



Research Paper

Modeling individual variation in early literacy skills in kindergarten children with intellectual disabilities[☆]



Arjan van Tilborg^{a,*}, Eliane Segers^a, Hans van Balkom^{a,b}, Ludo Verhoeven^{a,b}

^a Behavioural Science Institute, Radboud University, The Netherlands

^b Royal Kentalis, Sint-Michielsgestel, The Netherlands

ARTICLE INFO

Number of reviews completed are 2.

Keywords:

Children with ID

Early literacy

Phonological awareness

Word decoding

ABSTRACT

In the present study, we investigated (i) to what extent the early literacy skills (phonological awareness, letter knowledge, and word decoding) along with cognitive (nonverbal reasoning, attention, phonological short-term memory, sequential memory, executive functioning) and linguistic (auditory discrimination, rapid naming, articulation, vocabulary) precursor measures of 53 six-year old children with intellectual disabilities (ID) differ from a group of 74 peers with normal language acquisition (NLA) and (ii) whether the individual variation of early literacy skills in the two groups to the same extent can be explained from the precursor measures. Results showed that children with ID scored below the NLA group on all literacy and precursor measures. Structural equation modeling evidenced that in the children with NLA early literacy was directly predicted by phonological awareness, PSTM and vocabulary, with nonverbal reasoning and auditory discrimination also predicting phonological awareness. In children with ID however, the variation in word decoding was predicted by letter knowledge and nonverbal reasoning, whereas letter knowledge was predicted by rapid naming, which on its turn was predicted by attentional skills. It can be concluded phonological awareness plays a differential role in the early literacy skills of children with and without ID. As a consequence, the arrears in phonological awareness in children with ID might put them on hold in gaining proper access to literacy acquisition.

What this paper adds: This paper adds to the theoretical knowledge base on literacy acquisition in a special population, namely children with intellectual disabilities (ID). It addresses factors that influence early literacy learning, which have not been investigated thoroughly in this special and specific group. Furthermore, the children are not tested solely on literacy, but also on cognitive measures that may influence literacy acquisition. Whereas most research in ID focuses on groups with specific syndromes/etiologies, this paper takes a varied group of children with ID into account. The paper also adds to educational insights, since the findings imply that children with ID are able to use phonological pathways in learning to read. Educators could teach these children phonics-based literacy skills tailored to their individual learning needs.

1. Introduction

It is a well-established fact that phonological awareness is critical for literacy acquisition (Melby-Lervåg, Halaas Lyster, & Hulme, 2012; Verhoeven, van Leeuwe, Irausquin, & Segers, 2016). In kindergarten classrooms, children begin to discover that sounds can be

[☆] This research was funded by the Royal Kentalis, Sint-Michielsgestel.

* Corresponding author at: Behavioural Science Institute, Radboud University, Montessorilaan 3, P.O. Box 9104, 6500 HE Nijmegen, The Netherlands.

E-mail address: a.vantilborg@pwo.ru.nl (A. van Tilborg).

manipulated (while singing rhyme- and nursery songs), and that letters represent sounds (while playing games like searching for words that start with a specific letter or sound). Through all these early literacy experiences, children become prepared for formal literacy instruction in first grade (Dickinson, McCabe, Anastasopoulos, Peisner-Feinberg, & Poe, 2003; Lonigan, Burgess, & Anthony, 2000). For children with intellectual disabilities (ID), however, only the first steps have been made in understanding how and to what extent these children can become literate (e.g., Barker, Sevcik, Morris, & Ronski, 2013). Whereas both children with normal literacy acquisition (NLA) and children with ID are exposed to literacy from a young age onwards, it can be assumed that there are differences in the significance of precursor measures of literacy skills in both groups. There is an ongoing debate on the question to what extent children with ID can become phonologically aware and how this impacts the development of their early literacy skills. Therefore, the present study investigated to what extent children with mild ID with mixed etiologies develop early literacy skills, and how the individual variation related to the complex process of learning to read in this group can be explained.

1.1. Early literacy in children with normal language acquisition

Before children receive formal literacy education, they develop early literacy skills such as knowledge of grapheme to phoneme connections and word decoding (see Pullen and Justice, 2003; Storch and Whitehurst, 2002). Phonological awareness, rapid automatic naming (RAN) and phonological short-term working memory (PSTM) are considered to be important predictors of later word decoding skills (e.g. Melby-Lervåg et al., 2012; Näslund and Schneider, 1996). The lexical restructuring hypothesis (Goswami, 2001; Metsala, 1999, 2011) claims that oral vocabulary may trigger children to develop phonological representations of language, thus strengthening their phonological awareness and early literacy skills. Furthermore, at a higher-order level, the development of early literacy has shown to be dependent on higher-order skills such as sequential memory processing, (e.g., rhythm; David, Wade-Woolley, Kirby, & Smithrim, 2007), selective attention, and executive functioning (Diamond, 2013). As a case in point, Van de Sande, Segers, and Verhoeven (2013) found that phonological awareness mediated the relation between executive functioning and learning to read in a group of typically developing children from kindergarten to first grade.

1.2. Early literacy in children with intellectual disabilities

The aforementioned theoretical framework of the relationship between phonological awareness and literacy skills stems from research in children with NLA and it can be questioned whether the same framework applies to literacy acquisition in children with mild ID (International IQ criterion = 50–70; Boat & Wu, 2015, pp. 170–171; Dutch IQ criterion = 50–85; de Beer, 2011). Research in literacy acquisition in children with ID is relatively scarce and findings are not always congruent (Erickson, Hanser, Hatch, & Sanders, 2009). There is evidence that children with ID learn to read in a similar fashion as children with NLA by using, at least to some extent, explicit phonological skills such as phonological awareness and letter knowledge. In a study by Wise, Sevcik, Ronski, and Morris (2010), it was found that children with ID in Grade 2–5 relied heavily on phonological processing in identifying words and nonwords. These findings were confirmed by Barker et al. (2013) in a study with children with ID in the upper primary grades. They found phonological awareness and naming speed to be related to reading abilities, suggesting that children with ID use the same phonological processing structures compared to children with NLA. In a similar vein, Soltani and Roslan (2013) found both phonological awareness and naming speed to be related to word decoding in a group of adolescents with ID, with PSTM supporting decoding abilities by influencing explicit phonological awareness skills. Furthermore, research on literacy skills in groups of children and adolescents with Down syndrome (DS) showed that this specific group is weak in linguistic processing (for a meta-analytic review, see Næss, Melby-Lervåg, Hulme, & Halaas Lyster, 2012). Both phoneme awareness and vocabulary turned out to be important for reading in this specific group. Kennedy and Flynn (2003), for example, found that in three children with DS aged 7 and 8 years old, their ability to get a grasp of phoneme awareness was related to better performances in literacy outcomes.

The studies above show that children with ID are lagging behind in literacy development, yet they may ultimately become phonologically aware and may have the possibility to unravel the orthographic code. An important question is then to what extent children with ID are capable of developing early literacy skills at kindergarten level and first grade and how the individual variation in early literacy in this heterogeneous group can be explained. Van Tilborg, Segers, van Balkom, and Verhoeven (2014) found that children with ID who possessed some letter knowledge skills, still had lower levels of early literacy skills as compared to their kindergarten peers with NLA. Within a group of children being marked as having an ID, variation in nonverbal reasoning levels in this study still significantly predicted early literacy skills, which especially applied to learning grapheme-to-phoneme correspondence rules. Nonverbal reasoning thus seemed to play an important role in the emergence of early literacy skills in children with ID, which is in support of Levy (2011), claiming that word decoding is a task that primarily relies on general cognitive resources that are often distorted in children with ID. Also, Catts, Fey, Tomblin, and Zhang (2002) found in their longitudinal study that nonverbal reasoning was related to differences in reading outcome in both groups of children with NLA and children with ID. This implies that visual-spatial and analytical skills that are tapped with nonverbal reasoning skills are involved in learning to read. In all, nonverbal reasoning can be seen as a cognitive predictor influencing literacy acquisition in both groups of children.

Furthermore, it has been found that phonological awareness and PSTM processes can affect early literacy acquisition in children with ID (Dahlin, 2011; Schuchardt, Maehler, & Hasselhorn, 2011). Moreover, abilities related to attention, working memory, and executive functioning also have found to be related to the development of early literacy in children with ID (Costanzo et al., 2013; Danielson, Henry, Messer, & Rönnerberg, 2012). In the field of research of literacy acquisition in children with ID, a comprehensive, comparative account on the cognitive and linguistic precursors of early literacy development in children with ID so far is generally lacking. No attempt has been made to relate precursor measures and early literacy measures at kindergarten level in children with ID

as compared to NLA children. Whereas both groups of children are exposed to literacy over a same amount of time during their lives, there are differences in various literacy-related precursors. Investigating literacy acquisition in both groups within one research design can give further insight into the underlying processes at the start of literacy acquisition.

1.3. The present study

Consequently, in the present study, a model was explored in which the early development of literacy was predicted by a set of basic precursors of literacy which are known to play a role in literacy acquisition in children with NLA. In addition, we measured this set of precursors of literacy in a group of children with ID, in order to be able to compare the individual variation in early reading skills over the two groups. In this model, it was presumed that the development of letter knowledge and word decoding can be explained from literacy-related predictors like phonological awareness, rapid naming and PSTM, and that the development of early literacy including its predictor measures could be explained by both cognitive (nonverbal reasoning, attention, sequential memory, executive functioning) and linguistic (auditory discrimination, RAN, articulation, vocabulary) precursor measures. We selected children from comparable (kindergarten) age groups. This way, we were able to detect differences in precursors measures and literacy processes between the two groups not influenced by the amount of literacy exposure. By incorporating two groups within one research design, the following questions were posited to further clarify the process of literacy acquisition in children with ID:

1. To what extent do kindergarten children with NLA and ID differ on early literacy skills and precursor measures?
2. How can the individual variation of early literacy development in the two groups be explained from the precursor measures?

With regard to the first research question, it was expected that children with ID would perform weaker on literacy measures, literacy predictor- and precursor measures compared to children with NLA. With regard to the second research question, it was expected that in both groups the variation in early literacy development could be explained by the children's levels of predictor and precursor measures.

2. Method

2.1. Participants

Children with ID were recruited from 19 schools for special education, located in the middle and southern part of the Netherlands. In order to attend special education for children with ID in the Netherlands, the children need to have a medical indication (classification) for ID, and their IQ level can be tested in various ways. In the present study, a group of 53 children with ID (38 boys, 15 girls; $M_{\text{age}} = 75.26$ months, age range between 65 and 83 months) participated. The selection criteria for the children with ID were as follows: age between 5;6 and 6;6 years, an IQ level between 50 and 75, Dutch as native language, and no additional visual, hearing-, or motor impairment that would interfere with the test assessment. Not all IQ scores or diagnosis of the children were known or available. In total, the IQ of 29 children was known (IQ range 50–71, $M_{\text{IQ}} = 58.3$, $SD = 6.3$). Most children with ID in the study were generally classified as intellectually disabled with unknown or non-specified etiology ($n = 37$). The other children with ID were diagnosed with Down Syndrome ($n = 4$), and/or were multiple disabled because of one or more accompanying conditions as for instance autism or ADHD ($n = 11$), or mild physical disorders ($n = 4$), metabolic disease ($n = 1$) or chronic illness ($n = 1$).

Furthermore, the study included children with NLA from four regular primary schools. Three schools were situated in small villages in the east of the Netherlands, and one school in a larger city in the west of the Netherlands. In total, a group of 74 children with NLA (33 boys, 41 girls; $M_{\text{age}} = 69.58$ months, age range between 63 and 78 months) participated, all attending the second year of kindergarten. Kindergarten is a two-year program in the Netherlands in which attention is being given to emergent literacy development, prior to formal reading education in Grade 1. None of these children had visual- or hearing impairments, and the native language of the children was Dutch.

The two groups of children differed on nonverbal reasoning, $t(125) = 12.06$, $p < .001$, $d = 2.19$. Furthermore, although all children were selected between 5;6 and 6;6 years of age, children with ID were 5.8 months older than children with NLA, $t(125) = 7.72$, $p < .001$, $d = 1.40$. On average, the schools from the children with NLA were in regions of average social-economic status (SCP, 2014). For the schools of children with ID, no such score was calculated, since children in these schools often reside further away from their school, and are brought to school by taxi buses. Parents of all children that participated in the present study provided active consent for the participation of their child. All test moments were scheduled in consultation with schools, teachers, and parents.

2.2. Materials

2.2.1. Word decoding

Word decoding was assessed with a shortened and adapted version of the *Leerling- en Onderwijs Volgstelsel Technisch lezen groep 3* [Student- and Educational Tracking system Technical reading class 3] (Jongen, Krom, & Roumans, 2009). In this task, children saw a picture and five words next to it. The child was asked to point at the word that matched the picture. Words increased in difficulty, starting with simple CVC words and ending with multisyllabic words. A total of 40 items were presented, and one point was given per correct answer. The task was terminated after 5 min, or if the child made four consecutive errors. Reliability calculated for the task

was high (Cronbach's $\alpha = .90$).

2.2.2. Letter knowledge

Receptive letter knowledge was assessed with the *Screeningsinstrument Beginnende Geletterdheid* (Diagnostic Instrument for Emerging Literacy; Vloedgraven, Keuning, & Verhoeven, 2009). With each item, four graphemes or digraphs were presented on the computer screen, and the child had to point to the grapheme/digraph that was provided by the computer voice. Low-frequency letters in the Dutch language (the letters [c], [x], [q], and [y]) were not included. Frequent Dutch digraphs (e.g. [aa], [oe], [uu]) were added to the task. A total of five practice items and 34 critical items were presented to the child. High reliability of the receptive letter knowledge task was found (Cronbach's $\alpha = 0.93$).

2.2.3. Phonological awareness

Phonological awareness was also assessed with the *Screeningsinstrument Beginnende Geletterdheid* (Diagnostic Instrument for Emerging Literacy; Vloedgraven et al., 2009). In this computer task, four subtests of phonological awareness were assessed: rhyme, phoneme identification, segmentation, and deletion. Each subtest entailed 15 critical items and two practice items. At each item, across the subtests, the child saw three pictures and was presented with an auditory stimulus, provided by a computer voice. In the *rhyme* task, the child had to point to the picture that rhymed with the stimulus. In the *phoneme identification* task, the child had to point to the picture that started with the same phoneme as the word that was produced by the auditory stimulus. In the *phoneme segmentation* task, the phonemes of a word were pronounced one-by-one, and the child had to point to the picture that matched with the word. In the *phoneme deletion* task, the child had to delete a given phoneme from a presented word, and had to point to the picture that matched the new word (e.g., *druif* [grape], minus *r*/makes *duif* [dove], and the child had to point to the picture of a dove). For each measure of phonological awareness, a *z*-score was calculated. The four *z*-scores were then added to create the variable phonological awareness which was used for further analyses. The reliability of all tasks combined was high (Cronbach's $\alpha = .91$).

2.2.4. Rapid naming objects

The rapid naming objects subtest from the *Ernstige Spraak-taal Moeilijkheden toets* [Specific Language Impairment test] by Verhoeven (2005) was used to assess rapid automatic processing. An A4-sized card with five common objects ([duck], [glasses], [shoe], [comb], and [house]) was presented to the child. A total of 120 items were randomly provided, divided over 4 rows of 30 items. The child was asked to call out the objects as fast and accurately as possible within 60 seconds. Good internal consistency was found (Cronbach's $\alpha = .86$).

2.2.5. Phonological short-term memory (PSTM)

PSTM was measured via a serial word-recognition task, which was adapted to assess children who were not able to speak, by making use of a hand doll (Peeters, Verhoeven, van Balkom, & de Moor, 2008). The experimenter sat in front of the child, holding a kumquats hand puppet (www.handpop.nl) in one hand. The experimenter spoke out a string of words, and after a pause of 2 s, the hand puppet copied the string of words, correctly or incorrectly (meaning that one word was incorrectly repeated, e.g. *raam* [window] – *zon* [sun] vs. *mes* [knife] – *zon* [sun]). The child was asked whether the hand puppet copied the string of words correctly or incorrectly. If the hand puppet correctly repeated the word-string of the experimenter, the child had to point at a happy smiley, and if the hand puppet incorrectly repeated the word-string, the child had to point at a sad smiley. The word-strings were divided in eight sets of six items, and the length of word strings increased after each set (from one word in the first set to eight words in the final set). If the child made three or more errors within one set, the set was finished and the task was terminated. The reliability of the task was high (Cronbach's $\alpha = .97$).

2.2.6. Word span

The subtest *Geheugentest: woorden* [Memory test: words] from the *Ernstige Spraak-taal Moeilijkheden toets* [Specific Language Impairment test] by Verhoeven (2005) was used to measure word span, a short-term memory span task. In this task, children were asked to repeat a spoken string of words in the exact same order, ranging from two to eight words per string. The first set comprised two strings of two words. In each next set, the word string increased with one additional word, with a maximum of eight words. If the child made an error on both word strings in one set, the task was terminated. Good reliability was found (Cronbach's $\alpha = 0.71$).

2.2.7. Vocabulary

A computerized Dutch version of the *Peabody Picture Vocabulary test III* (Dunn & Dunn, 1997) was used to measure receptive vocabulary. During this task, the child sat in front of a computer screen and had to point to one out of four pictures that corresponded to a word provided by a computer voice. There were 17 sets of 12 items within each set, and if a child made nine or more errors within one set, the task was terminated. Raw scores were used for analysis, since norm scores did not account for the children with ID. Internal consistency of this test was between Lambda-2 = .92 and .95.

2.2.8. Nonverbal reasoning

The level of nonverbal reasoning was measured by using the *Raven Coloured Progressive Matrices* (Raven, 1956). The task comprised 36 items, subdivided in three sets of 12 items, increasing in difficulty within each set. The child was presented to a figure with a missing piece, and was asked by the experimenter to point at one piece out of six presented below the figure, that correctly completed the incomplete figure. Good reliability for this task is found (Cronbach's $\alpha = .82$).

2.2.9. Auditory discrimination

To measure auditory perception, the *auditory discrimination task* developed by Peeters et al. (2008) was used. Two pictures representing monosyllabic words, differing minimally on one phoneme (difference in the first- or last consonant of the word, or difference in the vowel), were orally and visually presented to the child. The experimenter then pronounced one word that matched with one of the two pictures, and the child had to point to the correct picture. The task consisted of three practice items and 20 critical items. The reliability of the task was good (Cronbach's $\alpha = .76$).

2.2.10. Word and pseudoword articulation

Both word and pseudoword articulation were measured with the standardized Word Articulation subtest from the *Ernstige Spraak-taal Moelijkheden toets* [Specific Language Impairment test] (Verhoeven, 2005). In the word articulation task, the child was asked to repeat a word that was provided by a computer voice. The task started with simple monosyllabic words, and increased in difficulty (e.g. CCCVC words, multisyllabic words). The pseudoword articulation task comprised syntactically correct Dutch pseudowords, increasing in difficulty comparable to the word articulation task. Both tasks entailed two practice items and 40 critical items. If a child made five consecutive articulation errors, the task was terminated. The reliability of both tasks was high (Cronbach's $\alpha > .95$).

2.2.11. Selective attention

The subtest *Attention sustained* from the *Leiter International Performance Scale – Revised* (Roid & Miller, 1997) was used to measure selective attention. This pencil and paper cross-out task suited the present research sample, since the task could be administered almost completely non-verbally. The child was presented with a card with strings of various drawings (e.g., flowers, butterflies, stars, and snails), and on top of the card, a critical drawing (e.g., a flower) was presented that the child needed to search for. The child was asked to cross out all critical items that were scattered between other distracter drawings, within a time span of 30 s for the first three cards and 60 s for the final card. In total, four cards were presented to the child, increasing in difficulty (more difficult to distinguish between items and items presented in different angles). The reliability of the subtest for attention ranged from $\alpha = .65$ –.87.

2.2.12. Sequential memory

Sequential memory was assessed using the *Ritme test* [Rhythm test] by Van Uden (1983). The task assesses rhythm reproduction, both from copying a rhythm pattern presented by the examiner and from copying a rhythm pattern from memory. The child was given a pencil and was asked to tap a rhythm pattern that was presented by the examiner. If the child was able to copy the rhythm partly (meaning that the amount of taps was correct, but the exact rhythm of the taps was not correct) or completely correct, it was asked to copy the same rhythm pattern again for five consecutive times from memory. If a child failed to (partly) copy the rhythm pattern of the experimenter twice in a row, the task was terminated. Z-scores of both parts of the rhythm task (copying a rhythm pattern from the experimenter and copying a rhythm pattern from memory) were added to create the variable sequential memory. Excellent reliability was found (Cronbach's $\alpha = .99$).

2.2.13. Executive functioning: inhibition

The *Grass/Snow task* and the *Day/Night task* were assessed to measure inhibitory executive functioning skills. These complex response tasks focus on the inhibition capacities of the child. In the Grass/Snow task (Carlson & Moses, 2001), children were presented with a white and a green card. The experimenter asked the child to point at the card whose colour matched with *grass* or *snow*. Then, the child was told that a strange game was played, and that the child had to point to the white card if *grass* was called out, and that the child had to point to the green card if *snow* was called out. After the child was able to at least once point to the correct card after *grass* and *snow* was called out, 16 critical trials were presented in a pseudorandom order and accuracy was scored. The first initial choice of the child was always scored, meaning that self-correction still was scored as incorrect.

For the Day/Night task (Gerstadt, Hong, & Diamond, 1994), comparable instructions were provided. In this task, the child saw two opposite pictures next to each other (being *day-night*, *big-small*, *boy-girl*, and *above-below*) and was asked to point at the opposite picture of the one that was called out by the experimenter. Z-scores of the Grass/Snow task and the Day/Night task were added to create the variable Executive Functioning. Reliability of both tasks combined appeared to be high (Cronbach's $\alpha = .95$).

2.3. Procedure

All children were tested individually in a silent room at their school by a trained experimenter, between March and November. To enhance the intrinsic motivation, children were invited to be involved as partner in educational games with the experimenter. It was chosen to start with tasks wherein interaction with the child was involved, in order to make the child comfortable with the experimenter and with the set-up of the test setting. For practical reasons, it was chosen not to switch between computer tasks and pencil-and-paper tasks, and so the tests were assessed in a fixed order in four blocks of 30 min. Each block was administered on different days, with a maximum of two blocks on one day with at least a one hour break between them. This restriction was incorporated in the procedure to prevent a lack of concentration or extreme disturbance of daily routines during the assessment of the children. Instructions were given verbally and in advance of each task: practice items were presented with feedback in order to improve understanding of the task. Except for rapid naming of objects, word span and articulation, which had expressive modes of output, all tasks were answered receptively by pointing at pictures or words presented to the child. We chose to incorporate receptive test assessment in our study, to offer children who were not yet able to speak the possibility to provide an answer. If a child was not able to use a computer mouse, the child was asked to point to the answer at the computer screen, and the experimenter then clicked

on the provided answer. After completing a task, the child was rewarded with a sticker on a certificate, and after completion of all tests, the certificate was given to the child.

2.4. Data analysis

For answering the research questions, descriptive statistics and independent samples *t*-tests (with Bonferroni correction), as well as correlations for both groups between all variables were calculated. Both groups of participants were relatively small compared to the large amount of variables measured. In view of that, several adaptations were made to reduce the amount of variables involved in the SEM analyses. For both the PSTM and the word span task, z-scores were generated for creating a variable called “memory”. Since some students missed a test session or did not want to cooperate in a few tasks, multiple imputation was used wherein repeated simulations of datasets were created based upon parameter estimates from the initial measurements, in order to preserve cases with small numbers of missing values (Howell, 2008). The average score of the 5 imputed scores replaced each missing data point and was used for further analysis. Multiple imputation can be used in large sample sizes when the missing rate is low (Dong & Peng, 2013; Schafer, 1997).

To calculate the models of individual variation, LISREL (<http://www.ssicentral.com>) was used to analyze the data. SIMPLIS analyses were used for modeling the individual variation in early literacy skills in both groups of children. First, the model for children with NLA was calculated based upon theoretical presuppositions towards the relationships between the variables. The tested model was based upon a theoretical framework for children with NLA, wherein phonological awareness and letter knowledge predicted word decoding, and phonological awareness, rapid naming and memory were seen as predictors of letter knowledge. Then, it was presupposed by theory which of the predictor variables was related to those three constructs, and tested whether these variables fit the model. Significant relations were simultaneously incorporated to the final model. The goodness of fit statistics of the analyses that were taken into account were χ^2 , Root Means Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Goodness of Fit index (GFI). A strong fit was reckoned if the χ^2 was non-significant ($p > .05$), RMSEA was $< .08$ for acceptable fit and $< .06$ for strong fit. CFI and GFI were supposed to be strong if they both were $> .90$.

3. Results

Descriptive statistics, independent samples *t*-test results and effect sizes of the raw data are shown in Table 1. A Bonferroni correction, with $\alpha = .05$ divided by 14 (total number of variables), revealed that all *p*-values were below this corrected score (all *p*'s $< .004$). Children with ID scored lower than children with NLA on all variables, with large effect sizes.

To answer the second research question, first correlations were calculated. The correlation matrix (see Table 2) revealed that in children with ID, most tasks correlated significantly with each other. Phonological awareness was not related to word decoding, but letter knowledge did show a strong relationship with word decoding. All correlations between all the other variables imply that there are underlying processes involved in both the acquisition of early literacy skills, as well as within the early literacy pathway of learning to read. Nonverbal reasoning correlated with all other variables except for sequential memory, implying an important underlying role in all those variables. In the NLA group, a more typical pattern of relationships was found, with early literacy skills all strongly related to another, as was vocabulary, implying lexical restructuring to occur.

Structural equation modeling was next used to study the individual variation between the two groups. First, the theoretical framework on early literacy was modeled on the data of the NLA group. All predictor variables were related to the dependent variable

Table 1
Descriptive Statistics, Group Differences and Effect Sizes between Children with ID ($n = 53$) and Children with NLA ($n = 74$).

Variable	ID			NLA			<i>t</i>	<i>d</i>
	Range	<i>M</i>	<i>SD</i>	Range	<i>M</i>	<i>SD</i>		
WD	0–28	3.02	5.49	0–18	7.30	4.39	4.88	.88
LK	5–33	15.15	7.54	8–34	24.85	6.91	7.51	1.36
PA	17–46	24.34	5.49	25–58	42.28	7.28	15.84	2.74
RAN	0–55	22.25	12.74	14–63	38.41	8.80	7.97	1.53
PSTM	1–27	10.60	7.25	3–46	30.78	7.24	15.48	2.81
WS	0–5	2.68	1.36	3–10	4.74	1.39	8.35	1.51
VOCA	15–77	50.11	12.86	59–120	83.74	10.99	15.83	2.87
NvIQ	6–25	13.55	3.81	13–31	22.03	3.98	12.06	2.19
AD	9–20	15.64	3.04	15–20	18.77	1.15	7.14	1.47
Arti W	0–35	16.62	10.07	20–40	35.05	4.14	12.59	2.57
Arti PW	0–25	5.38	5.96	3–35	20.97	7.90	12.69	2.20
Att.	0–57	22.79	14.94	23–67	53.16	9.35	13.08	2.55
Seq. Mem	0–64	10.55	12.66	0–184	44.69	46.00	6.08	.95
EF	4–46	22.70	9.28	21–48	41.43	5.22	13.27	2.62

Note: All *p*'s $< .001$; WD = Word Decoding, LK = Letter Knowledge, PA = Phonological Awareness, RAN = Rapid Naming, PSTM = Phonological Short-term Memory, VOCA = Vocabulary, NvIQ = Nonverbal Reasoning, AD = Auditory Discrimination, Arti W = Articulation Words, Arti PW = Articulation Pseudowords, Att. = Selective Attention, Seq. Mem = Sequential Memory, EF = Executive Functioning.

Table 2

Correlations Between the Predictor Measures in Children with ID (below diagonal, N = 53) and Children with NLA (above diagonal, N = 74).

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. WD		.72**	.59**	.16	.26*	.35**	.04	.00	.06	.09	0.06	.35**	0.21
2. LK	.66**		.55**	.05	.33**	.39**	.17	-.08	.20	.15	0.08	.41**	.27*
3. PA	.20	.39**		.20	.27*	.37**	.19	.18	.15	.19	0.18	.32**	.25*
4. RAN	.23	.44**	.29*		.19	.08	.07	-.05	.16	.01	.37**	0.17	0.13
5. Phon. STM	.09	.31*	.33*	.40**		.17	.23*	-.10	.20	.13	0.06	.37**	0.11
6. VOCA	.25*	.34*	.30*	.50**	.42**		.24*	.15	.16	.22*	0.18	0.13	0.19
7. NvIQ	.42**	.43**	.37**	.43**	.52**	.45**		-.09	.07	.15	.46**	0.20	0.13
8. AD	.32*	.43**	.37**	.25*	.49**	.48**	.49**		.30**	.27*	0.11	-.017	0.18
9. Arti. W	.06	.16	.24	.41**	.66**	.50**	.58**	.46**		.54**	.26*	0.05	.34**
10. Arti. PW	.03	.08	.17	.31*	.43**	.27*	.46**	.29*	.81**		0.20	0.05	.22*
11. Att.	.30*	.32*	.29*	.51**	.45**	.62**	.66**	.45**	.54**	.48**		.22*	.22*
12. Seq. Mem.	.09	.30*	.18	.28*	.57**	.34*	.38**	.23	.36**	.30*	.36**		.28*
13. EF	.08	.24	.30*	.20	.32*	.29*	.24	.24	.27*	.32*	.40**	.36**	

Note: WD = Word Decoding, LK = Letter Knowledge, PA = Phonological Awareness, RAN = Rapid Naming, Phon. STM = Phonological Short-term Memory, VOCA = Vocabulary, NvIQ = Nonverbal Reasoning, AD = Auditory Discrimination, Arti. W = Articulation Words, Arti. PW = Articulation Pseudowords, Att. = Selective Attention, Seq. Mem = Sequential Memory, EF = Executive Functioning.

* $P < .05$.** $P < .01$.† $P < .07$.

word decoding. Then, all precursors were related to the predictor variables, and non-significant relationships between precursor variables and predictor variables were deleted. This resulted in a final model yielding an acceptable fit: $\chi^2(28) = 36.26$, $p = .14$, RMSEA = .064, CFI = .97, GFI = .92, explaining 56.0% of variance of the dependent variable word decoding (see Fig. 1).

The final model provided evidence that in children with NLA, lexical restructuring occurred in this stage of early literacy acquisition. Vocabulary, phonological awareness and letter knowledge all contributed to the early literacy pathway. Rapid naming did not occur to be involved. The predictor variable memory was related to letter knowledge as well. Although the relationship between vocabulary and phonological awareness just did not reach significance, vocabulary was strongly related to letter knowledge.

When modeling the predictor variables on the dependent variable word decoding in children with ID, the predictor variables phonological awareness and memory did not significantly relate to letter knowledge. Phonological awareness did significantly relate to word decoding, and rapid naming related significantly to letter knowledge, contrary to the NLA group. The precursor variables were incorporated into the model, and the model was adjusted by removing the non-significant relations, resulting in a model with insufficient fit ($\chi^2(27) = 39.95$, $p = .05$, RMSEA = .096). To reach an acceptable fit, adjustments to the model were made. Since nonverbal reasoning correlated with all other predictors, it was chosen to relate nonverbal reasoning directly to word decoding.

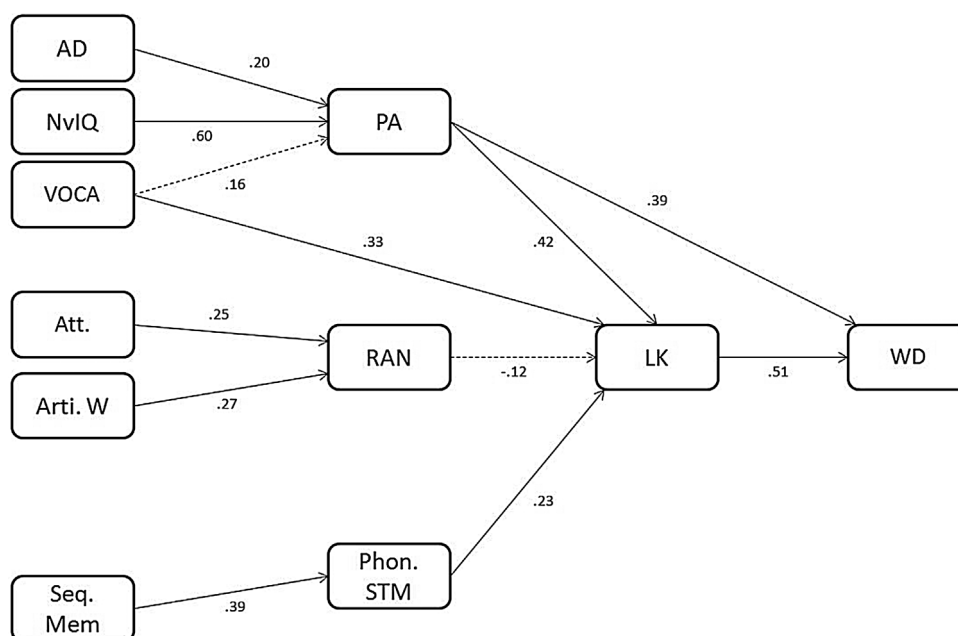


Fig. 1. Final model of predictors of literacy acquisition in children with NLA.

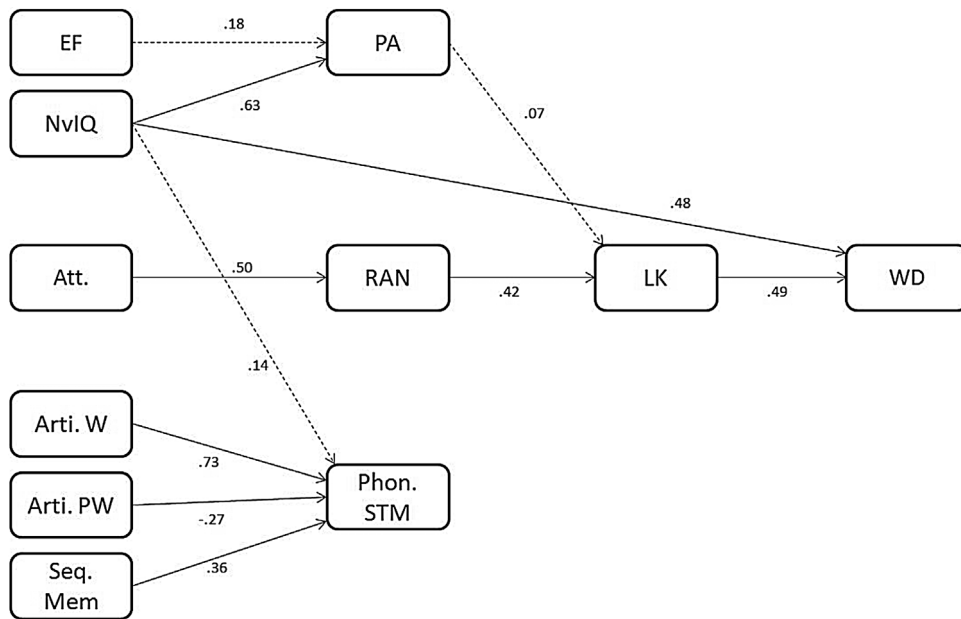


Fig. 2. Final model of predictors of literacy acquisition in children with ID.

Nonverbal reasoning is known to be important in literacy acquisition in children with ID (Laing, Hulme, Grant, & Karmiloff-Smith, 2001; Van Tilborg et al., 2014), and appeared to strongly predict word decoding. As a result of adding this relationship, slight changes occurred in the relationship between phonological awareness and word decoding, as well as between memory and letter knowledge, and these non-significant relationships were deleted from the model. This resulted in a final model with a correct fit, $\chi^2(29) = 29.45$, $p = .44$, RMSEA = .017, CFI = 1.00, GFI = .91, explaining 50.8% of the variance in word decoding (see Fig. 2).

Contrary to children with NLA, phonological awareness was not related to both letter knowledge and word decoding in children with ID, implying that this skill is either not applied or not developed yet in literacy acquisition in these children. Furthermore, after the addition of the relation between nonverbal reasoning and word decoding, the model gets a good fit, indicating the importance of nonverbal reasoning in word decoding. Contrary to children with NLA, rapid naming skills in children with ID predicted letter knowledge. Finally, three precursor variables, namely articulation of words- and pseudowords, and sequential memory, predicted PSTM, but PSTM eventually did not predict any other early literacy skills in this model.

4. Discussion

The present study investigated a group of children with ID and NLA on their early literacy skills. It was aimed to find out to what extent children between the two groups differed on linguistic and cognitive skills related to early literacy acquisition. Moreover, it was investigated whether group differences (in terms of special educational needs) led to comparable or dissimilar pathways of early literacy acquisition. We found that children with NLA outperformed children with ID on all linguistic and cognitive measures related to early literacy. We also studied models of early literacy in children with NLA and ID. It was hypothesized that children with NLA and ID would show comparable models of early literacy acquisition, but that precursors of literacy would vary between the groups. We found a literacy model in children with NLA that corresponded to findings in previous research (e.g., Melby-Lervåg et al., 2012; Storch and Whitehurst, 2002). Phonological awareness and letter knowledge predicted word decoding, and vocabulary and PSTM predicted letter knowledge. In children with ID, however, a different model for early literacy skills was found. Although letter knowledge was an important predictor for word decoding, phonological awareness did not predict both letter knowledge and word decoding. It was nonverbal reasoning that directly predicted phonological awareness and word decoding, implying the importance of nonverbal reasoning in young children with ID during literacy acquisition (Van Tilborg et al., 2014).

4.1. Differences in early literacy between children with NLA and ID

When comparing both groups on their literacy- and literacy related skills, children with ID were outperformed by the children with NLA. This finding was not remarkable, since children with ID attend special education due to problems in development and general cognitive delay. This delay can lead to severe difficulties in important skills related to learning to read (Schuchardt et al., 2011). Moreover, problems in early literacy acquisition can be a result of problems in phonological processing, which affects children with ID in their struggle towards literacy acquisition (e.g. Channell, Loveall, & Conners, 2013).

It was unclear to what extent the differences between children with ID and children with NLA would affect the relatedness of precursor skills of literacy acquisition. We tested a theoretical framework of predictors of literacy acquisition on the data of children

with NLA. Structural equation modeling revealed a model of early literacy acquisition in children with NLA that partially confirmed our hypothesis.

Although children with NLA were still in kindergarten, some of them were already able to decode words, even without having received formal literacy instruction. Some children with NLA were already able to apply explicit phonological skills like phonological awareness in decoding words. Concurrently with a sufficient level of vocabulary, these two factors play an important role in lexical restructuring, benefiting early reading (Goswami, 2001; Metsala, 1999, 2011). The lexical restructuring hypothesis claims that vocabulary reorganizes phonological representations of language in the brain. Contrary to our expectations, vocabulary was not a precursor of phonological awareness, but was related to letter knowledge. Still, deep lexical knowledge will benefit grapheme-to-phoneme connections, wherein letter knowledge is strengthened. Whereas vocabulary did affect letter knowledge, the kindergartners in the present study did not seem to apply rapid naming in early literacy. In the Netherlands, word decoding is not yet instructed in kindergarten, and so automatization is not yet a predictive factor in reading during this particular educational phase of reading for these children. For instance, Verhoeven et al. (2016) found in a group of kindergartners that although lexical retrieval affected word decoding, this effect was small and indirect in nature. Therefore, it is assumed that in the current model, rapid naming does not predict letter knowledge.

4.2. Individual variation in early literacy

The predictors of literacy in the NLA model were previously found to be important in children with ID as well (e.g., Barker et al., 2013; Wise et al., 2010). However, when applying the theoretically motivated and empirically tested early literacy model on the data of children with ID, and adjusting this model to reach a proper fit, some striking differences between the models of the two groups were revealed. First of all, the presupposed theoretical relationships between phonological awareness, and letter knowledge and word decoding were not found in children with ID. There are two possible explanations for the absence of these relationships in children with ID. It might be the case that if children with ID were able to ‘read’ words, a logographic, whole-word recognition (visual inspection, word-image based; often used in prealphabetic readers (Bowman & Treiman, 2008)) strategy was used, which is different from typical phonology-based word decoding strategies. When using logographic strategies of word reading, children do not strongly rely on phonological awareness or on PSTM. An alternative explanation could be that children with ID are not yet able to use explicit phonological skills, which is reflected by their relatively low phonological awareness skills. In the case that auditory recognition of phonemic boundaries between the consecutive sounds within words cannot be identified and manipulated, PSTM will quickly reach its maximum capacity, and decoding will not take place (see Dickinson et al., 2003). Children with ID will only learn and remember those words that they implicitly or explicitly learn by experiencing modeling and repetition. Less frequently encountered words or unfamiliar words, however, will not be recognized or remembered to the same extent. The inability to use their phonological awareness skills restrains them from unraveling an unfamiliar word by using word decoding skills. Contrary to children with NLA, lexical retrieval predicted letter knowledge in children with ID. Children with ID struggle to learn the grapheme-phoneme connections and to learn that the abstract symbolic patterns of letters entail phonological information. It may well be the case that lexical retrieval compensates for phonological awareness when phonological awareness is not predicting letter knowledge, and therefore predicts letter knowledge in this group of children.

From the precursor measures that were used in the present study, nonverbal reasoning yielded a strong effect on the model in children with ID, which can be related to differences in cognitive or higher-order level processing compared to children with NLA (Catts et al., 2002). Our data showed nonverbal reasoning to be related to all other variables in children with ID, which indicates its important underlying role in the prediction of literacy-related variables. Nonverbal reasoning directly affected word decoding, implying that children with ID need nonverbal reasoning skills (i.e., matching, categorizing, comparing) to get a grasp of literacy in the first place. Contrary to children with NLA, children with ID seem to have a hard time reflecting on phonemic constituents in words, which prevents many of them to become phonologically aware. Nonverbal reasoning thus may act as some sort of ‘control mechanism’ in literacy acquisition in children with ID, which then interferes with normal literacy acquisition. It can be claimed that only if a child is able get a grasp of such reasoning, it can learn to understand the principles of grapheme-to-phoneme connections, and thus develop word decoding skills.

Cognitive processes in learning to read prove pivotal in the segmentation of lexical representations, which is reflected in the lexical restructuring hypothesis. In the present study, it was found that in PSTM predicted letter knowledge in children with NLA, which proves the important role of this factor in learning to read (Henry and Winfield, 2010; Melby-Lervåg et al., 2012). Typically, children start to derive, identify and learn sounds from words and its respective letters and learn to (re)combine these letters and sounds to decode words, gradually relying on phonological working memory to process subsequent letters in a word. In children with ID, however, the PSTM of the children may quickly reach maximum capacity, leading to an inability to hold (multiple) letters and its corresponding sounds in memory (Connors, Atwell, Rosenquist, & Sligh, 2001; Soltani & Roslan, 2013). This is reflected in our model by an absence of PSTM to predict letter knowledge. In a similar vein, it is interesting to note that in the present study, the word decoding ability of children with ID was strongly associated with letter knowledge without a significant association between phonological awareness, on the one hand, and both letter knowledge and word decoding, on the other hand.

A final point of discussion entails the heterogeneity of the group of children with ID. Research in children with ID always has to deal with heterogeneity, different etiologies, and the complexity of the disorders that can cause intellectual and developmental disorders (Ratz, 2013). We do acknowledge that there are differences in literacy skills and development in some groups with a specific etiology such as children with Down Syndrome (Jarrold & Baddeley, 2001). In Down Syndrome, weaknesses and small variability in verbal short-term memory may account for reading problems. Research focusing on Williams Syndrome, however, also

points out that within a diagnostic subgroup, variation in (linguistic) profiles also occur (Mervis, 2009). It is therefore not known whether, for example, etiology-based interventions will be more effective than interventions for more general groups of children with ID, indifferent of clinical subtypes of ID (Hodapp, DesJardins, & Ricci, 2003). Finally, the majority of children with ID do not have a specific or known etiology, despite the fact that they are intellectually disabled. Therefore, this group of children needs to be taken seriously in research and education too, and despite the heterogeneous composition of such groups, conclusions can be drawn on related to their literacy skills and development.

4.3. Limitations

There are some limitations to the present study that must be acknowledged. Within this field of research, we were able to test two groups of children ($n = 74$ and $n = 53$), of whom one group was a clearly defined Dutch, heterogeneous group of children with ID with mixed etiologies. It is debatable to what extent the group sizes in the present study are problematic in SEM analysis. In a study by Wolf, Harrington, Clark, and Miller (2013) it was claimed that for SEM, sample size requirements could be as small as $N = 30$ and still show important associations between parameters. We therefore assume that our models add to the literature how and which variables predict early literacy acquisition in children with ID.

Another limitation concerns the tasks being used in the present study. Because it was expected that some children with ID would possibly not be able to speak, it was chosen to provide all measurements receptively (except for the articulation tasks, word span and rapid naming, since these tasks cannot be assessed in a receptive manner). Receptive answering occurred by pointing to pictures or words, in so providing all children the possibility to execute these tasks. When children become older and develop speech, it is important to assess them on both receptive and oral word decoding tasks such as nonword reading tasks. With these extra measures, word decoding can be controlled for sight word learning strategies. Moreover, making use of various word decoding tasks such as word attack or pseudoword reading will tap further into phonological processing, extending the view on the role of phonological awareness in early literacy acquisition in children with ID.

A final limitation concerns the fact that the present study followed a cross-sectional design so that causal interpretations of criterion and predictor measures should be interpreted with caution. In order to further investigate the possible role of phonological awareness in learning to read in this special group of children, longitudinal research within this group of children seems pivotal. It will provide new insights on how these children learn literacy, what skills or which combinations of skills hamper them in their quest towards literacy acquisition, but it will also show these children's strengths. This information will eventually lead to a clearer understanding of (the development of) literacy acquisition in children with ID.

4.4. Conclusions and implications

To conclude, the present research provides evidence that children with ID may become literate while not using the same strategy as children with NLA. In the present study, early literacy levels of children with NLA could be predicted by phonological awareness, PSTM and vocabulary, with nonverbal reasoning and auditory discrimination predicting phonological awareness. In children with ID, the variation in word decoding was predicted by letter knowledge whereas letter knowledge was predicted not by phonological awareness but by rapid naming which on its turn was predicted by attentional skills. It can thus be concluded that the arrears in phonological awareness in children with ID may put them on hold in gaining proper access to literacy acquisition.

For educators, findings of the present study indicate that it is important to explicitly teach phonological awareness to children with ID to help them to become literate, in the perspective of successful participation in society. Since nonverbal reasoning predicted both phonological awareness and word decoding, it is assumed that if children strengthen their overall cognitive skills, they could learn to apply phonological awareness skills in literacy acquisition. It is also important that educators should keep stimulating these early literacy skills and not switch too quickly to a whole-word reading strategy. Besides strengthening cognitive skills, training phonological awareness skills in this group of children is important too (Joseph & Seery, 2004), since children with ID already start to apply these skills as reading strategy from a young age onwards. Of course, whilst training phonological awareness, educators should adjust literacy material to the learning pace of each individual child. For example, educators may sing nursery rhymes or develop rhyming exercises, or practice with letter-names.

Children with ID also need to have access to early literacy not only in their schools in order to start to develop early literacy. This could be provided to the child at home, without it being so much that the child gets overwhelmed. Again, home literacy materials have to be suitable to the developmental age of the child. It is known that the home literacy environment of NLA children (e.g., Sénéchal & LeFevre, 2014), and children with ID (e.g., Van der Schuit, Peeters, Segers, Van Balkom, & Verhoeven, 2009) can strengthen prior knowledge, which will provide children a basis for proper literacy acquisition, once they enter formal literacy education. By these means, children may become able to discriminate phonemes passively, and this potential will help them in their active phonological processing once they start acquiring early literacy skills.

References

- Barker, R. M., Sevcik, R. A., Morris, R. D., & Ronski, M. (2013). A model of phonological processing, language, and reading for students with mild intellectual disability. *American Journal on Intellectual and Developmental Disabilities*, 118, 365–380. <http://dx.doi.org/10.1352/1944-7558-118.5.365>.
- Boat, T. F., & Wu, J. T. (2015). *Clinical characteristics of intellectual disabilities. Mental disorders and disabilities among low-income children*. Washington D.C: The National Academies Press 169–178.

- Bowman, M., & Treiman, R. (2008). Are young children logographic readers and spellers? *Scientific Studies of Reading*, 12, 153–170. <http://dx.doi.org/10.1080/10888430801917233>.
- Carlson, S. M., & Moses, L. J. (2001). Individual differences in inhibitory control and children's theory of mind. *Child Development*, 72, 1032–1053.
- Catts, H. W., Fey, M. E., Tomblin, J. B., & Zhang, X. (2002). A longitudinal investigation of reading outcomes in children with language impairments. *Journal of Speech Language and Hearing Research*, 45, 1142–1157. [http://dx.doi.org/10.1044/1092-4388\(2002\)093](http://dx.doi.org/10.1044/1092-4388(2002)093).
- Channell, M. M., Loveall, S. J., & Connors, F. A. (2013). Strengths and weaknesses in reading skills of youth with intellectual disabilities. *Research in Developmental Disabilities*, 34, 776–787. <http://dx.doi.org/10.1016/j.ridd.2012.10.010>.
- Connors, F. A., Atwell, J. A., Rosenquist, C. J., & Sligh, A. C. (2001). Abilities underlying decoding differences in children with intellectual disability. *Journal of Intellectual Disability Research*, 45, 292–299.
- Costanzo, F., Varuzza, C., Menghini, D., Addona, F., Giansesini, T., & Vicari, S. (2013). Executive functions in intellectual disabilities: A comparison between Williams syndrome and Down syndrome. *Research in Developmental Disabilities*, 34, 1770–1780. <http://dx.doi.org/10.1016/j.ridd.2013.01.024>.
- Dahlin, K. I. E. (2011). Effects of working memory training on reading in children with special needs. *Reading and Writing*, 24, 479–491. <http://dx.doi.org/10.1007/s11145-010-9238-y>.
- Danielson, H., Henry, L., Messer, D., & Rönnerberg, J. (2012). Strengths and weaknesses in executive functioning in children with intellectual disability. *Journal of Research in Developmental Disabilities*, 33, 600–607. <http://dx.doi.org/10.1016/j.ridd.2011.11.004>.
- David, D., Wade-Woolley, L., Kirby, J. R., & Smithrim, K. (2007). Rhythm and reading development in school-age children: A longitudinal study. *Journal of Research in Reading*, 30, 169–183. <http://dx.doi.org/10.1111/j.1467-9817.2006.00323.x>.
- de Beer, Y. (2011). *De kleine gids mensen met een licht verstandelijke beperking*. Alphen aan den Rijn: Kluwer.
- Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, 64, 135–168. <http://dx.doi.org/10.1146/annurev-psych-113011-143750>.
- Dickinson, D. K., McCabe, A., Anastasopoulos, L., Peisner-Feinberg, E. S., & Poe, M. D. (2003). The comprehensive language approach to early literacy: The inter-relationships among vocabulary, phonological sensitivity, and print knowledge among preschool-aged children. *Journal of Educational Psychology*, 95, 465–481. <http://dx.doi.org/10.1037/0022-0663.95.3.465>.
- Dong, Y., & Peng, C. J. (2013). Principled missing data methods for researchers. *SpringerPlus*, 2(222), <http://dx.doi.org/10.1186/2193-1801-2-222>.
- Dunn, L. M., & Dunn, L. M. (1997). *Peabody picture vocabulary test* (3rd ed.). Circle Pines: AGS.
- Erickson, K., Hanser, G., Hatch, P., & Sanders, E. (2009). *Research-based practice for creating access to the general curriculum in reading and literacy for students with significant intellectual disabilities*. Retrieved from http://www.ccsso.org/Documents/2009/Research_Based_Practices_Reading_2009.pdf.
- Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance in children 3.5–7 years old on a stroop-like-day-night test. *Cognition*, 53, 129–153.
- Goswami, U. (2001). Early phonological development and the acquisition of literacy. In S. B. Neuman, & D. Dickinson (Eds.). *Handbook of early literacy research* (pp. 111–125). New York: Guilford.
- Henry, L., & Winfield, J. (2010). Working memory and educational achievement in children with intellectual disabilities. *Journal of Intellectual Disability Research*, 54, 354–365. <http://dx.doi.org/10.1111/j.1365-2788.2010.01264.x>.
- Hodapp, R. M., DesJardin, J. L., & Ricci, L. A. (2003). Genetic syndromes of mental retardation. Should they matter for the early interventionist. *Infants and Young Children*, 16, 152–160.
- Howell, D. C. (2008). The treatment of missing data. In W. Outhwaite, & S. Turner (Eds.). *Handbook of social science methodology* (pp. 208–224). London: Sage.
- Jarrold, C., & Baddeley, A. D. (2001). Short-term memory in Down syndrome: Applying the working memory model. *Down Syndrome Research and Practice*, 7(1), 17–23. <http://dx.doi.org/10.3104/reviews.110>.
- Jongen, I., Krom, R., & Roumans, P. (2009). *Technisch lezen groep 3: Handleiding*. Arnhem: Cito.
- Joseph, L. M., & Seery, M. E. (2004). Where is the phonics: A review of the literature on the use of phonetic analysis with students with mental retardation. *Remedial and Special Education*, 25, 88–94.
- Kennedy, E. J., & Flynn, M. C. (2003). Early phonological awareness and reading skills in children with Down syndrome. *Down Syndrome Research and Practice*, 8, 100–109.
- Laing, E., Hulme, C., Grant, J., & Karmiloff-Smith, A. (2001). Learning to read in Williams syndrome: Looking beneath the surface of atypical reading development. *Journal of Child Psychology and Psychiatry*, 42, 729–739.
- Levy, Y. (2011). IQ predicts word decoding skills in populations with intellectual disabilities. *Research in Developmental Disabilities*, 32, 2267–2277. <http://dx.doi.org/10.1016/j.ridd.2011.07.043>.
- Lonigan, C. J., Burgess, S. R., & Anthony, J. L. (2000). Development of emergent literacy and early reading skills in preschool children: Evidence from a latent-variable longitudinal study. *Developmental Psychology*, 36, 596–613. <http://dx.doi.org/10.1037/0012-1649.36.5.596>.
- Melby-Lervåg, M., Halaas Lyster, S. A., & Hulme, C. (2012). Phonological skills and their role in learning to read: A meta-analytic review. *Psychological Bulletin*, 138, 322–352. <http://dx.doi.org/10.1037/a0026744>.
- Mervis, C. B. (2009). Language and literacy development of children with Williams syndrome. *Topics in Language Disorders*, 29, 149–169. <http://dx.doi.org/10.1097/TLD.0b013e3181a72044>.
- Metsala, J. L. (1999). Young children's phonological awareness and nonword repetition as a function of vocabulary development. *Journal of Educational Psychology*, 91, 3–19.
- Metsala, J. L. (2011). Repetition of less common sound patterns: A unique relationship to young children's phonological awareness and word reading. *International Journal of English Linguistics*, 1, 3–17. <http://dx.doi.org/10.5539/ijel.v1n2p3>.
- Näslund, J. C., & Schneider, W. (1996). Kindergarten letter knowledge, phonological skills, and memory processes: Relative effects on early literacy. *Journal of Experimental Child Psychology*, 62, 30–59. <http://dx.doi.org/10.1006/jecp.1996.0021>.
- Næss, K. B., Melby-Lervåg, M., Hulme, C., & Halaas Lyster, S. (2012). Reading skills in children with Down syndrome: A meta-analytic review. *Research in Developmental Disabilities*, 33, 737–747. <http://dx.doi.org/10.1016/j.ridd.2011.09.019>.
- Peeters, M., Verhoeven, L., van Balkom, H., & de Moor, J. (2008). Foundations of rhyme perception in children with cerebral palsy: The impact of cognitive impairment. *Journal of Intellectual Disability Research*, 52(1), 68–78. <http://dx.doi.org/10.1111/j.1365-2788.2007.00986.x>.
- Pullen, P. C., & Justice, L. M. (2003). Enhancing phonological awareness, print awareness, and oral language skills in preschool children. *Intervention in School and Clinic*, 39(2), 87–98.
- Ratz, C. (2013). Do students with Down syndrome have a specific learning profile of reading? *Research in Developmental Disabilities*, 34, 4504–4514. <http://dx.doi.org/10.1016/j.ridd.2013.09.031>.
- Raven, J. C. (1956). *Guide to using the coloured progressive matrices*. London: H.K. Lewis.
- Roid, G. H., & Miller, L. J. (1997). *Leiter international performance scale – revised: Examiner's manual*. In G. H. Roid, & L. J. Miller (Eds.). *Leiter international performance scale – revised*. Wood Dale, IL: Stoelting Co.
- Sénéchal, M., & LeFevre, J. (2014). Continuity and change in the home literacy environment as predictors of growth in vocabulary and reading. *Child Development*, 85, 1552–1568. <http://dx.doi.org/10.1111/cdev.12222>.
- SCP (2014). *Sociaal en cultureel planbureau. statusscores [Status scores]*. Retrieved on 17–11–2014 from www.scp.nl.
- Schaefer, J. L. (1997). *Analysis of incomplete multivariate data*. CRC Press.
- Schuchardt, K., Maehler, C., & Hasselhorn, M. (2011). Functional deficits in phonological working memory in children with intellectual disabilities. *Research in Developmental Disabilities*, 32, 1934–1940. <http://dx.doi.org/10.1016/j.ridd.2011.03.022>.
- Soltani, A., & Roslan, S. (2013). Contributors of phonological awareness, phonological short term memory, and rapid automated naming, toward decoding ability in students with mild intellectual disability. *Research in Developmental Disabilities*, 34, 1090–1099. <http://dx.doi.org/10.1016/j.ridd.2012.12.005>.
- Storch, S. A., & Whitehurst, G. J. (2002). Oral language and code-related precursors to reading: Evidence from a longitudinal structural model. *Developmental Psychology*, 38, 934–947. <http://dx.doi.org/10.1037/0012-1649.38.6.934>.
- Van Tilborg, A., Segers, E., Van Balkom, H., & Verhoeven, L. (2014). Early literacy skills in children with intellectual disabilities: A clinical perspective. *Research in*

- Developmental Disabilities*, 35, 1674–1685. <http://dx.doi.org/10.1016/j.ridd.2014.03.025>.
- Van Uden, A. (1983). *Diagnostic testing of deaf children. The syndrome of dyspraxia*. Lisse, The Netherlands: Swets & Zeitlinger.
- Van de Sande, E., Segers, E., & Verhoeven, L. (2013). How phonological awareness mediates the relation between children's self-control and word decoding. *Learning and Individual Differences*, 26, 112–118. <http://dx.doi.org/10.1016/j.lindif.2013.05.002>.
- Van der Schuit, M., Peeters, M., Segers, E., Van Balkom, H., & Verhoeven, L. (2009). Home literacy environment of pre-school children with intellectual disabilities. *Journal of Intellectual Disability Research*, 53, 1024–1037. <http://dx.doi.org/10.1111/j.1365-2788.2009.01222.x>.
- Verhoeven, L., Van Leeuwe, J., Irausquin, R., & Segers, E. (2016). The unique role of lexical accessibility in predicting kindergarten emergent literacy. *Reading and Writing*, 29, 591–608. <http://dx.doi.org/10.1007/s11145-015-9614-8>.
- Verhoeven, L. (2005). *ESM-toets [Test for children with specific language impairment]*. Arnhem, The Netherlands: Cito.
- Vloedgraven, J., Keuning, J., & Verhoeven, L. (2009). *Screeningsinstrument beginnende geletterdheid diagnostic instrument for emerging literacy*. Arnhem, The Netherlands: Cito.
- Wise, J. C., Sevcik, R. A., Ronski, M., & Morris, R. D. (2010). The relationship between phonological processing skills and word and nonword identification performance in children with mild intellectual disabilities. *Research in Developmental Disabilities*, 31, 1170–1175. <http://dx.doi.org/10.1016/j.ridd.2010.08.004>.
- Wolf, E. J., Harrington, K. M., Clark, S. L., & Miller, M. W. (2013). Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and Psychological Measurement*, 73, 913–934. <http://dx.doi.org/10.1177/0013164413495237>.