Solvent extractable components of oil paint films

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Appendix 4: formulae for statistical analysis

In Chapter 6, the quantities of extractable fatty acids in samples taken from paintings before and after solvent cleaning treatments were compared, and the results subjected to statistical analysis, using $t$ tests to assess the significance of differences observed between the different groups of samples. The $t$ test is a standard statistical procedure [1, pp. 166-181], and involves a calculation of the $t$ ratio, according to equation 1:

$$ t = (\bar{X}_1 - \bar{X}_2) / (s_{\bar{X}_1, \bar{X}_2}) $$

where $\bar{X}_1$ and $\bar{X}_2$ are the mean values for the two groups of samples (in this case, the proportions of a given fatty acid extractable from paint samples before and after solvent cleaning), and $s_{\bar{X}_1, \bar{X}_2}$ is the estimated standard error of the difference between the means. The estimated standard error is calculated according to equation 2:

$$ s_{\bar{X}_1, \bar{X}_2} = \sqrt{(s_1^2 / N_1) + (s_2^2 / N_2)} $$

where $s_1$ and $s_2$ are the standard deviations for the two groups of samples, and $N_1$ and $N_2$ are the numbers of samples in each group.

As described in Chapter 6, calculated $t$ ratios are then compared with critical values of $t$, supplied in standard tables [1, p. 356]. A $t$ ratio greater than the critical value provides evidence for a systematic effect (i.e., in this study, a leaching effect).

In Chapter 6, critical values were used corresponding to a "two-tailed test", i.e. one that accounts for possible differences between the groups of samples in either direction (in the cleaning tests, either an increase or decrease in the proportions of extractable fatty acids). Although a one-tailed test could be justified in this type of comparison, since the expected result of solvent treatment is a reduction in the proportion of extractable fatty acids, the use of two-tailed tests appears to be more widely accepted [2, p. 57-58]. The two-tailed test can be considered more rigorous, since the critical $t$ values are higher at a given significance level than in a one-tailed test.
The critical values of $t$ used in the test also depend on the number of degrees of freedom ($df$) associated with the experiment. The $df$ for each group of samples is equal to $N-1$, and the $df$ used in a $t$ test is the sum of the $df$'s for the two groups, i.e. $N_1 + N_2 - 2$ [1, p. 177]. For the cleaning tests, in which five samples were analysed before and after each treatment, critical values of $t$ were therefore used corresponding to $df = 8$.

References
