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## Quantile-based MANOVA: A new tool for inferring multivariate data in factorial designs

Multivariate Analysis of Variance (MANOVA) allows for the joint comparison of multiple responses and is commonly used in fields such as medicine, ecology or psychology. However, the classical MANOVA relies on assumptions, e.g. normality or homogeneous covariance matrices, which are often difficult to justify. To overcome these difficulties there are less restrictive mean-based MANOVA concepts proposed for testing global hypothesis about multivariate expectations, e.g. Friedrich and Pauly (2018). In case of outliers or distributions with larger tails, however, non-robust estimators like the mean can have some drawbacks. Despite the usage of quantiles is intuitive in that case and often applied in descriptive statistics, e.g. boxplots, quantiles "[appear] to be quite underused in medical research" (Beyerlein, 2014).

Therefore we developed a flexible quantile-based MANOVA method. The approach is adaptable to general factorial designs and has the advantage that it fits to median and other quantile-based statistical methods. To achieve this, we considered two quadratic-form type test statistics and three different strategies for estimating the covariance. The test statistics' distribution is approximated via resampling. We prove that our method is valid in theory and even works in case of general heterogeneous or heteroscedastic data beyond normality. In a simulation study, we compare the novel procedures with state-of-the-art mean-based approaches.

## References

- Beyerlein, A. (2014). Quantile Regression—Opportunities and Challenges From a User's Perspective. *American Journal of Epidemiology*, 180(3):330–331.
- Friedrich, S. and Pauly, M. (2018). MATS: Inference for potentially singular and heteroscedastic MANOVA. *Journal of Multivariate Analysis*, 165:166–179.