Move over ANOVA?

Aspects of analysing longitudinal data with Repeated Measures ANOVA and Mixed Models Regression

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Outline

- Introduction:
  - Recap: Repeated Measures ANOVA
  - Recap: Mixed-effect Regression Models
- Categorical Data
- Akaike Information Criterion
- Comparison and Summary

Repeated Measures ANOVA

- Same assumptions as regular ANOVA, only samples are not independent
- Particularly suited for longitudinal studies where change through time is the main subject of research
- Main difference with regular ANOVA is partitioning of variance
  - SSE is divided into a within-subjects (SSS) and among-subjects part
  - The within-subjects differences are removed from SSE

Mixed Models

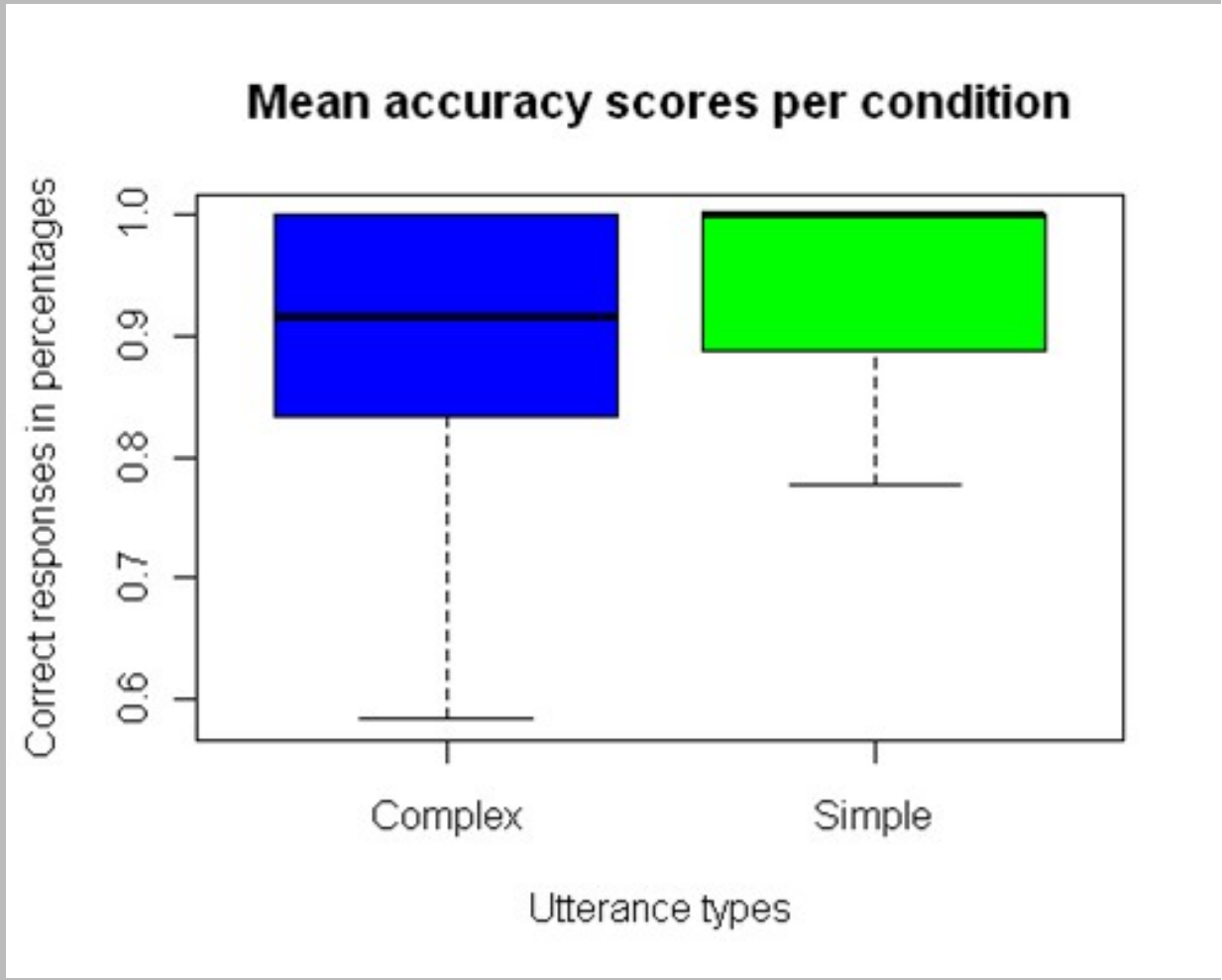
- Multiple regression models look for the best fitting formula, i.e. the combination of effects for each variable that best fits the observed data
- Mixed Models distinguish between random-effect and fixed-effect factors
- In longitudinal studies, time can be one of the independent variables

Some previously mentioned issues

- Use of Repeated Measures ANOVA on categorical data
- Akaike Information Criterion

Categorical Data

- Categorical data:
  - ANOVA Confidence intervals may extend into non-existent ranges
  - This underestimates the probability of existent values



AIC

- Using Mixed-effects Regression Models, adding additional random factors is relatively easy
  - Will always lead to a better fit, but at the cost of adding complexity
- We can use the *Akaike Information Criterion* (AIC), to evaluate whether adding particular random effects is beneficial to the overall model

AIC

- AIC is a function of the amount of parameters used, and the fit of the model
  - Lower result = better fit, given the amount of parameters

- In Ruggero's mixed models analysis, we can see this progression:

AIC

```
         Df  AIC    BIC     logLik    Chisq Chi  Df   Pr(>Chisq)
mmodel1  18  449.24 562.55 -206.62
mmodel2  19  286.84 406.45 -124.42 164.3964      1     <2e-16 ***
mmodel4  21  290.79 422.98 -124.39   0.0567      2     0.9720
mmodel5  21  271.20 403.39 -114.60  19.5866      0     <2e-16 ***
mmodel3  28  275.32 451.58 -109.66   9.8796      7     0.1955

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mmodel2  19 286.84 406.45 -124.42
mmodel5  21 271.20 403.39 -114.60 19.643      2  5.426e-05 ***
```

AIC

```
         Df    AIC    BIC logLik Chisq Chi Df  Pr(>Chisq)
mmodel5  21 271.2 403.39 -114.6
mmodel6  22 273.2 411.69 -114.6     0      1      0.9991

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mmodel5  21 271.20 403.39 -114.60
mmodel7  22 249.23 387.72 -102.62 23.966      1  9.804e-07 ***
```

AIC

```
          Df     AIC    BIC logLik  Chisq Chi Df Pr(>Chisq)
mmodel8   23 -31.656 113.13 38.828
mmodel10  24 -51.621  99.46 49.810 21.965      1  2.777e-06 ***

---

mmodel11  25 -52.813 104.56 51.407
mmodel12  26 -54.469 109.20 53.234 3.6555      1    0.05588 .
```

AIC

- In short: the AIC is one way to answer Ruggero's question: «Where is it convenient to stop?»
- There are also related measures for model fit:
  - Bayesian Information Criterion
  - AICc: takes into account sample size

Comparison / Summary

- Aspects of Repeated Measures ANOVA:
  - Does not deal well with missing values
    - sometimes subjects have to be dropped due to this, which introduces the possibility of sample bias
  - Observations need to be made at the same time points for each subject
  - Requires tests for conditions of *sphericity*
  - Leads to spurious results for categorical outcomes
    - confidence intervals may extend beyond interpretable ranges

Comparison / Summary

- Aspects of Mixed-effects regression:
  - Can use all available data points
    - not affected by *randomly* missing data
    - can model time effects
  - Can handle both covariates that change over time, and static covariates
  - Can be relatively difficult to implement
    - though see Wieling's presentation
  - Does not work very well on small samples

Comparison / Summary

- Aspects of Mixed-effects regression:
  - Easy to add extra random factors
    - Testable how these factors affect the fit of the model using AIC

When to use which method?

- Mixed Models:
  - missing data
  - irregular time points
  - modest to large samples
  - categorical outcomes
- RM ANOVA:
  - complete data
  - regular time points
  - small samples
  - assumptions of normality and sphericity satisfied

When to use which method?

method	data missing?		time points		sample size		categorical data
	yes	no	regular	irregular	small	medium to large	
Mixed Models							
RM ANOVA							

References

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