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DO ZERO CORRELATIONS REALLY EXIST AMONG MEASURES OF DIFFERENT INTELLECTUAL ABILITIES?

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Whether measures of different intellectual abilities are positively intercorrelated has been a topic of interest and debate since the turn of the century. The data from an article by Guilford pivotal to this debate are reexamined. It is argued that, contrary to the original claim of the article, the data set of over 7,000 correlations does *not* provide support for the existence of zero correlations among tests of intellectual abilities.

THAT different measures of intelligence are correlated positively had long been assumed prior to Guilford (1964). As early as the first decade of this century, investigators who conducted extensive studies using widely varying tests of intellectual ability concluded that zero correlations did not exist in nature (Simpson, 1912). A belief in the positive correlative structure of intelligence has crucial implications for one's conception of intelligence. Most important may be that the assumption of only positive correlations among tests of intelligence supports the concept of a "general factor," or *g*.

During the 1950's and 1960's Guilford and his colleagues at the University of Southern California were engaged in extensive research on tests of intellectual ability. The eventual fruit of this work was of course Guilford's (1967) *The Nature of Human Intelligence* and the structure-of-intellect (SOI) model of intelligence. As anyone acquainted with the SOI model of intelligence will understand, one of the proximal goals of this work was the isolation of new factors of intelligence. In this pursuit, zero correlations among the various tests developed were considered highly desirable, as they were thought to represent factoral purity. In 1964 Guilford published an article presenting correlational data collected over the previous 15 years. This article addressed what Guilford and Zimmerman (1963) had termed the "obsessional" belief in positive relationships among intellectual measures. Specifically, the 1964 article purported to show that there is a substantial number of zero correlations among tests of intellectual ability. This article subsequently came to wield influence and is still being favorably cited over 20 years later. The purpose of the present article was to argue that Guilford's (1964) data-based conclusion that zero correlations exist in nature is flawed by oversights of problems in the data.

Guilford's Correlational Data and Their Influence

The article Guilford published in 1964 was entitled *Zero Correlations Among Tests of Intellectual Abilities*. In this paper Guilford tabled 7,082 correlations among various tests administered over 15 years at the University of Southern California. These data (Guilford, 1964, Table 1) were grouped in categories incremented by .1, with a mean of .226 and with a standard deviation of .137. Guilford argued that a substantial proportion of these correlations could be considered zero. For example, he noted that as the "typical" sample size on which the correlations were based was 225, the standard error of r when the population value is zero is .067; $\pm$ 2SE then gave a range of $-.134$ to $+.134$ around zero. This circumstance means that "as many cases as 24%" of the correlations can be considered zero.

The presentation of these data was influential. For example, Epstein and O'Brien (1985) have pointed out that reported low correlations between measures of the same trait bolstered the situationist position vis-a-vis the trait position in the person-situation debate begun by Mischel (1968); Guilford (1964) was one of the later sources cited in this regard. Some studies have cited Guilford (1964) as proof that early work on intelligence that almost invariably found positive correlations among measures has now been superceded (e.g., Diamond and Royce, 1980). Others even appeared to use the proportion of zero correlations reported by Guilford as a standard against which to judge their own work (e.g., Undheim, 1978). Guilford (1967) himself used these data to further his argument against the concept of g by stating that it is "illogical to insist on [g] in the face of zero correlations."

The Critique

Problems in the data. There are several problems with accepting Guilford's position that a sizable proportion of the correlations reported in the 1964 article can be considered zero. First, the correlations appear to have been based on samples that were subject to range restriction. Second, as the measures cannot have been perfectly reliable, the correlations were also subject to attenuation. Third, many of the correlations were estimates of Pearson *r*'s from 2×2 contingency tables; this situation can mean serious underestimation of the *r*. Fourth, if Guilford's distribution of correlations represents itself as a single normal distribution, then the best estimator of that distribution is the mean (or, as will be argued, the corrected mean). Considering one of the tails of such a distribution, such as those correlations around zero, as a phenomenon in itself makes little sense.

That the correlations were subject to range restriction is attested to by Guilford (1964) when he commented that "most of the analyses were based upon males with generally higher-than-average IQ levels" (p. 403). Such non-random sampling would have reduced the size of the correlations.

Attenuation due to measures that are not perfectly reliable would have further reduced the correlations. As Guilford did not report reliabilities in his 1964 article, it is assumed for the sake of argument that those reliabilities were high but not perfect.

Estimates of *r* from 2×2 tables can be too low. This conclusion is true because the nature of the cuts on the underlying distributions can have immense impact on the size of the estimation. Alexander, Alliger, Carson, and Barrett (1985), for example, have shown that different measures of 2×2 association may provide very different and often misleading estimates of the underlying correlation.

That the distribution of correlations is normal may not be so immediately obvious. Figure 1 may be considered in this regard. In this figure, the percentage of correlations in each .1 category is plotted at the midpoint of the category, and these points are connected by a smoothed curve. An expected distribution (assuming normality and a mean of .226 and a standard deviation of .137) is plotted also. It can be seen that the expected distribution differs very little from the observed one. Moreover, the Kolmogorov-Smirnov test for normality does not reject the null assumption of normality ($D = .006$, D crit $= .019$, $\alpha = .01$) even though for such a large sample size ($N = 7{,}082$) the K-S is known for excessive power (rejecting the

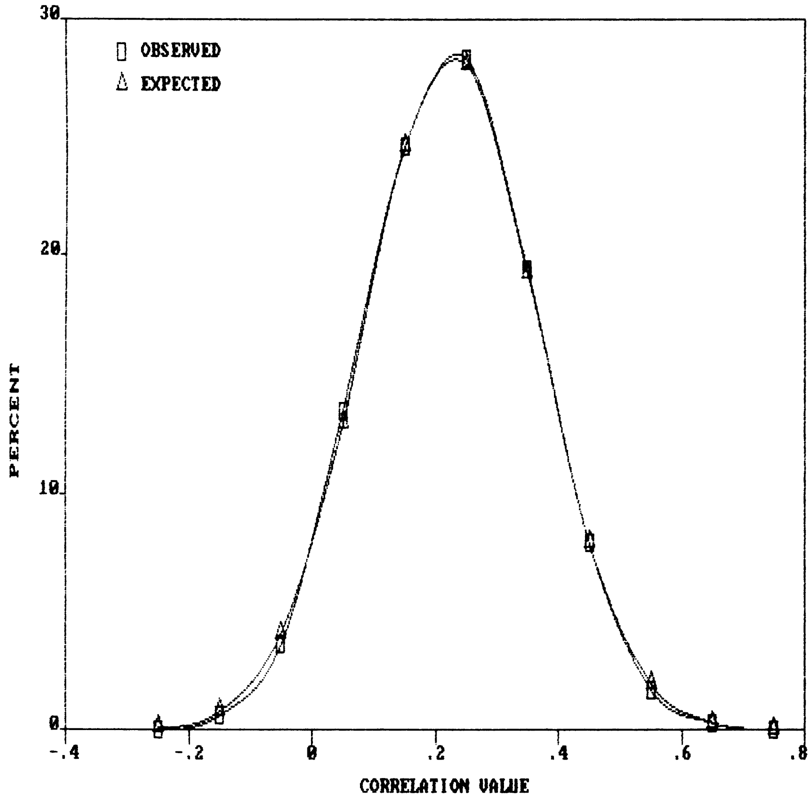

Figure 1. Observed distribution of correlations and expected normal distribution.

null for trivial differences). Finally, a validity generalization procedure, which removes the variance due to artifactual sources from a distribution, (and assuming for this case that sample size varied randomly from 200 to 250 around the "typical" value of 225), showed a residual variance of .013, small enough to allow the conclusion that a single population distribution underlies the observations (McDaniel, Hirsch, Schmidt, Raju, and Hunter, 1986).

Correcting the Mean r. Assuming, then, that the distribution in question is normal and represents a single population, it is the mean of this distribution that constitutes the best estimator of the population value. That mean is .226. Now, Guilford reported that most subjects were above average intelligence. If truncation at the mean on the tests used is assumed, the mean of the ratio of restricted to the unrestricted standard deviations (*U*) can be estimated at .603 (cf. Alexander, Alliger and Hanges, 1984). The Thorndike (1949) formula for correction for range restriction is:

$$r = r^*/(r^{*2} + U^2 - r^2U^2)^{1/2},$$

where r is the unrestricted coefficient and r^* is the restricted coefficient. If U is as defined previously, and if r^* is taken as .226, then $r = .359$. This estimate can then be corrected for attenuation. Conservatively assuming mean test reliabilities of .8, letting $r^* = .359$ and correcting for attenuation by the familiar formula:

$$r_c = r^*/(r_{xx}r_{yy})^{1/2},$$

finds r increased to .449, where rxx and ryy are the respective reliability coefficients of the x and y measures and rc is the final corrected correlation coefficient.

Thus an estimate of a population correlation of .449 instead of .223 has been obtained. This result represents a fourfold increase in the variance accounted for (20% vs. 5%). Indeed, this estimate of r itself may be too low, because of the frequent presence of dichotomization on one or both variables, for which no correction for this set of correlational data is possible. In any case, if the standard deviation of the distribution represented by this mean correlation is estimated at .137 (reduced to .114 if estimated artifactual variance is removed), a distribution with this mean and variance will virtually never encompass zero.

An important caveat concerning this reanalysis was provided by a reviewer and the editor: Guilford included in the 1964 article some correlations meant to measure the same factor; such correlations would be expected to be moderately positive, and would spuriously inflate the mean of the distribution. But, even if the uncorrected mean of the distribution were, for example, .17, instead of .223, the corrected estimate of the population correlation arrived at by the same means as previously presented would be .344. Again, the distribution represented by this corrected mean and a standard deviation of .137 (or .114) would allow virtually no zero correlations.

Conclusion

The purpose of this article was not to attack the SOI model of intelligence, but to correct the perception that zero correlations between tests of intellectual abilities were routinely found in the work of Guilford as reported in this 1964 article. Any such correlations should be considered as perhaps having occurred because of the problems that have been outlined. This critique, of course, has larger implications for discussions on the nature of intelligence, such as whether *g* is a supportable concept and, relatedly, whether orthogonal rotations are advisable in factor analytic studies of intelligence.

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