

# Analyzing individual differences

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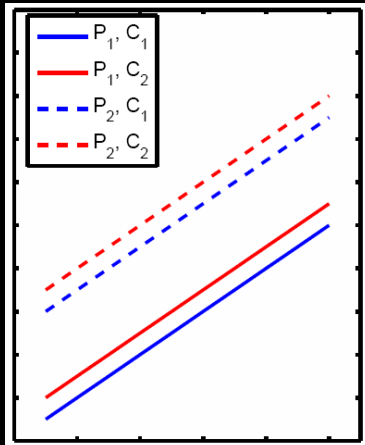
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## Yesterday

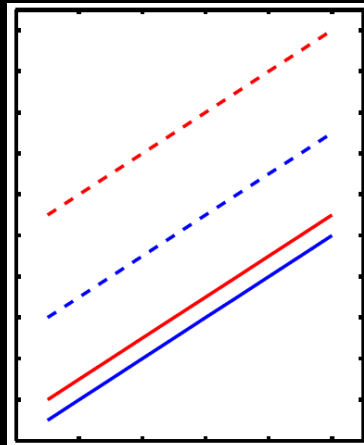
- “ Advantages of multilevel modeling approach to analyzing eye tracking data
- “ Structure of multilevel models
- “ Orthogonal polynomials
- “ Interpreting fixed effects
- “ Covariates
- **Individual differences**

# Individual differences

Fixed effects



Fixed and random effects



## A closer look at random effects

$$Y_{ij} = \beta_{0i} + \beta_{1i} * \text{Time}_j$$

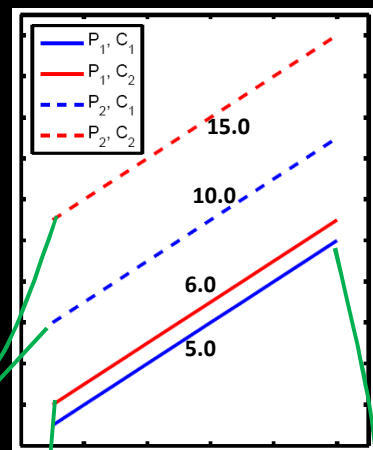
$$\beta_{0i} = \gamma_{00} + \gamma_{0c} * C + \gamma_{0i} * P_i + \zeta_{0i}$$

Fixed effects

- $\gamma_{00}$  : baseline intercept (5.0)
- $\gamma_{0c}$  : RED relative to BLUE (3.0)
- $\gamma_{0i}$  : DASHED relative to SOLID (7.0)

$$5.0 + 3.0 * 1 + 7.0 * 1 = 15.0, \zeta = 0$$

$$5.0 + 3.0 * 0 + 7.0 * 1 = 12.0, \zeta = -2.0$$



$$5.0 + 3.0 * 1 + 7.0 * 0 = 8.0, \zeta = -2.0$$

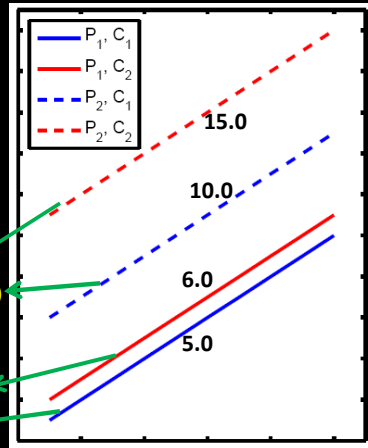
$$5.0 + 3.0 * 0 + 7.0 * 0 = 5.0, \zeta = 0$$

## Using random effects to compute individual effect sizes

- **DASHED** participant had larger effect of condition than **SOLID** participant

$$\text{Effect size} = \begin{cases} 5.0 + 3.0*1 + 7.0*1 = 15.0, \zeta = 0 \\ 0 - (-2.0) = 2.0 \\ 5.0 + 3.0*0 + 7.0*1 = 12.0, \zeta = -2.0 \end{cases}$$

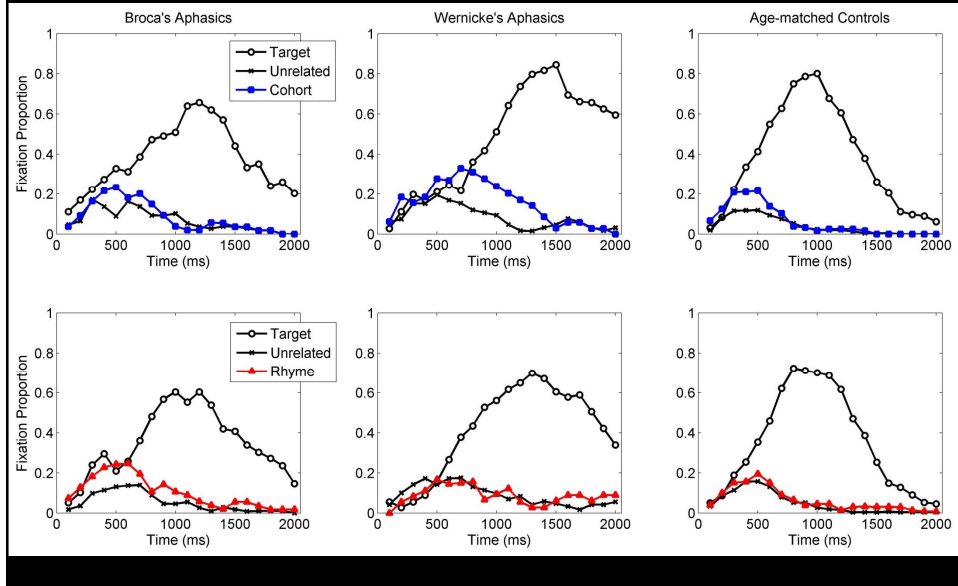
$$\text{Effect size} = \begin{cases} 5.0 + 3.0*1 + 7.0*0 = 8.0, \zeta = -2.0 \\ (-2.0) - 0 = -2.0 \\ 5.0 + 3.0*0 + 7.0*0 = 5.0, \zeta = 0 \end{cases}$$



## A real example

- “ Time course of spoken word activation and competition (Allopenna et al., 1998; Yee et al., 2008; Mirman, Yee, et al., under review)
- “ Phonological competitors
  - . **Cohort**: beaker – beetle
  - . **Rhyme**: beaker – speaker
- “ Participants
  - . Broca’s aphasics (N=5)
  - . Wernicke’s aphasics (N=3)
  - . Age-matched controls (N=12)

# Results

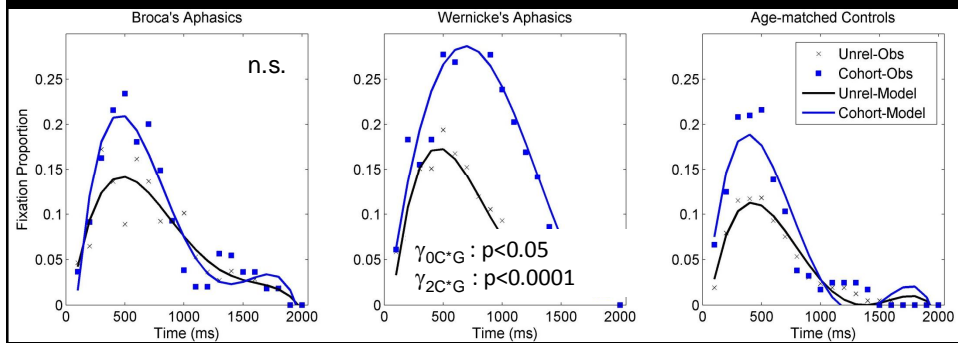


## Cohort: Group-x-condition effects

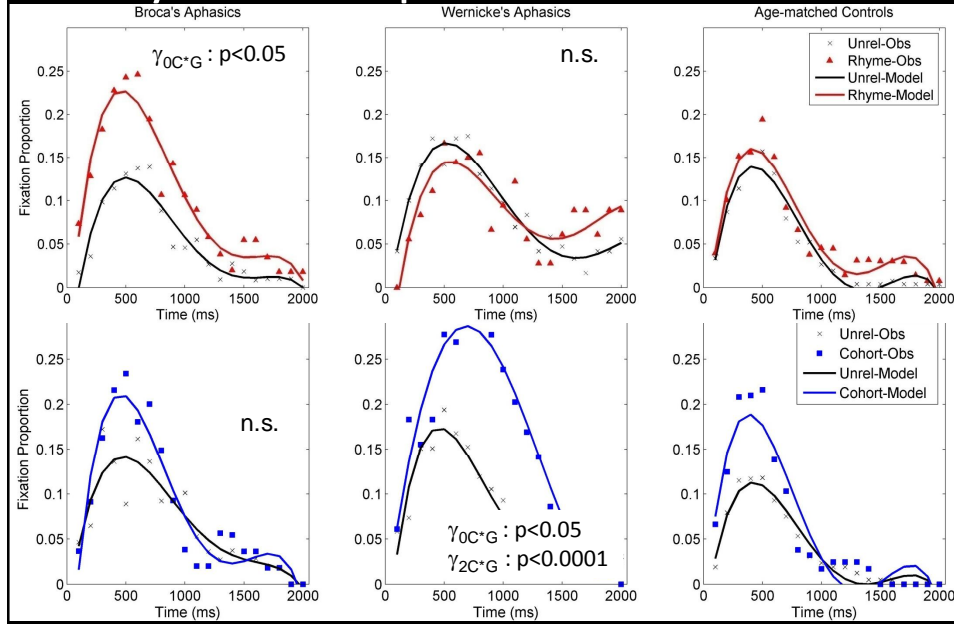
$$\text{Level 1: } \gamma_{ij} = \beta_{0i} + \beta_{1i} * \text{Time}_j + \beta_{2i} * \text{Time}_j^2 + \beta_{3i} * \text{Time}_j^3 + \beta_{4i} * \text{Time}_j^4 + \epsilon_{ij}$$

$$\text{Level-2: } \beta_{0i} = \gamma_{00} + \gamma_{0c} * C + \gamma_{0g} * G + \gamma_{0c*g} * C * G + \zeta_{0i}$$

$$\beta_{2i} = \gamma_{20} + \gamma_{2c} * C + \gamma_{2g} * G + \gamma_{2c*g} * C * G + \zeta_{2i}$$



# Rhyme: Group-x-condition effects



# Individual-level analysis

Level 1:  $Y_{ij} = \beta_{0i} + \beta_{1i} * Time_j + \beta_{2i} * Time_j^2 + \beta_{3i} * Time_j^3 + \beta_{4i} * Time_j^4 + \epsilon_{ij}$

Level-2:  $\beta_{0i} = \gamma_{00} + \gamma_{0c} * C + \zeta_{0i}$

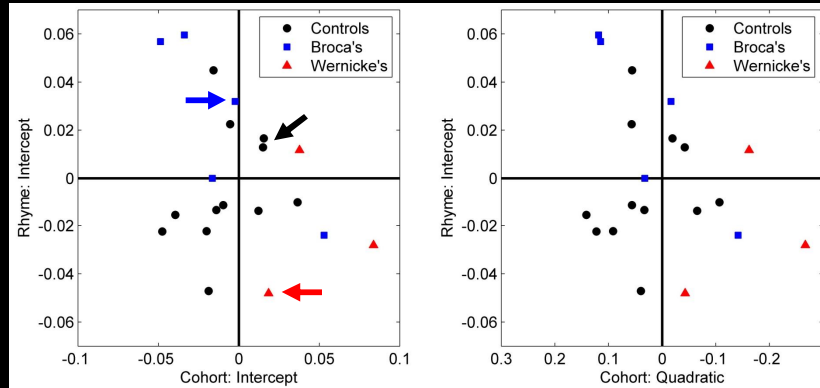
$\beta_{2i} = \gamma_{20} + \gamma_{2c} * C + \zeta_{2i}$

PID	Group	Cond.	Cohort: $\zeta_{0i}$	Cohort: $\zeta_{2i}$	Rhyme: $\zeta_{0i}$
102	Broca	Unrel	0.0074	-0.013	-0.0067
102	Broca	Comp	0.0051	-0.030	-0.025
		<b>Effect size</b>	-0.0023	-0.017	0.032
107	Control	Unrel	-0.022	0.063	-0.0026
107	Control	Comp	-0.0075	0.021	0.010
		<b>Effect size</b>	0.015	-0.042	0.013
120	Wernicke	Unrel	0.031	-0.074	0.028
120	Wernicke	Comp	0.050	-0.12	-0.020
		<b>Effect size</b>	0.0185	-0.043	-0.048

```

R Console
(Intercept)      ot2
10212  0.0216909215 -0.050009712
10113  0.0051901660 -0.020005153
10212  0.0073827133 -0.013309589
10213  0.0081300889 -0.029946159
10312  0.0046713111 -0.023646520
10313  0.0576887846 -0.165171736
10412  0.0160714777 -0.046644351
10413  -0.0326143553  0.067967426
10512  0.0153337582 -0.047260160
10513  -0.018343081  0.071314049
10602  -0.012782021  0.039692570
10603  -0.026140852  0.038412617
10702  -0.0225309716 -0.063243133
10703  -0.0075307212  0.021309311
10802  -0.0097462302 -0.003646943
10803  -0.0430139266  0.117615345
10902  -0.032458413  0.030100545
10903  -0.0272836445  0.063271561
11002  -0.025549482  -0.050500410
11003  -0.0352675585  0.112687958
11102  0.0207393803 -0.061991469
11103  0.001945071  -0.022248106
11202  0.0032975785 -0.016293762
11203  -0.0442785709 -0.126248658
11302  -0.0133514271 -0.060710373
11303  -0.0011282824 -0.054591475
11402  -0.0230494115  0.064412451
11403  0.0137376666 -0.040215320
11502  -0.0215951011  0.063069285
11503  -0.0060806900  0.044023020
11602  -0.0226986688 -0.049974518
11603  -0.0427425255  0.141526540
11702  0.0047124099 -0.023915832
11703  -0.0064689399 -0.003136789
11822  -0.0255877695 -0.042257248
11823  0.1093289859 -0.309403048
11824  0.0176990575 -0.023240410
11902  -0.0446006266 -0.148440064
12022  0.0311699344 -0.074337456
12023  0.0497146632 -0.117118770
    
```

## Effect Size Distribution



### Correlations

~ All participants:  $r = -0.32, p = 0.17$

~ Just patients:  $r = -0.76, p = 0.028$

### Correlations

~ All:  $r = 0.30, p = 0.20$

~ Patients:  $r = 0.70, p = 0.052$

## Unique insight from individual-level analysis of residuals

- ~ On typical statistical approaches:
  - . Effects of interest are fixed effects
  - . Individual differences are essentially noise
- ~ Multi-level modeling allows meaningful quantification of individual differences
- ~ Use residual error to compute a measure of each individual participant's effect size
  - Correlations between experimental effects (rhyme vs. cohort)
  - Correlations with other measures