Person-Specific Dynamics Manifest in Single- and Dual-Tasking Practice Gains

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Background

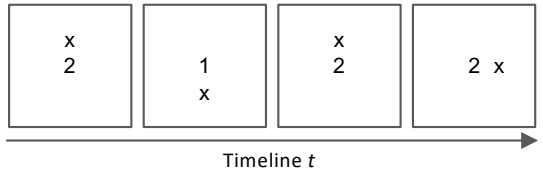
Objectives:
Practice can improve individuals' multitasking ability. This poster examines how **dual- and single-tasking practice gains are associated at individual level** using multilevel models of change. While many previous studies focused on task-specific changes, our analysis illustrates how tracking of **learning processes across tasks** provides insight into how different people gain differently from dual- and single-tasking practice.

Keywords:
Dual-tasking, Between-person variability, Within-person variability, Multilevel modeling, Generalizability theory

Data / Methods

- **Data:** Reaction time (RT) data from 58 participants who completed two forced-choice tasks A/B in single- and dual-tasking blocks for 32(single-)/64(dual-task) trials over 20 sessions were obtained from Naefgen et al. (2023) and used for analysis. In the *dual-tasking* phase, participants may complete Tasks A and B in any order.
- **Methods:** Within-person changes in RT across tasks were examined using a combination of (1) hierarchical variance decomposition to invoke the generalizability theory perspective, and (2) (non-)linear mixed models.

Figure 1. *Illustration of a sequence of stimuli*

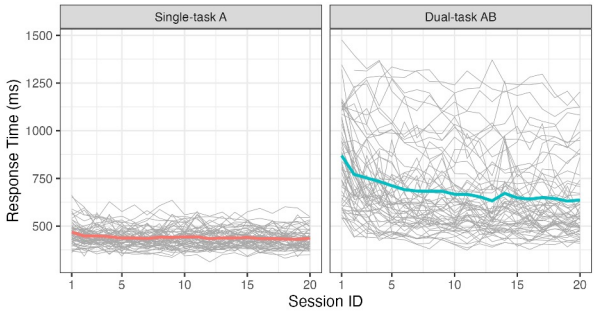


Task A: press key **"1" or "2"**, identifying the number in the central position of the screen [*two*-choice]
Task B: press arrow key, identifying the position of the "x" as **above, below, left, or right** from the center [*four*-choice]

Scaling Person-Specific Dynamics

Between- and Within-Person Variability of Practice Gains
Overall, RTs decreased from 466 to 436ms for Single-task A and from 852 to 634ms for Dual-task AB across 20 sessions. However, individuals showed high levels of variability both in initial performance and in rates of improvement.

Figure 2. *Observed decreases in RT for Single A vs. Dual AB*



Hierarchical Variance Decomposition
We specify a three-way, crossed random effects ANOVA model (person *i* x session *s* x trial *t*). A linear model for RT_{ist} is

$$RT_{ist} = \mu + P_i + S_s + T_t + (PS)_{is} + (ST)_{st} + (PT)_{it} + (PST)_{ist} + e_{ist}$$

Table 1 shows that within-person fluctuations over time accounted for **~12%** of the total variance (= 23.58 / 184.72). It demonstrates potential for exploring within-person changes.

Table 1. *Variance decomposition for Single A vs. Dual AB*

	Single-task A			Dual-task AB		
	Gauss.	Inv.Gauss	Gamma	Gauss.	Inv.Gauss	Gamma
Fixed Effect						
(Intercept)	440.68 (7.10)	507.15 (2.59)	463.32 (2.67)	686.20 (31.33)	1334.58 (8.33)	733.86 (10.11)
Random Effect						
Participant	44.45	13.83	14.36	212.14	51.89	64.57
Session	7.58	3.35	3.54	60.83	18.43	21.89
Trial	20.25	8.37	8.57	31.38	13.53	14.75
Participant:Session	23.58	18.90	19.06	70.52	46.59	47.36
Session:Trial	3.80	7.60	7.52	10.10	17.36	16.73
Participant:Trial	10.18	13.89	14.05	21.99	29.87	29.90
Residual	74.9	0.01	0.17	197.23	0.01	0.27
AIC	404944	399578	399906	944053	908320	912217

Note: N_A = 35,076. N_{AB} = 70,119. Data obtained from 58 participants during the first 20 sessions (M = 20) and all trials (K_A = 32, K_{AB} = 64). Outliers removed with cutoff 2 standard deviations from the mean. Standard errors in parentheses.

Consistency across Single/Dual-Tasks

(Non-)Linear Process Models
On average, RTs improved by 10 milliseconds per session ($\beta_{Session}$= -9.6), and the rate of improvement was higher in dual-tasking compared to single-tasking ($\beta_{Dualtask:Session}$ = -67.7). Importantly, there was consistency of within-person differences in initial performance (σ_{u0u1} = .41) and in rates of improvement (σ_{u2u3} = .74). The high correlation of individual time trends suggest that participant characteristics driving single- and dual-tasking gains overlap substantially.

Table 2. *Mixed model analysis of Single A vs. Dual AB*

	Fixed Effect			Random Effect			
Coefficient	Estimate	Std.Err	Std.Dev	(0)	(1)	(2)	(3)
Gaussian Distribution (AIC = 1525875)							
(Intercept)	**450.02**	6.72	49.17	1.00			
Dualtask	**317.87**	27.58	209.32	0.41	1.00		
Session	**-9.58**	2.11	11.87	-0.56	-0.54	1.00	
Dualtask:Session	**-67.70**	6.50	47.69	-0.22	-0.44	0.74	1.00
Inverse Gaussian Distribution (AIC = 1454024)							
(Intercept)	**481.31**	2.76	19.32	1.00			
Dualtask	**527.21**	8.18	60.35	-0.01	1.00		
Session	**-13.32**	1.42	8.79	-0.56	-0.11	1.00	
Dualtask:Session	**-69.71**	3.06	20.53	0.01	-0.50	0.05	1.00
Gamma Distribution (AIC = 1465011)							
(Intercept)	**453.68**	2.85	19.67	1.00			
Dualtask	**324.31**	9.27	69.06	0.14	1.00		
Session	**-9.47**	0.94	2.15	-0.55	-0.90	1.00	
Dualtask:Session	**-63.40**	3.48	24.24	-0.02	-0.46	0.40	1.00

Note: N = 115,661. Bold values denote statistical significance at the p < .001 level.

Discussion
Results suggest that multitasking ability can be improved by training. The person-specific dynamics manifesting over time and across tasks illustrate commonality of within-person processes driving dual- and single-tasking practice gains.

① Practice improves dual-tasking; *faster* than single-tasking.
② Person-specific single- and dual-tasking gains overlap.

References

Naefgen, C. et al. (2023). Between-and within-subject covariance perspectives matter for investigations into the relationship between single-and dual-tasking performance. *Methods in Psychology, 8*, 100110.

More questions? *Feel free to reach out!* **Rinseo Park (rinseo@stanford.edu)** is PhD Candidate in the Department of Communication at Stanford University. ☺