

# R...you aware how useful it is? The value of correlation coefficients in meta-analysis



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## Introduction

Meta-analysis involves pooling effect sizes to combine results from studies attempting to answer similar research questions. Typically, a common metric is used to estimate associations between independent and dependent variables in pooled studies. Nonetheless, studies vary considerably in their measurement of effect sizes as well as the nature of studied variables. The calculation of an effect size  $r$  allows the pooling of results that are reported in a variety of forms. In the presence of needed raw data,  $r$  can be computed from relative risks, odds ratios,  $t$  statistics,  $F$  statistics, chi-square statistics, standard normal deviate  $z$  statistics, and beta coefficients.

The objective of this work is to show how  $r$  can be used to pool data from studies using different point estimates in order to obtain an overall parameter that presents the direction and strength of an association. This methodology was described by Rosenthal and DiMatteo<sup>1</sup> and is demonstrated herein by pooling data from the published literature on the association between age and the incidence of post traumatic stress disorder (PTSD).

## Methodology

We retrieved data from 10 studies, which reported on the association between age and PTSD incidence. Reported point estimates included correlation coefficients ( $r$ ), odds ratios (OR),  $p$  values, and  $F$ ,  $t$  and  $\chi^2$  statistics. Before these point estimates could be pooled in a meta-analysis, they needed to be converted into  $r$  values.

In general, the conversion process entails additional considerations to ensure reporting consistency. Before a correlation  $r$  can be computed for each study, it may be necessary to average effect size estimates where multiple estimates are reported across categories of the same variable. For example, Phillips *et al.*<sup>2</sup> reported odds ratios for multiple age groups. These were averaged into one OR (a conservative approach) before converting to  $r$ . In addition, close attention must be paid to ensure that the correct attributions are made with respect to interpretation based on the same reference group. As such, the direction of association should be considered. For example, in Phillips *et al.*<sup>2</sup>, the youngest age group was used as the reference group, while Bromet *et al.*<sup>3</sup> and Dahl *et al.*<sup>4</sup> used the oldest age group as the reference category. ORs in the later two studies were inverted using the original data, so that ORs were expressed consistently across included studies.

For studies, which only report  $p$  value ranges (e.g.,  $p < 0.05$ ),  $p$  can be converted into its associated one-tailed standard normal deviate  $z$  before calculating  $r$ . This conversion was conducted for Boscorino *et al.*<sup>5</sup> Moreover, in studies where the independent variable has no significant effect on the dependent variable, a value of zero can be assigned to  $z$ , with a corresponding  $r$  of zero. It must be noted, however, that this approach represents an underestimate of the effect size.

Table 1 provides a listing of included studies, reported measures of association, and corresponding conversion equations, where appropriate.

**Table 1:** Types of measures of association reported in studies and equations for conversion to  $r$

Study	Measure of association	Equation for conversion to $r$
Acierno 2006 <sup>6</sup> , Foa 1999 <sup>7</sup>	$F$	$r = \sqrt{\frac{F_{1,v2}}{F_{1,v2} + df_{error}}}$
Bromet 1998 <sup>3</sup> , Dahl1998 <sup>4</sup> , Phillips 2010 <sup>2</sup>	OR	$r_{\cos-\pi} = \cos\left(\frac{180^\circ}{1 + \sqrt{\frac{ad}{bc}}}\right)$
Rimmo 2005 <sup>8</sup>	$\chi^2$	$r = \sqrt{\frac{\chi^2(1)}{N}}$
Matsuo 2003 <sup>9</sup>	$t$	$r = \sqrt{\frac{t^2}{t^2 + df}}$
Boscorino 2006 <sup>5</sup>	$p$ value	Convert $p$ to its associated one-tailed standard normal deviate $z$ and use: $r = \frac{z}{\sqrt{N}}$

It is important to note that  $r$  values, which are computed from individual studies, are not normally distributed. Therefore, we used the Fisher's  $z$  transformation to convert  $r$  to the normally distributed variable  $z'$ . The formula for the transformation is:  $z' = 0.5 \ln(1 + r) - \ln(1 - r)$

Table 2 lists computed  $r$  values and transformed  $z'$  values for each of the included studies.

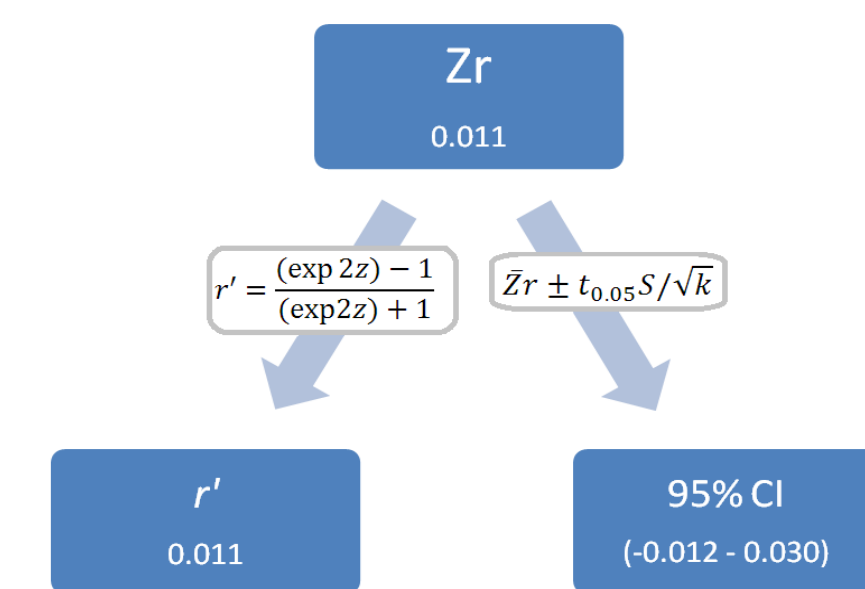
**Table 2:** Conversion of point estimates to  $r$  and Fisher's  $z'$  values

Study	Point estimate	$r$	$z'$
Acieno 2006 <sup>6</sup>	$F = 24.6(1, 1541)$	-0.12555	0.12621
Foa 1999 <sup>7</sup>	$F = 21.52(2, 440)$	-0.18623	0.18842
Phillips 2010 <sup>2</sup>	OR = 1.07	0.02657	0.02657
Bromet 1998 <sup>3</sup>	OR = 1.05	-0.08429	-0.08449
Dahl 1998 <sup>4</sup>	OR = 0.75	0.11254	0.11301
Rimmo 2005 <sup>8</sup>	$\chi^2 = 3.1(2)$	-0.173	-0.17476
Landolt 1998 <sup>10</sup>	$r = -0.01$	-0.01	-0.01
Boscorino 2006 <sup>5</sup>	$p < 0.001$	0.02499	0.02500
Matsuo 2003 <sup>9</sup>	$t = 0.38$	0.06610	0.06619
Thabet 2004 <sup>11</sup>	$r = 0.12$	0.12	0.12058
<b>Pooled</b>		<b>0.010875</b>	<b>0.010875</b>

The next step was to average the individual  $z'$  values to produce an unweighted pooled  $Z_r$ . This pooled parameter was then converted back into  $r$  resulting in a summary unweighted mean  $r'$  (0.011).

The final step was to compute a 95% confidence interval around  $r'$ . Figure 1 provides formulas for computing the pooled  $r'$  and 95% confidence interval using  $Z_r$ .

**Figure 1** Computation of pooled  $r'$  and 95% confidence interval



## Discussion

We combined findings from 10 studies reporting varying measures of association between age and the incidence of PTSD. It is evident that including studies on the basis of similarity in reported point estimates would have excluded the majority of them from the analysis. Therefore, the previous conversions minimized the loss of data in the meta-analysis. The pooled estimate demonstrated that there is a small positive correlation between age and the incidence of PTSD.

Although popular in the psychological and social literature, the utility of  $r$  can be extended to include other areas of science where associations are reported using a variety of point estimates. Mention must be made that Cohen's  $d$  can also be used to pool different measures of association. However, effect size  $r$  has several advantages over  $d$  since it allows for analyses across more than two groups, whereas  $d$  is limited to two. Moreover,  $r$  is easier to interpret than  $d$ .<sup>1</sup>

## Conclusions

The analysis shows how diversely-reported effects sizes can be combined to produce a summary effect size  $r$  that provides the direction and strength of association between two variables.

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