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Factor Analyses and Age Effects in the CCAB At-Home Computerized Cognitive Test Battery

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Introduction

The California Cognitive Assessment Battery (CCAB ; ccabstudy.com) is a remotely monitored, at-home, computerized behavioral test and questionnaire suite. Here we evaluate the interpretation of 25 tests within the US English version of the CCAB using both an exploratory factor analysis (EFA) of 155 healthy adults and a confirmatory factor analysis (CFA) of 312 healthy older adults participating in a longitudinal study. We also estimated cross-sectional age gradients for best fitting latent factors [1].

Methods

- One set of latent factors (from 1 to 8 factors) was extracted from the literature [2][3][4][5][6] for assignment of CCAB tests into traditional test categories.
- 155 adult participants (age 22-86 y.o., mn 54, 57% male, education 8-20 yrs., md 14, 73% white) participated in a prefinal version of the CCAB. EFA was performed on their primary CCAB results using the 'psych' (v. 1.9.12.31-1) toolbox in R (v. 3.6.3) with 11 different rotations to extract a second set of CFA latent factors.
- The two sets of latent factors defined models used in the 'lavaan' CFA toolbox (v. 0.6.5-1) in R and applied to the first timepoint (enrollment and session 1) of CCAB longitudinal data from an older adult group (age 56-89 y.o., mn 71, 58% male, education 8-20 yrs., mn 14, 71% white).

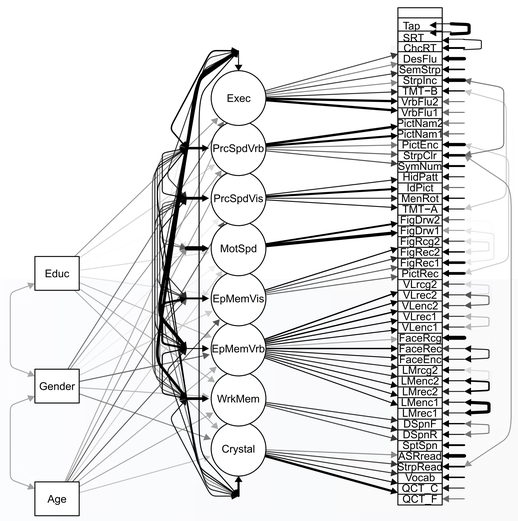

Figure 1: Literature-based 8 latent factor CFA model including 3 demographic regressors. Edge thickness reflects SEM link standardized strength. Circles are latent variables (LVs). RHS arrows are model covariates.

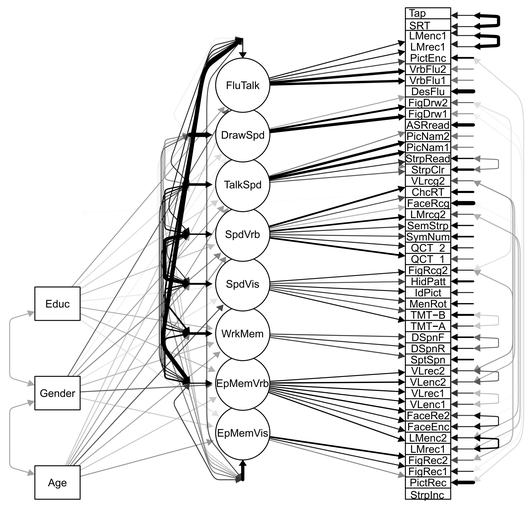

Figure 2: EFA-based 8 latent factor CFA model including 3 demographic regressors. Note that Finger tapping, simple reaction time, and stroop inhibition did not cluster substantially with other tests in the EFAs under these LVs.

		Z-score
Executive	**Age**	**4.0**
	Female	**-6.4**
	Education	**-4.8**
Perceptual Speed Verbal	**Age**	**4.1**
	Female	**-4.2**
	Education	-1.9
Perceptial Speed Visual	**Age**	**6.3**
	Female	0.8
	Education	-0.1
Sensory Motor Speed	**Age**	**2.0**
	Female	-0.6
	Education	1.5
Episodic Memory Visual	**Age**	**5.8**
	Female	-1.9
	Education	-1.2
Episodic Memory Verbal	**Age**	**-4.1**
	Female	**7.2**
	Education	**3.4**
Working Memory	**Age**	**-2.8**
	Female	**2.4**
	Education	**2.6**
Crystallized Ability	**Age**	**2.7**
	Female	**-5.0**
	Education	**-3.5**

Figure 3: Estimated regressor z–scores for the CFA (Fig 1) using literature-based latent factors.

		Z-score
Fluency Plus	**Age**	**-2.7**
	Female	**7.0**
	Education	**4.6**
Drawing Speed	**Age**	**2.3**
	Female	-0.6
	Education	1.5
Talking Speed	**Age**	**4.1**
	Female	**-4.0**
	Education	**-2.0**
Speed Verbal	**Age**	**5.3**
	Female	**-5.4**
	Education	**-3.0**
Speed Visual	**Age**	**7.2**
	Female	-1.1
	Education	-1.0
Working Memory	**Age**	**-3.0**
	Female	**2.4**
	Education	**2.6**
Episodic Memory Verbal	**Age**	**-2.7**
	Female	**7.1**
	Education	**3.6**
Episodic Memory Visual	**Age**	**3.9**
	Female	**-2.0**
	Education	-1.1

Figure 4: Estimated regressor z–scores for the CFA using EFA-based latent factors (Fig 2).

LV factor model	Literature-based CFA		EFA-based CFA	
	RMSEA	BIC	RMSEA	BIC
1-factor	0.073	37044		
2-factor	0.072	36999	0.073	37031
3-factor	0.071	36951	0.071	36011
4-factor	0.068	36818	0.067	36742
5-factor	0.068	36805	0.063	36609
6-factor	0.064	36652	0.062	36564
7-factor	0.064	36617	0.061	36510
8-factor	0.062	36545	0.058	35624

Figure 5: CFA model fit scores for both classes of models. The 8 LV factors were best in both cases. RMSEA: root mean square of approximation; BIC: Bayesian information criterion

Test List for Figure 1 CFA model

[*Executive*] Category Fluency 1&2, Trails-B, Stroop Interference, Design Fluency, Choice RT
[*Perceptual Speed Verbal*] Symbol-Number, Stroop Color, Picture Description, Continuous Picture Naming 1&2
[*Perceptual Speed Visual*] Trails-A, Mental Rotation, Identical Pictures, Hidden Patterns
[*Sensory Motor Speed*] Figure Copy 1&2
[*Episodic Memory Visual*] Picture Description Recall, Figure Copy Recall 1&2 & Recognition
[*Working Memory*] Digit Span Forward and Reverse, Spatial Span
[*Crystallized Ability*] Questionnaire Completion Time 1&2, Vocabulary, Reading Speed 1&2
[*Episodic Memory Verbal*] Logical Memory Encoding 1&2, Delayed Recall 1&2 & Recognition, Face-Name Encoding, Delayed Recall & Recognition, Verbal Learning Encoding 1&2, Delayed Recall 1&2 & Recognition

Results

- The two CFA models (Fig 1 & 2) show reasonably good model fits (Fig 5) for the best fitting, 8-factor, models using both literature-based latent variables (LVs) or EFA-based LVs.
- The demographic regressions (Figs 3 & 4) showed particularly strong age regressors for perceptual speed and episodic memory LVs.
- There were significant education and gender regressors in both models, particularly of verbal vs. visual LVs.

Discussion

- Visual tests of both speed and memory displayed more reliable cross-sectional age gradients than did respective verbal response tests.
- In both models, CCAB test speed measures showed steeper cross-sectional age gradients than did episodic memory measures.
- The EFA-derived latent factors were better fitting than were the classic factors as they were derived from other CCAB data.
- The EFAs produced neither an executive nor a crystallized LV.
- Ongoing longitudinal work will test the utility of visuospatial speed measures in aging and for early detection of MCI [6].

References

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