COGS 202

4 May 2017

Linear mixed effect models (and the story of my dissertation...)

Alexia Galati, Ph.D.

Marie Skłodowska-Curie fellow

Cognitive and Information Sciences

University of California, Merced

Check out Bodo Winter's tutorial:

http://www.bodowinter.com/tutorial/bw_LME_tutorial2.pdf

Linear mixed effect models (LMEMs)

- Mixed:
  - Fixed effects: systematic, predictable influence
  - Random effects: nonsystematic, unpredictable influence

- Linear: Fixed effects, random effects, and trial-level noise contribute linearly to the dependent variable

Well-suited when observations are clustered.

Some papers

- Clark, H. H. (1973). The language-as-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior*, *12*(4), 335-359.
- Forster, K. I., & Dickinson, R. G. (1976). More on the language-as-fixed-effect fallacy: Monte Carlo estimates of error rates for F1, F2, F ', and min F'. *Journal of Verbal Learning and Verbal Behavior*, *15*(2), 135-142.
- Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390-412.
- Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255-278.
- Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. *arXiv preprint arXiv:1506.04967*.

Some papers

- Clark, H. H. (1973). The language-as-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior*, *12*(4), 335-359.
- Forster, K. I., & Dickinson, R. G. (1976). More on the language-as-fixed-effect fallacy: Monte Carlo estimates of error rates for F1, F2, F ', and min F'. *Journal of Verbal Learning and Verbal Behavior*, *15*(2), 135-142.
- Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390-412.
- Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255-278.
- Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. *arXiv preprint arXiv:1506.04967*. (submitted to JML!)

1970s: Standard by-subjects ANOVAs are inadequate

- Herb Clark (1973): there are two random effects in psycholinguistic experiments!
  - Participants and linguistic materials (e.g., words)
  - No appropriate error term for F-ratio in standard ANOVA

Two proposals:

- Use *F'* (quasi-F ratio, Winer, 1971) or *minF'*
  - Constructs an approximate error term
- Do two sets on analyses: by-subjects and by-items (*F1* x *F2*) (see also Foster & Dickinson, 1976)

The standard for publishing in JML for a while

Table 2
Experiment 1, Partner-specific contrasts for percentage of narrative elements realized in stories, number of words per narrative element, and duration of lexically identical expressions. Significant effects are highlighted.

Contrasts	Narrative elements	Words per narrative element	Duration
For-the-speaker effect:			
$Speaker_{new}$–$Addressee_{new}$	$F_1(1, 18) = .58$, *n.s.*	$F_1(1, 18) = .11$, *n.s.*	$F_1(1, 18) = 2.05$, $p = .17$
vs.	$F_2(1, 84) = .77$, *n.s.*	$F_2(1, 74) = .00$, *n.s.*	$F_2(1, 16) = .40$, *n.s.*
$Speaker_{old}$–$Addressee_{new}$	min F $(1, 49) = .33$, *n.s.*	min F $(1, 74) = .00$, *n.s.*	min $F(1, 22) = .33$, *n.s*
For-the-addressee effect:			
$Speaker_{old}$–$Addressee_{old}$	$F_1(1, 18) = 16.11$, $p < .01$	$F_1(1, 18) = 10.80$, $p < .01$	$F_1(1, 18) = .01$, *n.s.*
vs.	$F_2(1, 84) = 10.81$, $p < .01$	$F_2(1, 74) = 8.97$, $p < .01$	$F_2(1, 16) = 1.08$, *n.s.*
$Speaker_{old}$–$Addressee_{new}$	min F $(1, 76) = 6.47$, $p < .05$	min F $(1, 64) = 4.90$, $p < .05$	min F $(1, 18) = .01$, *n.s.*

Some papers

- Clark, H. H. (1973). The language-as-fixed-effect fallacy: A critique of language statistics in psychological research. *Journal of verbal learning and verbal behavior*, *12*(4), 335-359.
- Forster, K. I., & Dickinson, R. G. (1976). More on the language-as-fixed-effect fallacy: Monte Carlo estimates of error rates for F1, F2, F ', and min F'. *Journal of Verbal Learning and Verbal Behavior*, *15*(2), 135-142.
- Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-effects modeling with crossed random effects for subjects and items. *Journal of Memory and Language*, *59*(4), 390-412.
- Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*, *68*(3), 255-278.
- Bates, D., Kliegl, R., Vasishth, S., & Baayen, H. (2015). Parsimonious mixed models. *arXiv preprint arXiv:1506.04967*.

Most downloaded papers!

ELSEVIER

SEARCH

Home › Journals › Journal of Memory and Language

ISSN: 0749-596X

Submit Your Paper

View Articles

Guide for Authors

Abstracting/ Indexing

Track Your Paper

Order Journal

Journal of Memory and Language

› Supports Open Access

Editor: Richard J Gerrig

› View Editorial Board

Articles in the *Journal of Memory and Language* contribute to the formulation of scientific issues and theories in the areas of **memory**, **language comprehension** and **production**, and **cognitive processes**. Special emphasis is given to research articles that provide new theoretical insights based on a carefully...

Read more

Most Downloaded | Recent Articles | Most Cited | Open Access Articles

Mixed-effects modeling with crossed random effects for subjects and items R.H. Baayen | D.J. Davidson | ...

Random effects structure for confirmatory hypothesis testing: Keep it maximal Dale J. Barr | Roger Levy | ...

Memory and the self Martin A. Conway

View All Articles ›

Different approaches to LMEMs

- Baayen et al (2008) – Intro to LMEMs
  - Introduction to LMEMs and lmer package in R
  - Random effects for subjects and items can be included in the same analysis
  - Preferable to quasi F', F1 x F2, or regressions (simulations)
- Barr et al. (2013) – Keep it maximal
  - The maximal random effect structure should be taken into account (for confirmatory hypothesis testing
  - Random intercept models (that don't include random slopes) are anti-conservative and increase Type 1 error (simulations)
- Bates et al. (2015) – Parsimonious models
  - Maximal models often fail to converge; overparameterization can make them uninterpretable
  - Recommendations for model simplification

Random intercept vs. random slope models

- Not a LMEM! No clustering:

$Y_{si} = \beta_0 + \beta_1 X_i + e_{si}$

Words ~ copresence

- LMEM: Clustering by subject (random intercept model):

$Y_{si} = \beta_0 + S_{0s} + \beta_1 X_i + e_{si}$

Words ~ copresence + (1 |speaker)

- LMEM: Clustering by subject and item (random intercept model):

$Y_{si} = \beta_0 + S_{0s} + I_{0i} + \beta_1 X_i + e_{si}$

Words ~ copresence + (1 |speaker) + (1 |item)

- Adding random slope for subjects (random slopes model):

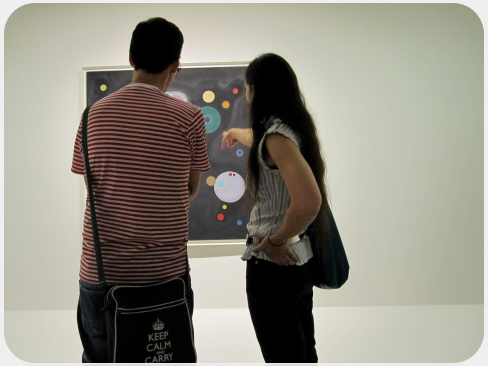
$Y_{si} = \beta_0 + S_{0s} + I_{0i} + (\beta_1 + S_{1s}) X_i + e_{si}$

Words ~ copresence + (1+copresence |speaker) + (1 |item)

Get data and R code from:

https://github.com/alexiagalati/copresence

How do we keep track of "common ground" in complex multimodal experiences?



sharing things perceptually and linguistically

sharing things perceptually

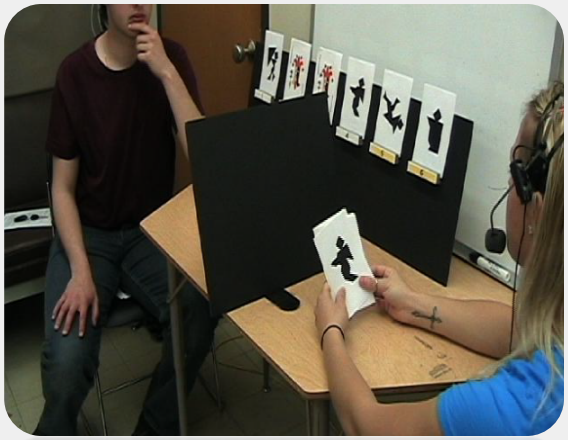
sharing things linguistically

The study

Phase 1

Round 1

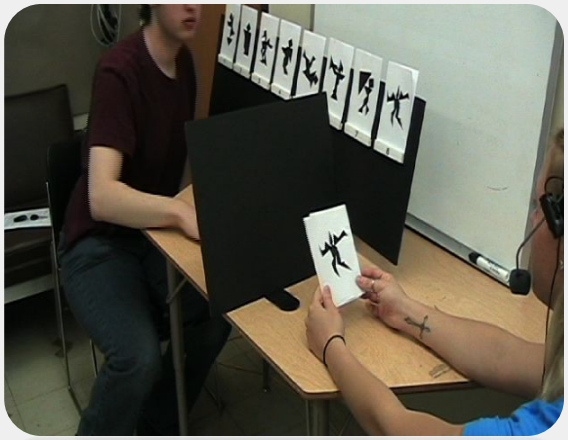
Round 2



Phase 2

Round 3

Round 4

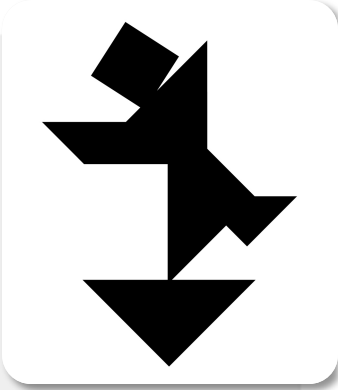


Partner order:
ABAB or ABBA

Design: Establishing co-presence in Phase 1

	Round 1		Round 2	
	Director	Matcher A	Director	Matcher B
Card 1	Full (L&P)	Full (L&P)		
Card 2	Full (L&P)	Full (L&P)		
Card 3	Linguistic	Joker	Physical	
Card 4	Linguistic	Joker	Physical	
Card 5		Physical	Linguistic	Joker
Card 6		Physical	Linguistic	Joker
Card 7			Full (L&P)	Full (L&P)
Card 8			Full (L&P)	Full (L&P)

Sample dialogue



Phase 1

D: okay
this looks like a<a> / ballerina /
on a triangle*
upside down triangle stage /
<um> it's doing a pirouette /
I don't know what those things
{are} %laugh

M_A: %laugh
I don't think I have it /
[*puts up joker card*]

D: even if I know {I...} %laugh

M_A: %laugh

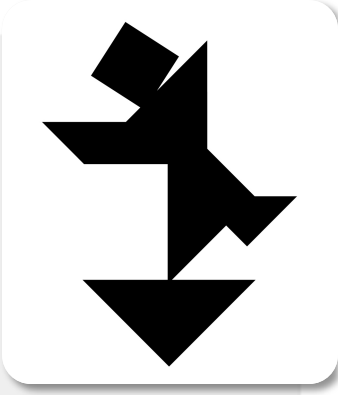
Phase 2, same partner

D: this is the ballerina %laugh

M_A: %laugh
[*puts up correct card*]

D: on the stage /

Sample dialogue



Phase 2, same partner

D: this is the ballerina %laugh

M_A: %laugh
[*puts up correct card*]

D: on the stage /

Fixed effects:
Co-presence, (LP, L, P, N)
Partner ID (M_A , M_B)
Partner Order (ABAB, ABBA)

DVs: initial words, initial propositions, reconceptualizations, hedges, definite expressions, description onset times, (Matcher contributions, errors, etc.)

Phase 2, new partner

D: okay
this look like
somebody / <um>
twirling on a st* <uh>
triangle s*
upside down triangle stage ? /
with one leg up in the air /
on pointy toes /

M_B: okay /
this<s> ? /
[*puts up correct card*]

D: yep

OK, let's play with some models in R!

- *Parsimonious models* approach:
  - We'll start with a random intercept model (i.e., random effects for directors and tangram items)
  - We'll compare a few models by adding fixed effects and comparing them
    - We'll include some random slopes for fixed effects in the random effect structure, too!
- *Maximal random effect structure* approach:
  - We'll define the maximal random effect structure of the model
  - We'll discuss how to simplify this model if it does not converge