NOTE ON THE ASSUMPTIONS UNDERLYING HOLZINGER'S h^2 STATISTIC.

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HOLZINGER set up his equations to show the combination of the factors —nature (A), nurture (B), and error(E)—which go to make up a score obtained by a particular twin on a particular test. If ${}_iX_1$ and ${}_iX_2$ are the twins in an identical pair and ${}_fX_1$ and ${}_fX_2$ are the twins in a fraternal pair then :—

$$(1)\begin{cases} {}_iX_1 = {}_iA + {}_iB_1 + {}_iE_1 \\ {}_iX_2 = {}_iA + {}_iB_2 + {}_iE_2 \end{cases} \qquad ({}_iA_1 = {}_iA_2 = {}_iA)$$

$$(2)\begin{cases} {}_fX_1 = {}_fA_1 + {}_fB_1 + {}_fE_1 \\ {}_fX_2 = {}_fA_2 + {}_fB_2 + {}_fE_2 \end{cases} \qquad (\textit{note } {}_fA_1 \neq {}_fA_2).$$

It should be noted here that no provision has been made for an interaction term between factors A and B. It is certain that such interaction takes place, and that a term of this kind should be included in a complete account.

Holzinger then considers the difference within a pair of twins—both identical and fraternal. Using his notation we have the difference between a pair of identical twins iD, where—

$$\begin{aligned} {}_iD &= {}_iX_1 - {}_iX_2 \\ &= {}_iD_B + {}_iD_E. \end{aligned}$$

The variance of this difference (${}_i\sigma^2_D$) will be—

$$\begin{aligned} {}_i\sigma^2_D &= {}_i\sigma^2_B - r_{B_1B_2}\,{}_i\sigma^2_B + {}_i\sigma^2_E{}^* \\ &= {}_i\sigma^2_{D_B} + {}_i\sigma^2_E. \end{aligned}$$

It will be seen that Holzinger gives (p. 113 [15])

$$ {}_i\sigma^2_D = {}_i\sigma^2_{D_B}.$$

assuming that—

(1) ${}_i\sigma^2_E = 0$
(2) $r_{EB} = 0$.

Considering these assumptions,

(1) The error variance cannot be equated to zero. It is obvious that one cannot eliminate experimental error—its inclusion in an equation of the above type (1) is fundamental.

* Since ${}_i\sigma_{B_1} = {}_i\sigma_{B_2} = {}_i\sigma_B$. It should be remembered that in Holzinger's notation ${}_i\sigma_B$ is a double entry standard deviation of the difference ${}_iD_B$.

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(2) By definition of our error term we can assume orthogonality of any residual.

Similarly Holzinger considers the difference ($_fD$) between a pair of fraternal twins where—

$$\begin{aligned} {}_fD &= {}_fX_1 - {}_fX_2 \\ &= {}_fD_A + {}_fD_B + {}_fD_E \end{aligned}$$

as over, the variance of this difference ($_f\sigma^2_D$) will be—

$$_f\sigma^2_D = {}_f\sigma^2_A - r_{A_1A_2}\,{}_f\sigma^2_A + {}_f\sigma^2_B - r_{B_1B_2}\,{}_f\sigma^2_B + 2R\sigma_{D_A}\,\sigma_{D_B} + {}_f\sigma^2_E.$$

Therefore $_f\sigma^2_D = {}_f\sigma^2_{D_A} + {}_f\sigma^2_{D_B} + 2R\,{}_f\sigma_{D_A}\,{}_f\sigma_{D_B} + {}_f\sigma^2_E$, where R = correlation between D_A and D_B.

Holzinger gives the variance of the difference

$$\sigma^2_D = {}_f\sigma^2_{D_A} + {}_f\sigma^2_{D_B} + 2R\,{}_f\sigma_A\,{}_f\sigma_B \qquad \text{(p. 113 [16])};$$

and on p. 114 assumes $R = 0$, i.e.:

$$_f\sigma^2_D = {}_f\sigma^2_{D_A} + {}_f\sigma^2_{D_B}$$

assuming that—

(1) $_f\sigma^2_E = 0$
(2) $r_{EA} = r_{EB} = 0$.
(3) $R = 0$.

Again, in considering these assumptions,

(1) The error variance is not zero.

(2) It is legitimate to assume that $r_{EA} = r_{EB} = 0$.

(3) This will be true if $r_{AB} = 0$, which Holzinger has implicitly assumed. It is certain, however, that there is a correlation between the nature and nurture factors.*

Unless we make definite assumptions about—

(1) The size of R,

(2) The relative sizes of the two error variances,

it can be seen from (17), p. 113, and (25), p. 115, that it cannot be shown whether the more accurate estimates of the variances of the differences will increase or decrease h^2.

* Shuttleworth *J. ed. Psychol.*, **26**, Part 1, 561–578, "The Nature *versus* Nurture Problem." Part 2, 655–681.

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