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The issue in attentional-control research is not the reliability, but the validity

Alodie Rey-Mermet

UniDistance Suisse

From the reliability paradox to the validity issue

- The **convergent validity** of **attentional-control measures** has been questioned because it is difficult to establish attentional control at the latent-variable level (e.g., Karr et al., 2018, *Psychol Bull*; Rey-Mermet et al., 2018, *JEP:LMC*).

- This **validity issue** has been assumed to result from the **low reliability of the attentional-control measures**. In turn, this **low reliability** has been explained by using **difference scores** (e.g., Draheim et al., 2019, *Psychol Bull)*.

Main question

- Does **acceptable to good** **reliability** solve the **validity** **issue**?

Three ways to go beyond the reliability issue

1. using **attentional-control measures with acceptable reliability estimates**

2. bypassing difference scores by using a **bifactor modeling** approach

3. reducing measurement error by **combining hierarchical-Bayesian Wiener diffusion modeling with structural equation modeling (SEM)**

Dataset from Rey-Mermet et al. (2018, *JEP:LMC*)

Antisaccade	arrow Flanker
stop-signal	letter Flanker
color Stroop	number Stroop
Simon	N-2 repetition cost
negative compatibility	positive compatibility
global-local task	

Note. Sample = 107 young adults

Spearman-Brown corrected split-half reliability computed on difference scores

Task	Estimate
Antisaccade (accuracy)	.95
Stop signal (SSRT)	.88
Color Stroop	.63
Simon	.68
Negative compatibility	.54
Local task	.54
Arrow flanker	.64
Letter flanker	.37
Number Stroop	.66
Positive compatibility	.61
N-2 repetition cost	.27

- *For the stop-signal task:*
  Split half = first vs. second half of the task
- *For the remaining tasks:*
  Split half = a permutation-based split-half approach with 5000 random splits
  (see Parsons et al., 2019, *AMPPS*)

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Correlations

	1.	2.	3.	4.	5.	6.
1. antisaccade	-					
2. stop signal	**-.22**	-				
3. color Stroop	**.19**	-.05	-			
4. Simon	-.05	-.14	-.02	-		
5. arrow flanker	-.17	-.02	**-.21**	.04	-	
6. number Stroop	-.02	-.03	.01	.00	**.26**	-
7. positive compatibility	.01	-.04	-.08	.14	.05	.12

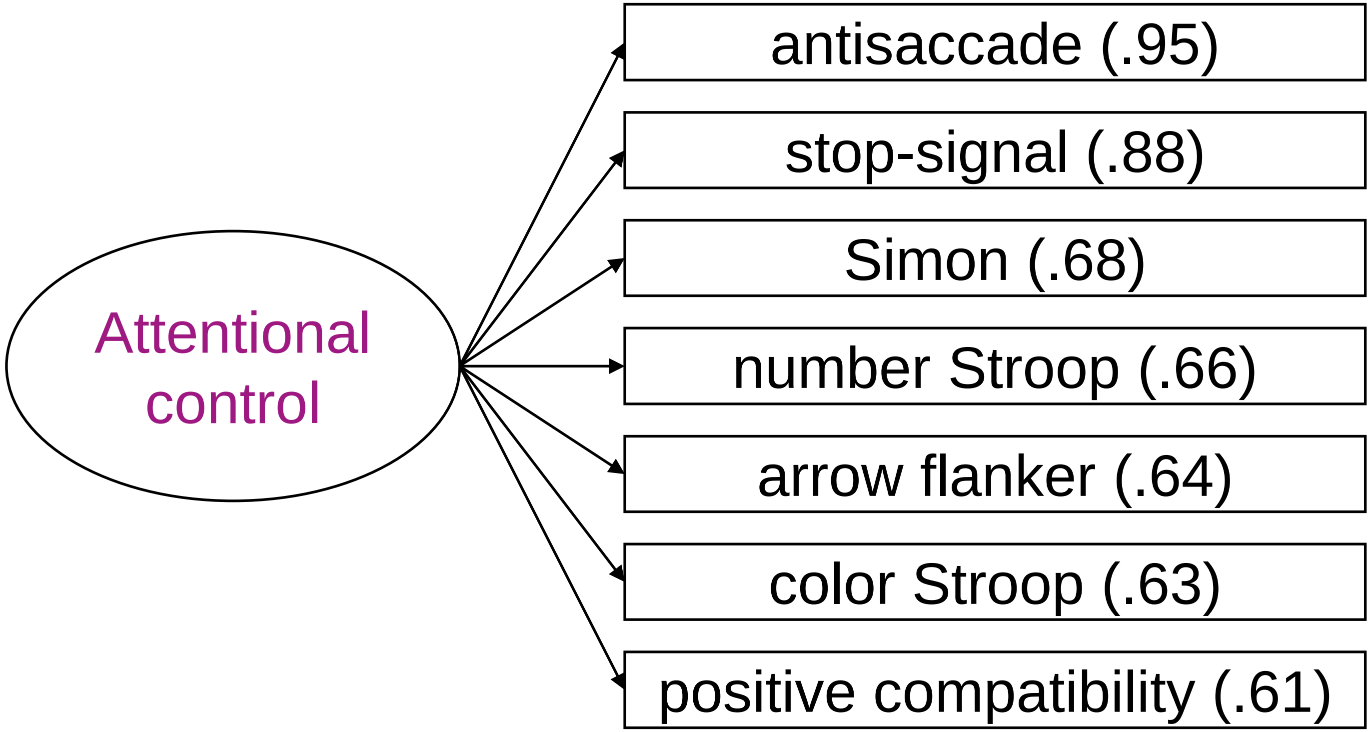
bold = *p* < .05

Correlations

	1.	2.	3.	4.	5.	6.
1. antisaccade	-					
2. stop signal	**-.22**	-				
3. color Stroop	**.19**	-.05	-			
4. Simon	-.05	-.14	-.02	-		
5. arrow flanker	-.17	-.02	**-.21**	.04	-	
6. number Stroop	-.02	-.03	.01	.00	**.26**	-
7. positive compatibility	.01	-.04	-.08	.14	.05	.12

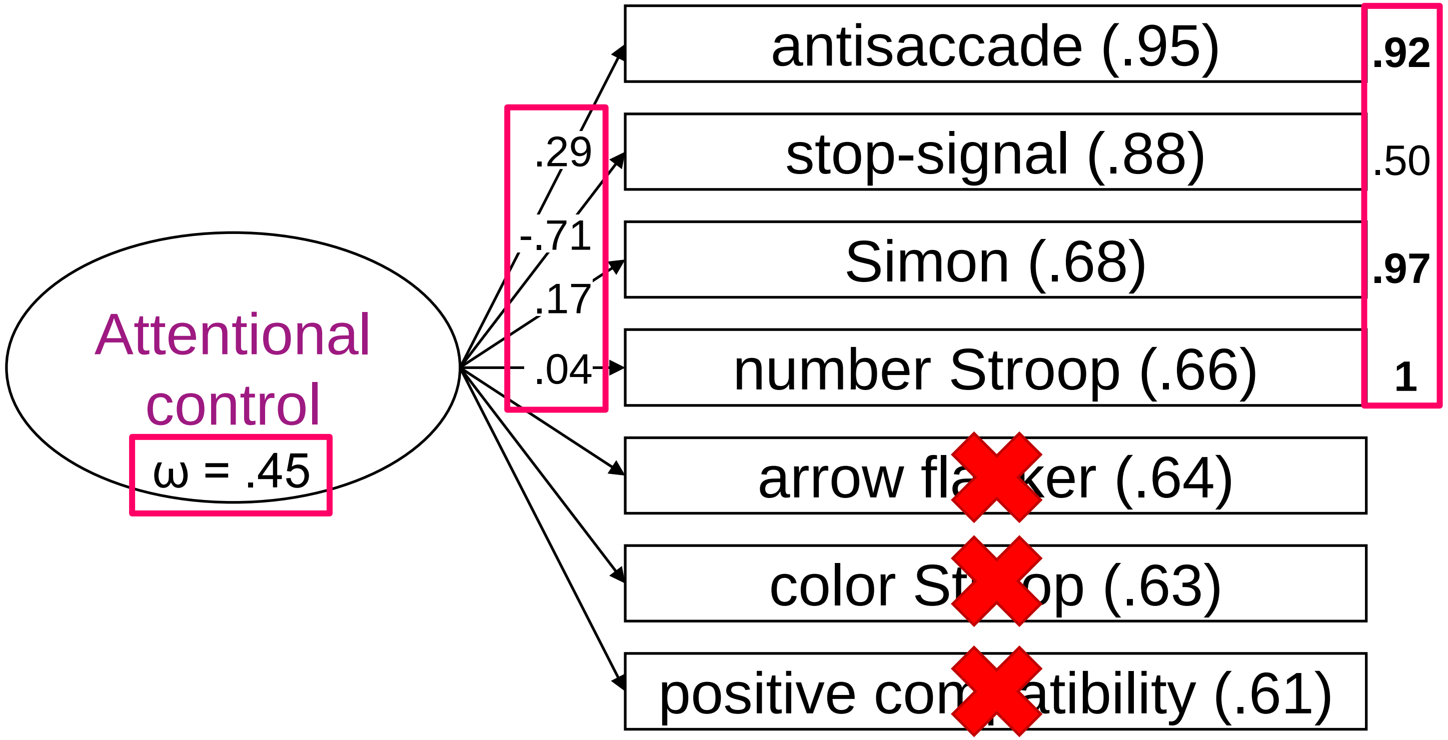
bold = *p* < .05
$BF_{10} > 3$
$BF_{01} > 3$

Structural equation modeling



Note. Reliability estimates are presented in parentheses.

Structural equation modeling



Note. Reliability estimates are presented in parentheses. Bold = $p < .05$

CFI = 1, SRMR = .03

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Spearman-Brown corrected split-half reliability

Task	Trial type	Estimate
Antisaccade (accuracy)	-	.95
Stop signal	SSRT	.88
Color Stroop	Incongruent	.97
	Congruent	.98
Simon	Incongruent	.97
	Congruent	.98
Arrow flanker	Incongruent	.98
	Congruent	.98
Number Stroop	Incongruent	.97
	Congruent	.98
Positive compatibility	Incongruent	.94
	Congruent	.95

- *For the stop-signal task:* Split half = first vs. second half of the task
- *For the remaining tasks:* Split half = a permutation-based split-half approach with 5000 random splits (see Parsons et al., 2019, *AMPPS*)

Correlations

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. antisaccade	-										
2. stop signal	**-.22**	-									
3. color Stroop: incongruent	.07	.16	-								
4. color Stroop: congruent	.01	**.21**	**.94**	-							
5. Simon: incongruent	.07	.13	**.59**	**.59**	-						
6. Simon: congruent	.08	.16	**.57**	**.58**	**.93**	-					
7. arrow flanker: incongruent	-.07	.12	**.63**	**.67**	**.59**	**.57**	-				
8. arrow flanker: congruent	-.01	.15	**.67**	**.69**	**.63**	**.62**	**.95**	-			
9. number Stroop: incongruent	-.07	**.21**	**.61**	**.64**	**.57**	**.53**	**.61**	**.60**	-		
10. number Stroop: congruent	-.07	**.26**	**.66**	**.68**	**.59**	**.55**	**.57**	**.57**	**.93**	-	
11. positive compatibility: incongruent	.05	.07	**.42**	**.41**	**.39**	**.38**	**.54**	**.57**	**.42**	**.44**	-
12. positive compatibility: congruent	.04	.08	**.38**	**.36**	**.36**	**.36**	**.46**	**.49**	**.35**	**.39**	**.87**

bold = *p* < .05

$BF_{10} > 3$

$BF_{01} > 3$

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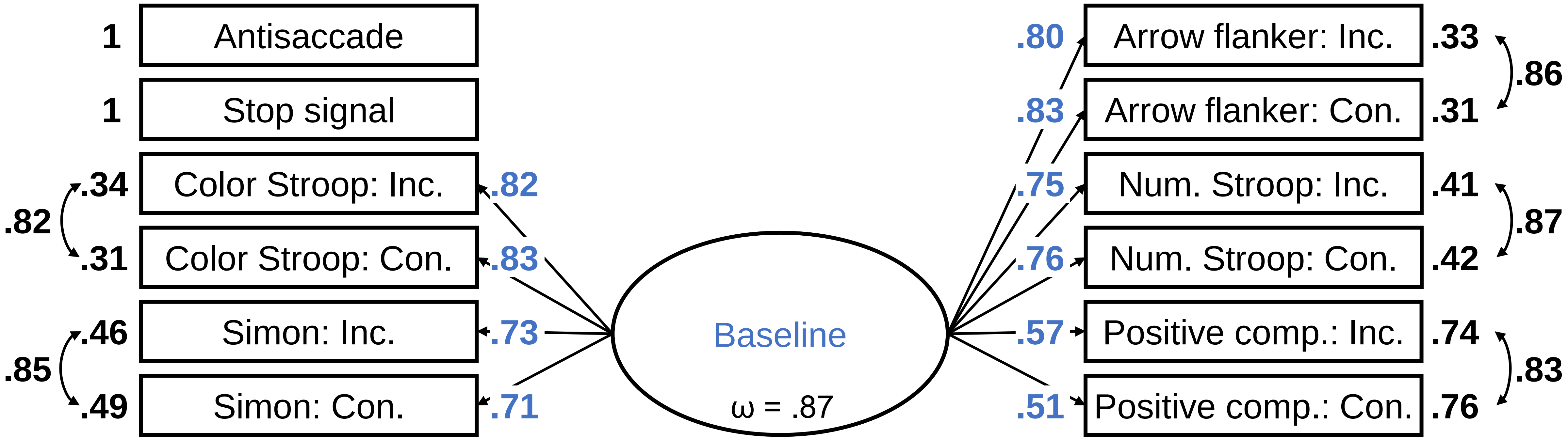
Structural equation modeling: Bifactor model



Note. Factor loadings were constrained to be positive. Bold = $p < .05$

CFI = .99, SRMR = .07

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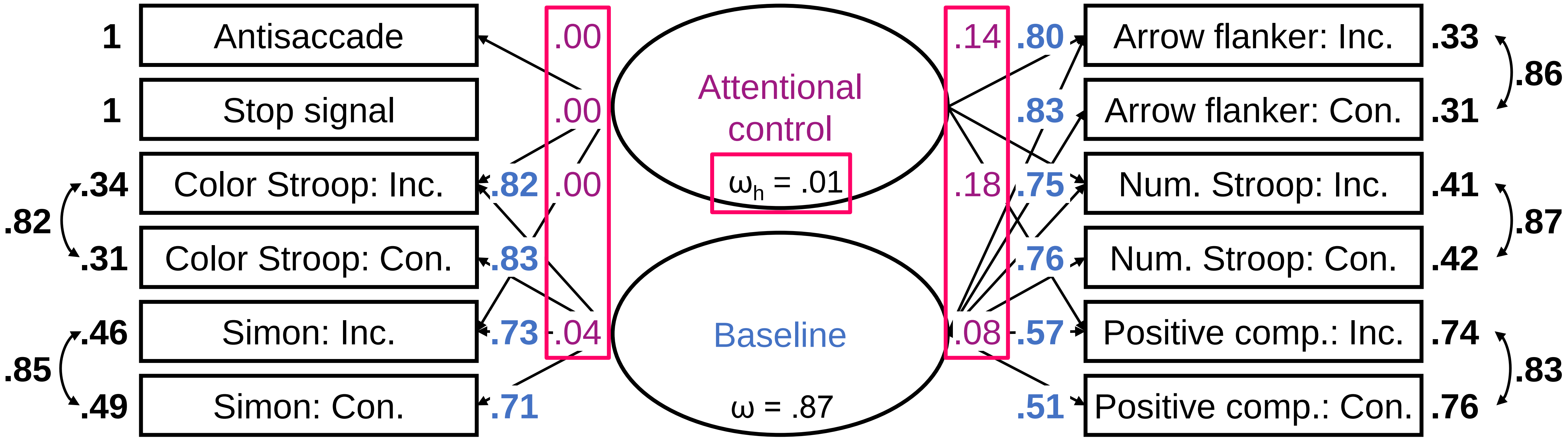
Structural equation modeling: Bifactor model



Note. Factor loadings were constrained to be positive. Bold = $p < .05$

CFI = .99, SRMR = .07

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3. reducing measurement error by **combining hierarchical-Bayesian Wiener diffusion modeling with structural equation modeling (SEM)**

Measurement error is reduced because…

- The **diffusion model** is fitted to the **joint distribution of RT and accuracy**, thus reducing the effect of individual RTs and the associated noise.

- The **diffusion-model parameters** account for the **trial-by-trial variability** of each participant.

- In a **hierarchical-Bayesian framework**, the parameter estimates of each participant are informed by the data of all other participants.

Hierarchical-Bayesian Wiener diffusion modeling further reduces the measurement error because…

- The **Wiener diffusion model** predicts the presence of long RTs, thus accounting for the right-skewed nature of the RT distribution.

- We modeled the **variance-covariance matrix of the individual-level effects** as a parameter of the hierarchical model.
  $\Rightarrow$ Joint estimation (≠ two-step procedure used in previous research)

We expected to establish a coherent factor of **attentional control** on the **drift-rate parameter**.

Posterior Mean Correlations
Difference coding

	1.	2.	3.	4.	5.	6.	7.
1. Color Stroop	-						
2. Number Stroop	-.02	-					
3. Arrow flanker	-.14	.03	-				
4. Letter flanker	-.09	.10	.26	-			
5. Simon	-.13	.04	.08	.21	-		
6. Local	.11	.03	.06	.09	.19	-	
7. Positive comp.	-.02	.03	.00	.16	.11	.07	-
8. Negative comp.	-.04	.16	.06	.12	.02	.04	.09

bold = the 95% CI excludes 0

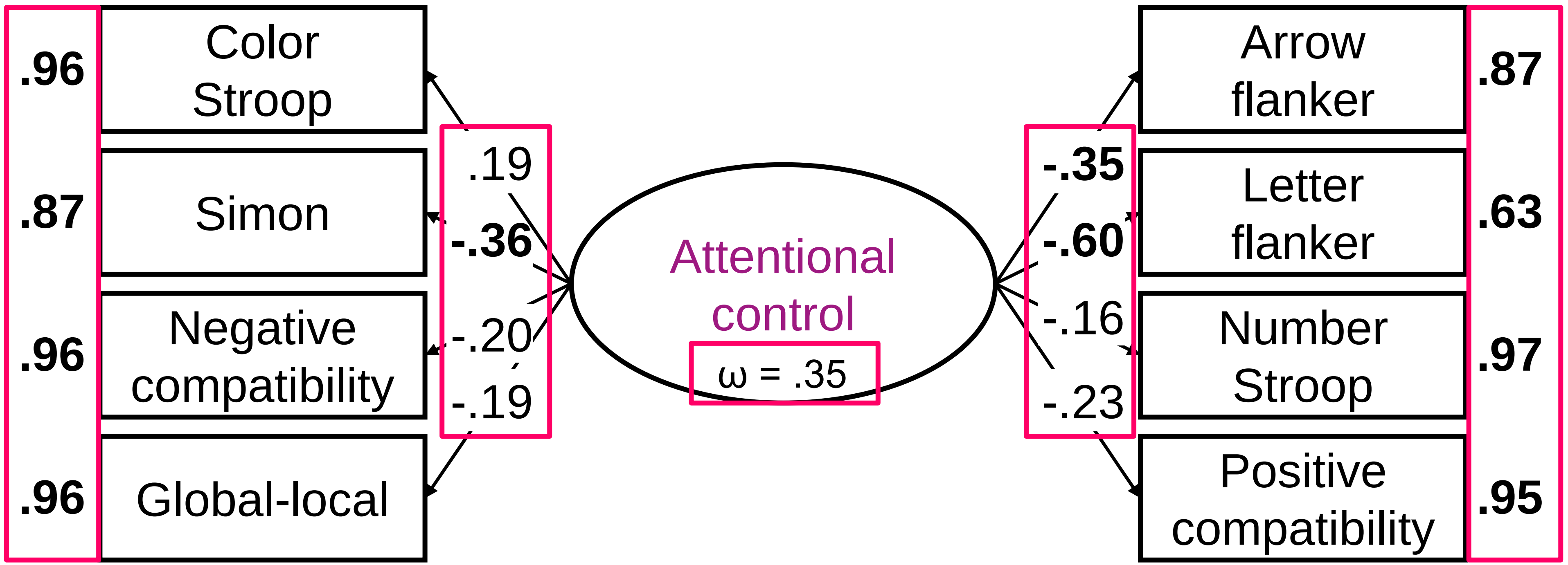
Posterior Mean Correlations + 95% Credibility Intervals *Difference coding*

	1.	2.	3.	4.	5.	6.	7.
1. Color Stroop	-						
2. Number Stroop	-.02 [-.30, .26]	-					
3. Arrow flanker	-.14 [-.42, .17]	.03 [-.23, .30]					
4. Letter flanker	-.09 [-.37, .21]	.10 [-.18, .37]	.26 [-.01, .51]	-			
5. Simon	-.13 [-.40, .17]	.04 [-.18, .27]	.08 [-.15, .31]	.21 [-.04, .45]	-		
6. Local	.11 [-.21, .39]	.03 [-.25, .32]	.06 [-.22, .34]	.09 [-.21, .36]	.19 [-.08, .44]	-	
7. Positive comp.	-.02 [-.31, .27]	.03 [-.22, .28]	.00 [-.25, .25]	.16 [-.11, .41]	.11 [-.11, .33]	.07 [-.21, .35]	-
8. Negative comp.	-.04 [-.32, .23]	.16 [-.10, .41]	.06 [-.20, .33]	.12 [-.16, .37]	.02 [-.21, .25]	.04 [-.23, .30]	.09 [-.15, .35]

- The intervals are quite narrow around 0
- They exclude medium or large correlations.

$\Rightarrow$ **The correlations are estimated quite precisely!**

Structural equation modeling: Difference coding

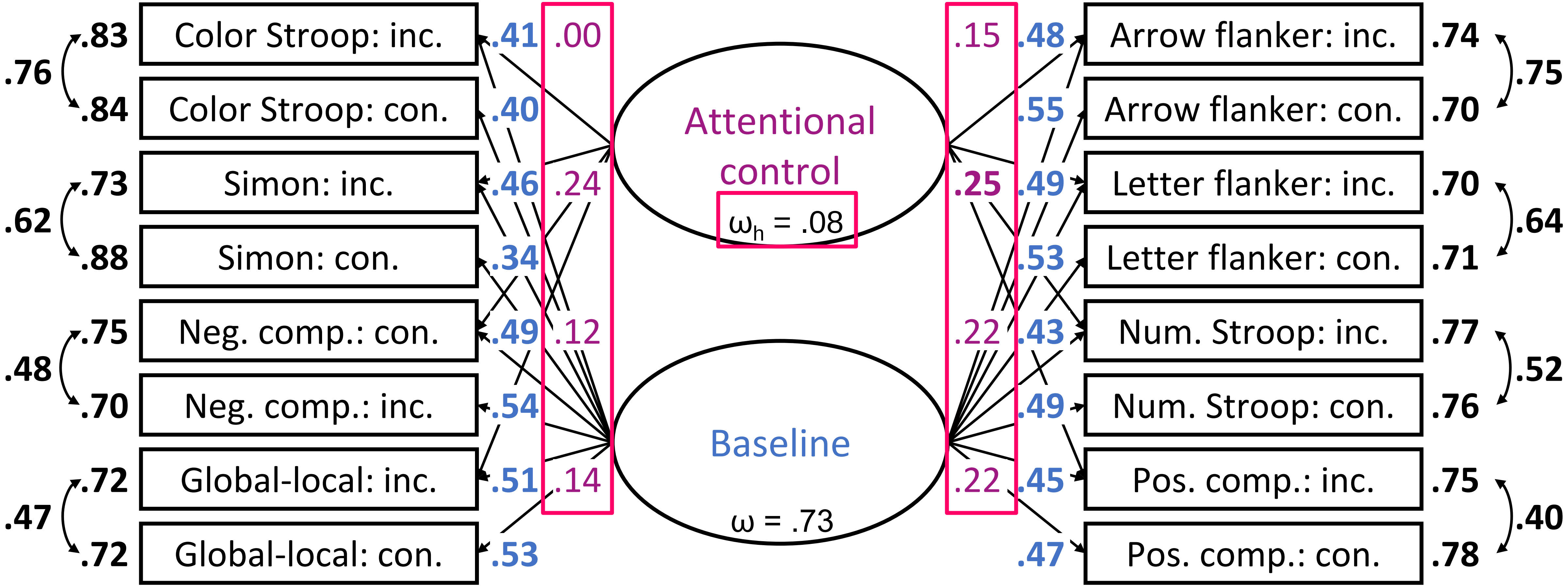


Note. Bold = $p < .05$

CFI = 1, SRMR = .05

(see Rey-Mermet et al., 2021, *PsyArXiv*)

Structural equation modeling: Bifactor model



Note. Factor loadings were constrained to be positive. Bold = $p < .05$

CFI = 1, SRMR = .06

(see Rey-Mermet et al., 2021, *PsyArXiv*)

Three ways to go beyond the reliability issue

- using **attentional-control measures with acceptable reliability estimates**
- bypassing difference scores by using a **bifactor modeling** approach
- reducing measurement error by **combining hierarchical-Bayesian Wiener diffusion modeling with structural equation modeling (SEM)**

⇒ Solving or going beyond the **reliability issue** does **not** solve the **validity issue**.

Conclusion

- Should we **continue to use the current measures** to assess **attentional control**?
  - No, not for assessing **attentional control**.
  - It remains **unclear what we assess with these tasks**.

- Should we create **new tasks**?
  - Most probably yes, but we must create **reliable and valid tasks.**

$\Rightarrow$ We must **rethink the concept of attentional control**.

Thank you for your attention!

Contact: alodie.rey-mermet@fernuni.ch

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