribution of its items within population P. That is to say, test dimensionality is not an immutable property of a test, but, rather, a property of a given pairing of *test* and *population*.

A fact, crucial to both our case and to fruitful dimensionality assessment, but seldom if ever acknowledged in published test analytic work, is that there exists, not one, but a multiplicity of distinct species- varieties or senses- of dimensionality (unidimensionality). Additional to what might be called the standard Euclidean sense of dimensionality (the sense which informs Principal Component Analysis; PCA), and among countless others- including that on which non-metric multidimensional scaling is founded-, a novel sense of dimensionality is defined under each and every latent variable procedure that has, to date, been invented. We have, e.g., dimensionality in the senses of linear factor analysis, quadratic factor analysis, d-class latent profile analysis, etc.

A test T is unidimensional in the sense of PCA if and only if the rank of the s by s covariance matrix Σ of its items is equal to 1 (equivalently, if Σ has but one positive eigenvalue). It is unidimensional in the sense of linear factor analysis (LFA) if and only if it has, as a latent structure, the unidimensional linear factor structure (see Appendix 1). The unidimensional linear factor structure asserts the state of affairs wherein there exists a continuously distributed latent variable (common factor), upon which T's items are jointly causally dependent. In the case of LFA, causal dependency is given a paraphrase in terms of partial correlation. Specifically, "the items are jointly causally dependent on the common factor" is given meaning as, "partialling the common factor from each of the items, would render the items uncorrelated." Equivalently, the sole reason that the items are correlated- i.e., for the *nondiagonality* of their correlation matrix- is that they share a common cause, that being the common factor. In Spearman's seminal formulation of LFA, the common factor was labeled g (general intelligence) and the "items" were different intelligence tests.

Now, it can be proven (e.g., Mardia, Kent, and Bibby, 1980; see Appendix 2) that a set of items has a unidimensional linear factor structure if and only if its covariance matrix Σ can be represented as $\Lambda\Lambda' + \Psi$, wherein Λ is an s-vector of loadings and Ψ, an $s \times s$ diagonal, positive definite, matrix of unique (or residual) variances. Not surprisingly, then, the latter is employed in virtually all implementations of linear factor analysis as a test condition of the LFA brand of unidimensionality. With an n by s data matrix as input, a program such as LISREL (Joreskog and Sorbom, 1993) searches for an s-vector $\widehat{\Lambda}$ and an s by s diagonal, positive definite, matrix $\widehat{\Psi}$, such that $\widehat{\Lambda}\widehat{\Lambda} + \widehat{\Psi}$ is maximally similar to the input sample covariance matrix S. If the former is deemed to be sufficiently similar to the latter, the decision is made that Σ is, in fact, representable as $\Lambda\Lambda' + \Psi$, and, consequently, that the items are unidimensional in the linear factor analytic sense.

According to McDonald (1977, p.165), linear factor analysis "...is probably the most widely employed device for the statistical analysis of multivariate data." It seems, in fact, that researchers treat linear factor analysis as something of a default choice when undertaking test analytic work, and, even more consequentially, take *test dimensionality* to be