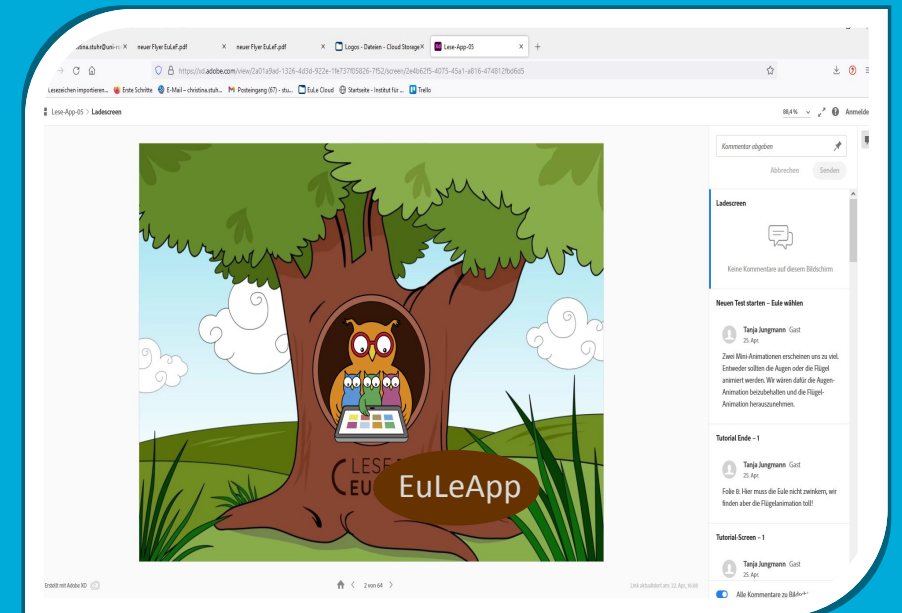


# Adaptive assessment and promotion of early literacy skills with a newly designed App

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Dr. Melike Yumus

23<sup>rd</sup> European Conference on Literacy &  
7<sup>th</sup> Panhellenic Literacy Conference





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Students



Tabea Testa

## EuLe-F project



- Joint research project between the Universities of Oldenburg and Rostock
- Funded by the Federal Ministry of Education and Research
- Project duration: 09/2021 – 11/2024

GEFÖRDERT VOM



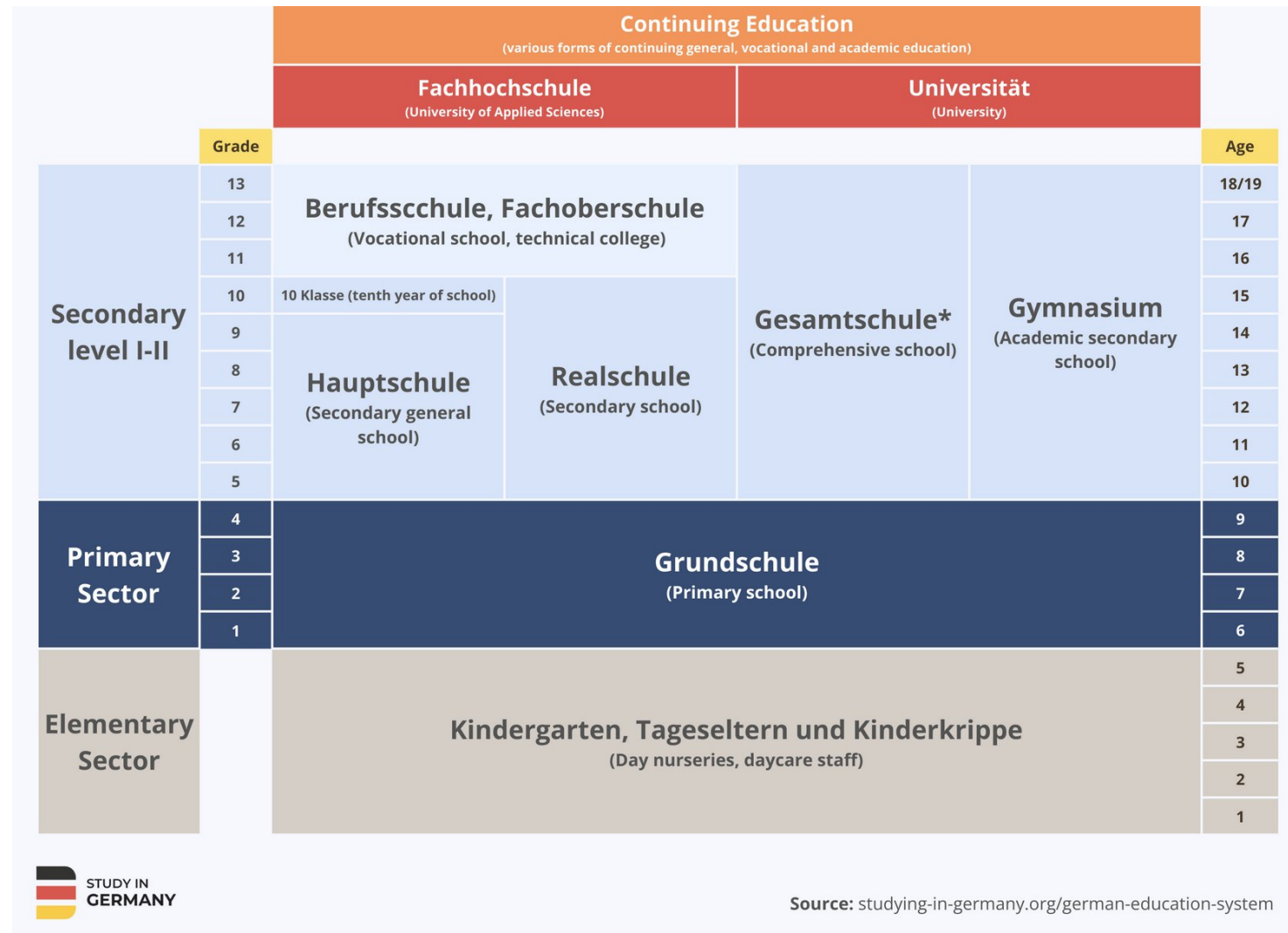
Bundesministerium  
für Bildung  
und Forschung

# Symposium Overview

1. Background and Introduction
2. Development of the EuLeApp©
3. Methods
4. Results
  - 4.1 Psychometric properties of the EuLeApp©
  - 4.2 Applicability of the EuLeApp© in primary school
  - 4.3 Identification of latent early literacy profiles
5. Development of the Adaptive Support Concept
6. Research Perspectives

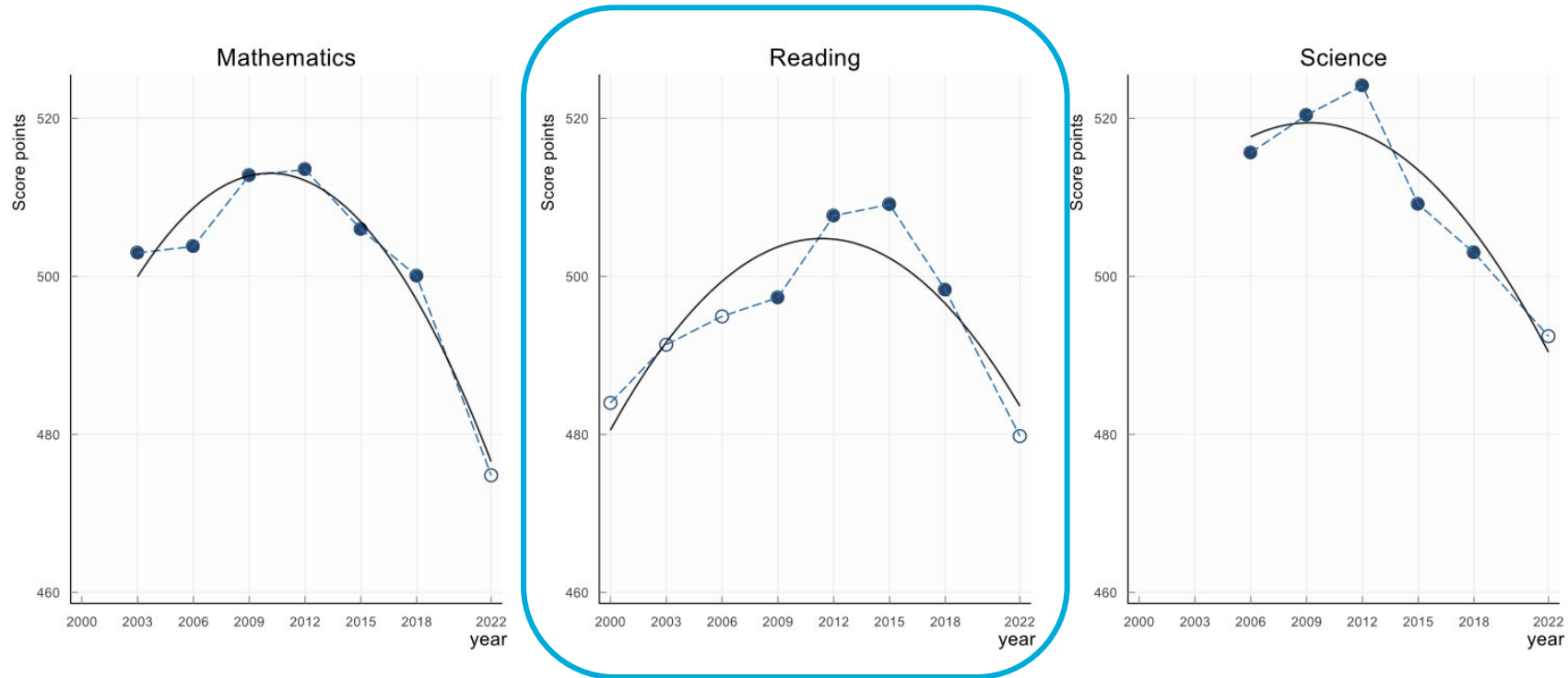
# Background and Introduction

# The German Early Childhood Education and Care System



# Relevance of early prevention in Germany

Figure 1. Trends in performance in mathematics, reading and science



Note: White dots indicate mean-performance estimates that are not statistically significantly above/below PISA 2022 estimates. Black lines indicate the best-fitting trend. An interactive version of this figure is available at <https://oecdch.art/a40de1dbaf/C074>.

Source: OECD, PISA 2022 Database, Tables I.B1.5.4, I.B1.5.5 and I.B1.5.6.

# Relevance of early prevention in Germany

## Current status and challenges

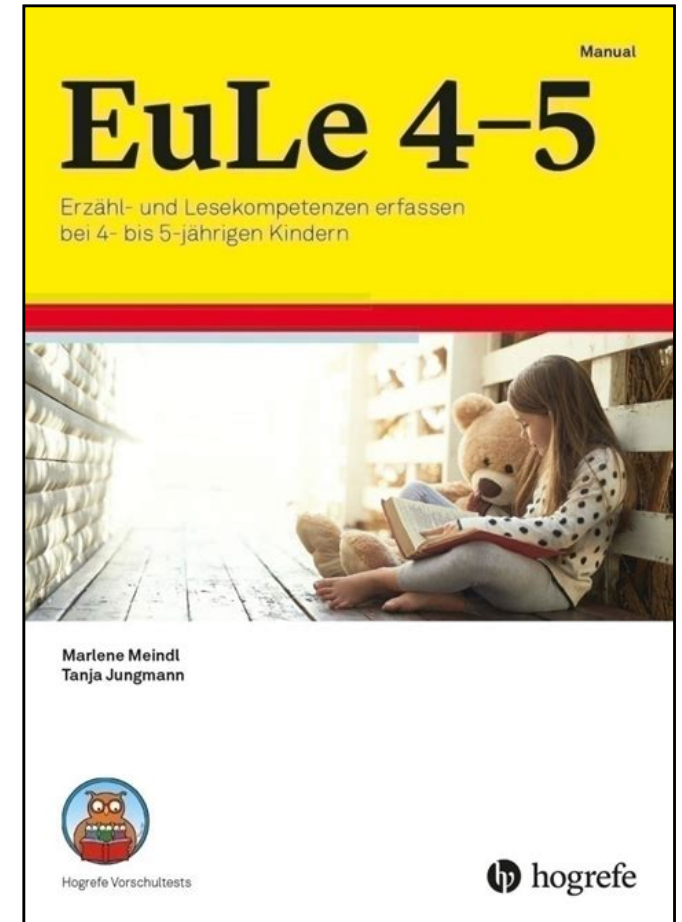
- Despite high attendance rates in daycare, significant variations exist in the early literacy skills of children as they start primary school (e.g., Brügelmann, 1998).
  - These differences can be attributed to the inconsistent exposure children receive to early literacy activities in ECEC environments (Tietze et al., 1998; Wirts et al., 2017).
  - Problems in reading and spelling competences are not assessed before children already failed ('dyslexia paradox') (Ozernov-Palchik & Gaab, 2016).
  - Shortage of diagnostic tools for the assessment of early literacy skills in preschool children
  - Shortage of skilled workers in pre-school.
  - Limited resources to foster prerequisites for reading and spelling in daycare institutions.
- (e.g. Wirts et al., 2017; Bock-Famulla et al., 2021)



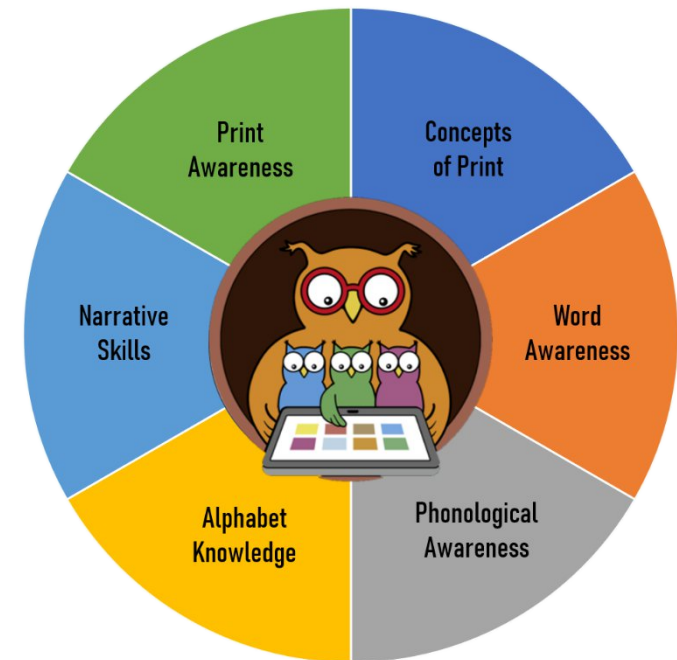
# Relevance of early prevention in Germany

## Assessment of prerequisites for later reading and writing

- In the Anglo-Saxon (e.g., the United States, the United Kingdom) countries, early literacy knowledge and skills can be comprehensively evaluated using paper-pencil assessments (e.g. Dynamic Indicators of Basic Early Literacy Skills, DIBELS, Good and Kaminski, 2002), Test of Preschool Early Literacy, TOPEL, Lonigan et al., 2007), Phonological Awareness and Literacy Screening PreK (PALS-PreK, Invernizzi et al., 2004).
- In Germany, a comprehensive standardized early literacy assessment had been lacking until Meindl and Jungmann (2019) developed a paper-pencil assessment to evaluate early literacy and narrative skills among children aged 4 to 5 years in Germany, the EuLe 4-5 according to the TOPEL-Test.



# Development of the EuLeApp©





# EuLe-F project Framework Overview

## Research Aims

- **Preventive approach:** Assessment and promotion of early literacy skills in daycare long before problems in reading and writing occur.
- **Development of a digital tool that is applicable for assessment in daycare:** timesaving and personal resources saving, motivating for children
- **Adaptive promotion of Early Literacy skills:** Interlaced assessment and promotion of early literacy in everyday activities in ECEC environments
- **Creating an evidence base:** Assessing the effectiveness of educational process diagnostics on the institutional literacy environment and children's competencies.



# Relevance of early prevention in Germany

## From paper-pencil to digital assessment

### EuLe 4-5



Assessment of learning status

paper-pencil format

Classical test theory

normed und standardized:  
T-scores / percentile rank

5 aspects of Early Literacy:

- Narrative skills
- Concepts of print
- Print awareness
- Word awareness
- Alphabet knowledge

### EuLeApp©



Assessment of learning progress

App-based, adaptive testing

Item-Response-Theory

Rasch-scaled, z-standardized

6 aspects of Early Literacy

- all aspects of the EuLe 4-5 +  
phonological awareness
- Embedment in a motivating story  
adequate for children



# EuLe-F project

## Theoretical background

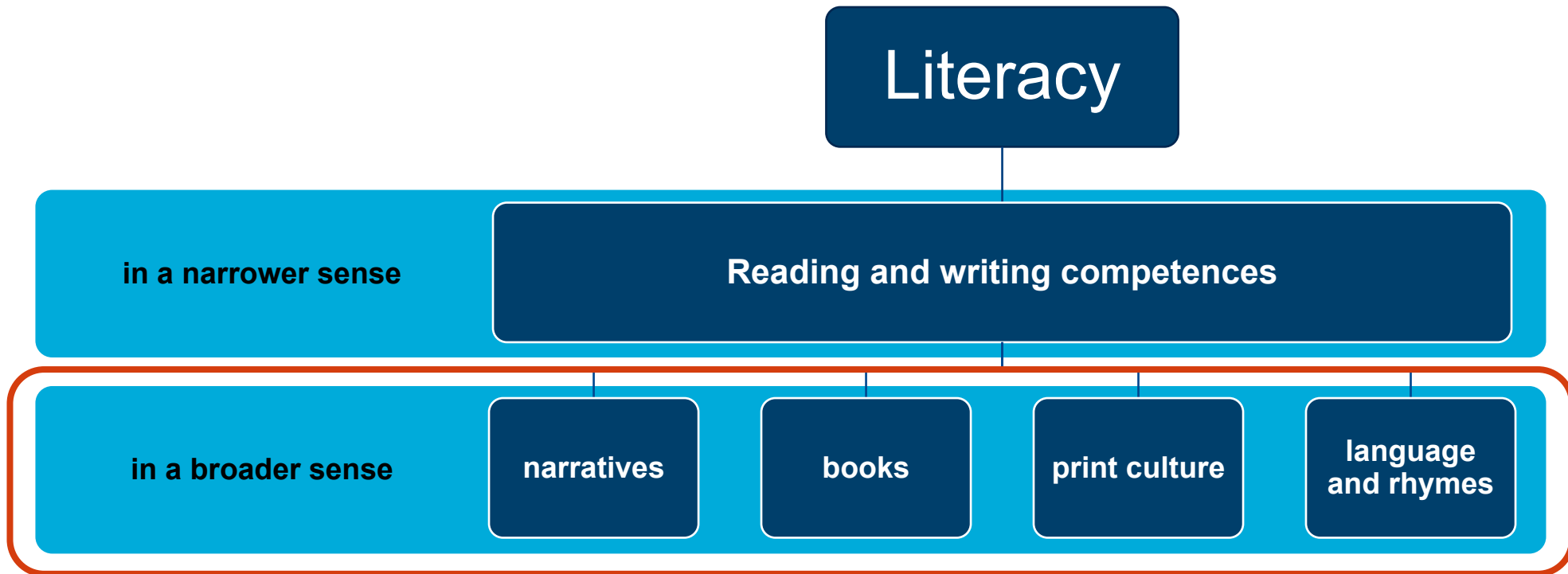
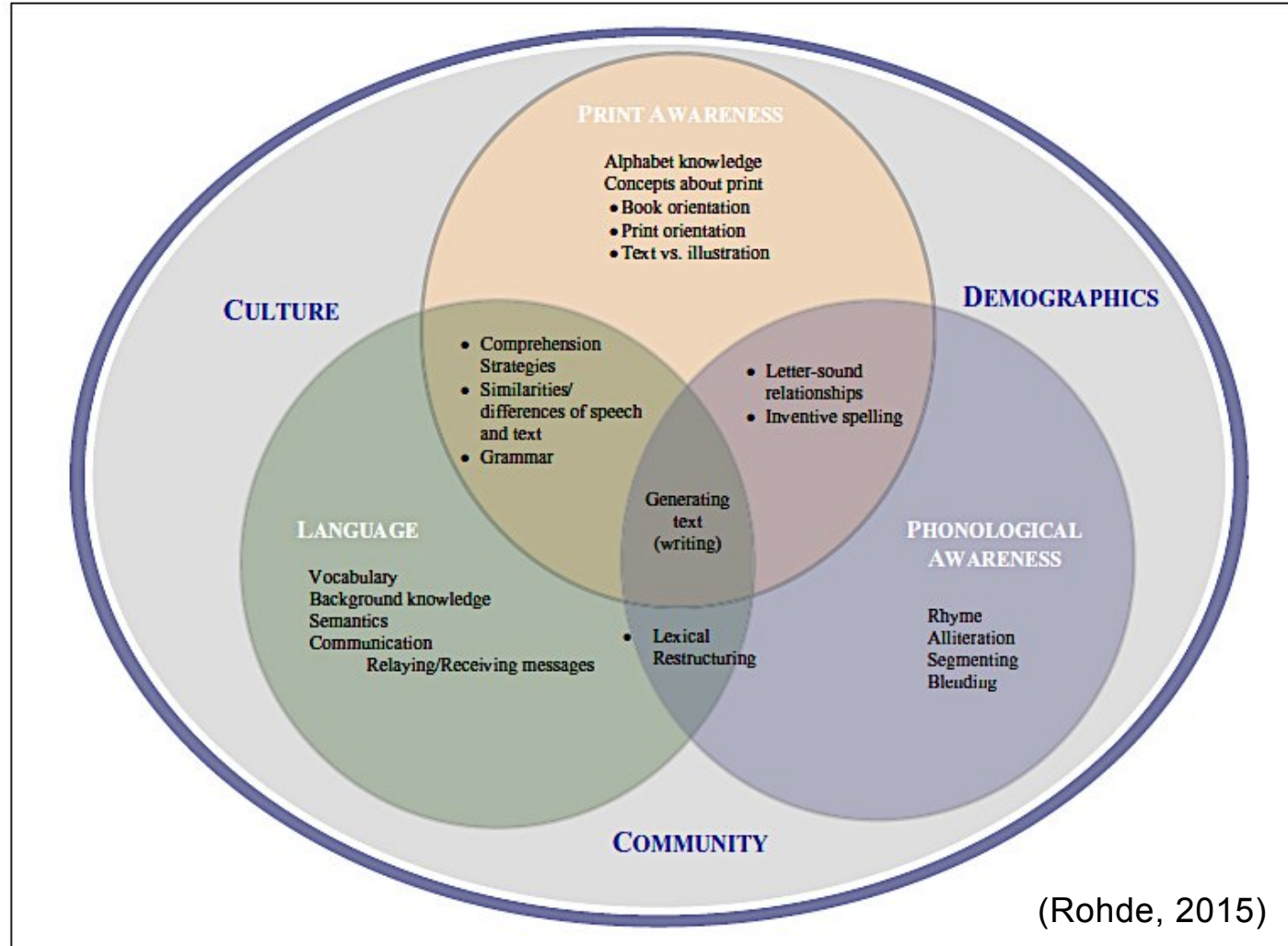


Fig. 1: Literacy in a narrower and in a broader sense

# EuLe-F project

## Theoretical background: CELM-Modell

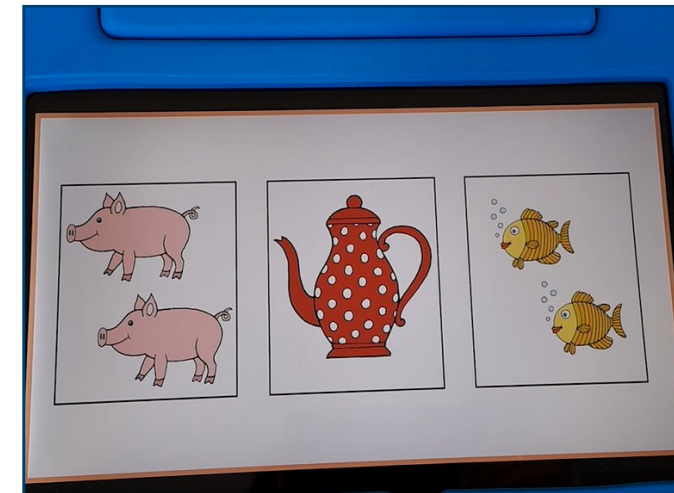


# EuLe-F project

## Development of the EuLeApp©



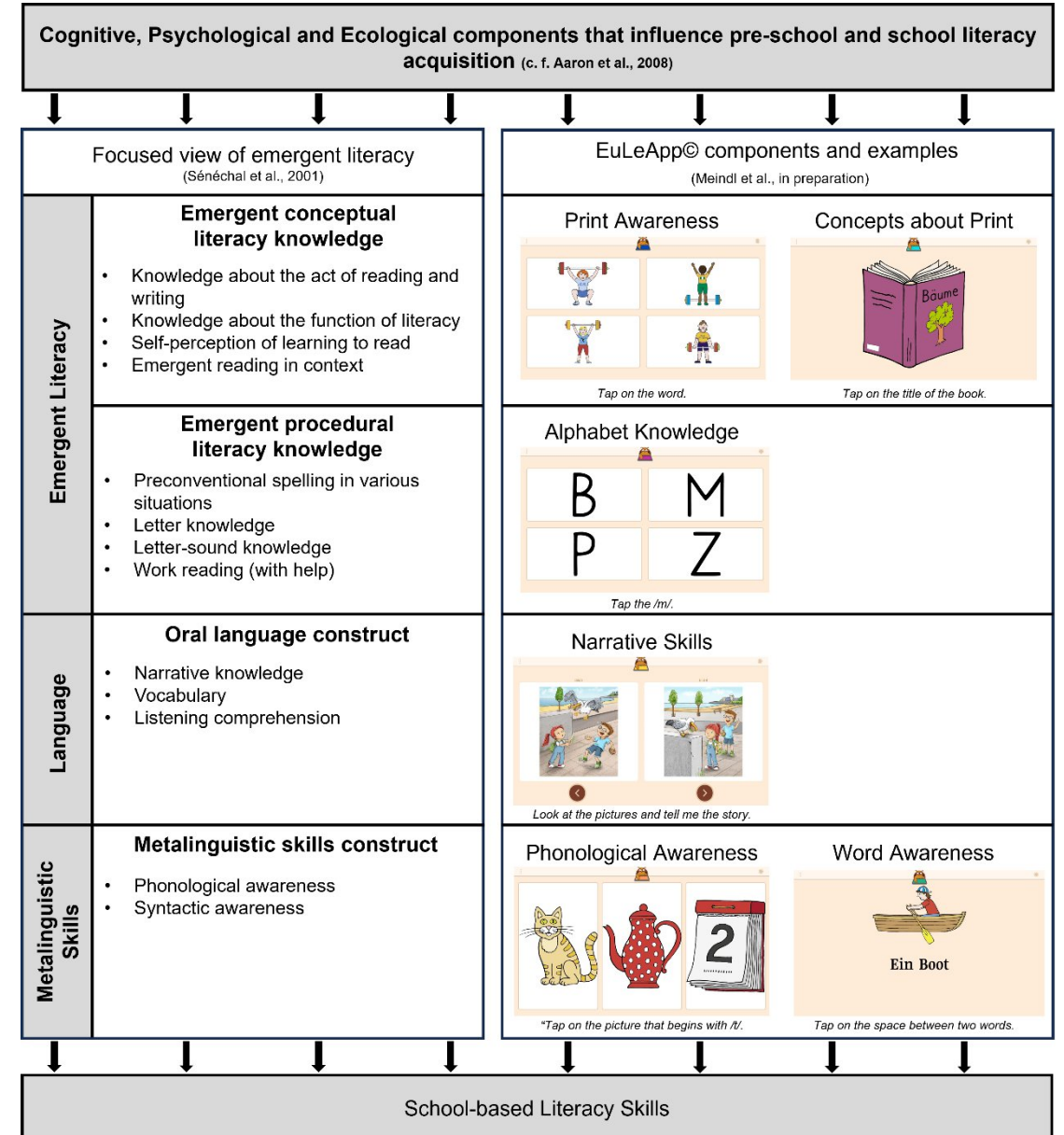
- **Framing Story:** A full-grown owl and her three owlets explore the world of letters and print. The child chooses his or her owlet as an avatar to master the items.
- Young children may not feel comfortable interacting with adults who are testing them. Therefore, digital tools may better assess their early literacy skills.



GEFÖRDERT VOM




# EuLeApp©

- The EuLeApp© allows to assess six early literacy components
  - Print Awareness
  - Concepts of Print
  - Alphabet Knowledge
  - Narrative Skills
  - Phonological Awareness
  - Word Awareness



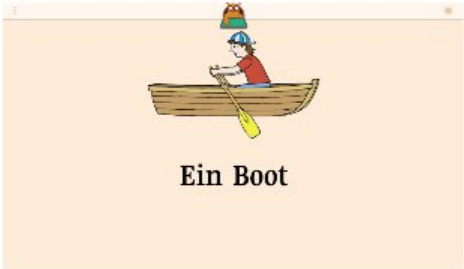






Focused view of emergent literacy (Sénéchal et al., 2001)		EuLeApp© components and examples (Meindl et al., in preparation)	
<b>Emergent Literacy</b>	<p><b>Emergent conceptual literacy knowledge</b></p> <ul style="list-style-type: none"> <li>• Knowledge about the act of reading and writing</li> <li>• Knowledge about the function of literacy</li> <li>• Self-perception of learning to read</li> <li>• Emergent reading in context</li> </ul>	<p><b>Print Awareness</b></p>  <p><i>Tap on the word.</i></p>	<p><b>Concepts about Print</b></p>  <p><i>Tap on the title of the book.</i></p>
	<p><b>Emergent procedural literacy knowledge</b></p> <ul style="list-style-type: none"> <li>• Preconventional spelling in various situations</li> <li>• Letter knowledge</li> <li>• Letter-sound knowledge</li> <li>• Work reading (with help)</li> </ul>	<p><b>Alphabet Knowledge</b></p>  <p><i>Tap the /m/.</i></p>	(Stuhr et al., 2024)

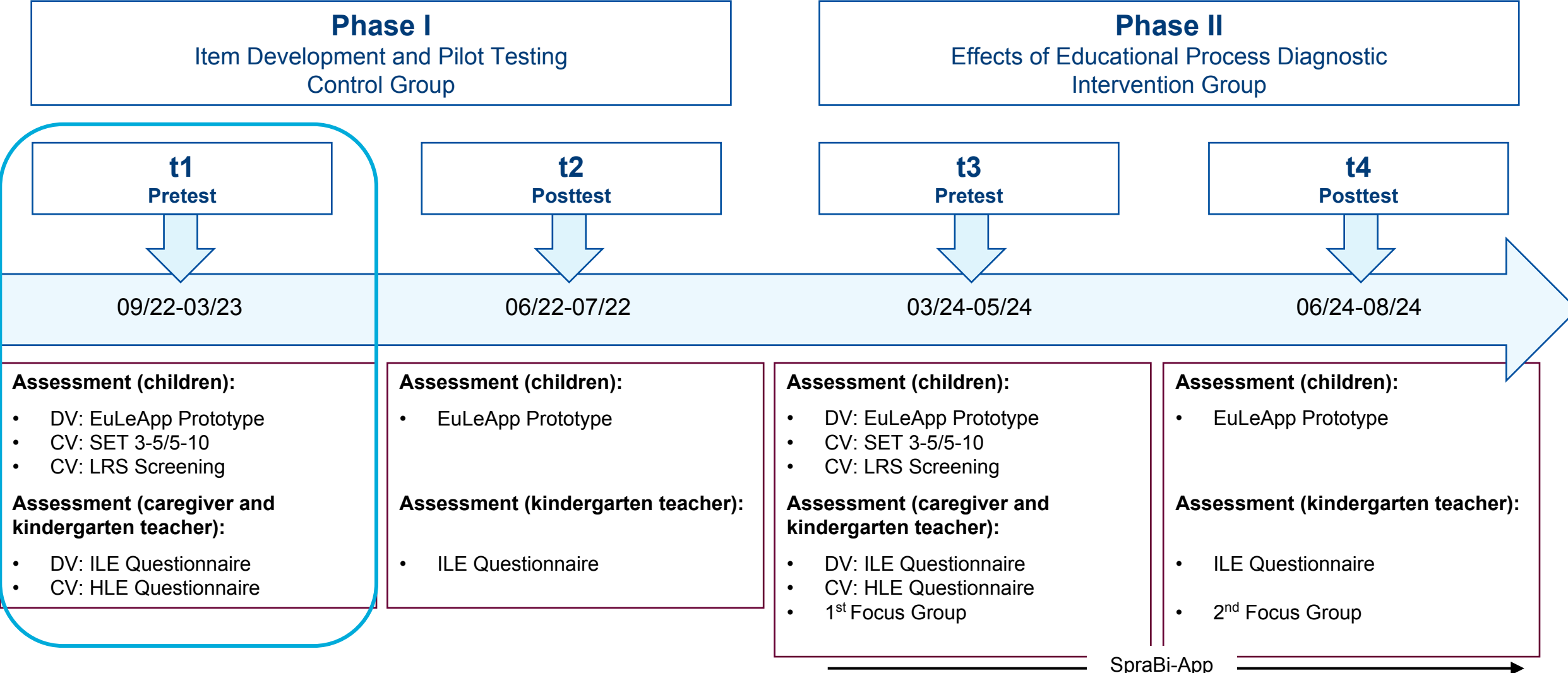


<b>Language</b>	<b>Oral language construct</b> <ul style="list-style-type: none"><li>• Narrative knowledge</li><li>• Vocabulary</li><li>• Listening comprehension</li></ul>	<b>Narrative Skills</b>  <p>Look at the pictures and tell me the story.</p>	
<b>Metalinguistic Skills</b>	<b>Metalinguistic skills construct</b> <ul style="list-style-type: none"><li>• Phonological awareness</li><li>• Syntactic awareness</li></ul>	<b>Phonological Awareness</b>  <p>"Tap on the picture that begins with /t/.</p>	<b>Word Awareness</b>  <p>Tap on the space between two words.</p>

(Stuhr et al., 2024)

# Methods

# Study Design



# Participants (Children)



	Calibration Sample N = 318	Intervention Sample N = 378
<b>Federal State</b>		
Mecklenburg-West	n = 177 (55.7%)	n = 105 (27.8%)
Pomerania	n = 141 (44.3%)	n = 273 (72.2%)
Lower Saxony		
<b>Gender</b>		
Female	n = 140 (44.0%)	n = 178 (47.1%)
Male	n = 178 (56.0%)	n = 200 (52.9%)
<b>Age group</b>		
4-year-old	n = 101 (31.8%)	n = 152 (40.2%)
5-year-old	n = 149 (46.9%)	n = 168 (44.4%)
6-year-old	n = 41 (12.9%)	n = 58 (15.3%)
7-year-old	n = 24 (7.5%)	n = 0 (0%)
8-year-old	n = 3 (0.9%)	n = 0 (0%)

**Calibration Sample**

**N = 318**

**Intervention Sample**

**N = 378**



**Language development**

Age appropriate	n = 276 (86.6%)	analysis in process
Language problems	n = 37 (11.6%)	
Missing Data	n = 5 (1.6%)	

**Multilingual**

Monolingual	n = 253 (79.6%)	analysis in process
Multilingual	n = 24 (7.5%)	
Missing Data	n = 41 (12.9%)	

**Risk for dyslexia**

Reading and writing	n = 18 (5.7%)	n = 44 (9.8%)
Reading	n = 6 (1.9%)	n = 37 (11.6%)
Writing	n = 41 (12.9%)	n = 66 (17.4%)

**Parental graduation**

secondary modern school or below	n = 50 (16.4%)	
Vocational school		
Vocational diploma	n = 32 (10.1%)	analysis in process
University-entrance diploma	n = 23 (7.2%)	
Polytechnic degree	n = 50 (15.7%)	
University degree	n = 113 (35.5%)	
missing data	n = 48 (15.1%)	

# Participants (kindergarten teacher)



	Calibration Sample N = 47	Intervention Sample N = 72
<b>Federal State</b>		
Mecklenburg-West Pomerania	n = 41	n = 30
Lower Saxony	n = 6	n = 42
<b>Gender</b>		
Female	n = 38 (80.9)	n = 61 (84.7%)
Male	n = 7 (14.%)	n = 11 (15.3%)
Missing Data	n = 2 (4.2%)	

# Assessment



## Children

Early literacy skills	Prototyp EuLeApp© (Jungmann & Meindl, in Vorb.)
Language development	SET 3-5 (Petermann, 2016) oder SET 5-10 (Petermann, 2018)
Risk for dyslexia	Würzburger LRS-Screening (Endlich et al., 2019)

## Parents

Home Literacy Environment (HLE) Sociodemographic Data	Standardized questionnaire (according to Niklas et al., 2020)
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## Kindergarten Teachers

Institutional Literacy Environment (ILE)	Questionnaire according to LiSKit (Mayr et al., 2013) und German adaption of Get Ready to Read Questionnaire
Daily early literacy activities (type/frequency)	SpraBi-App (Wirts et al., 2019)
Focus Groups	Interview with predetermined questions (e.g. on early literacy, attitudes towards digital tools, practicability of the EuLeApp© and adaptive support concept)



# Psychometric properties of the EuLeApp©

# The EuLeApp is a digital touchscreen assessment tool for preschool-aged children that can be completed in a single session

~20 min



## EuLeApp© Features



- The "*Definition*" feature provides short information on what and how children will do.
- The "*Modelling*" feature demonstrates the use of the system
- The "*Practice*" feature provides practice to the child on how the system works before starting the assessment process
- "*Motivation*" feature to motivate children to participate in assessment the tool

## Development of the EuleApp



### First phase

- Item selection/development
- Categorization
- Visualized
- Evaluation design
- Prototype

### Second phase

- Adaptation
- Scale



## The psychometric properties of the EuLeApp were examined through five main sets of analysis

Reliability was evaluated in terms of the relative efficiency of the EuLeApp compared to the full set of items in the screened pool

Determination of an exploratory model ( based on the IRT model, items with commonalities below 0.5 were removed )

Development of a confirmatory model.

The confirmatory model and the simulation of the CAT with all items in the item bank

Subsequent comparison of the estimate of personal ability with all items and the estimate of personal ability with the sub-selection running in the CAT



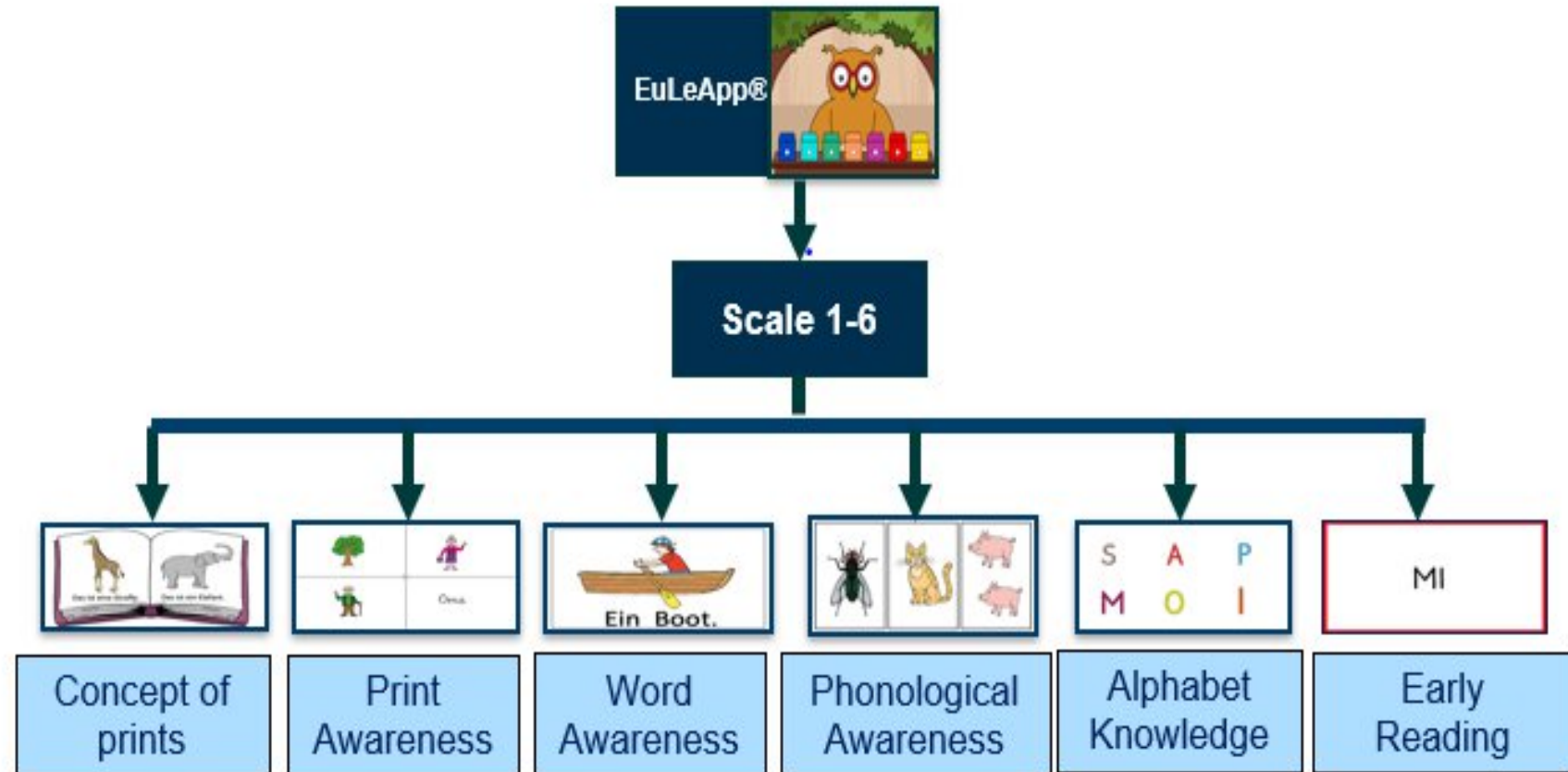
# Results

## Item characteristics und reliability

- **Item difficulties** between 0,1 and 0,9 on all scales of the EuLeApp©
- Although items with extreme difficulties are considered as problematic in Classic Test Theory, Item Response Theory allows for adequate modeling of items in the whole spectrum of difficulty (e.g. van der Linden & Hambleton, 1995)
- We analyzed narrative skills on the picture story “Seagull Marius” on the macrostructural level according to the Edmonton Narrative Norms Instrument (ENNI, vgl. Schneider u.a. 2005)
  - Interrater reliability on  $n = 31$  narrations reaches  $r = .84$  (Kendall’s Tau).
  - We calculate internal consistency (items with corrected item-total correlation above  $r = .30$ ), Cronbach’s Alpha varies between  $\checkmark = .82$  (print awareness) und  $\checkmark = .96$  (narrative skills).



The EuLeApp consists of six EL subscales, comprising 175 items in total



# Construct Validity

## Multidimensional IRT for Factor Structure



The model includes all six EuLe scales and is a 4PL model with a reliability of 0.80 on all scales.

In the second step, **Computerized Adaptive Testing (CAT)** was developed within the Item Response Theory (IRT) framework to examine children's early literacy skills.



The CAT was developed based on this multidimensional IRT model, and the item base was calibrated during model development.





# Construct Validity

## Multidimensional IRT for Factor Structure

### WHY MULTIDIMENSIONAL MODELING?

IRT has several attractive **features** for investigating the psychometric properties of psychological instruments (Reise et al., 2013).

- ✓ Item parameter estimates are independent or invariant of the sample. This provides a basis to estimate an individual's probability of a correct response at any given ability or trait level.
- ✓ Therefore, the same set of items do not need to be administered to estimate an individual's trait estimate. In this case, a sample of items can be selected from a bank of calibrated items and administered to individuals to determine their standing on the measured skills, which is the basis of computerized adaptive testing.
- ✓ IRT yields a measure of the precision, or standard error, for each trait/skills estimate.

# Construct Validity

## Multidimensional IRT for Factor Structure



- ✓ Another notable feature of IRT is the ability to inspect an item's functioning graphically. Specifically, item characteristic curves model the probability of an item response for a given ability level (Embretson & Reise, 2000)

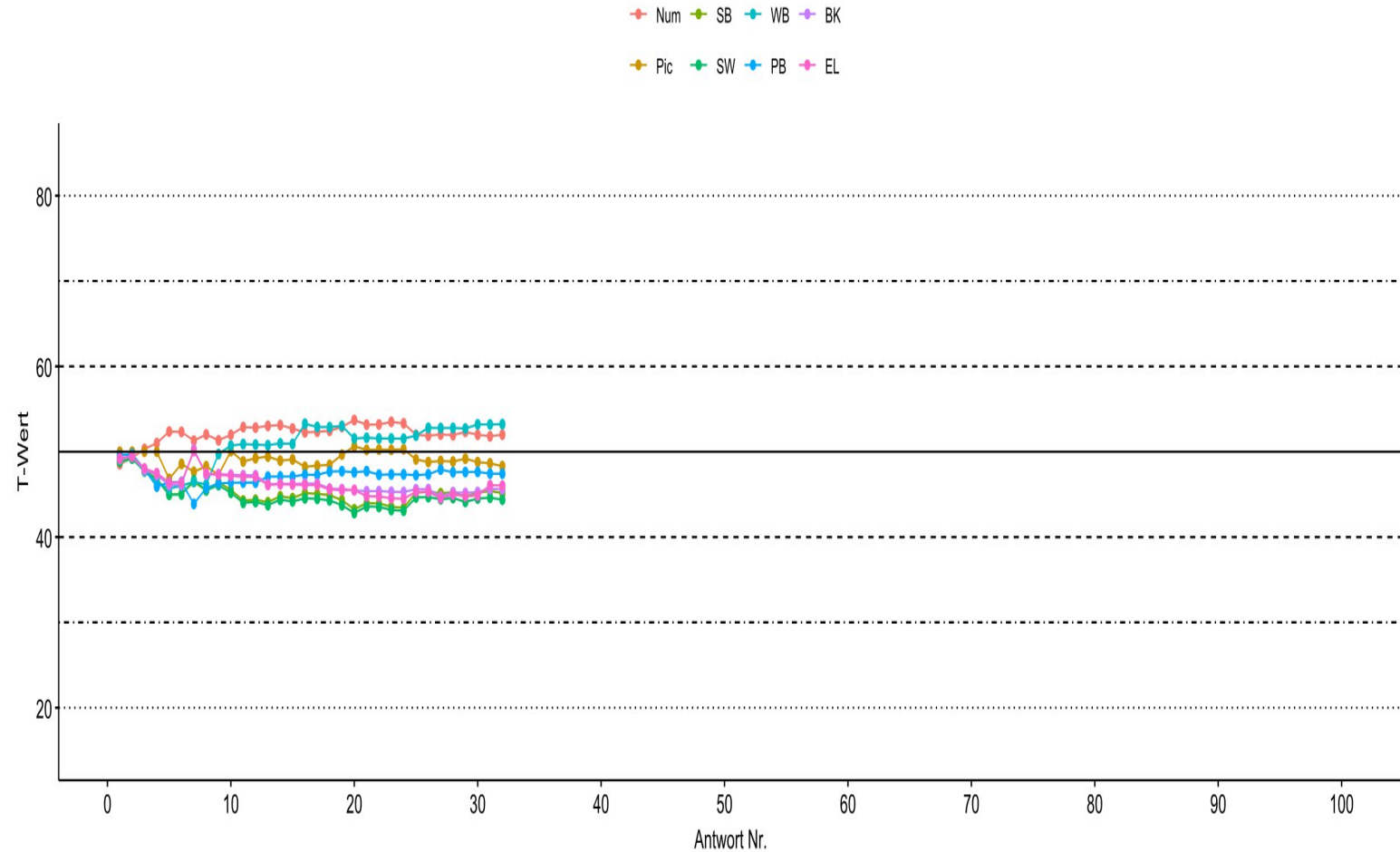
### Scale 1-4

- Print awareness
- Concepts of Print
- Word awareness
- Phonological awareness

### Scale 5-6

- Alphabet knowledge - productive
- Alphabet knowledge- receptive

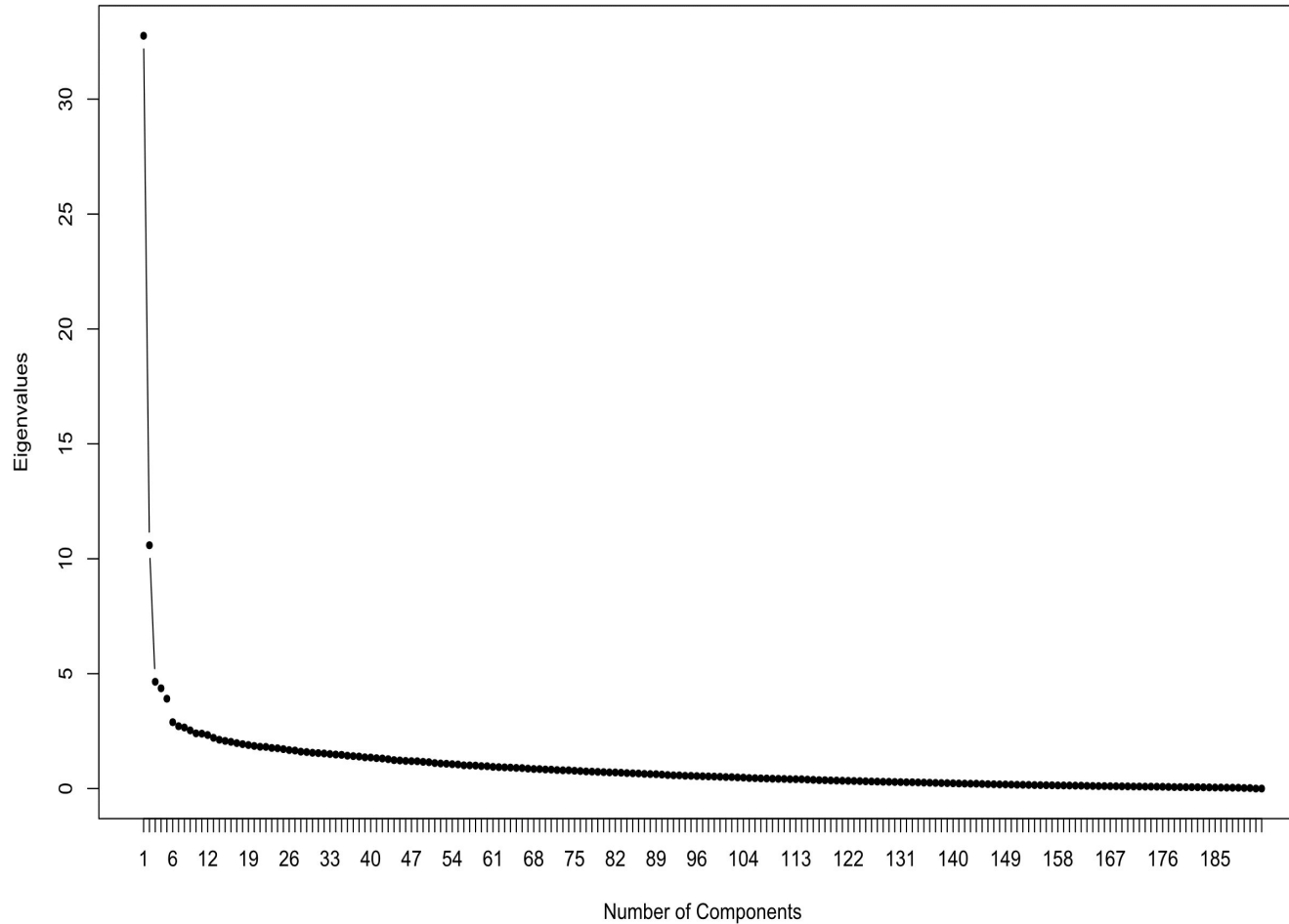
Case 2 DPrule



# Result Scales 1-6



Scree Plot for EuLe Scales 01 - 06



To develop the multidimensional IRT models used by the CAT, exploratory IFA models were first applied to determine the number of dimensions in the EuLe scale data.

Based on these exploratory results, a multidimensional bi-factor IRT model for the EuLeApp© scales 1-6 was developed, with six primary factors representing EuLeApp©.

All factor loadings were higher than 0.50. IRT item discrimination values were mostly high or very high in all subscales.



# Results

## Construct Validity (Multidimensional IRT for Factor Structure)

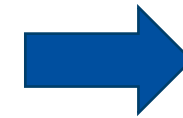
EuLeApp Model	CFI	TLI	RMSEA (%95 CI)	SRMSR	AIC	BIC
Scale 1-6; six - factor	0,995	0,995	0,013	0,0624	24834,99	25998,28

For scale 1- 6 the bifactor IRT model shows an acceptable model-data fit and the psychometric properties of the EuleApp© are satisfactory

# Results

## Intercorrelations between the Early Literacy domains - Scales 1-5

	Print Awareness	Concepts of Print	Word awareness	Phonological awareness	Alphabet Knowledge	Early reading
Print Awareness		0,745	0,685	0,267	0,637	0,713
Concepts of Print	0,745		0,517	0,413	0,682	0,611
Word awareness	0,685	0,517		0,459	0,409	0,351
Phonological awareness	0,267	0,413	0,459		0,029	0,140
Alphabet Knowledge	0,637	0,682	0,409	0,029		0,913
Early Reading	0,713	0,611	0,351	0,140	0,913	



Tables present the Spearman correlation coefficients among each of the early literacy domain scores in early years



# Results

## Construct Validity - Summary

The results show adequate dimensionality and reliability of the subscales. Regarding item difficulty values, the screening tool presents items that are easy for the children in both subscales, with slight ceiling effects observed toward the end of kindergarten

The fact that the screening tool includes items that are easy for children (Starkey & Gelman, 2020) in these subscales suggests that these skills are generally well-developed in the target age group.

# Results

## Convergent validity – EuLeApp© and SET 3-5



SET 3-5	Image search	Naming Images	Category Recognition	Phoneme Differentiation	Plural formation	Play actions	Comments on play actions	Nonword repetition
<b>EuleApp©</b>								
Print Awareness	.296*** N = 244	.272*** N = 244	<b>.303***</b> N = 244	<b>.347***</b> N = 244	.316*** N = 244	.187** N = 244	<b>.386***</b> N = 244	.190** N = 244
Concepts of Print	.368*** N = 244	<b>.416***</b> N = 244	.372*** N = 244	.376*** N = 244	.276*** N = 244	<b>.440***</b> N = 244	.336*** N = 244	.171** N = 244
Phonological Awareness	<b>.360***</b> N = 244	.295*** N = 244	.246*** N = 244	<b>.419***</b> N = 244	.303*** N = 244	<b>.369***</b> N = 244	<b>.385***</b> N = 244	.242*** N = 244
Word Awareness	.276*** N = 244	<b>.326***</b> N = 244	.310*** N = 244	<b>.376***</b> N = 244	.333*** N = 244	<b>.478***</b> N = 244	.286*** N = 244	.205** N = 244
Alphabet Knowledge	.171** N = 244	.099 N = 244	.104 N = 244	<b>.292***</b> N = 244	.119 N = 244	.217*** N = 244	.227*** N = 244	.145* N = 244
Narrative Skills	.357*** N = 238	.256*** N = 238	.241*** N = 238	.255*** N = 238	.274*** N = 238	<b>.337***</b> N = 238	<b>.234***</b> N = 238	.194** N = 238

# Results

## Convergent validity – EuLeApp© and SET 5-10



SET 5-10	Image search	Category Recognition	Play actions	Questions to Text	Sentence Construction	Plural formation	Correction of Sentences	Nonword repetition
<b>EuleApp©</b>								
Print Awareness	.370* N = 36	<b>.449**</b> N = 36	.317 p=.056 N = 36	.335* N = 36	<b>.549***</b> N = 36	<b>.509**</b> N = 36	.285 p=.092 N = 36	<b>.481**</b> N = 36
Concepts of Print	<b>.654***</b> N = 36	<b>.469**</b> N = 36	.447** N = 36	.425** N = 36	.492 p=.085 N = 36	.342* N = 36	<b>.493**</b> N = 36	.343* N = 36
Phonological Awareness	.373* N = 36	.360* N = 36	.353* N = 36	<b>.454**</b> N = 36	.309 p=.067 N = 244	.331* N = 36	<b>.642**</b> N = 36	.282 p=.096 N = 244
Word Awareness	<b>.519**</b> N = 36	<b>.437**</b> N = 36	.301 p=.074 N = 36	.406* N = 36	.471** N = 36	.345* N = 36	.392* N = 36	<b>.430**</b> N = 36
Alphabet Knowledge	.160 N = 36	.102 N = 36	.100 N = 36	<b>.476**</b> N = 36	.180 N = 36	.229 N = 36	<b>.493**</b> N = 244	.355* N = 36
Narrative Skills	.426* N = 33	<b>.481**</b> N = 33	<b>.356*</b> N = 33	.362* N = 33	<b>.496**</b> N = 33	<b>.464**</b> N = 33	<b>.518**</b> N = 33	.097 N = 33



# Results

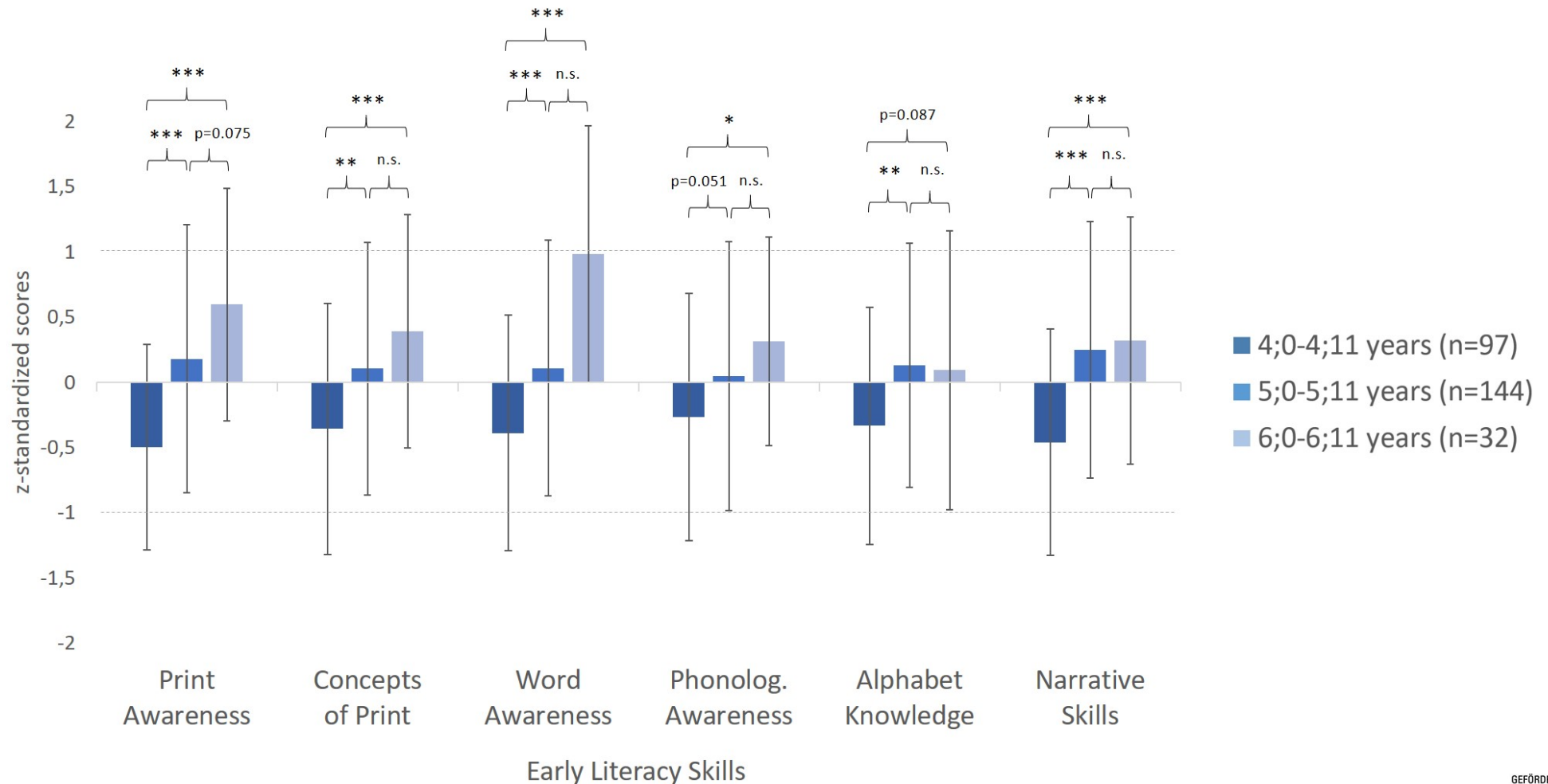
## Convergent validity – EuLeApp© and Screening (Risk of Dyslexia)



Risk for Dyslexia Screening	Phonological Awareness	Phonological Working Memory	Alphabet Knowledge	Rapid Automated Naming (RAN)	Screening Total T-Value
<b>EuleApp©</b>					
Print Awareness	.424** N = 137	.463** N = 137	.311** N = 137	.397** N = 137	<b>.518**</b> N = 130
Concepts of Print	.480** N = 137	.445** N = 137	.321** N = 137	.327** N = 137	<b>.498**</b> N = 130
Phonological Awareness	.393** N = 137	<b>.604**</b> N = 137	.366** N = 137	.443** N = 137	<b>.630**</b> N = 130
Word Awareness	.353** N = 137	<b>.482**</b> N = 137	.330** N = 137	.293* N = 137	<b>.489**</b> N = 130
Alphabet Knowledge	<b>.588**</b> N = 137	.399** N = 135	<b>.786**</b> N = 137	.400** N = 137	<b>.659**</b> N = 130
Narrative Skills	.199* N = 130	.120 N = 128	-.071* N = 130	.153 N = 130	.061 N = 123

# Results

## Discriminant Validity: Developmental trajectories on the six domains of the EuLeApp© for different age groups

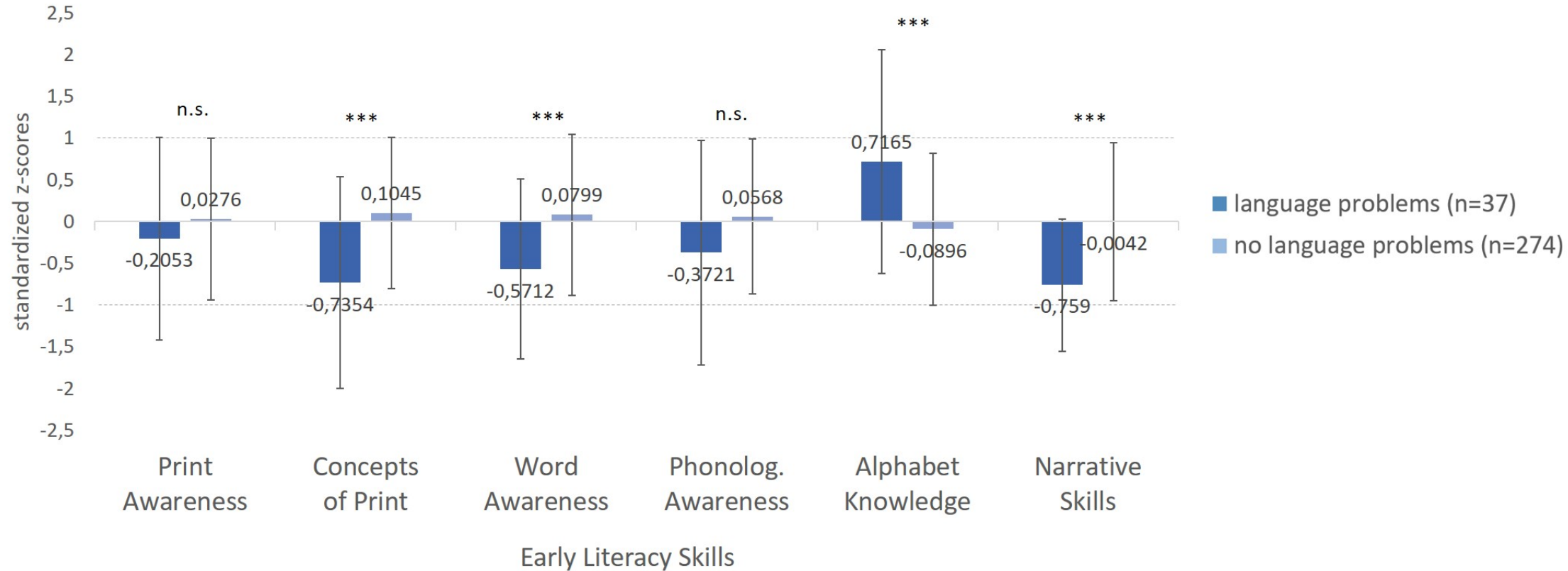


\*p < 0,05, \*\*p < 0,01, \*\*\*p < 0,001



# Results

## Discriminant Validity: Early Literacy Skills of children with and without language problems



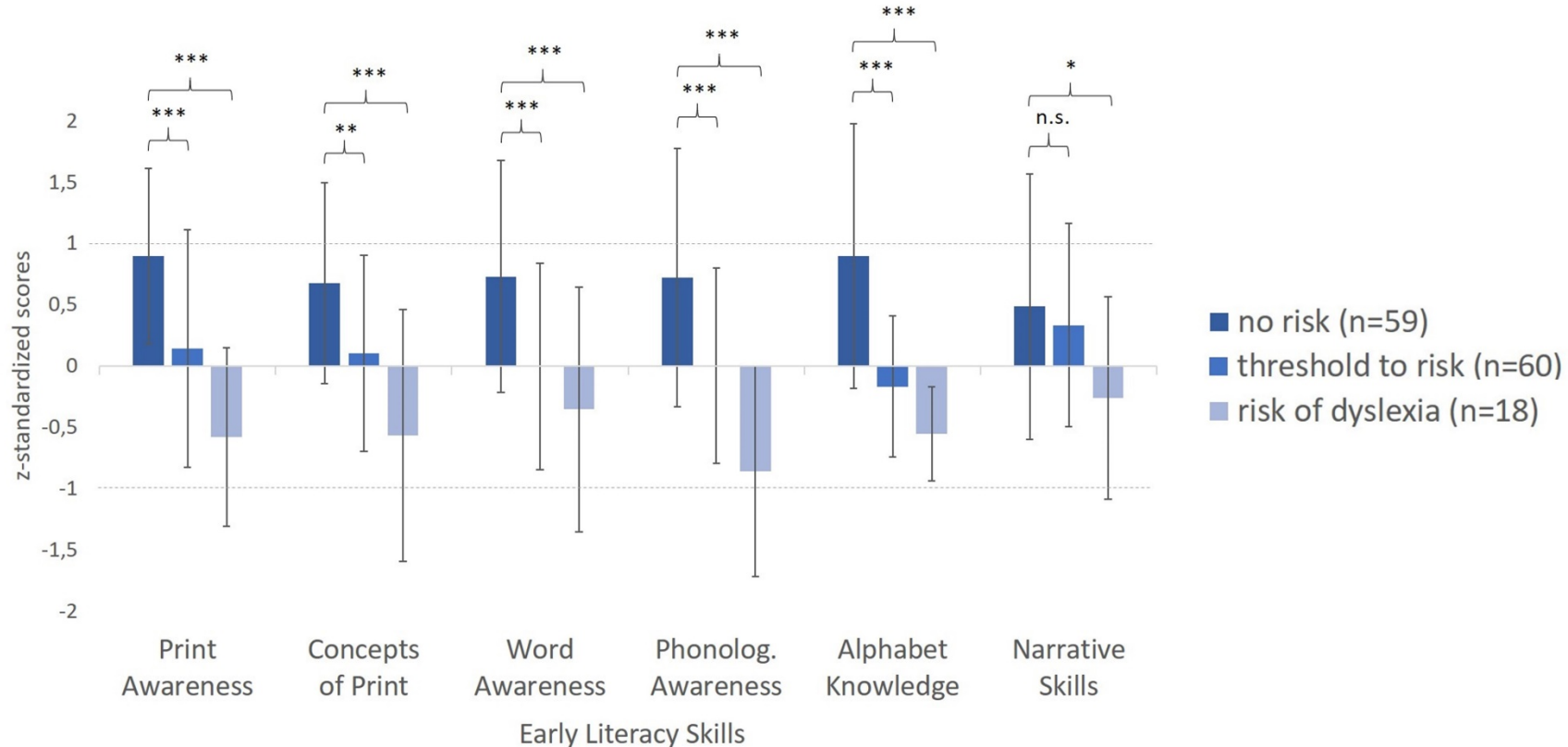
\*p < 0,05, \*\*p < 0,01, \*\*\*p < 0,001

(Testa et al., submitted)



# Results

## Discriminant Validity: Early Literacy Skills of children with and without risk for dyslexia



\* $p < 0,05$ , \*\* $p < 0,01$ , \*\*\* $p < 0,001$

(Testa et al., submitted)

# Applicability of the EuLeApp© in primary school



# Research Questions

1. Is (the prototype of) the EuLeApp© also applicable in children with special educational needs in language and communication in primary school in terms of item difficulty and item discriminability?
2. Is the reliability of (the prototype of) the EuLeApp© satisfactory?



# Methods

## Participants



- n = 47 children attending 5 primary schools (classes for children with special educational needs (SEN) in language and communication) in Lower Saxony
- 70,2% are males
- $M_{age} = 87.4$  months (Range: 75-100)
- Inclusion criteria: sufficient German language proficiency to comprehend the instructions in literacy assessments

# Results

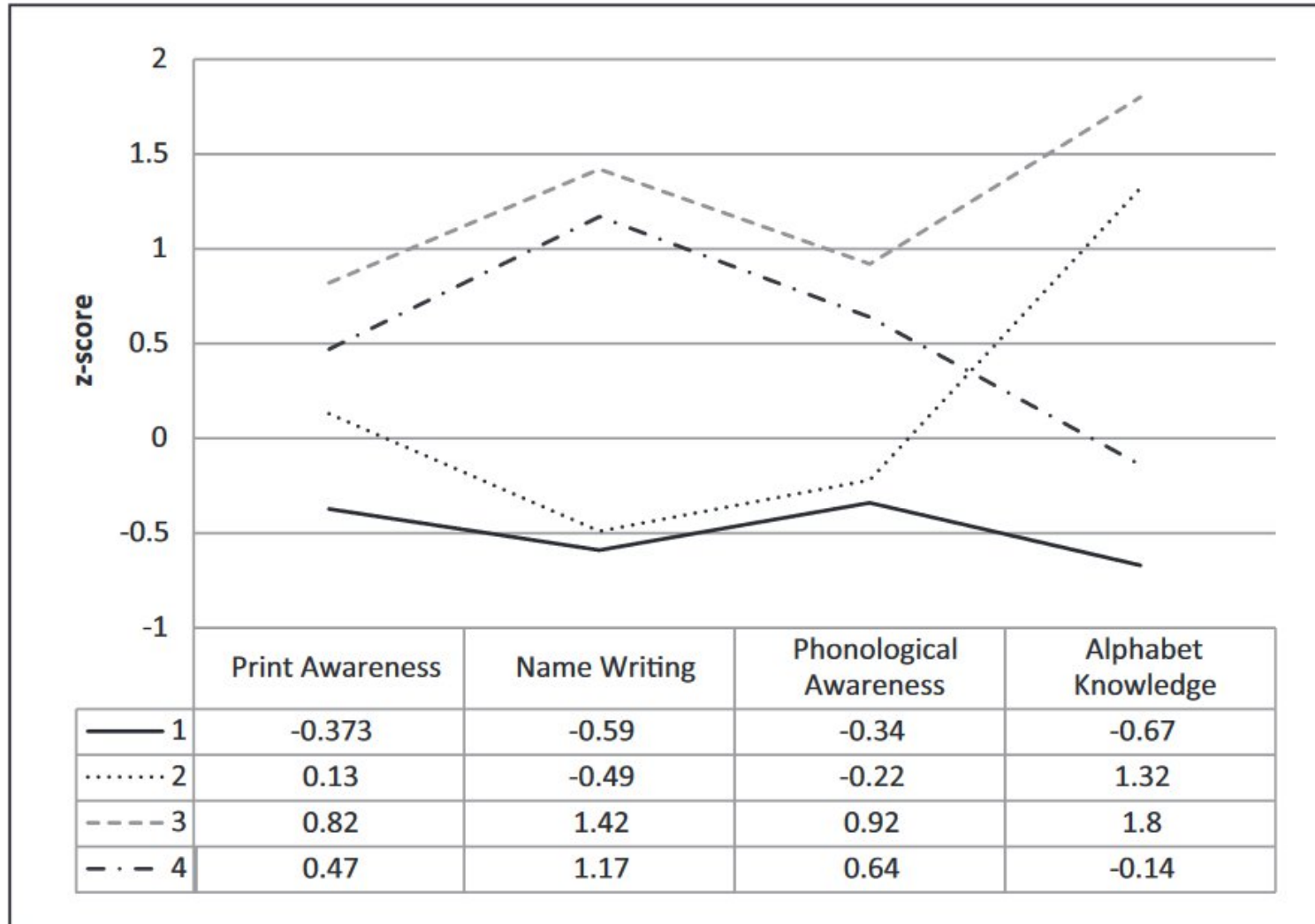


EuLe Scales	n Items	P <sub>i</sub>		r <sub>i</sub>		Internal consistency
		min.-max.	M	min.-max.	M	
Print awareness	40	43,7-75,0	67,97	-.07 - .77	.46	.90
Concepts of print	20	25,0-78,1	63,75	.04 - .583	.39	.77
Word awareness	12	34,4-71,9	52,27	.31 - .70	.55	.83
Phonological awareness	29	37,5-78,1	64,89	-.09 - .60	.26	.75
Alphabet knowledge	83	28,1-78,1	61,35	.07 - .63	.38	.96
Narrative skills	21	26,9-65,4	50,55	.26-.51	.34	.67
EuLeApp© total	205	25,0-78,1	61,35	.018-.797	.48	.97



# Identification of latent Early Literacy Profiles with the EuLeApp©

# Identification of Early Literacy Profiles International Research



(Justice et al., 2015)

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# Research Questions

1. How effective is the tablet-based EuLeApp© assessment tool in identifying distinct latent early literacy profiles among German kindergarten children?
2. How do factors such as age, biological sex, and language impairment contribute to the manifestation and prevalence of these latent literacy profiles?



# Methods

## Participants



- N = 285 children from 14 local daycare centers in Mecklenburg-West Pomerania and Lower Saxony, 54% are males
- $M_{\text{age}} = 62.37$  months (SD = 7.39; Range: 3;11 and 6;11 years)
- Inclusion criteria: sufficient German language proficiency to comprehend the instructions in the language and literacy assessments

# Methods Assessment



- Early literacy: prototype of the EuLeApp©
- Language development: Language level test for children aged 3–5 years/5-10 years (SET 3–5/5-10; Petermann et al., 2016, 2018)



- productive and receptive vocabulary
- processing speed
- language production



- semantic relations
- language comprehension
- grammar/morphology
- auditory memory

(Stuhr et al., 2024)

# Methods Procedure



- A trained test supervisor administered the assessment individually in a quiet room at their respective daycare center.
- Each child participated in two sessions lasting between 20 and 30 min, respectively.

(Stuhr et al., 2024)

# Methods

## Data Analysis



### Person-centered latent class analysis (LCA)

1. Examination for the number and patterns of missing values (exclusion of  $n = 14$ ), and normality tests were performed by calculating skewness and kurtosis (no specific issues, no outliers)
2. Defining Class variables for the LCA
  - early literacy scores (EuLeApp)
  - language impairment (SET: scoring at or below the 10th percentile in at least two subtests)
  - age
  - biological sex

(Stuhr et al., 2024)

# Methods

## Data Analysis



### Person-centered latent class analysis (LCA)

3. Progressive examination of model fits by successively increasing the number of classes until a model was received where a class comprised less than 5% of the total sample  
(Nylund-Gibson and Choi, 2018)
4. Relative model fit for each class model was evaluated using four information theory-based metrics (BIC, SABIC, CAIC, AIC): the lower the BIC, AIC, and CAIC values, the better the comparative fit of the model to the k-1 class model
5. Assessing absolute model fit (log-likelihood): higher value (closer to 0) represents a better fit
6. Model fit was also examined using the Lo-Mendell-Rubin adjusted likelihood ratio test: significant p-value signifying that the model with k classes fits the data better than the simpler k-1 model

(Stuhr et al., 2024)



# Methods

## Data Analysis



### Person-centered latent class analysis (LCA)

7. After identifying the best-fitting class solution: extent to which the classes could be differentiated was examined using multiple metrics (relative entropy, average posterior probabilities, substantive knowledge and expertise by the project team, and univariate statistics)

(Stuhr et al., 2024)



# Methods

## Results: Determination of latent classes

### Goodness of fit indices for the competing LCA models

Classes	Log likelihood	AIC	BIC	CAIC	SABIC	Entropy	aLMR-LRT	Smallest class size (%)
1	-1839.01	3710.03	3767.66	3783.66	3806.57	-inf	-	1.00
2	-1539.96	3145.92	3264.79	3297.79	3345.03	0.87	<b>p &lt; 0.001</b>	0.50
3	-1436.53	2973.05	3153.16	3203.16	<b>3274.73</b>	0.85	<b>p &lt; 0.001</b>	0.20
<b>4</b>	-1371.54	<b>2877.08</b>	<b>3118.42</b>	<b>3185.43</b>	3281.33	0.86	<b>p &lt; 0.001</b>	0.07
5	-1355.53	2879.06	3181.64	3265.64	3385.88	0.83	<b>p = 0.035</b>	0.07
6	<b>-1316.09</b>	2834.19	3198.00	3299.00	3443.57	0.85	<i>p</i> = 1.000	0.03

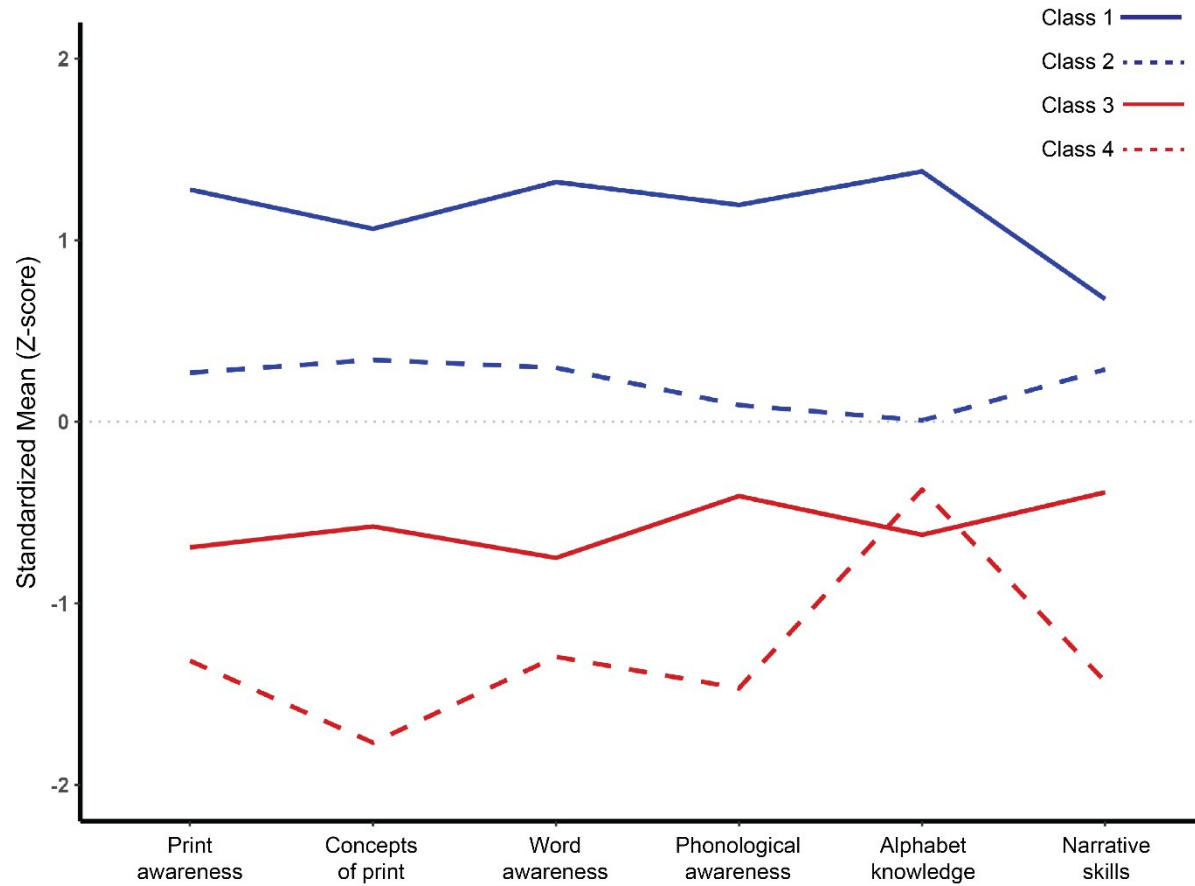
Bolded values in the tables indicate the model that was preferred by the given fit index.  
aLMR-LRT Lo-Mendell-Rubin adjusted likelihood-ratio test for k-1 versus k classes.

(Stuhr et al., 2024)



# Results

## Four latent profiles of Early Literacy



(Stuhr et al., 2024)

# Results



## Model-estimated, class-specific means and standard deviations based on latent class membership

	Class 1 (exceptional performers)	Class 2 (typical performers)	Class 3 (marginal performers)	Class 4 (subpar performers)
N, %	47 (17%)	111 (41%)	94 (35%)	19 (7%)
<b>Participant characteristics</b>				
Age (mean, SD)	66.74 (5.69)	64.15 (7.12)	58.94 (6.17)	58.05 (8.41)
Biological males (%)	40.43%	52.25%	55.32%	89.47%
Language impairment present (%)	10.64%	36.94%	52.13%	94.74%
<b>Literacy raw scores</b>				
Print awareness	36.02 (4.17)	25.58 (7.89)	15.62 (6.15)	9.16 (4.09)
Print knowledge	15.83 (2.03)	13.11 (2.43)	9.65 (2.65)	5.16 (2.61)
Word awareness	9.23 (1.91)	6.05 (2.17)	2.80 (1.46)	1.11 (0.99)
Phonological awareness	23.30 (2.77)	18.79 (3.21)	16.74 (2.99)	12.42 (2.50)
Letter knowledge	41.70 (15.41)	22.98 (9.15)	14.38 (4.07)	17.79 (16.13)
Narrative skills	8.87 (3.75)	7.44 (3.33)	4.95 (2.62)	1.11 (1.29)

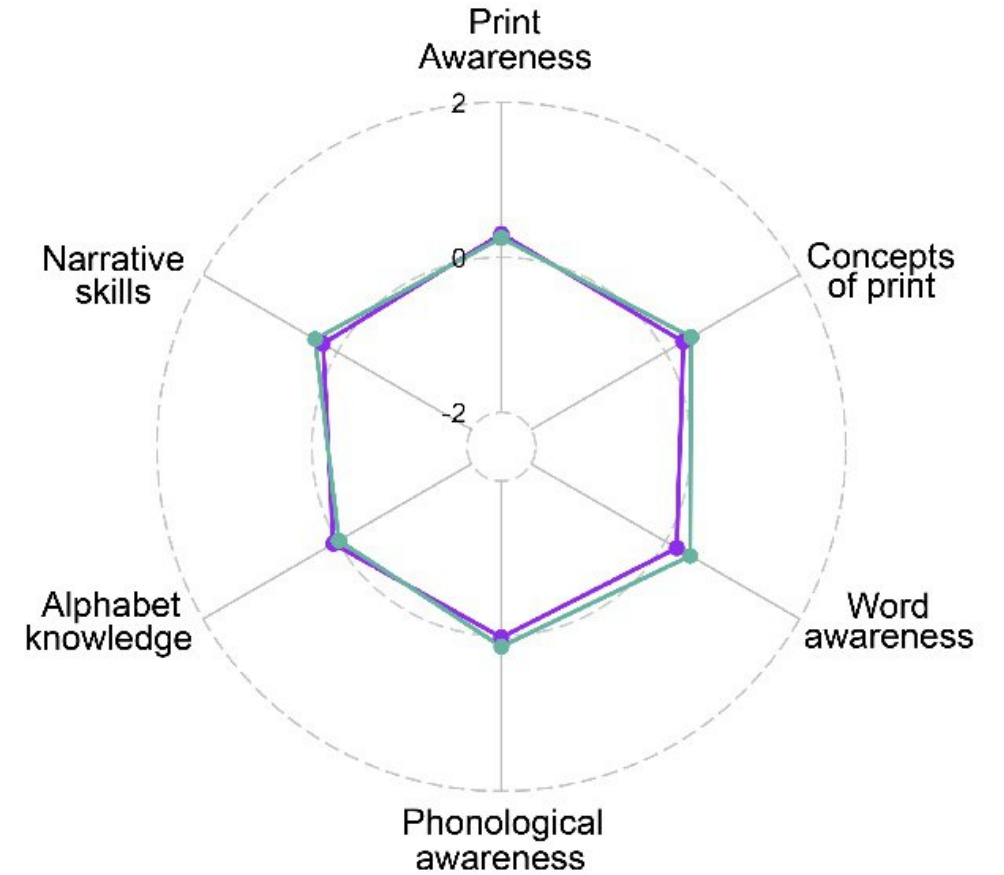
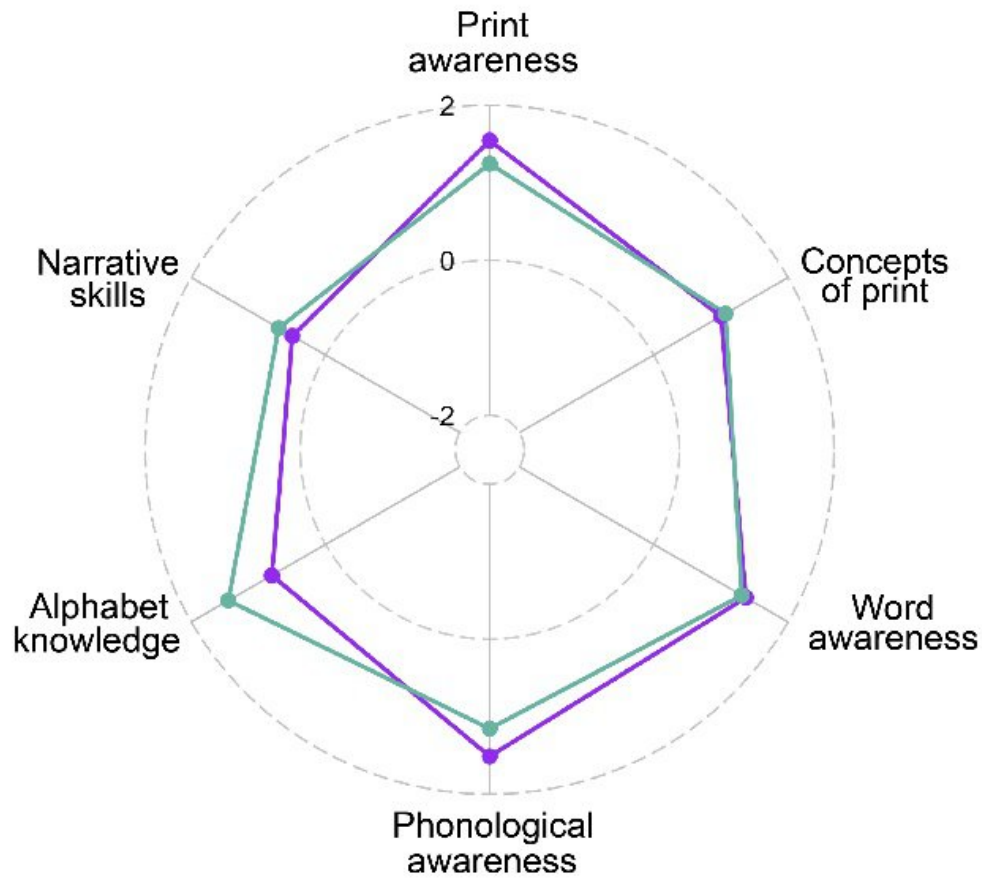
(Stuhr et al., 2024)



# Results

## Class 1: Exceptional Performers

## Class 2: Typical Performers



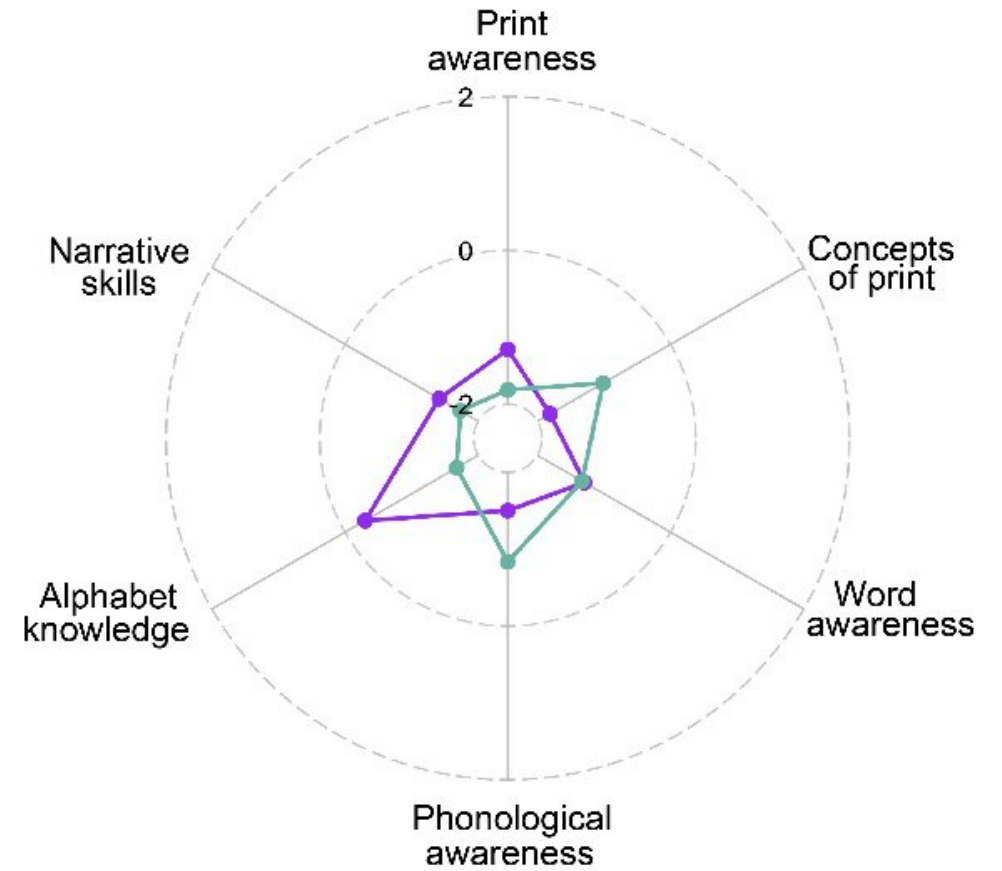
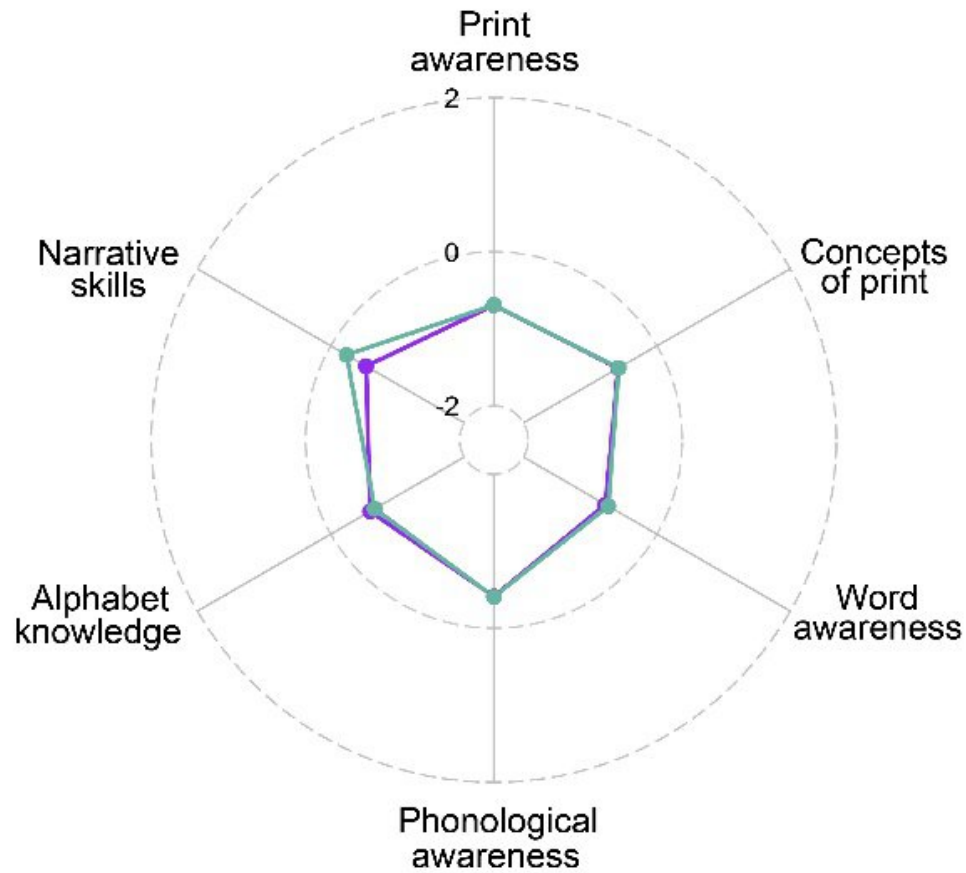
(Stuhr et al., 2024)



# Results

## Class 3: Marginal Performers

## Class 4: Subpar Performers



(Stuhr et al., 2024)

# Discussion

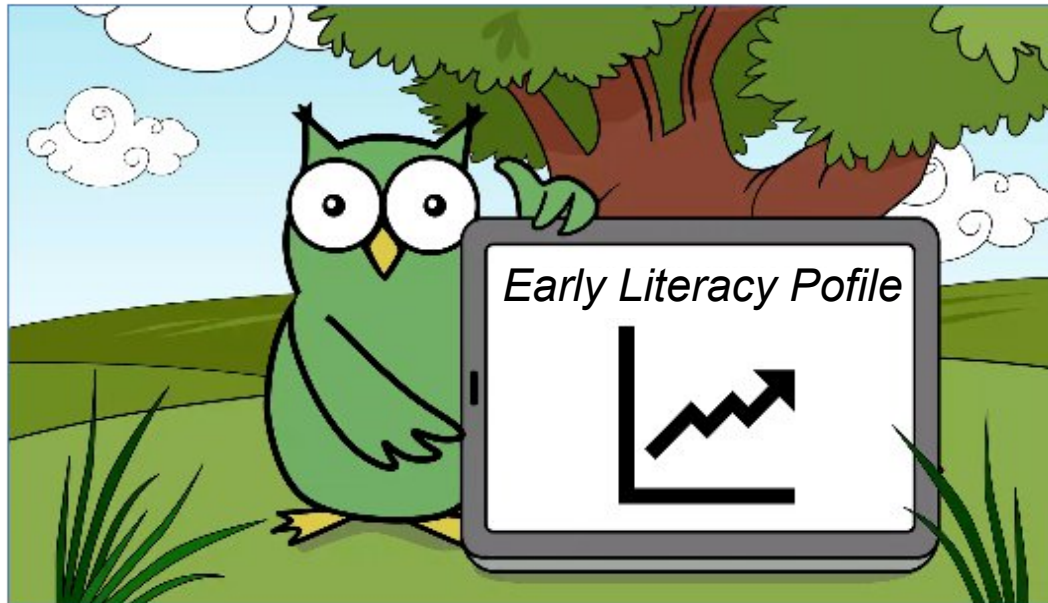


- LCA revealed **four distinct classes** of early literacy performance measured by the EuLeApp© prototype → entropy was 0.86 (indicating a high level of discrimination among the four latent classes)
- **Age** played a role in shaping the latent classes (with the two highest-performing early literacy groups primarily composed of older children, while the two lowest-performing classes consisted mainly of younger children) → the identification of more than two latent classes through LCA suggests that age is unlikely to serve as the sole determinant of the latent structure
- **Gender:** Although there are **more males in Class 4 (Subpar Performers)**, biological sex distribution is balanced in Class 1 (Exceptional Performers)
- Children with **language problems** were present in all four groups → contributing factor to class differentiation (Cabell et al., 2010; Justice et al., 2015), but do not solely determine class assignments

(Stuhr et al., 2024)

# EuLeApp©

## From assessment to support



(Meindl et al., in prep.)

### Individual support of early literacy skills

Which skills should be focused in daily activities?

How can support be implemented in daycare?

(Jungmann et al., in prep.)



# Development of the Adaptive Support Concept



# Treasure Map „The Owl-Island“

## Village

Print Awareness

- 11 Activities
- 14 Impulses

## Lake

Concepts of Print

- 6 Activities
- 4 Impulses

## Marsh

Word Awareness

- 19 Activities
- 3 Impulses

## Meadow

Alphabet Knowledge

- 21 Activities
- 2 Impulses

## Forest

Phonological Awareness

- 31 Activities
- 1 Impulse

## Beach

Narrative Skills

- 15 Activities
- 7 Impulses



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# Development of the adaptive Early Literacy support concept

## Playful Early Literacy Activities

**1 8** **Wildes Wuseln** 1 2 3 4 5 6

**Förderziele:** Wortbewusstheit

**Durchführung:**  
Die Kinder und Sie sitzen im Stuhlkreis zusammen und zählen reihum bis sechs durch. Sie entfernen ihren Stuhl aus dem Kreis, treten in die Mitte und sagen laut einen Satz (oder ein einzelnes Wort). Die Kinder zählen die Wörter des Satzes in Gedanken. Alle Kinder, die der Anzahl der Wörter zugehören, springen nun auf und wechseln die Plätze. Das Kind, das keinen Platz bekommt, bleibt in der Mitte stehen und ruft das nächste Wort oder den nächsten Satz, das bzw. den Sie ihm ins Ohr vorsagen. Wird ein zuvor festgelegtes Codewort (z. B. „Wuseln!“) gerufen, tauschen alle Kinder ihre Plätze.

15 Minuten  
4-6 Jahre  
12-20 Kinder  
Stühle

Es wird nur bis vier durchgezählt und somit Sätze mit maximal 4 Wörtern gesprochen.  
Die beschriebene Spielvariante ist als mittel einzustufen.  
Das Kind in der Mitte gibt selbst einen Satz oder ein Wort vor.



**weitere Kompetenzbereiche:**

- mathematische Basiskompetenzen
- Grobmotorik

**Glossar:**

- Wortkonzept

**zum Weiterlesen:**  
Zettl, E. (2019). *Mehrsprachigkeit und Literalität in der Kindertagesstätte*. Springer.

**WEITERE VARIATIONEN:**

- Der Anzahl der Wörter im Satz werden Bewegungen zugeordnet, z. B. springen, klatschen, auf den Boden legen, leichtes Wippen mit dem Körper, schnippen.
- Bei Kindern, die unterstützte Kommunikation gebrauchen, können Sie zudem Symbole verwenden, die für die Wörter stehen und mit diesen den Satz zusammenbauen.

**FRAGEN AN DIE KINDER:**

- Wie viele Wörter zählt ihr?
- Was ist ein Wort?

**FRAGEN FÜR DEN PÄDAGOGISCHEN ALLTAG:**

- Wie kann ich die Kinder auf Wortgrenzen aufmerksam machen?
- Wie kann ich Sprachenvielfalt bzw. Mehrsprachigkeit berücksichtigen?

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# Impulses und Activities

## Competence domains:



Print Awareness



Concept about Print



Word Awareness



Phonological Awareness



Alphabet Knowledge



Narrative Skills

## Level of difficulty:



easy



medium



demanding

## Further Symbols:



Duration



Appropriateness  
for age



Group Size



Material  
needed

## Everyday situations in daycare:

1

Morning circle

3

Making music together

5

Free play

2

Picture book session

4

Painting and handicraft work

6

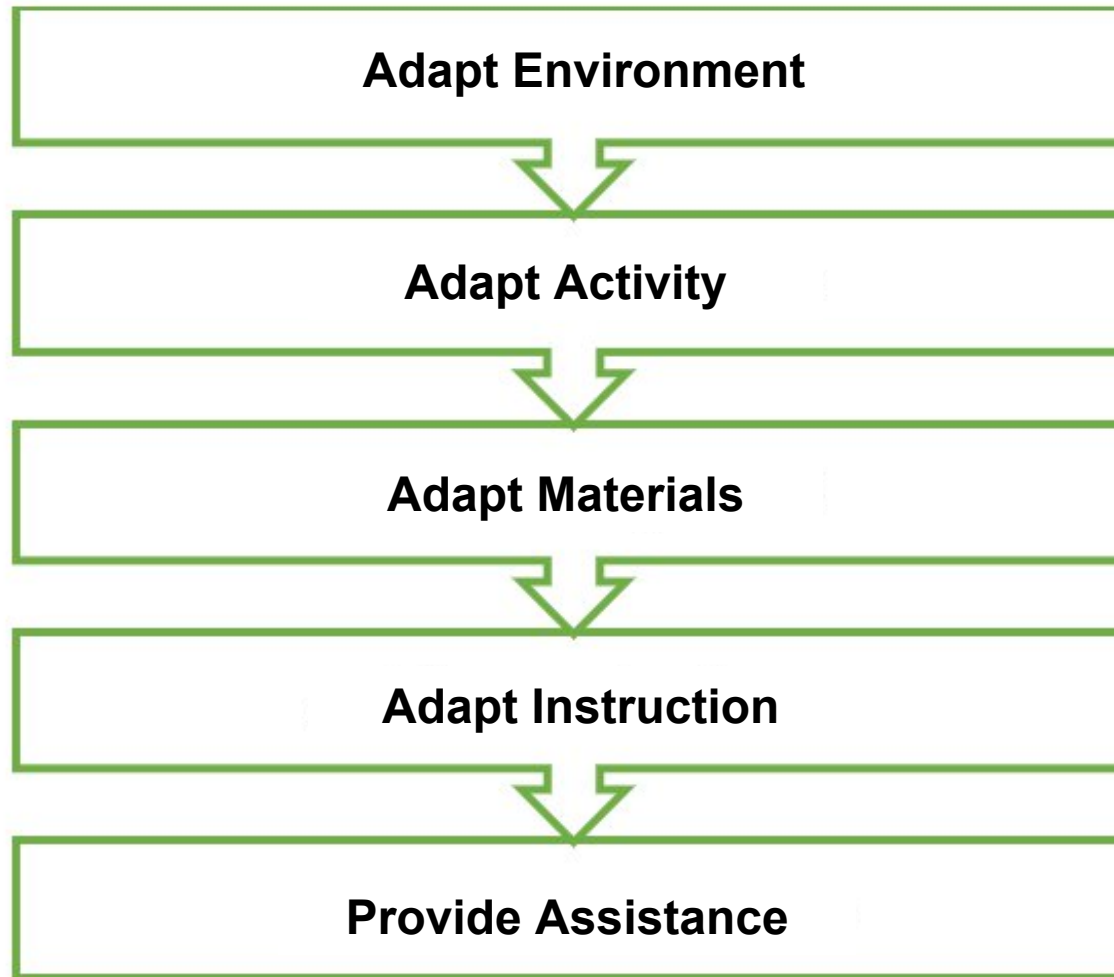
Structured play

## QR-Code to linktr.ee:

Scan this code access the links on the activity cards, the glossary and further recommendations



# Development of the adaptive Early Literacy support concept – Adaptation continuum

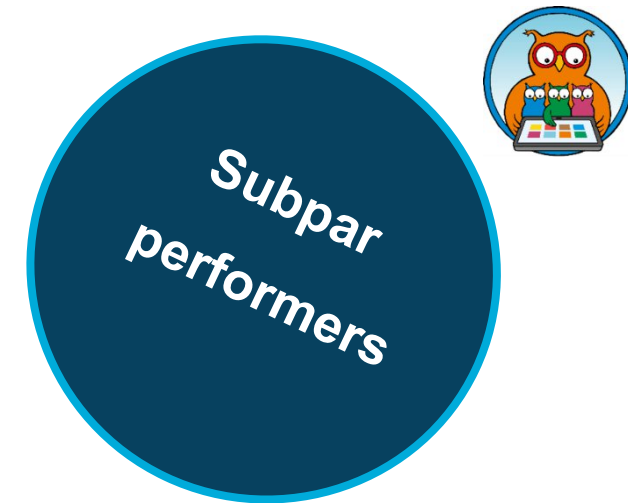


# Adaptive support recommendations during dialogic book reading

Beyond understanding meaning, also focus on drawing the child's attention to the form and structure of language

Nurture language development

Include daily playful early literacy activities at a low level of difficulty



## Implementation in dialogic book reading

**Print Awareness:** Collaboratively search for and *identify words* and text within a book *alongside images*

**Concepts of Print:** Introduce writing conventions (e.g. “*Where is the title of the book?*”)

**Phonological Awareness:** Employ dialogic reading to enhance phonological awareness more broadly, incorporating activities like *syllable clapping and identifying rhymes*

**Alphabet Knowledge:** Connect letters to corresponding images, assist the child in identifying the initial letter of his/her name

**Narrative Skills:** Stimulate discussions about the story or the book cover (e.g. “*What do you think the story is about?*”; “*Where do you think the story takes place?*”)

(Stuhr et al., 2024)

# Adaptive support recommendations during dialogic book reading

Cultivate joy and motivation for books and storytelling  
Enhance language development  
Include daily playful activities that aim to promote early literacy at levels ranging from low to medium difficulty



## Implementation in dialogic book reading

**Word Awareness:** Explore words within the book, distinguishing between long and short words and discussing how word length relates to meaning (e.g., comparing “honeybee” to “bear”)

**Phonological Awareness:** Engage in dialogic reading to develop *phonological awareness broadly*, including activities such as identifying *rhyming words* (“What rhymes with mouse?”)

**Alphabet Knowledge:** Connect letters to corresponding images and help the child identify the *initial letter of their name* with the assistance of the teacher or caregiver

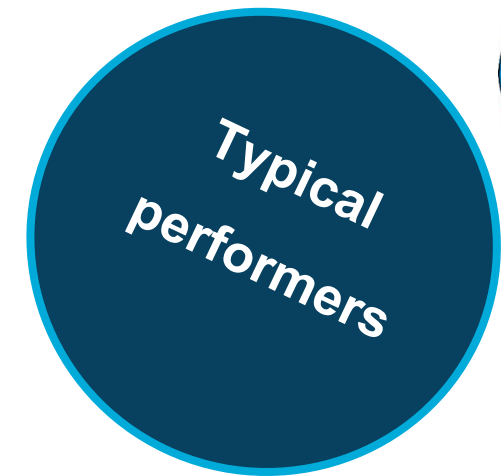
**Narrative Skills:** Talk about the story structure (e.g., sequencing story sections) and practice *shifting perspectives*; prompt discussions by *asking questions about the story*

(Stuhr et al., 2024)

# Adaptive support recommendations during dialogic book reading

Cultivate and maintain enthusiasm for books, storytelling and reading

Integrate playful daily early literacy activities at a moderate level of difficulty



## Implementation in dialogic book reading

**Word Awareness:** Assist children recognize *differences between short and long words, identify identical words* consistently

**Phonological Awareness:** Implement dialogic reading techniques to enhance phonological awareness, particularly focusing on *recognizing initial sounds*

**Alphabet Knowledge:** Introduce children to the *first letters* they learned, including those of their own name, to reinforce familiarity with the alphabet

**Narrative Skills:** Encourage children to *retell stories or speculate on potential story continuations* (“What do you think, how might the story continue?”)

(Stuhr et al., 2024)



# Adaptive support recommendations during dialogic book reading

Cultivate and maintain enthusiasm for books, storytelling and reading

Engage in daily higher difficulty level early literacy activities that are playful and progressively challenging



## Implementation in dialogic book reading

**Phonological Awareness:** Employ dialogic reading to enhance phonological awareness, focusing on tasks such as analyzing *sounds within words*, *manipulating sounds within words*, and *synthesizing sounds to form words*

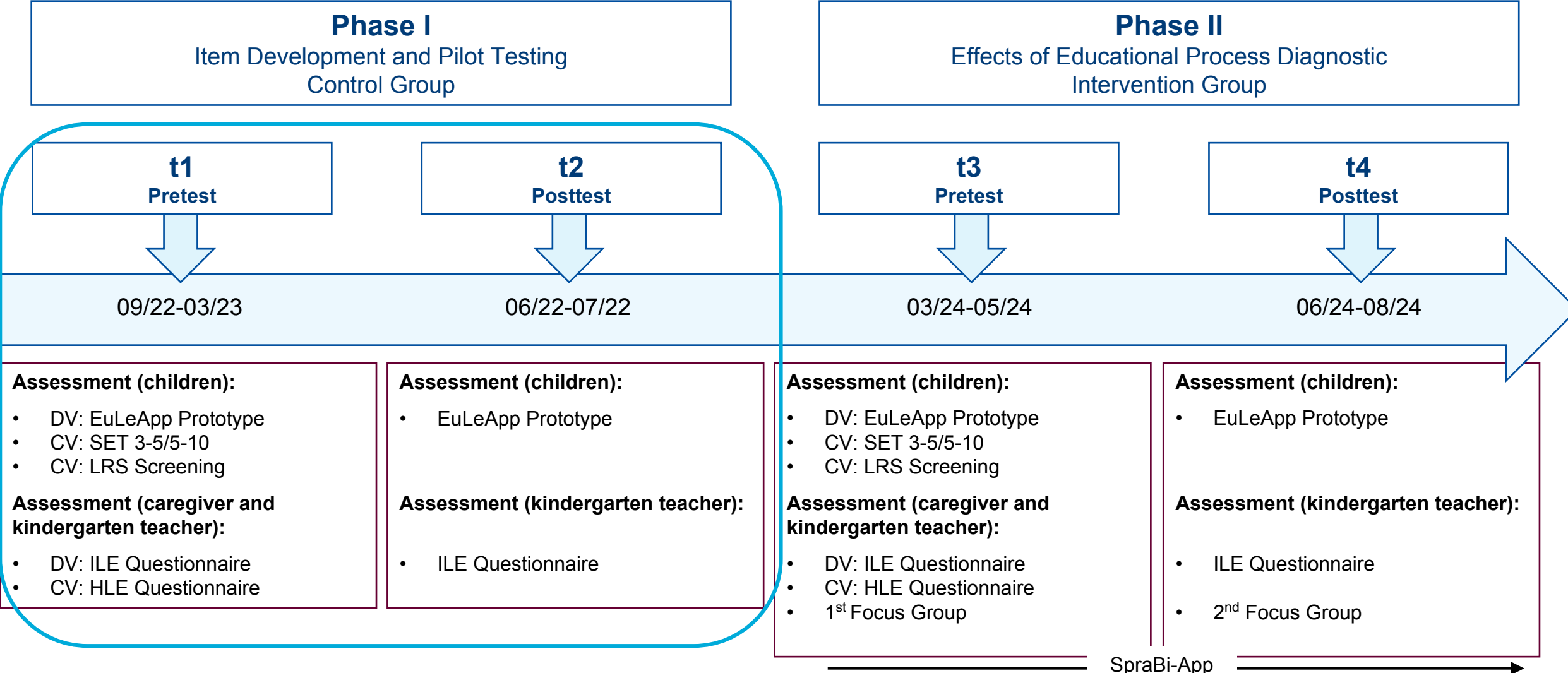
**Alphabet Knowledge:** Engage children in *identifying both familiar and unfamiliar letters within the text*, encouraging them to recognize the visual and auditory *characteristics of individual letters* (“Which letters have a curved shape?”)

**Narrative Skills:** Encourage children to *create their own stories* or contribute to completing existing narratives

(Stuhr et al., 2024)

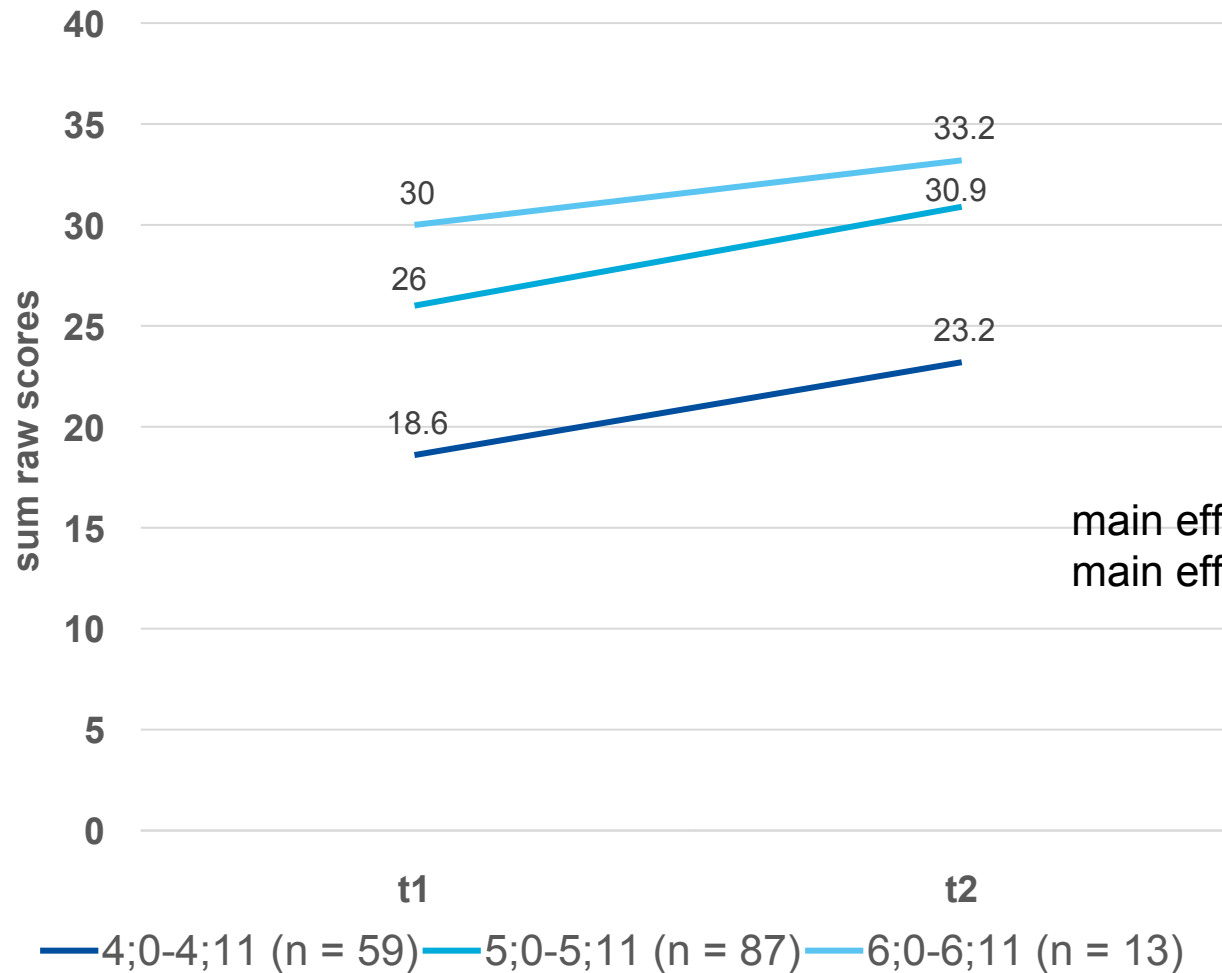
# Research Perspectives

# Study Design



# Results from longitudinal research

## Print Awareness (Control group)

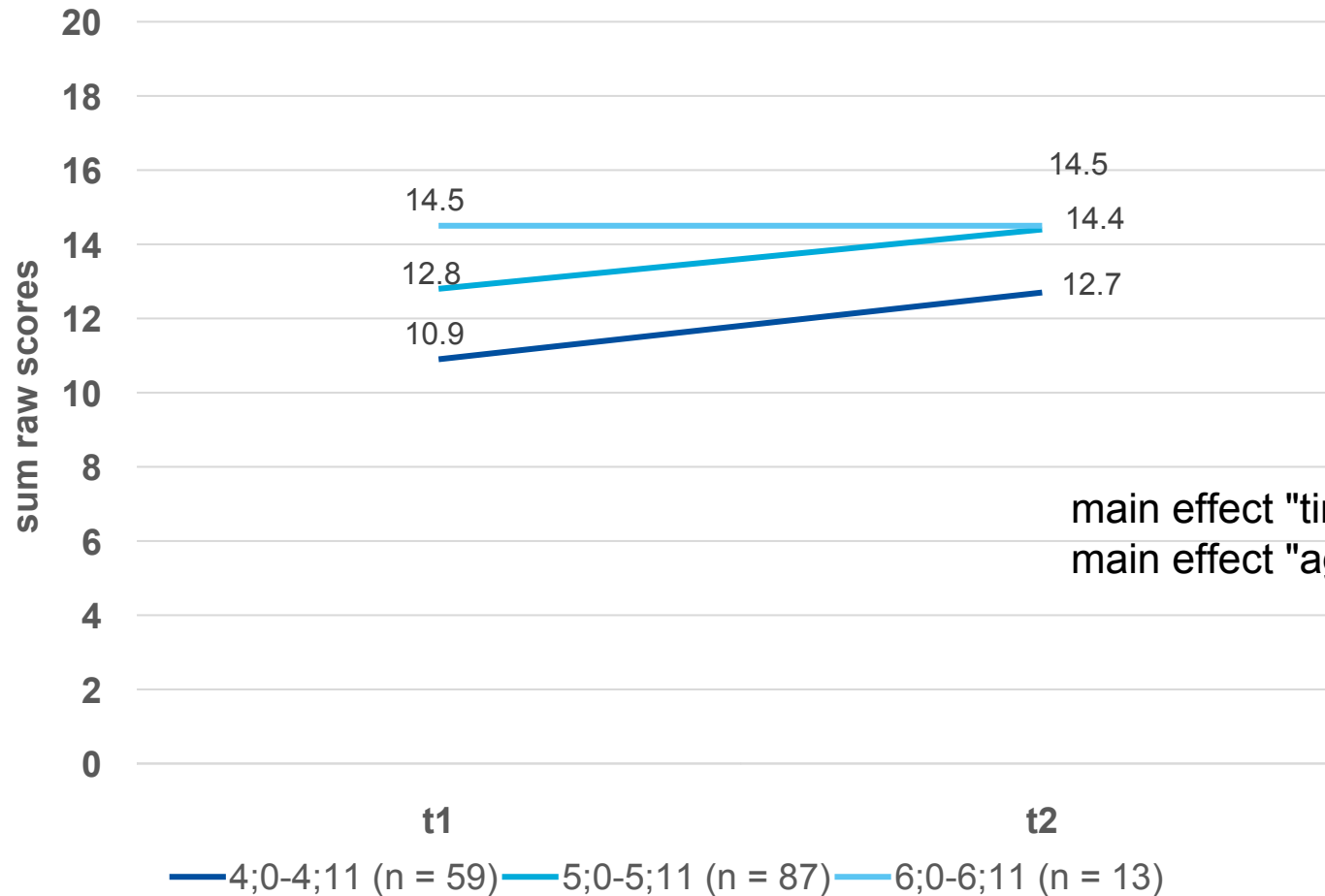


main effect "time":  $F_{(1;156)} = 19,894^{***}$

main effect "age group":  $F_{(2;156)} = 19,436^{***}$

# Results from longitudinal research

## Concepts of Print (Control Group)

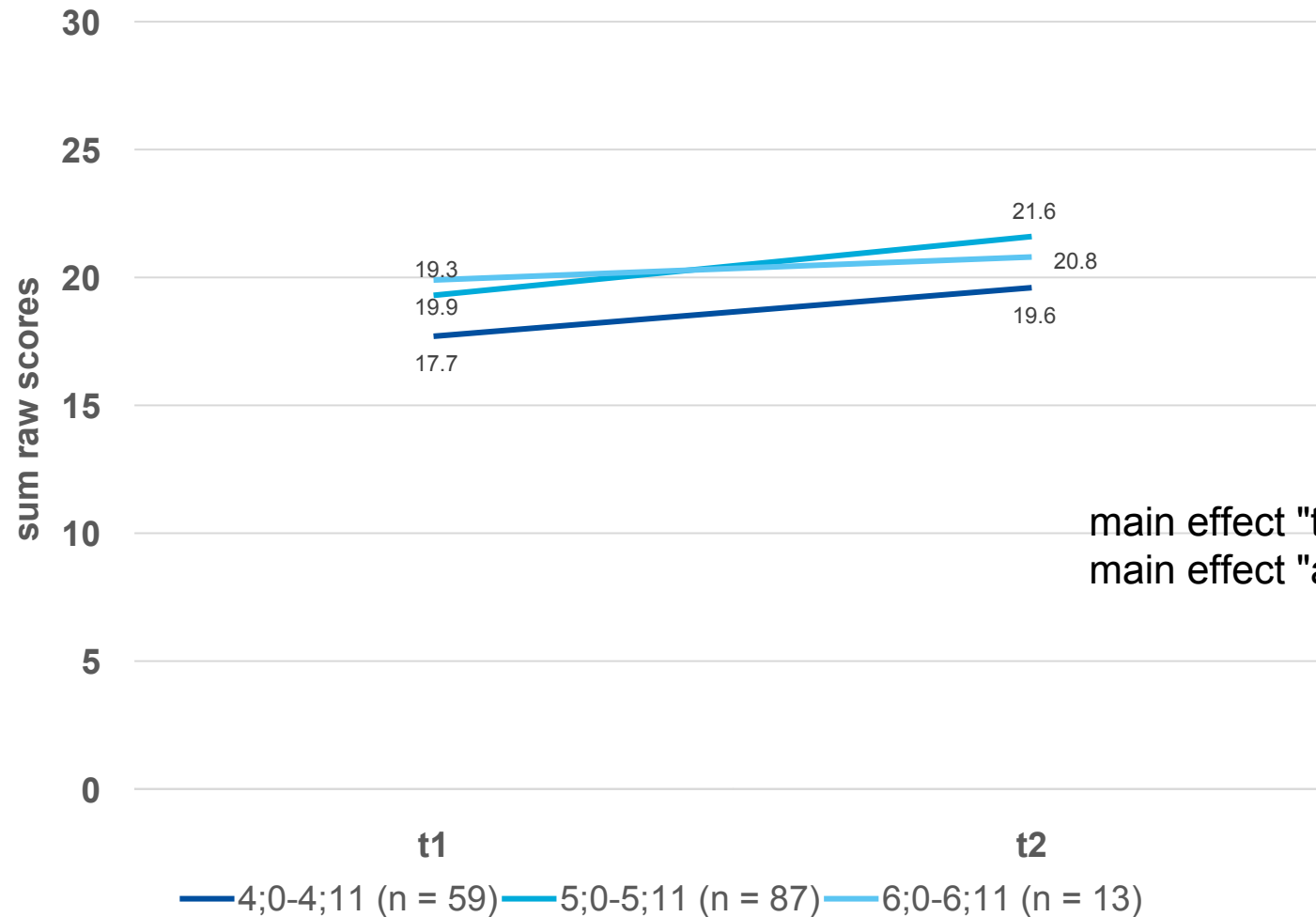


main effect "time":  $F_{(1;156)} = 8,137^{**}$

main effect "age group":  $F_{(2;156)} = 7,496^{***}$

# Results from longitudinal research

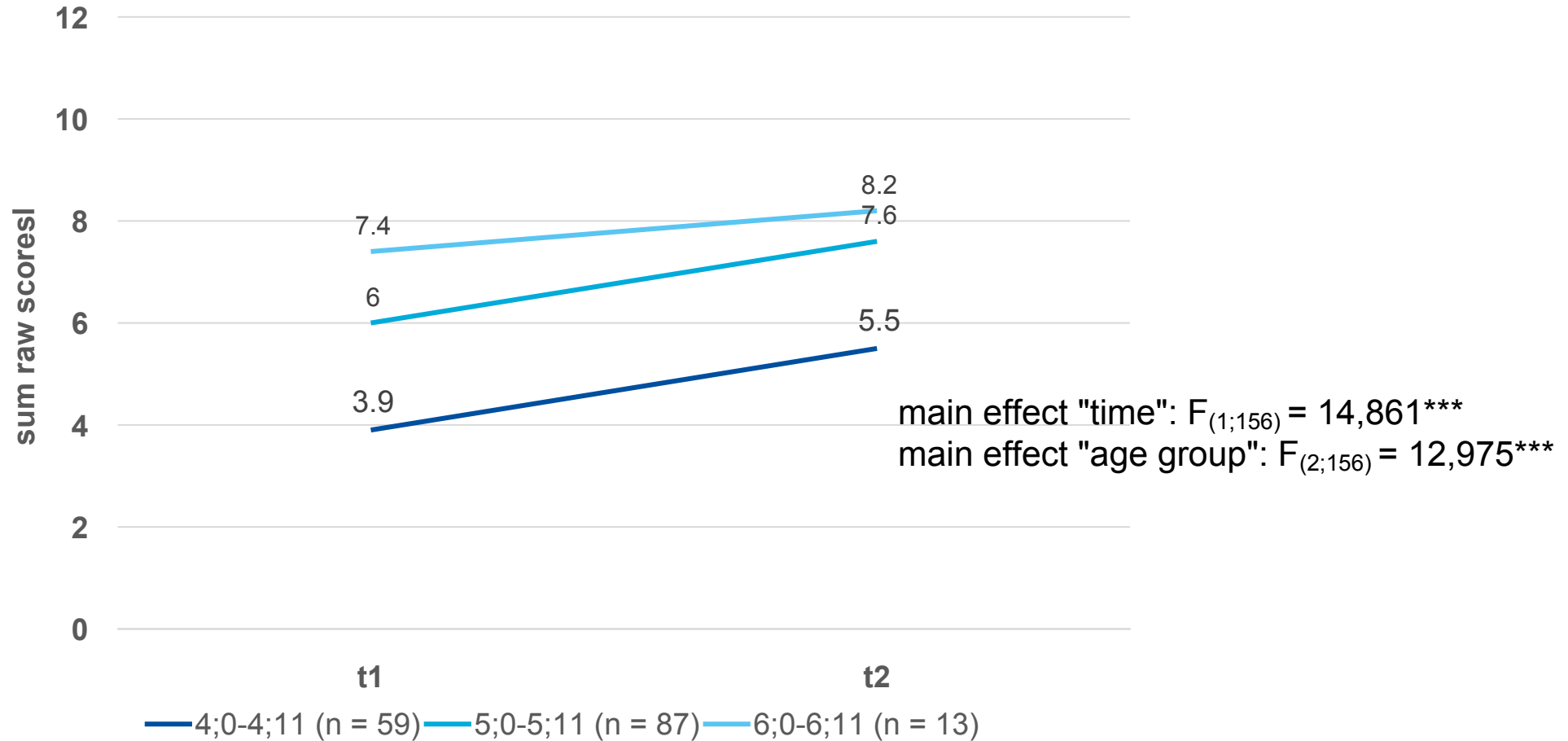
## Phonological Awareness (Control Group)



main effect "time":  $F_{(1;156)} = 11,798^{***}$   
main effect "age group":  $F_{(2;156)} = 4,273^*$

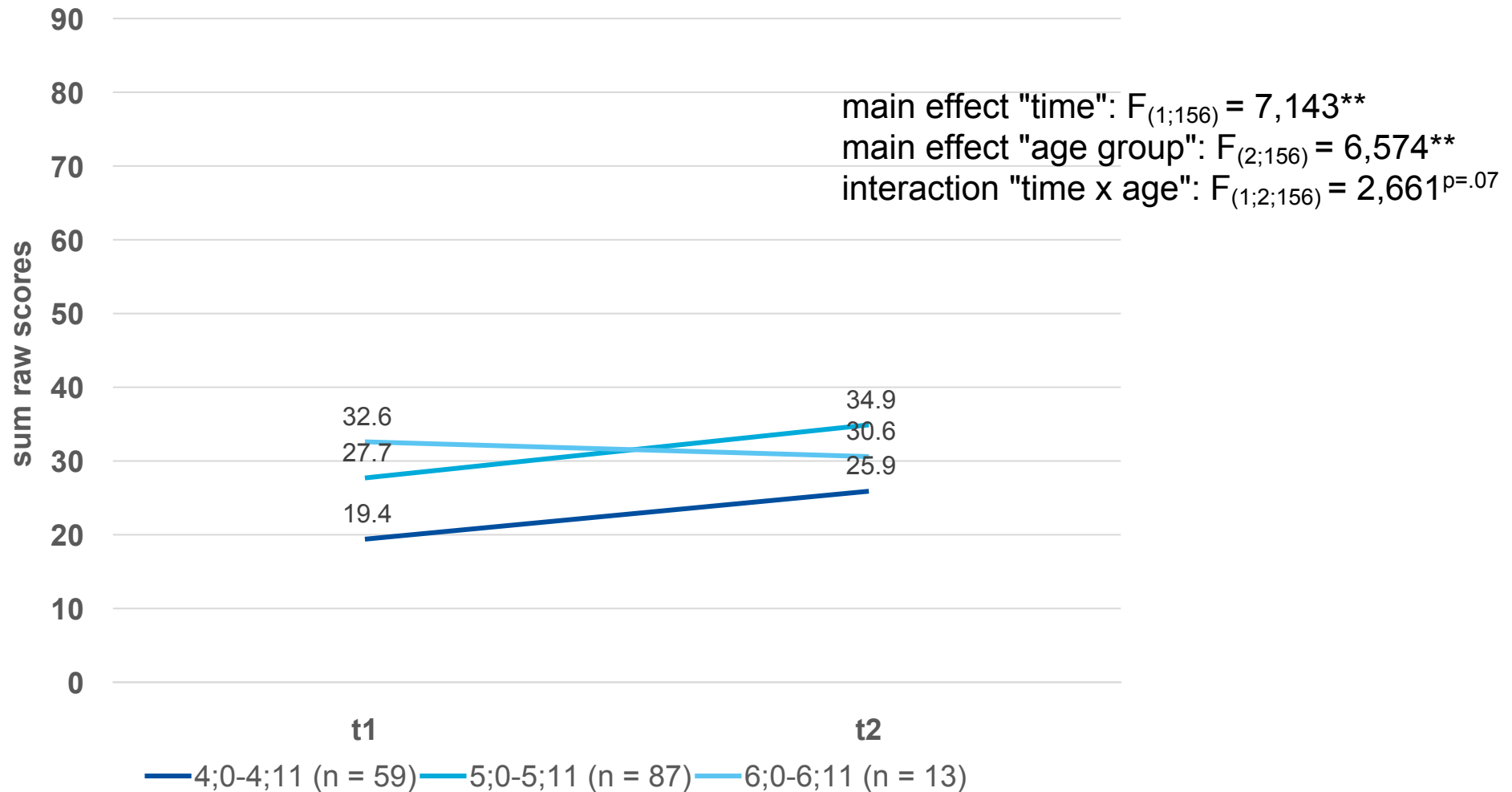
# Results from longitudinal research

## Word Awareness (Control Group)



# Results from longitudinal research

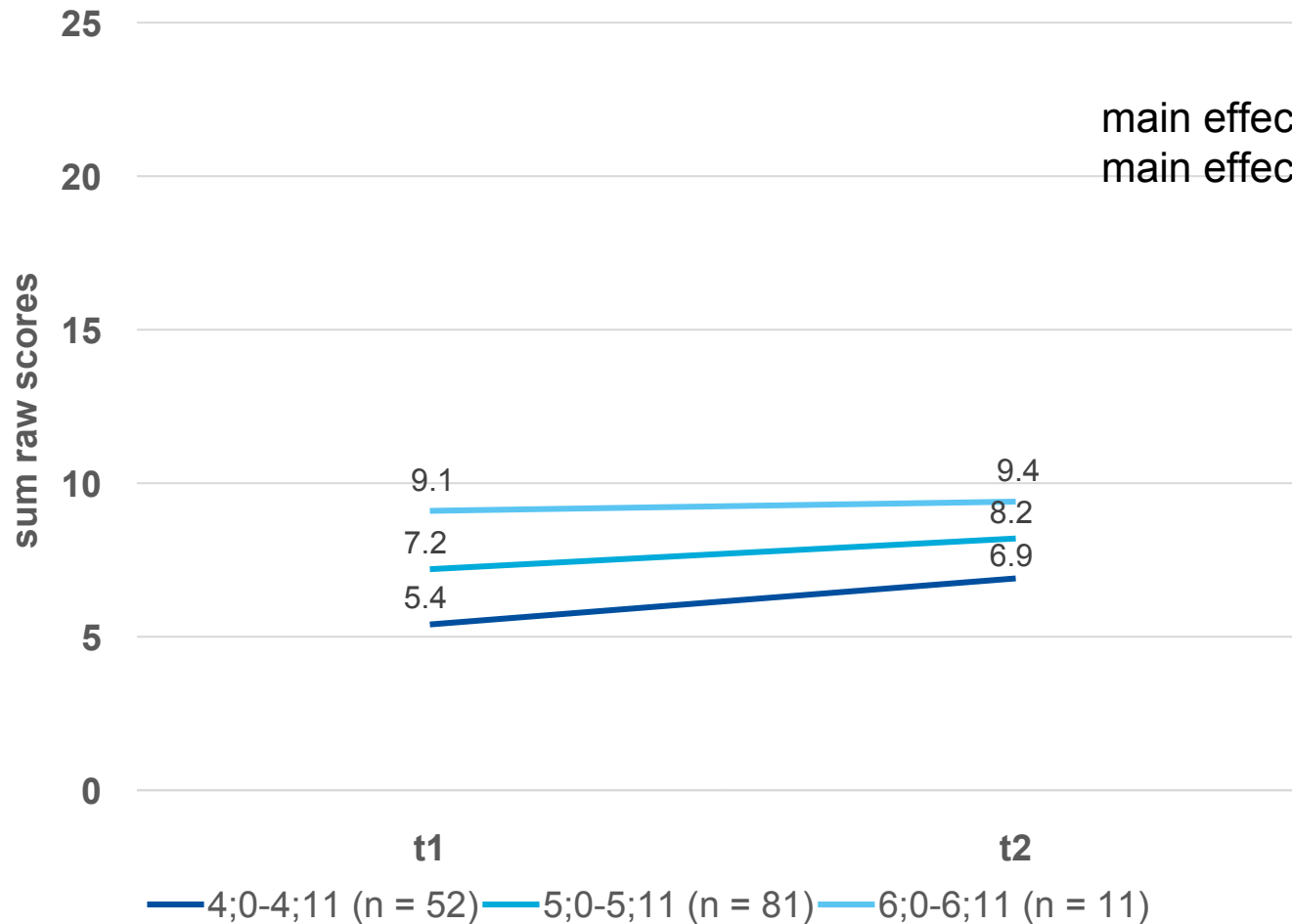
## Alphabet knowledge (Control Group)





# Results from longitudinal research

## Narrative Skills (Control Group)



main effect "time":  $F_{(1;156)} = 5,202^*$

main effect "age group":  $F_{(2;156)} = 5,806^{**}$

Pre-posttest comparisons from Phase 2: analyses of the intervention effects / educational process diagnostics are still running

# Conclusion

**Our main findings are concluded in terms of two points;**

## **1- Psychometric qualities of the EuLeApp**

- The preliminary evidence showed that the EuLeApp© is a reliable and valid tool for assessing children's early literacy skills.
- EuleApp© has been established as a tool that is standardized and comprehensive toward children.

# Conclusion

## 2- Potential usage

- Given the potential importance of assessment for supporting children's language and literacy development, an app-based standardized assessment tool could help to gain a clearer understanding of macro variables and provide better support.
- This assessment tool is used in Germany in daycare and primary school settings, offering children numerous opportunities to enhance their reading and writing skills, aligning with the national educational approaches to developing skills and interest in reading and writing.
  - It is also beneficial to the research community.

# Limitations



- **Sample size:** only 15 daycare centers in two German federal states, deliberately excluding children with limited German language proficiency → restricted representativity of results
- Educational systems of different German states or countries could play a significant role in determining the early literacy profiles → replication with independent sample sharing
- Focus on how factors such as age, biological sex, and language impairment influence the variety and occurrence of these latent literacy profiles → further studies should include other influencing factors such as HLE
- Classification accuracy for Class 4 (Subpar Literacy Performers) did not meet the threshold for robust classification
- **Replication and additional validation of profiles in a larger, more representative sample needed**

(Stuhr et al., 2024)

# Recommendations for future research

When we consider;

- globalization, the proportion of children who speak a language other than their first language at home is increasing. For example, approximately 40% of young learners in Germany are multilingual, bilingual, etc.
- heterogeneity in the population,
- variation in the native language and socioeconomic status

**It also reveals the importance of this app-based assessment tool (EuLeAPP) in different languages.**

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