Modeling Between- and Within-person Response Time-Response Dependency

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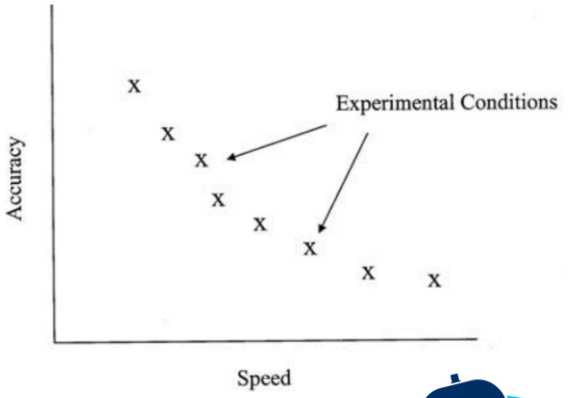
Outline

- Background
- Methods
- Empirical study
- Discussions

Background

- Response Time (RT) can provide essential information in understanding individuals' test-taking processes.
- To properly model RTs, it is necessary to figure out the relationship between RTs and responses.
- Paradoxical Relationship! (van der Linden, 2007)
  - Speed-accuracy correlation between subjects (Positive)
  - Speed-accuracy trade-off within subjects (Negative)



Methods: Under the multilevel modeling framework

- Fixed Item-effect (Rasch Model; M1)

$$\text{logit}(y_{ij}) = \gamma_{00.0} + U_{0j} + \sum_{k=1}^{I-1} \gamma_{\text{k0}} \text{X}_{ij}^{(k)} + e_{ij}$$

Dummy coding of *I* items

- Fixed Item & RT-effect (M2)

$$\text{logit}(y_{ij}) = \text{Rasch Model} + \gamma_{I0} ZRT_{CMC} + \gamma_{01} ZRT_{GMC}$$

- Fixed Item & RT-effect with Item-RT Interactions (M3)

$$\text{logit}(y_{ij}) = \text{M2} + \Sigma_{k=I+1}^{2I-1} \gamma_{\text{k0}} \text{X}_{ij}^{(k)} \cdot ZRT_{CMC} + \Sigma_{k=2}^{I} \gamma_{0\text{k}} \text{X}_{ij}^{(k)} \cdot ZRT_{GMC}$$

- Fixed Item & RT-effect with Item-RT Interactions and Random RT (M4)

$$\text{logit}(y_{ij}) = \text{M3} + U_{Ij} \cdot ZRT_{CMC}$$

Empirical study

- Subset of Cluster 03 of the Program for International Student Assessment (PISA) 2018 science test data
- To control the RT distribution, only the simple multiple-choice items on the field of living and participants from China were selected
- Due to the skewed distribution of RT in its original unit, a log – transformation was conducted
- In total, we have 13,377 responses from 1,911 15-year-old Chinese students on seven items

Results

Table 2

Multilevel Logstic Regression Model Results for Responses

	M1			M2			M3			M4		
Fixed Effects	*Coeff*	*SE*	*Z*	*Coeff*	*SE*	*Z*	*Coeff*	*SE*	*Z*	*Coeff*	*SE*	*Z*
Intercept (Mean)	0.65	0.06	10.80 ***	0.78	0.06	12.64 ***	0.67	0.07	9.33 ***	0.69	0.07	9.40 ***
Item_2	1.94	0.10	19.99 ***	1.94	0.10	19.73 ***	2.27	0.13	17.96 ***	2.30	0.13	17.83 ***
Item_3	2.67	0.12	22.77 ***	2.30	0.13	18.18 ***	1.83	0.18	10.29 ***	1.80	0.18	10.07 ***
Item_4	0.14	0.08	1.82	-0.08	0.08	-1.01	-0.09	0.09	-0.99	-0.11	0.09	-1.20
Item_5	1.14	0.08	13.61 ***	0.98	0.09	11.38 ***	1.07	0.09	11.47 ***	1.07	0.10	11.28 ***
Item_6	-0.69	0.07	-9.23 ***	-0.58	0.08	-7.71 ***	-0.77	0.11	-7.01 ***	-0.77	0.11	-6.84 ***
Item_7	0.57	0.08	7.28 ***	0.39	0.08	4.79 ***	0.54	0.09	6.04 ***	0.54	0.09	5.98 ***
ZRT_CMC				-0.26	0.03	-8.73 ***	-0.06	0.07	-0.83	-0.08	0.08	-1.02
ZRT_agg_GMC				0.36	0.03	10.73 ***	0.28	0.06	4.68 ***	0.29	0.06	4.78 ***
Item_2*ZRT_CMC							-0.41	0.13	-3.23 **	-0.43	0.13	-3.26 **
Item_3*ZRT_CMC							-0.91	0.16	-5.68 ***	-0.98	0.16	-5.94 ***
Item_4*ZRT_CMC							-0.60	0.11	-5.49 ***	-0.62	0.11	-5.50 ***
Item_5*ZRT_CMC							-0.27	0.12	-2.27 *	-0.30	0.12	-2.40 *
Item_6*ZRT_CMC							0.13	0.11	1.22	0.13	0.11	1.18
Item_7*ZRT_CMC							0.05	0.10	0.50	0.03	0.11	0.27
Item_2*ZRT_agg_GMC							0.46	0.09	5.13 ***	0.48	0.09	5.22 ***
Item_3*ZRT_agg_GMC							0.17	0.09	1.82	0.16	0.10	1.63
Item_4*ZRT_agg_GMC							-0.18	0.07	-2.36 *	-0.19	0.08	-2.45 *
Item_5*ZRT_agg_GMC							0.12	0.08	1.52	0.11	0.08	1.35
Item_6*ZRT_agg_GMC							-0.09	0.08	-1.23	-0.10	0.08	-1.27
Item_7*ZRT_agg_GMC							0.20	0.08	2.47 *	0.18	0.08	2.18 *
Random Effects	*Var*			*Var*			*Var*			*Var*		
Intercept (Students)	*1.30*			*1.19*			*1.10*			1.15		
ZRT_CMC										0.10		
Model Fit												
BIC	13284.80			13112.20			13047.80			13046.30		
Deviance (-2LL)	13208.80			13017.20			12838.70			12827.80		
Residual *df*	13369			13367			13355			13354		
LRT Chi-square test												

Note. $N = 13377$ responses within 1911 students; any acronyms for outcomes/predictors here; metrical predictors are standardized in z-scores and categorical predictors are effect coded. Model estimated with full information maximum likelihood using *R* lme4 and lmerTest packages. All values in logits. * $p < .05$, ** $p < .01$, *** $p < .001$.

Thanks!
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