Working Memory and Learning: Evidence From a Population of Trilingual Children

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1. BACKGROUND

Working memory (WM) – the ability to store and manipulate information in the course of ongoing cognitive activities - has been suggested to play a key role in supporting learning in many different domains (Pickering, 2006). **This study** presents the findings of a **3-wave**, latent variable longitudinal study, exploring variations and the **development** of two working memory components - **verbal short-term storage** and the **central executive** - **in young children,** their **distinctiveness** from related cognitive abilities**,** and **their contributions to learning** in the key domains of language, literacy, and mathematics.

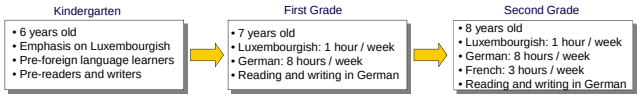
2. METHOD

Summary

Central executive, verbal short-term storage, phonological awareness, fluid intelligence, vocabulary, language comprehension, reading, spelling, mathematical skills, and foreign language acquisition were investigated **longitudinally** in a population of children growing up in **Luxembourg** - a country in which **Luxembourgish** is mainly used in social interactions, and **German** and **French** are instructed in schools.

Participants

119 Luxembourgish speakers with both parents speaking Luxembourgish. Children were assessed in **kindergarten**, in **1st, and in 2nd grade** of Luxembourgish schools.



Tasks

		K	Gr1	Gr2
Central executive	Counting recall	X	X	X
	Backw. digit recall	X	X	X
Short-term storage	Digit recall	X	X	X
	Nonword repetition	X	X	X
Phonological awareness	Rhyme easy	X	--	--
	Rhyme difficult	X	--	--
	Alliteration	--	X	--
	Spoonerism	--	X	X
	Odd-one-out	--	--	X
Fluid intelligence	Raven CPM	X	X	X
Vocabulary	Expressive Lux.	X	X	X
	Expressive German	X	X	X
Comprehension	Listening Lux.	X	X	X
	Listening German	--	X	X
	Reading German	--	--	X

		K	Gr1	Gr2
Reading	Letter decision	X	--	--
	Word detection	X	--	--
	Single words	--	X	X
	Text	--	X	X
	Nonwords	--	--	X
Spelling	German words	--	--	X
	French words	--	--	X
French	French expressive	--	--	X
	French receptive	--	--	X
	Listening compreh.	--	--	X
Mathematics	Numbers	--	--	X
	Operations	--	--	X
	Problems	--	--	X

K: Kindergarten Gr1: First grade Gr2: Second grade

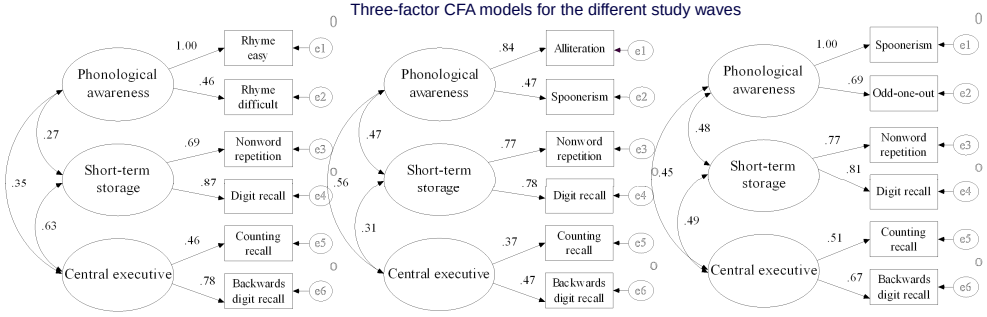
Analyses

Confirmatory Factor Analyses (CFA) to explore the **structure of WM** in young children: Evaluate **adequacy of measurement model**; Model relationships between **latent constructs** that are not directly observed but relate to observed variables; **Reduce measurement error** by having multiple indicators per latent variable.

Hierarchical regression models (HRM) to explore the **specific contribution** of different **WM componants** to subsequent **learning**: Latent predictors are entered into the regression equation in a pre-specified order.

3. RESULTS I: Structure of working memory in young multilingual children

Three-factor CFA models for the different study waves



Kindergarten measures $\chi 2\ (8) = 15.53;\ p = .05;\ CFI = .94;\ RMSEA = .09$

First grade measures $\chi 2(7) = 9.72;\ p = .20;\ CFI = .97;\ RMSEA = .05$

Second grade measures $\chi 2\ (8) = 7.89;\ p = .44;\ CFI = 1;\ RMSEA = .00$

Stability of the WM constructs

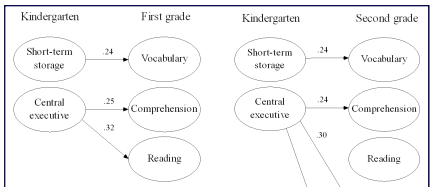
	Time interval		
Latent variable	K-Gr1	Gr1-Gr2	K-Gr2
1. Short-term storage	.99	1.00	.98
2. Central executive	.52	1.00	.75

WM system with **seperate but related** elements correspodning to **verbal short-term storage** and a **central executive**

WM measures: good **discriminant** and **convergent validity**.

Stability of individual differences in young children's WM abilities

4. RESULTS II: Links between working memory and learning

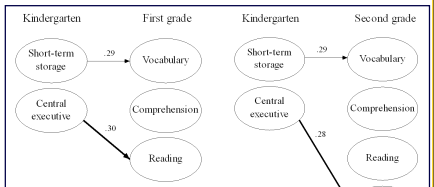


*Summary of the **HRM** with **short-term storage** and the **central executive** in kindergarten **predicting** the different **learning** domains one and two years later.*

*Links represent **specific contributions** of either short-term storage or the central executive to learning (i.e. controlling for the variance shared with the central executive or short-term storage respectively).*

Verbal short-term storage significantly predicted **vocabulary** one and two years later. Highly **specific links** were further observed between the **central executive** and **reading** in first grade and **spelling** in second grade. These links remained significant even after the autoregressive effect was taken into account.

The **central executive** predicted subsequent **comprehension** and **mathematical skills** when short-term storage was controlled. After entering **fluid intelligence** as additional covariate these **links disappeared**, suggesting that it is the variance that the central executive and fluid intelligence have in common that accounts for the observed relationships with comprehension and mathematics.



*Summary of the **HRM** exploring **specific links** between **short-term storage** and the **central executive** with subsequent **learning** after **controlling** for **fluid intelligence, phonological awareness**, and **vocabulary**.*

*Lines in **boldface** indicate path coefficients that remained significant after taking the **autoregressive effect** into account.*

5. CONCLUSION

Results indicate that relations between the measures were best characterized by a model consisting of two **related but separable constructs** - corresponding to **short-term storage** and a **central executive** - that were highly **stable** across the years. Whereas **verbal short-term memory** was more specifically linked to early **vocabulary** development, the **central executive** appeared to support learning in a wide range of domains, including **language comprehension**, **literacy**, and **mathematics**. The findings reinforce previous evidence indicating that **verbal short-term memory** is one of the main contributors to **vocabulary** development by **supporting** the formation of **stable phonological representations** of new words in long-term memory. Furthermore, the findings fit well with the position that the **central executive** makes **general** rather then specific contributions to learning - possibly in terms of an **attentional control system** that actively maintains crucial information and regulates controlling processes during complex cognitive activities. In **conclusion**, the findings indicate that different components of the WM system can be **reliably assessed** in **children** as young as 5; that individual differences in these abilities are highly **stable** over time; and that WM assessments are **predictive of future learning** in key academic domains. This reinforces the value of **early screening** of working memory abilities to identify children who are at a present and future **educational risk**.

REFERENCES: Pickering, S. J. (2006). *Working memory and education*. London: Elsevier