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The Influence of Regulatory Skills on Early Literacy Development During e-storybook Reading

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Abstract
The effects of a classroom-focused intervention using a print referencing technique with shared e-book reading on a whiteboard is examined on different domains of early literacy. The goals of this study were to examine whether the impact of a print referencing embedded reading tool on learning capacities will be different for children varying in executive control functioning. Print knowledge, including phonics, and phonological awareness increase after the print referencing e-book interventions compared to the control conditions with a large effect size. Print referencing did not hinder children in learning new words, but enhanced vocabulary to the same extent as e-books normally do in kindergarten. Print referencing especially supports children with low regulatory skills to learn printed matters and to increase phonological awareness and remarkably, enhances vocabulary much better than reading without referring to print. The findings indicate that print referencing is a highly beneficial method to enhance all essential early literacy skills at the same time. It increases engagement in learning tasks, which potentially supports school achievement. The learning tool is particularly efficient for a tailor-made educational setting and will contribute to less workload for teachers.

Keywords Picture storybooks · E-books · Print referencing · Executive functions · Print knowledge · Phonological awareness · Expressive vocabulary

Introduction

Shared e-Storybook Reading and Early Literacy Development

For successful participation in a modern society with high information flow, becoming literate, and thus learning to read, is a prerequisite (Snow, 2017). Upon entering kindergarten, children differ largely in their development of emergent reading skills. Gaps in these foundational skills must be addressed early as these effect achievement in later grades (Coyne et al., 2004; D' Agostino, 2017). To protect children with inadequate emergent literacy skills for being at risk to develop reading problems, high-quality evidence-based early reading instruction is crucial (Foorman et al., 1998; Lonigan et al., 2013).

Many different intervention programs have been developed for struggling readers, including Reading Recovery, Success for All, Response to Intervention, Reading Rescue, and ULFI foundations (Lane & Contesse, 2022; Miles et al., 2022; Siegel, 2020; Slavin et al., 2010). The most effective programs contain a strong phonological component, because phonological awareness and phonics (letter-sound correspondence) are essential for word reading skills (Lane et al., 2025; Rice et al., 2022). Given the pivotal role of word decoding in children's reading development, foundational skills for word decoding are studied intensively (Bautista et al., 2024), and are identified as phonological awareness, letter-sound knowledge (phonics), and print awareness in alphabetic languages (e.g. Breadmore et al., 2019; Hjetland et al., 2017). However, overall reading success includes reading comprehension (Castles et al., 2018), requiring linguistic comprehension which highly correlates with vocabulary knowledge in preschool (Hjetland et al., 2017). Learning vocabulary, developing oral language skills, and acquiring knowledge is just as important for children as learning letters, sounds and decoding, to be prepared to understand literate language in books, both when they are

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read to or when they read themselves (Snow, 2017; National Reading Panel (NRP), 2000).

In the Netherlands no integrated program exists to develop foundational reading skills in kindergarten. A study has been set up to generate an integrated early reading tool called e-Prent&ABC to develop the foundational skills together (van Dijken, 2019, 2024). The precursor program of e-Prent&ABC has been tested and found positive results: children progressed in all foundational skills (van Dijken, 2023) and teachers in a tailor-made educational setting experienced the program as work-saving and efficient for classroom learning. Children however differed largely in growth of these skills even though they are in the same class and age range. Differences in regulatory skills between the kindergartners are a good candidate to explain some variances in learning gains. The purpose of this study is to determine the influence of relatively low executive function skills for learning with e-Prent&ABC to establish if differential attention is needed for these children. First, the design of e-Prent&ABC will be justified by discussing the theoretical base and practical application to develop early literacy, followed by the influence of EF on learning in general.

The acquisition of the key component of emergent literacy, phonological awareness, is explicitly taught by manipulating (groups of) phonemes in spoken words (National Reading Panel (NRP), 2000). Letters may facilitate the perception of phonemes and are essential for the transfer to word reading and word spelling (National Reading Panel (NRP), 2000), therefore, the phonological awareness training often includes the teaching of letters and phonics. Teaching print-related skills however is not part of the emergent reading instruction. For vocabulary development, teaching methods based on the 4-Cycle-model (Verhallen & Verhallen, 1994) are often used. The steps taken in teaching word meanings in this didactic model are based on the concept of 'robust' instruction which, according to research, has a great learning effect on vocabulary (Beck et al., 2013). In addition, storybook reading is applied to generally improve literacy development.

Teachers in kindergarten have the time-consuming task of stimulating foundational reading skills with a group of children who often differ considerably in their literacy development. Therefore, it is important to have an efficient program available in schools to stimulate early literacy skills for all children in the class. Reading aloud could potentially form the basis of such a program.

Storybook reading has been effective in stimulating all essential precursors of emergent literacy promoting later reading success with vocabulary (e.g., Justice et al., 2005; Kelley et al., 2015; Sénégal and Cornell, 1993; Stewart & Correia, 2023), and phonological awareness (e.g., Bowyer-Crane et al., 2008) including phonics (Ukrainetz et al., 2000) and print knowledge (e.g., Justice et al., 2009, 2010; Justice et al., 2015; Zucker et al., 2009).

An effective approach for children's literacy development has been identified by shared (story)book reading; that is, the interactions and discussions that occur when adults and children read a book together (Mol et al., 2008). Extratextual conversations and interactions beyond reading the text, are predictive of growth in code related skills (print knowledge), oral language (vocabulary and phonological awareness), and phonics (Campbell, 2021; Cabell et al., 2008; Blewitt et al., 2009; Mol et al., 2017; Zucker et al., 2013).

When reading storybooks with an adult, children spent more than 90% of the time looking at the pictures and about 5–6% is paying attention to the print features (Evans & Saint-Aubin, 2013). This helps children to expand their vocabulary: the illustrations are inspected in concert with the spoken text and the children try to match what they see with what they hear. This enables them to add new low frequency words to their vocabulary (Evans & Saint-Aubin, 2013). However, the degree to which children learn about print depends on the extent to which adults (non)verbally refer to the text and other printed elements of the book and the extent to which children pay attention to print (Justice et al., 2008). Also, Lin et al. (2018) showed that children's attention to words significantly predicted posttest word reading (Chinese two characters words).

An effective technique to draw children's attention to print is known as print referencing (Justice & Ezel, 2004). During shared book-reading sessions, verbal cues (e.g., 'this is the word Mother it starts with the letter M, which sounds like mmm'; or explaining the function of punctuation marks) and nonverbal cues (e.g., pointing to text and showing the direction in which a text is read) are used to shift the focus of children from the illustration to printed matters. Print referencing has been shown to improve print knowledge (Gettinger & Stoiber, 2014; Justice & Ezell, 2002; Justice et al., 2009) and it can also help with, for example, placing the focus on the spelling of words and, therefore, with the practice of letter-sound connection. Promoting spelling through print referencing was found to be effective in past research (e.g., Piasta et al., 2012). Spelling training also supports the development of phonological awareness in children (e.g., Stahl & Murray, 1994); so, print referencing could be used to stimulate phonological senses and thus reading development.

The use of interactive e-storybooks, electronic forms of a traditional print book, to enhance early literacy skills (Moody, 2010) can be more beneficial to literacy development than traditional storybooks (De Jong & Bus, 2003). Comparing traditional storybook reading with digital storybook reading gives mixed findings regarding the potential

benefits (Rohlfing et al., 2024). It is crucial to consider the features embedded in e-books, as their effectiveness varies, they can either be a distraction or they facilitate learning (Rohlfing et al., 2024). Moreover, an important factor in the development of early literacy skills is the interaction during reading aloud between the child and the caregiver. Meaningful interactions have a positive effect on early literacy (Savva et al., 2022; Zucker et al., 2013). The interactions that parents show when they read from traditional- or digital storybook are equally beneficial, provided that when reading e-books the parent finds the medium appropriate for reading and that the medium is familiar to the child as well as to the parent. Also, the supporting features in e-books must be context-relevant, intuitive, and familiar (Clinton-Lisell et al., 2024).

Taking the conditions under which e-books can be beneficial into account, there is ample evidence that they can be of added value to enhance early literacy skills. e-Storybooks offer, in addition to the text and pictures present in the paper version, digital features that can assist the reader (De Jong & Bus, 2002; Korat & Shamir, 2004). The digital features built into e-books can enhance children's motivation (Smith, 2012) and reading engagement (Moody et al., 2010; Zhou & Yadav, 2017) and draw their attention towards important aspects of print or story elements. In this way, the features provide a scaffold to children and contribute to improved emergent literacy (Takacs & Bus, 2016). Segal-Drori et al. (2010) showed that children made greater progress in word reading and concepts about print (CAP) with e-books than through traditional books. Zhou and Yadav (2017) proved the same evidence for the development of vocabulary as well as O'Toole and Kannass (2018) when comparing e-book reading with traditional print book reading.

Many studies in the last two decades have shown that all concepts of emergent literacy can be addressed using e-books. e-Book reading has been demonstrated to be effective for story comprehension, expanding vocabulary and syntax and promoting phonological awareness (e.g., Evans & Saint-Aubin, 2013; Korat, 2010; Shamir, 2017; Shamir et al., 2012; Smeets & Bus, 2012; Verhallen et al., 2006), as well as print knowledge when using print referencing (Gong & Levy, 2009; Gettinger & Stoiber, 2014) including phonics (Ihmeideh, 2014; Korat & Segal-Drori, 2016). Especially phonological awareness can be supported by drawing attention to print: animated e-books (Ihmeideh, 2014) and multimedia books with an embedded tool for dividing and sounding out words (Chera & Wood, 2003; Shamir & Shlafer, 2011) show improvement of phonological awareness in kindergartners.

Traditionally, e-storybooks are meant to be used individually by the children on a computer. Literacy training with all children in a classroom, however, offers children the opportunity to accelerate learning: they will learn from each other and will bond easier with their teacher (Roorda et al., 2011). It also offers teachers a time-saving and more effective tool to differentiate in learning opportunities for all children. A whole-classroom approach combining interactive reading of e-storybooks, with print referencing, is e-Prent&ABC (van Dijken, 2016, 2023). The program overcomes the limitations of conventional print book reading in classrooms. The storybooks are presented on a large screen, like a digital whiteboard. Projection of enlarged pictures and texts onto a large screen provides unhindered vision to all children in the classroom which makes it easier for the children to navigate the illustrations to match what they see with what they hear. Careful examinations of illustrations in concert with the spoken text helps children to retain the story (Verhallen & Bus, 2012) and enables them to add new low frequency words to their vocabulary (Evans & Saint-Aubin, 2013). The use of digital storybooks allows implementing effective learning tools (multimedia) such as sounds and moving images to support text (Verhallen et al., 2006). Moreover, implementation of non-verbal print referencing (Gill & Islam, 2011; Moody, 2010) shifts visual attention of children to print. Normally children focus on the pictures in a storybook while reading (Evans & Saint-Aubin, 2013), but the focus on print is essential to train code related skills.

There are 2 versions of e-Prent&ABC. The more advanced version uses on top of interactive reading and print referencing, the 4-Cycle model (Verhallen & Verhallen, 1994), to further improve vocabulary (van Dijken, 2018, 2019, 2024). The simpler form of e-Prent&ABC has proven to be effective for development of the essential emergent early literacy skills for later reading skills, vocabulary, print knowledge and phonological awareness (van Dijken, 2016, 2023). Kindergartners were exposed to a single intervention which combined code related as well as meaning related skill training and improved those skills without a loss of impact on the development of either skill. Children however differed largely in growth of these skills even though they were in the same class and age range. Differences in regulatory skills between the kindergartners are a good candidate to explain some variances in learning gains. According to the working memory model (Baddeley, 2003), children must switch between code and meaning related input. A useful integration of this wide-ranging nature of input will depend on the capacity of their working memory. Variability in other regulatory skills like cognitive flexibility and self-control will have similar effects (Diamond et al., 2007). Therefore, combining these interventions can be detrimental for learning for children with lingering executive function skills.

Combined Skill Training and Regulatory Skills

The use of a tool to focus on print within the context of an e-Prent&ABC read-aloud means that there will be a delay in storytelling which is further strengthened when phonological awareness training is incorporated at the same time. Also, children's focus on printed matters will divert them from navigating the illustrations. The delay and the changed focus might be detrimental to learn new words (Evans & Saint-Aubin, 2013) especially in children with weak cognitive control skills, often referred to as poor executive functioning (EF).

Regulatory skills are related to school success (Best et al., 2009; Morgan et al., 2019) and language and literacy outcomes (Skibbe et al., 2019) and predict academic achievement in kindergarten (Fuhs et al., 2014; Ne'eman & Shaul, 2022). Essential executive functioning skills in kindergarten are cognitive flexibility, working memory and inhibitory- or self-control (Diamond et al., 2007). Cognitive flexibility is the ability to shift between different sets of tasks in response to changing situational demands (Zelazo et al., 1996); working memory is the ability to keep information in mind and manipulate the information (Baddeley & Hitch, 1974); and inhibitory control is the ability to suppress predominant and inappropriate responses or to ignore interfering stimuli or information (Diamond, 1990). Many studies have examined which of these executive functions specifically predict or are related to the development of emergent literacy skills in (pre)kindergarten.

Cognitive flexibility has been found to play a direct role in the ability to acquire new vocabulary during shared reading (Hill & Wagovich, 2020), to predict improvement in early vocabulary in children aged around 5 years old (McClelland et al., 2014) and to be important in kindergarten classroom learning of new words (Diamond, 2006). Cognitive flexibility is also predictive for print knowledge (Welsh et al., 2010) and is essential to make connections between spoken and written language and for understanding sound- and word structures (Colé et al., 2014). McNeill et al. (2025) showed that early language developers exhibited stronger phoneme awareness and cognitive flexibility than intermediate and late language developers and they also showed accelerated growth in their phoneme awareness ability between the ages of 4 and 5.

The development of working memory has been found to co-occur with the development of vocabulary and to predict improvement in early vocabulary (McClelland et al., 2014; Gray et al., 2022; Weiland et al., 2014). When children's focus is directed on print, they use visual cues to recognize letters and words, making them familiar with word patterns (Ne'eman & Shaul, 2022). They use their working memory for this recognition and at the same time letters can be converted into sounds. A study that investigated the relations between executive functioning and individual components of literacy skills in preschool children found a connection between working memory and phonological awareness (Purpura et al., 2017) and a study examining the developmental patterns among the relations between components of executive functioning and academic outcomes, like reading and language in elementary-school-age children, found a strong relation between working memory and decoding skills (Spiegel et al., 2021).

Children making improvements in inhibitory control, also made significant improvements in vocabulary skills over the prekindergarten and kindergarten years in the study of McClelland et al. (2014). In the study of Gandolfi et al. (2021), inhibition control at 2.5 years predicted phonological awareness and early orthographic knowledge at 5 years old. The ability to inhibit was found to be especially important in the development of printing knowledge including letter-word identification (McClelland et al., 2014; Purpura et al., 2017; Spiegel et al., 2021).

Although regulatory skills are conceptually distinct, it is a matter of debate if they are represented by a unitary factor or need a multi-faceted solution in young children (Monette et al., 2011). Children of 3- and 4-years of age shift reliably between two tasks, and this ability is improved between ages 5 and 6, while performance of working memory increases Linearly between age 4 and 15 and inhibition develops rapidly between age 3 and 5 (Best et al., 2009). Whether these skills develop in concert in individuals is not known, but children vary considerably in the rate of developing self-regulation (Skibbe et al., 2019). Also, the specific relations between the different regulatory skills change across development (Best et al., 2009) and predict different language and literacy skills (e.g., Monette et al., 2011; Kegel & Bus, 2012) or make unique contributions to children's learning (Clair-Thompson, 2011; Spiegel et al., 2021; McNeill et al., 2025). Moreover, there is neural support for a multi-faceted nature of executive functioning (EF), as the different components of EF tap different regions within the prefrontal cortex (Huizinga et al., 2006). Because the construct of EF is inconclusive, it is advisable to measure the (different) EF components with separate tasks tapping distinct abilities.

As stated before, learning emergent literacy skills (concepts of print, word phonology and the meaning of new words) from e-books with print referencing probably requires well developed regulatory skills. Children must switch back and forward from the text to the pictures, keep the book story in mind and must process this information in memory. At the same time, they must inhibit distractions from classroom or peer activities and keep their focus on the screen. Kindergarteners showing insufficient cognitive flexibility will struggle to switch between tasks like following a

story while paying attention to print (Diamond et al., 2007; Cartwright, 2008). Print referencing forces them to focus on the print, but representations for word learning, like the illustration (Evans & Saint-Aubin, 2013) and the story read to them (Bus et al.,2009), will get less attention. Reduced attention to the illustrations can prevent the association of difficult words with pictures, which is detrimental to word learning. Fragmentation of the story can disrupt coherence and thus reduce story comprehension. However, this rigid behaviour could be beneficial for code-related learning in a print referencing condition which grasps their attention. Children with a poor working memory will benefit from print referencing learning print knowledge and probably also word phonology, but it might be detrimental for learning new words at the same time. In the model of working memory phonological and visual information enter via different subsystems (Baddeley, 2003). Gaining code-related knowledge as well as learning new words taxes the central executive requiring that attention will be devoted to both components. The focus on print when using print referencing will give the episodic buffer enough input to integrate the information for learning new print conventions but might be deprived of sufficient input for new word learning. Finally, children with poor self-control are sensitive to distractions from a task (Diamond et al., 2007). When listening to an e-book in the classroom they will be less proficient in ignoring disturbances from classmates and their inattentiveness will prevent them from engaging positively in learning behaviours (Nesbitt et al., 2015). Print referencing is a dominant stimulus and will focus their attention on the whiteboard, which will encourage learning-related performance in these children. The impact of print referencing on learning concepts of print and vocabulary or increasing phonological awareness might therefore be different for children varying in cognitive control skills, and this impact will be irrespective of the weakest component in their executive functioning.

The Present Study

The present study examines if the approach to enhance different domains of early literacy in one intervention i.e., training print knowledge, vocabulary and phonological awareness simultaneous during shared book reading with print referencing is suitable for children with relatively low executive function skills. Comparing e-Prent&ABC to e-book reading without using print referencing, proved to contribute to the development of print knowledge, phonological awareness and vocabulary to all children in a classroom setting (van Dijken, 2023) and it is expected that e-Prent&ABC will:

1. Benefit children with relatively less well-developed regulatory skills more in their progress in print knowledge and phonological awareness than children with relatively good developed regulatory skills;
2. Have no effect on vocabulary growth for children with relatively good executive functioning;
3. Have a detrimental effect on vocabulary expansion for children with relatively less well-developed regulatory skills.

Methods

Participants

This study is part of a bigger project in which a total of 80 kindergarteners (40 boys and 40 girls) between 4 and 6 years old (M = 60.13 months, SD = 6.74) from 6 different classroom groups participated. They were typically from mixed but generally middle-socioeconomic status (SES) families with Dutch as first language. Participating children's mean standardized scores on the Peabody Picture Vocabulary Test (PPVT-III-NL, Schlichting, 2005; M = 75,49, SD = 12.87) indicated that the sample was somewhat above average in vocabulary. Children were divided in 2 Cohorts (0 and 1) matched on their scores of the Concept of Print pretest and general vocabulary (PPVT). Cohort 1 (N = 43) was used in this study to determine the influence of regulatory skills on print knowledge and phonological awareness in early literacy development and for the influence of vocabulary, the whole sample was used (N = 80).

Design

A pretest-posttest within subject design, the same participants in all conditions of the experiment, was used to examine the influence of storybook reading with print referencing on the development of print knowledge, phonological awareness and book specific vocabulary.

Each group of children heard 4 different storybooks in 2 different formats on the whiteboard in the classroom: the first two stories (T1 and T2) were presented in a simple e-book format where a voice-over tells the story while the children look at the accompanying pictures with the written story text; the next 2 story books (PR1 and PR2) include, beside the (spoken and written) text, a print referencing tool (see below). The fifth storybook (CB) served as a control: book specific vocabulary was tested pre- and post-intervention without hearing the story. To diminish the influence of differential performance across storybooks, the books were counter-balanced for conditions and groups of children. All

children were pre- and post-tested on Print Knowledge, Phonological Awareness and book specific (target) expressive Vocabulary as well after the T (text) condition and after the PR (print referencing) condition (see Table 1 for the experimental set up and distribution of e-books on different groups and conditions).

Materials

Storybooks

Five Dutch storybooks were available in an e-book format: *Beer is op Vlinder* [Bear is in Love with Butterfly] (Van Haeringen, 2004), *Rokko Krokodil* [Rocco the Crocodile] (De Wijs & van den Hurk, 2001), *Tim op de Tegels* [Pete on the Pavement] (Veldkamp & de Boer, 2004), *Na-Apers* (Copycats) (Veldkamp & de Boer, 2006) and *Kleine Kangoeroe* [The Minute Marsupial] (Van Genechten, 2005). Each story was available in 2 forms (simple e-book with Text and e-book with Print Referencing).

Print Referencing Tool

To focus attention of children on printed matters several print referencing features were built into a power point presentation of the e-book to address all concepts of print knowledge: sentences were highlighted at the speed of the reading voice over; letters and words turned into a different color and were subsequently pronounced by a trained assistant (e.g., 'this is the letter B*ee*, the B*ə* from Bear); print conventions, like the usage of a comma or question mark, were pointed out and briefly explained by the assistant and print violations of words (e.g. words containing only vowels or consonants) and sentences (e.g., all words connected together) were commented upon by the assistant with: 'oh, oh this word is written the wrong way' or 'oh, oh this sentence is written the wrong way' and thereafter corrected by an animation. To be able to watch the animations and listen to the comments of the assistant, the story was interrupted for a short while.

To refer to phonics and phonology the highlighted letters in the print referencing e-books were sounded out loud in combination with the word they belong to (e.g., this is the Mmm from Mother) and the highlighted words were also sounded out loud by the assistant and either broken down into their phonemes and subsequently blended to the complete word (e.g., m/a/m/a, mama) or broken down into syllables while clapping hands for each part (e.g., wing flapping wing/fla/pping; one word in Dutch: 'fladderen'). An example of the instructional protocol is given in Apendix 1. For these comments, the story was again interrupted for a short while.

Vocabulary Tests

A Dutch version of the Peabody Picture Vocabulary Test (PPVT-III-NL, Schlichting, 2005) was used to assess children's verbal intelligence (general receptive vocabulary).

A cued Expressive Vocabulary test was administered to assess children's knowledge of words that were used in the target storybooks. Children were asked to complete sentences, which did not resemble the exact phrases in the storybooks, with target words. The experimenter read an incomplete sentence (e.g., 'Rokko is sitting on a ……'), while corresponding pictures from the storybooks (e.g., Rokko sitting on a 'jetty' with a rowing boat attached to it) were shown on screen. Children's responses were coded as correct when they completed the sentence with the target word. In creating this test, low frequency words as listed by Schrooten and Vermeer (1994) were selected assuming that they would be unknown by most kindergarten children. The test consisted of 35 target words (7 from each storybook). The words are found to be relatively unknown and revealed neither ceiling nor bottom effects in prior research (Smeets & Bus, 2012; Verhallen & Bus, 2010; Verhallen et al., 2006). The reliability of the test is high (Cronbach's Alpha = 0.85).

Code Related Skills Test

Print knowledge was measured with a Concepts of Print Test (CPT; van Dijken, 2023) containing all key areas of

Table 1 Experimental set up and E-books distribution over conditions and experimental groups

Group	Pre-tests	Condition T		Post-tests (T1&2)	Condition PR		Post-tests (PR1&2)	CB
		T1	T2		PR1	PR2		
1	PK/PhA/VOC	A	B	PK/PhA/VOC	C	D	PK/PhA/VOC	E
2	PK/PhA/VOC	B	C	PK/PhA/VOC	D	E	PK/PhA/VOC	A
3	PK/PhA/VOC	C	D	PK/PhA/VOC	E	A	PK/PhA/VOC	B
4	PK/PhA/VOC	D	E	PK/PhA/VOC	A	B	PK/PhA/VOC	C
5 & 6	PK/PhA/VOC	E	A	PK/PhA/VOC	B	C	PK/PhA/VOC	D

PR print referencing; T1&T2 = e-book read without PR; PR1&PR2 = e-book read with PR; CB = control e-book; PK = Print Knowledge, PhA = Phonological Awareness, Voc = target expressive vocabulary; Book A: Bear is in Love with Butterfly ('Beer is op Vlinder'); Book B: Rocco the Crocodile ('Rokko Krokodil'); Book C: The Minute Marsupial ('Kleine Kangoeroe'); Book D: Pete on the Pavement ('Tim op de Tegels'); E: Copycats ('Na-Apers'). Dutch titles between brackets

print awareness (print concepts, concept of word and alphabetic knowledge), based on Justice and Ezell (2004), Zucker et al. (2009) and the print tests used by Clay (1989, 2000) and Gong and Levy (2009). The CPT consists of 8 items about print concept (e.g., 'where do I start reading'), 7 items about the organization of text in sentences, words and letters (e.g., 'Point to the first sentence/word/letter'), 6 items about alphabetic knowledge and 8 items about interpunction (e.g. 'what is the name of this sign and where do you use it for'). The questions were asked by the experimenter, while the children looked at pictures from the story book, they had read that week. The CPT pre-test contains pictures from a storybook unknown to the children. The maximum score of this part of the test was 29. The last category was a discrimination task containing two classes, readable print and print violations, in 3 types of word concept: shape, elements and spelling (Gong & Levy, 2009). Each type was combined in 1 score (0 points for up to 3 successes (chance level), 1 point for 4 or 5 successes and 2 points for 6 successes), which make a maximum score of 30 for this category. The CPT post-tests were adapted for the alphabetic letters and pictures of the storybooks read. The reliability of the test is high (Cronbach's Alpha = 0.91).

Phonological Skills Test

Phonological awareness tasks were adjusted from 2 subtest of the Clinical Evaluation of Language Fundamentals, fourth edition, Dutch version (CELF-4-NL; Kort et al., 2008): Phoneme Combination and Syllables Clapping. For both tasks the CELF test of 5 items was completed with 10 words taken from the picture books with two up to five phonemes and 6 syllables to combine (Cronbach's Alpha = 0.94).

Regulatory Skills Test

All the tests to measure regulatory skills contain test trials to ensure that the children understand the responses that were required. The task started when the children made a correct response.

Memory was measured using the forward Digit Word Span Test (Leidse Diagnostische Test; Schroots & Van Alphen, 1976) and the Backward Digit Span (Wechsler Intelligence Scale for Children-Third edition; WISC, Wechsler, 1992). In the forward digit span test, children had to repeat a list of unrelated words that was read aloud by the experimenter at a rate of 1 word per second. The number of words per test trial increased from 2 to a maximum of 5. The total number of correct responses (maximum 12) was the score of this task. This test was combined with the backward digit span test: children had to repeat a gradually increasing string from 2 digits onwards in reverse order. The digits were read aloud by the experimenter at a rate of 1 symbol per second and each trial contained two strings of digits. The task ended when children failed to repeat two series of the same trial. The score of this task was the total number of correct responses (maximum 10). The reliability of the combined memory test is acceptable (Cronbach's Alpha = 0.74).

Inhibitory control was measured using a computerized Stroop-like task (opposites) (Kegel et al., 2009; based on Berlin & Bohlin, 2002). Children had to respond with the opposite to contrasting pairs of pictures (e.g., saying 'open' to a picture of a closed door and saying 'closed' to a picture of an open door). Incorrect naming and corrections were both scored as errors, with a maximum score of 18. The reliability of this test is high (Cronbach's Alpha = 0.88).

Cognitive flexibility was measured using the Dimensional Change Card Match (DCCM). This test is modeled on the FIST (Jacques & Zelazo, 2001), a test based on the Visual-Verbal Test (Feldman & Drasgow, 1951), which measures flexibility in preschoolers with child friendly stimuli and a few clearly defined dimensions, without imposing a heavy burden on the memory. The DCCM differs from the FIST in respect of administration. It is a computerized task with 4 items to practice, to exclude the abstraction component, and 12 test trials. On 9 trials 3 cards are shown on the screen, the experimenter shows 2 resembling cards on one dimension (color, shape or magnitude) and then children must switch by pointing to 2 of these cards showing resemblance on a different dimension. In each trial all 3 test cards differ on 2 dimensions. On 6 subsequent trials 4 cards are shown on the screen and after the experimenter showed them a resemblance on 1 dimension, children must switch by pointing to 2 of these cards showing resemblance on a different dimension and again switch and point to 2 cards showing resemblance on yet another dimension. In each trial all test cards differ on 3 dimensions. The score of this task was the total number of correct switches (max 21). The reliability of this test is high (Cronbach's Alpha = 0.81).

Procedure

Ethical Considerations

All children in the study had parental permission to participate. The ethics approval (ECPW-2016/149) has been given by a standard procedure of Leiden University, which includes the research proposal, the data collection tools, and an informed consent. Children were tested voluntarily and were returned to their classroom if they no longer wished to participate.

Data Collection Procedures

Storybooks were shown on a whiteboard or large screen and read to all children in the classroom on 4 successive weeks. The first two weeks two e-picture books in the simple format with the written story text were alternately presented 3 times on different days and the last two weeks the two e-picture books in the Print Referencing version were alternately presented 3 times on different days (the order in which book titles are read is shown in Table 1). In the Print Referencing condition, it was a trained experimenter who made the referencing note.

Testing took place in a spare room in the school. Experimenters tested the children of the experimental group individually. The tests were digitalized and shown on a laptop with a wide screen. All book-specific vocabulary (Voc), print knowledge (PK) and phonological awareness (PhA) tests were pretested in the week before the intervention started and post tested on a successive day after each condition (T or PR) in the same week. The control-test for book-specific vocabulary was post tested after the last intervention. Tests to measure general receptive vocabulary (PPVT; a measure of verbal intelligence) and regulatory skills were administered during the 4 intervention weeks on days that story books were read in class. The test sessions lasted about 15 min each.

Analysis

Data were analysed using a Repeated Measure ANOVA (RMA). When conducting ANOVA, the accuracy of the F-test depends upon the assumption that scores in different conditions are independent. When RMA are used this assumption is violated. Therefore, in RMA the assumption of sphericity is made that the level of dependence between experimental conditions is roughly equal (Field, 2009). Planned comparisons are conducted to reveal any difference between the conditions.

As explained in the introduction, the construct of executive functioning is inconclusive and for this study the expectation on their influence will be irrespective of the weakest component tested. In other words: one weak component will influence the result and therefore they are taken together in one composite executive functioning score. Independent t-tests and RMA are used to measure the influence of cognitive control on children's learning performance of the e-books.

Data were tested with a significance level of $\alpha = 0.05$ and $\alpha = 0.025$ when data are used twice. Testing under $\alpha = 0.05$ with a power of 80% a minimum sample size of $N = 35$ is recommended (Georgiev, n.d.). All sample sizes are $N \geq 36$. To discover whether the effects of the intervention are substantive, partial η^2 is given ($\eta_p^2 = 0.01$ represents a small, $\eta_p^2 = 0.06$ a medium and $\eta_p^2 = 0.14$ large effect) and the F-values of the tests are converted into r-values. An effect size $r > .5$ forms a large effect and accounts for 25% of total variance, $r = .30$ represents a medium effect accounting for 9% of the variance and $r = .10$ is a small effect, explaining 1% of the variance (Field, 2009).

Results

To test the effect of executive functioning on Print knowledge (PK) and Phonological Awareness (PA) the cohort 1 sample was split into low (L-EF) and high (H-EF) functioning on executive control (median split on combined EF), for Active Vocabulary (AVoc) all participating children were split in L-EF and H-EF.

The results were interpreted in the context of the results from the larger experiment (van Dijken, 2023): for cohort 1 print knowledge increased from being tested after the Text condition (T) and increased from print referencing after the Print Referencing condition (PR), no effect was found from being tested twice; phonological skills do not develop from being tested nor increase from books being read to children without referring to print, but books being read in a print referencing style do contribute to phonological abilities; vocabulary while reading e-books using a print referencing style improve to the same extent as in e-books with only a reading mode.

Print Knowledge

An independent sample t-test revealed that children with lower executive functioning (L-EF) scored significantly lower on the pre- and post-tests conditions Text (T) and Print Referencing (PR) for Print knowledge than the higher performing peers (H-EF), $t(40) = 2.85$, $p < .007$; $t(40) = 4.36$, $p < .001$; $t(40) = 3.5$, $p < .001$ respectively (Table 2).

A multivariate RMA was used with Time (pre and post interventions T & PR) as within factor for both Executive functioning Groups (low and high; medial split) for cohort 1. For L-EF Mauchly's test indicated that the assumption of sphericity has not been violated ($p < .695$). There was a significant main effect for Time, $F(2,40) = 18.21$, $p < .001$, $\eta_p^2 = 0.48$, indicating that post-intervention Print knowledge scores were higher than their pre-intervention scores. The polynomic within-subject contrast revealed a significant quadratic trend $F(1,20) = 6.64$, $p < .018$, $\eta_p^2 = 0.25$, indicating more Print knowledge growth over time. Pairwise comparisons showed that increase in Print knowledge was only significant after the PR post-test, $p < .001$ (Fig. 1). Also, for H-EF Mauchly's test of sphericity was

Table 2 Descriptive statistics print knowledge (PK), phonological awareness (PA) and target vocabulary (AVoc; N=) in the text and print referencing conditions and in the control for groups high and low executive functioning skills; gain = growth after pre-tests

Executive functions High (H-EF)	Mean	sd	Gain	Executive functions Low (L-EF)	Mean	sd	Gain
PK Pre-test	15.05	5,3		PK Pre-test	9.86	6.4	
PK Post-test T	18.29	4.6	3.24	PK Post-test T	10.52	6.7	0.66
PK Post-test PR	21.90	5.3	3.61	PK Post-test PR	14.90	7.5	4.38
PA Pre-test	13.57	5.1		PA Pre-test	9.05	7.3	
PA Post-test T	14.71	6.3	1.14	PA Post-test T	8.45	7.2	−0.50
PA Post-test PR	17.52	6.7	2.81	PA Post-test PR	13.09	8.5	4.64
AVoc Pre-test Ctr	1.67	2.02		AVoc Pre-test Ctr	1.24	2.07	
AVoc Pre-test T	1.86	1.35		AVoc Pre-test T	1,08	1.16	
AVoc Pre-test PR	1.74	1.33		AVoc Pre-test PR	1.11	1.37	
AVoc Post-test Ctr	2.29	2.95	0.62	AVoc Post-test Ctr	2.0	2.31	0.76
AVoc Post-test T	6.14	2.98	4.28	AVoc Post-test T	3.89	2.93	2.81
AVoc Post-test PR	6.29	3.09	4.55	AVoc Post-test PR	4.86	2.95	3. 75

not violated ($p<.168$). There was a significant main effect for Time, $F(2,40)=32.68$, $p<.001$, $\eta_p^2=0.62$, indicating that children's post-intervention print knowledge scores were higher than their pre-intervention scores. The polynomic within-subject contrast revealed a significant linear trend $F(1,20)=88.73$, $p<.001$, $\eta_p^2=0.82$, indicating a proportionate change of Print knowledge growth over time. Pairwise comparisons showed that increase in Print knowledge was significant after post-test T, $p<.004$ and after post-test PR, $p<.001$ (Fig. 1). These results indicate that children with relatively Low-EF not easily pick up Print knowledge from the environment (e.g., being tested before) but benefit from a print referencing style. All the test effect sizes (η_p^2) are high.

Phonological Awareness

An independent sample t-test revealed that children with lower executive functioning (L-EF) scored significantly lower on pre- and post-test Text (T) and marginal significant lower on post-test (PR) for phonological awareness (PA) than the higher performing peers (H-EF), $t(41)=2.35$, $p<.024$; $t(41)=3.03$, $p<.004$; $t(41)=1.90$, $p<.066$ respectively (Table 2). A multivariate RMA was used with Time (pre and post interventions T & PR) as within factor for both EF Groups (low and high; medial split) for cohort 1. For L-EF Mauchly's test indicated that the assumption of sphericity had been violated ($p<.023$), therefore degrees of freedom were corrected using Huynh–Feldt estimates of sphericity ($\varepsilon=0.81$). There was a significant main effect for Time, $F(1,6,40)=173.55$, $p<.001$, $\eta_p^2=0.37$, indicating that post-intervention phonological awareness scores were higher than their pre-intervention scores. The polynomic within-subject contrast revealed a significant quadratic trend $F(1,21)=8.37$, $p<.009$, $\eta_p^2=0.29$, indicating more PA growth over time. Pairwise comparisons showed that increase in phonological awareness was only significant after the PR post-test, $p<.001$ (Fig. 2). For H-EF Mauchly's test of sphericity was not violated ($p<.168$). There was a significant main effect for Time, $F(2,40)=86.87$, $p<.001$, $\eta_p^2=0.36$, indicating that children's post-intervention PA scores were higher than their pre-intervention scores. The polynomic within-subject contrast revealed a significant linear trend with a high effect size $F(1,20)=18.48$, $p<.001$, $\eta_p^2=0.48$, indicating a proportionate change of phonological awareness growth over time. Pairwise comparisons showed that increase in PA was only significant after post-test PR, $p<.001$ (Fig. 2). These results indicate that phonological awareness is not easily picked up from the environment and that children with L-EF benefit relatively more from a print referencing style than their higher performing peers.

Vocabulary

A multivariate RMA was used on target vocabulary with Time (pre- vs. post-test) and Condition (Control book (C), Text (T), and Print Referencing (PR)) as within-subjects factor for both Executive functioning Groups (Low and High; medial split). For the Low-EF group Mauchly's tests indicated that the assumption of sphericity has not been violated (Condition $p<.146$, Interaction Time x Condition $p<.983$). There was a significant main effect for Time $F(1,36)=67.79$, $p<.0001$, $\eta_p^2=0.65$ and Condition $F(2,72)=8.13$, $p<.001$, $\eta_p^2=0.18$ and a significant interaction effect between Time and Condition $F(2,72)=18.66$, $p<.001$, $\eta_p^2=0.34$. Helmert contrasts revealed that ratings were significantly higher after Text and Print Referencing compared to the Control condition, $F(1,36)=33.96$, $p<.001$, $\eta_p^2=0.49$ and marginal significant different between T and PR, $F(1,36)=3.53$, $p<.068$, $\eta_p^2=0.089$ with a medium effect size (Fig. 3L-EF). For the H-EF group Mauchly's test indicated that the assumption of sphericity has not been violated (Condition $p<.140$, Interaction Time x Condition $p<.876$). There was a significant main effect of Time $F(1,41)=110.82$, $p<.0001$, $\eta_p^2=0.73$

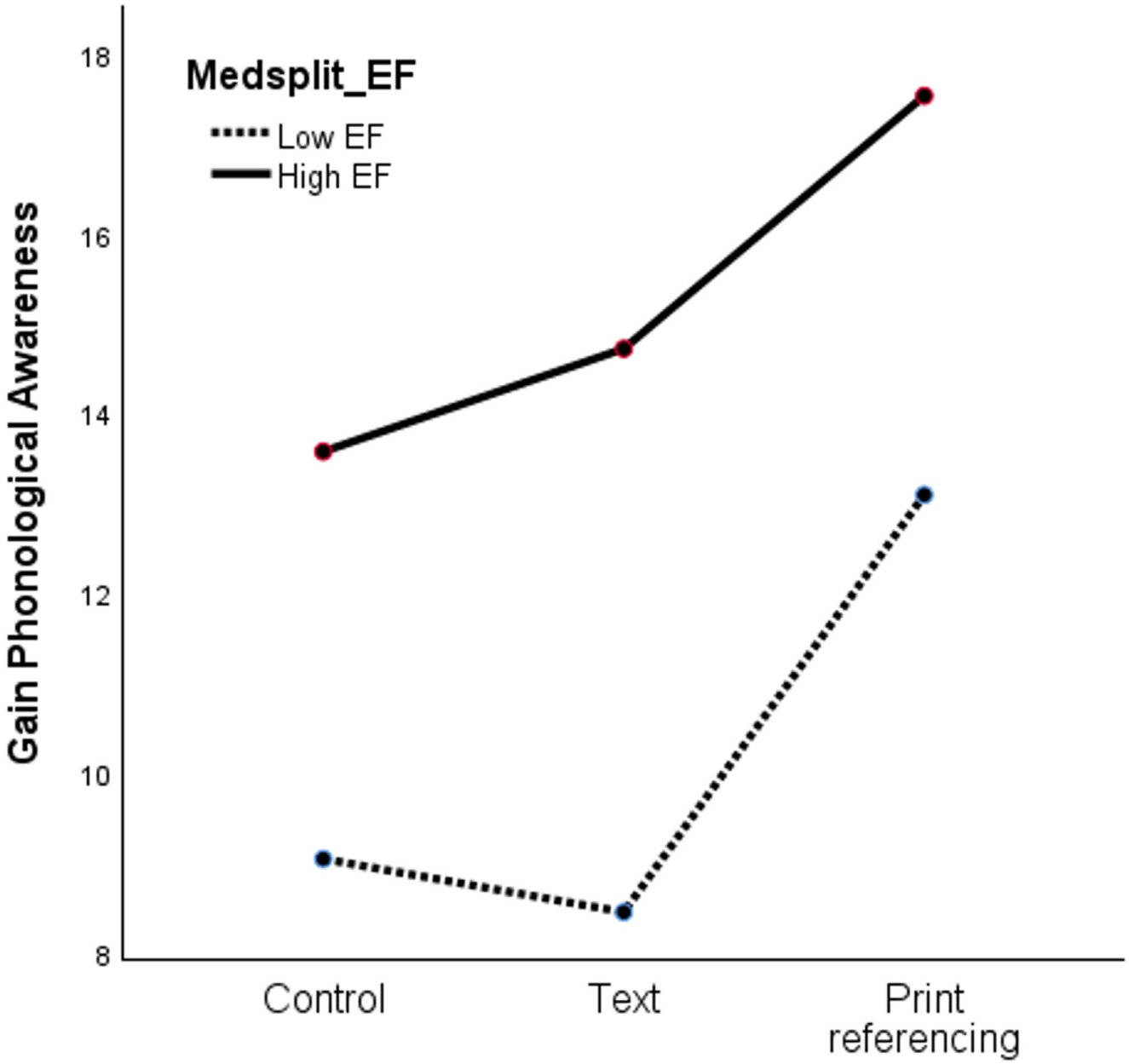

Fig. 1 Gain in Print knowledge for children with relatively low (Low EF) and high (High) executive function skills; time 1 = pre-test, time 2 = post-test Text Condition, time 3 = post-test Print Referencing Condition

and Condition $F(2,82)=20.89$, $p<.0001$, $\eta_p^2=0.34$ and a significant interaction effect between Time and Condition $F(2, 82)=31.58$, $p<.001$, $\eta_p^2=0.44$. Helmert contrasts revealed that ratings were significantly higher after Text and Print Referencing compared to the Control condition, $F(1, 41)=58.50$, $p<.001$, $\eta_p^2=0.59$ and the same between T and PR, $F(1, 41)=0.24$, $p<.068$, $\eta_p^2=0.006$ (Fig. 3H-EF). This indicates that word learning is less easily picked up from the environment for children with L-EF compared to their higher preforming peers and that they benefit from a print referencing style. The differences in new words learned after the Text condition is significant with a medium effect size between the two EF groups, $t(78)=2.66$, $p<.01$, $d=0.59$ and marginal significant with a small effect size after the Print Referencing condition, $t(78)=1.89$, $p<.062$, $d=0.43$.

Discussion

Storybook reading in schools is a widely used method to develop early literacy skills. The meaning of a new word and, to a lesser extent, its phonological aspects, are picked

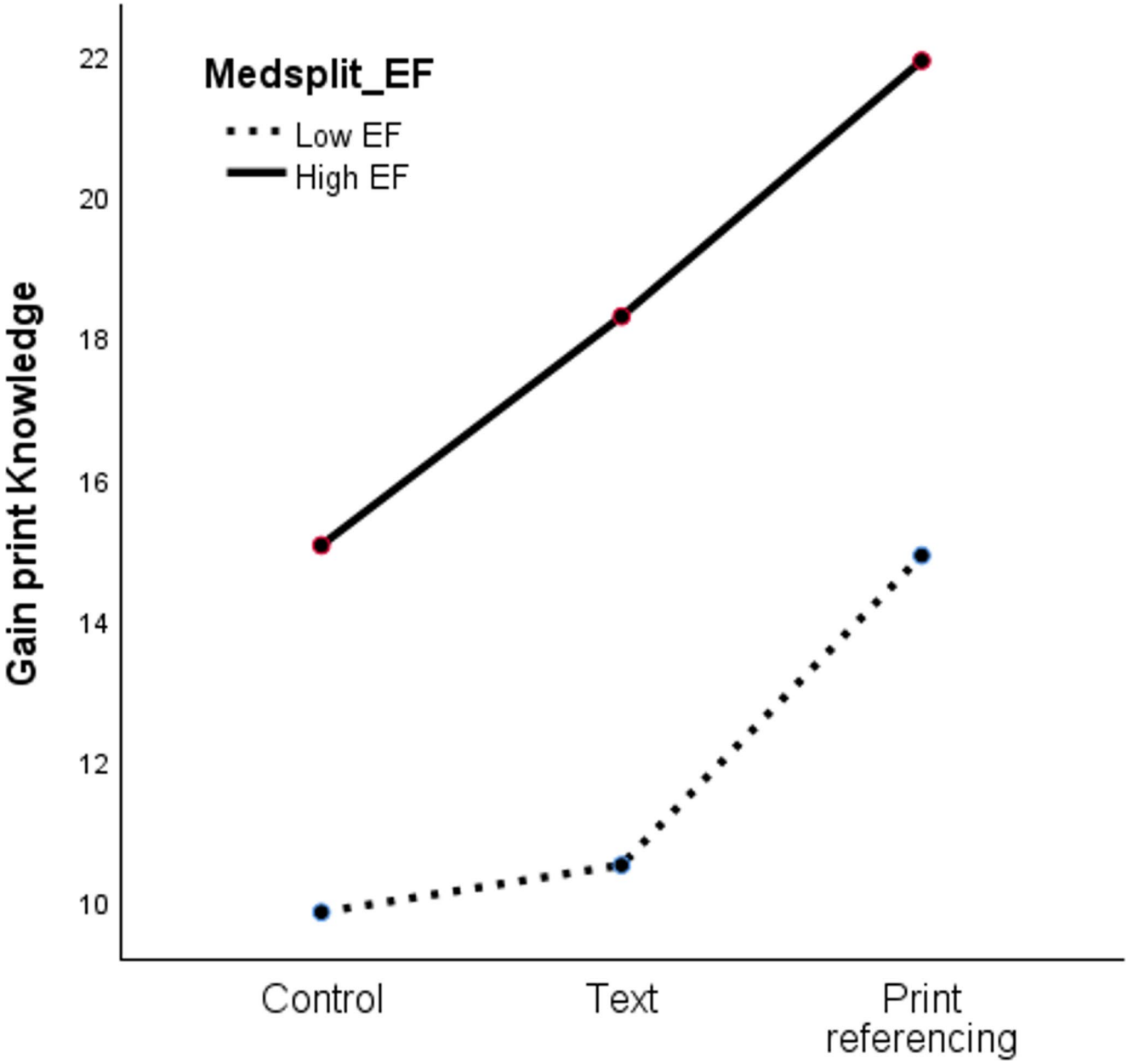

Fig. 2 Gain in Phonological Awareness for children with relatively low (Low EF) and high (High EF) executive function skills; time 1 = pre-test, time 2 = post-test Text Condition, time 3 = post-test Print Referencing Condition

up without specifically drawing attention to it (e.g., Robbins & Ehri, 1994; Sénéchal, 1997; Verhallen et al., 2006). During reading, children mainly focus on the illustrations in a book and pay less attention to the written text. Repeated reading of the same book increases the focus on text with just a few percent (Evans & Saint Aubin, 2013). The effect of storybook reading on print knowledge is therefore small and explicitly focusing attention to print seems important (Justice & Ezell, 2004). Also, development of phonological awareness and phonics benefits using verbal cues to draw children's attention to print (Justice & Ezell, 2004; Shamir et al., 2012). Storybook reading using a print referencing style could therefore be useful to develop the essential emergent literacy skills. In the previous (larger) study with combined skill training (van Dijken, 2023) results indicated that print knowledge (including phonics) and phonological awareness expand through a print referencing reading style and does not hinder vocabulary growth. Alternative explanations for literacy growth after reading storybooks using print referencing were less plausible. Testing effects as well as differential effects due to specific teacher behaviours were accounted for in the experimental set up by using a within

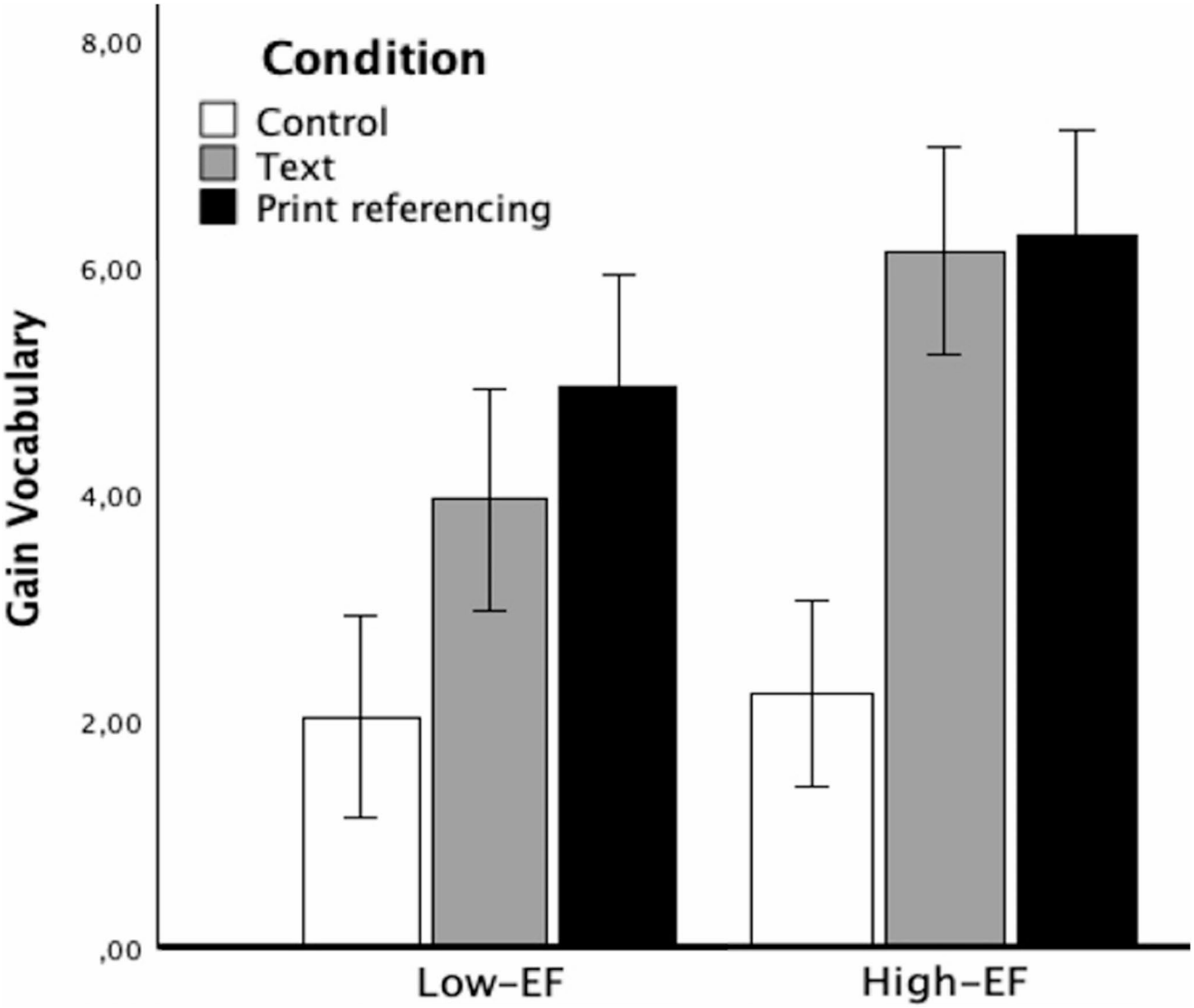

Fig. 3 Total gain in Vocabulary for children with relatively low (Low-EF) and high executive function skills (High-EF); Post tests Control, Text and Print Referencing condition

fixed order design and trained assistants, all unknown to the children, who followed a strict intervention protocol. Also, large maturation effects are unlikely in a 4 weeks' time frame. However, the individual differences in growth for phonological awareness, print knowledge and vocabulary were large between the kindergartners in the study. As one probably requires well-developed regulatory skills to learn from e-books with print referencing (Cartwright, 2008; Diamond et al., 2007; Evans & Saint-Aubin, 2013), the question remained whether executive functioning (EF) differentiates children's learning capabilities in a combined training of emergent literacy skills (e.g., Diamond et al., 2007; Nesbitt et al., 2015). In this study we separated the cohort of 80 children into 2 groups (relatively low (L-EF) and high (H-EF) functioning on executive control) and examined the association with literacy development to examine the interconnected nature of early language development and cognitive control (McNeill et al., 2025); Skibbe et al., 2019).

The results indicate that regulatory skills distinguish children who vary in learning abilities, to some extent. In general, both EF-groups profit from an interactive reading style using print referencing to develop emergent literacy skills; the lower EF-group scores are below the high EF-group, but children with low regulatory skills benefit relatively more from e-books with print referencing than from traditional e-books compared to their higher performing peers. As stated before, alternative explanations for literacy growth after reading storybooks using print referencing were less plausible. The results confirm earlier findings that children with higher levels of cognitive control were characterized

by higher levels of early literacy (McNeill et al., 2025; Skibbe et al., 2019). However, results did not show a greater improvement for print- and phonological knowledge after the print referencing intervention compared to their peers with relatively lower levels of cognitive control. Moreover, the lower EF group improved relatively more on these skills than the higher EF group, suggesting an underlying mechanism in technology use to connect self-control and literacy improvement; the enhanced e-books could have focused attention to the learning opportunities, thereby scaffolding the late early language developers. Previous research suggested that the effectiveness of reading aloud may depend on the students' behavior. If a child shows a high level of on-task behavior, the child feels involved in a task, regardless of whether the task requires a lot of effort (Halliday et al., 2018). This appears to be beneficial for their language development and learning performance (Gest & Gest, 2005; Mol et al., 2008; Rowe & Hill, 1998; Whitehurst et al., 1988). Feedback from the schoolteachers confirmed that all preschoolers in their classrooms were very attentive during the reading sessions.

For the H-EF group print knowledge increases after the reading intervention using print referencing, but also after the Text condition. This is contrary to what is found in the literature: a form of attention to print while listening to a story is necessary to gain print knowledge (e.g., Gong & Levy, 2009). In the study of van Dijken (2023) it is established that the children picked up some knowledge from the print knowledge pretest. It is hard to design a test without suggestive effects. Thus, when one asks: 'how many words do you see?' it is likely that a child will count only the obvious entities on the page without knowing what a word is and subsequently learn the concept 'word' from being tested. Children in the L-EF group do need the focus offered by print referencing to grow in print knowledge and do not easily learn from an implicit learning environment (traditional reading or being tested) as is found in other studies (e.g., Evans et al., 2008).

To become good readers, children must develop phonological skills (Joseph & McCachran, 2003). Weak phonological awareness predicts reading problems (Phillips et al., 2008), but for children with well-developed phonological skills the reading process improves faster and vice versa, through reading their phonological skills are stimulated (Whitehurst & Lonigan, 1998). Variance in exposure to spoken language before children enter school, leads to differences in the development of phonological skills (Antony & Francis, 2005). Training these skills will lead to a better reading process (Cunningham, 1990). Our results show that phonological awareness increases slightly after traditional reading for the H-EF group and much more after books read with print referencing. The L-EF group only increases in phonological awareness after print referencing. These results tie in with previous research findings that kindergartners are more aware of sounds in words (Justice & Ezell, 2004; Shamir et al., 2012) when books are read with explicit vocal attention to print matters compared to traditional reading. An easy way to stimulate this process is to draw attention to sound structures in words by means of print referencing. In this way print knowledge and phonological awareness will be stimulated together.

There is ample evidence that expanding vocabulary through reading storybooks is effective (e.g., Sénéchal 1997; Smeets & Bus, 2012; Verhallen et al., 2006; Evans & Saint-Aubin, 2013). The illustrations are inspected in concert with the spoken text. The children navigate the illustrations to match what they see with what they hear, which enable the children to add new low frequency words to their vocabulary (Evans & Saint-Aubin, 2013; Verhallen & Bus, 2012). Knowing that print referencing is interrupting the storyline and shifts the focus away from the story onto the text elements, we expected to find a trade-off between word learning and print awareness. The results of the larger study (van Dijken, 2023) indicate that print referencing not only stimulates print knowledge and phonological awareness but also new word learning when compared to the Text condition. It turned out that this effect is solely explained by the profit of print referencing for children with less well-developed regulatory skills (L-EF, Table 2), while for H-EF there is no adverse nor profitable effect of combined skill learning: as many words were learned in the Text and Print Referencing conditions (H-EF, Table 2). Moreover, the differences between the two EF groups in new words learned after the Text condition is significantly different with a medium effect size and only marginal significantly different with a small effect size after the Print Referencing condition, indicating a closing gap between the two groups. During the reading intervention, the children in the classroom did not bother each other; they were actively involved and commented on the story being read or the matters to be learned in the print referencing situation. Thus, all children were able to focus on the whiteboard and children normally easily distracted were able to learn (nearly) as many new words as their peers who can ignore disturbances. The results show clearly that a print referencing reading style mainly scaffolds children with relatively low EF-skills, preventing them to be left behind their higher functioning peers even further.

The classroom environment poses major challenges for self-regulation in young children. Typically, children must pay attention, avoid distractions, and divide their attention to different learning tasks. These essential self-regulation skills, which include executive functioning, are key predictors of school achievement (Spiegel et al., 2021; Cortés Pascual et al., 2019).

The classroom teachers proposed, based on their observations of the behaviour of the kindergartners during reading using a print referencing style, that the positive performance of the low EF group could partly be explained by improved learning behaviour and increased engagement in learning tasks. They noticed that the reading sessions created a learning friendly classroom environment. A positive classroom environment, like organizing the group work of children and using effective techniques for the development of preschoolers' thinking and speech, scaffolds executive functioning and enables better learning (Veraksa et al., 2020). Moreover, Howes et al. (2008) noted that children from groups with a positive atmosphere and discussion methods, have a richer vocabulary and have superior initial reading skills to than children from other groups. This observation was independent of the teachers' behaviour, as they played no role in the reading sessions conducted by research assistants who followed a strict protocol.

To close the gap in literacy performance it seems essential to know how to support children with difficulties in executive functioning (EF) from a very early age. However, a comprehensive systematic review of research on training EF found limited evidence of long-term benefits for EF (Diamond & Ling, 2020). Thus, interventions that provide support to children with weak EF to develop a more engaging approach to learning tasks, may be a potential opportunity for future research. Stimulating discussions and engagement for literacy learning, especially for increasing vocabulary, is targeted by introducing interactive reading with e-books (Mol et al., 2008). The e-Prent&ABC program has therefore been extended by including interactive reading based on the 4-Cycle-Model for robust vocabulary instructions (Beck et al., 2013; Verhallen & Verhallen, 1994) to scaffold children with less well-developed learning behaviour (van Dijken, 2018, 2019, 2024).

Implementation of e-Prent&ABC will be studied using this advanced e-Prent&ABC version to further improve vocabulary and scaffold children with less well-developed learning behavior (van Dijken, 2018, 2019, 2024). For practical guidance of the e-Prent&ABC version used in the present intervention (van Dijken, 2023), a specific protocol with print referencing instructions for print knowledge and phonological awareness is added (Appendix 1).

It should be noted that the number of participants in the study was rather small, however a repeated measure design is statistically powerful. When the same participants are used across conditions the error variance is reduced, making it easier to detect any systematic variance (Field, 2009). All sample sizes are $N \geq 36$ and sufficient to analyze with a power of 80% (Georgiev, n.d.). Nevertheless, there were too few participants to disentangle the different EF-components. Disentangling the different components of executive functioning might have given different results. For example, a low memory capacity constrains learning, but picture books with print referencing supports print learning by focussing shortly and restrictively on a single highlighting print matter and/or sound unit in words to be learned. However, an added benefit of highlighting and subsequent sounding out an unfamiliar word, is that this word is getting extra and vocal attention, in which it might be learned at the same time (de Jong et al., 2000). Nevertheless, if extra scaffolding is needed for children with very weak memories, an alternation between traditional book reading and books using print referencing might serve these children better. Poor inhibition control also constrains learning, yet print referencing introduces more involvement and focus, thereby cancelling out the detrimental effect of being distracted. However, for insufficient cognitive flexibility, a trade-off is expected between learning print matters and words, as in print referencing one is expected to switch back and forward between the written text and the story to be told. The development of either print knowledge and phonological awareness or new word learning will be affected. For cognitive inflexible children, an e-book can be introduced in its simple form followed by its print referencing version to support them to maximise their gain in vocabulary.

Another limitation of the study is a lack of generalizability. The participants were typically developing children from middle-socioeconomic status families with Dutch as first language. This is however a first study to test the effect of the e-Prent&ABC program and a follow up is planned in testing children from low-socioeconomic status families and special groups like children with specific language impairments. About this last group it is already known that special features in e-books like background music interferes with learning (Smeets et al., 2014).

Also, we used a fixed order condition design and started the intervention with the reference condition Text. In this way test learning interfering with print learning was avoided in picture book reading with print referencing; if we had alternated the Text and Print refencing conditions, it would have been impossible to disentangle test learning from print knowledge learning in the print referencing condition. In the main experiment (van Dijken, 2023) it was demonstrated that no print learning occurred in the Text condition and so the fixed order did not introduce any potential practice or familiarity cofounding effects.

Conclusions

e-Picture-books with a print referencing tool that focus children's attention on a classroom whiteboard (e-Prent&ABC) stimulates acquisition of print knowledge, growth of

phonological awareness and enrichment of vocabulary at the same time, as shown in the larger experimental study (van Dijken, 2023). The results of the current analyses reveal that pupil's level of executive functioning co-occur with their level of emergence literacy performance.

In line with expectations, children in the classrooms with relatively less well-developed regulatory skills benefit more from the Print Referencing compared to the Text condition for growth in print knowledge and phonological awareness, while their higher performing peers also and more easily learn from non-focused environmental stimuli.

Furthermore, the study revealed that vocabulary for children with relatively well developed regulatory skills, reading e-books using a print referencing style improve to the same extent as in e-books with only a reading mode, thereby confirming that print referencing has no detrimental effect on vocabulary expansion.

Last and not least, but contrary to the last expectation, the print referencing tool especially supports children with relatively less well-developed regulatory skills compared to a learning condition without print referencing. The Low-EF group does not easily pick up emergent literacy skills from a classroom setting, not even when this is an enriched reading environment, but catch up with their peers when print referencing was used while reading picture books.

The results of this study indicate that print referencing, including the attention to dividing words into sounds, while showing e-storybooks on a whiteboard in the classroom, seems a very promising whole-classroom method to enhance all key areas of print awareness (print concepts, concept of word, alphabetic knowledge), phonics and phonological awareness as well as vocabulary at the same time to all children in the same school year, especially to those with less well-developed executive function skills.

Appendix: Protocol print referencing instructions: print knowledge, phonics & phonological awareness

Rocco the Crocodile (de Wijs & van den Hurk, 2001; 22 pages) Print ReferencingWhat the reader says and points out after the text on the page is read and the animation is finished

Page 2: words are highlighted with the reading speed
Page 4:

- This is a semicolon (,) It is written when there is a pause in a sentence; point to the sentence while reading and pause for a while at the semicolon before reading further

Page 5:

- Here you see the letter B (bee) the B (buh) van Brusjes (Dutch for brothers and sisters)
- This is an exclamation mark (!) It is used when somebody screams, or is excited; repeat the sentence with intonation

Page 7:

- Oh, oh, this word is written the wrong way (mistake: the word 'Steiger' is written with only vowels and turns red); next the word will appear written properly
- Cap your hands twice and pronounce the syllables in sound parts: Stei-ger (Dutch for Yetty; Ye-tty)
- And here you see the letter S (es) the S (sss) from Steiger

Page 8:

- Oh, oh, this word is also written the wrong way (mistake: the word 'Mother' is written with only consonants and turns red); repeat the word Mother when it appears written properly

Page 11: words are highlighted with the reading speed
Page 12:

- -Oh, oh, this word is written the wrong way (mistake: in the word 'Tantes' the vowels are replaced by numbers and turns red); repeat the word 'Tantes' when it appears properly
- And here you see the letter T (tee) de T (tuh) from Tantes (Dutch for Aunts)

Page 13:
This is the letter M (em) the M (mmm) from Mij; spell the word: M-ij, and repeat Mij (Dutch for Me)
Page 15:

- Oh, oh, this word is written the wrong way (mistake: in the word 'Donker' the letter 'e' is replaced by how it sounds: 'u' and turns red); repeat the word 'Donker'when it appears properly (Dutch for Dark; the spoken and written word differ (are not transparent); in English this can be compared with the the phoneme 'a' in the word dark (a) and has (è).

Page 17:

- Oh, oh, this word is written the wrong way (mistake: in the word 'Valt' all letters are replaced by one type of letter and turns red); repeat the word 'Valt' when it appears written properly
- And here you see the letter V (vee) de V (tuh) from Valt (Dutch for falls) spell the word: Valt: V-a-l-t, Valt

Page 19:

- This is a question mark (?) It is used when somebody asks something; repeat the sentence with intonation

– And this is a point (.) It is written at the end of a sentence; repeat the sentence

Page 20: words are highlighted with the reading speed.

– Here you see the letter K (ka) de K (kuh) from Krokodillenbaby's (Dutch for baby Crocodiles)
– Clap your hands and pronounce the syllables in sound parts: Kro-ko-di-llen-ba-bys

Page 21:

– Oh, oh, these two sentences are written the wrong way (mistake: the words in the sentences are written together and turn red); Howcutethoselittlecrocodiles,saysRokko. Andtherearesomany! Repeat the sentences when written properly: How cute those little crocodiles, says Rokko. And there are so many!

Delarations

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