Random Factors in Animal and Lab Trials

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Random factors appear quite often in trials involving cell cultures or animals. Apart from breeding experiments, however, researchers are mainly interested in estimating and testing fixed effects while – in a certain sense – random effects are usually considered as 'nuisance effects'. Assessing random factors is important for planning and designing future trials. But the impact of random factors is also of interest if the results of the fixed effects depend on the design (hierarchical or crossed) and also on the number of the levels of the random factors. The research question of interest cannot be answered sufficiently if the analysis of a design involving a complicated structure of the factors of the experiment is unstable or even breaks down. What shall the statistician tell the researcher if the software used for the analysis stops or ends with an error massage such as 'Unable to make the final Hessian positive definite', 'No tests performed due to a MS with zero expectation', 'A linear combination of covariance parameters is confounded with the residual variance', 'Estimated G matrix is not positive definite'? Shall the statistician say 'Unfortunately, your data detract from an analysis'? This should motivate to take a closer look at models involving random factors.

In simple trials, different estimation and testing procedures may lead to similar results – depending on the software used. But as soon as two or more random factors are involved, estimation and testing results can be quite different – if results are produced at all. Even testing and estimating the fixed effects may be difficult - if results are produced at all.

Two random factors appear in all trials where treatment effects involving mother animals and their pups are of interest. The same problem appears when subjects are repeatedly observed to obtain more accurate measurements. Different examples from lab and animal trials are discussed and basic software implementations are considered discussing the underlying statistical model. General solutions in semi- and nonparametric models without the assumption of the normal distribution or for non-metric data are less developed and seem to be open problems for research. Some recent results can be found in Hui et al. (2019) and references cited therein.

In closing the discussion on this topic it is recommended to run simulation studies with known input reflecting the type of data and the design structure of the trial using the software at hand.

References

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R-Packages

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flc.R to perform the FLC test (Hui et al., 2019).