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Cognitive and environmental predictors of early literacy skills

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Abstract Not all young children benefit from book exposure in preschool age. It is claimed that the ability to hold information in mind (*short-term memory*), to ignore distraction (*inhibition*), and to focus attention and stay focused (*sustained attention*) may have a moderating effect on children's reactions to the home literacy environment. In a group of 228 junior kindergarten children with a native Dutch background, with a mean age of 54.29 months (SD = 2.12 months), we explored therefore the relationship between book exposure, cognitive control and early literacy skills. Parents filled in a HLE questionnaire (book sharing frequency and an author recognition checklist as indicator of parental leisure reading habits), and children completed several tests in individual sessions with the researcher (a book-cover recognition test, PPVT, letter knowledge test, the subtests categories and patterns of the SON, and cognitive control measures namely digit span of the KABC, a peg tapping task and sustained attention of the ANT). Main findings were: (1) Children's storybook knowledge mediated the relationship between home literacy environment and literacy skills. (2) Both vocabulary and letter knowledge were predicted by book exposure. (3) Short-term memory predicted vocabulary over and above book exposure. (4) None of the cognitive control mechanisms moderated the beneficial effects of book exposure.

Keywords Author recognition test · Cognitive control · Book-cover recognition test · HLE · Letter knowledge · Vocabulary

Environmental variables that include parental leisure reading practices and family storybook sharing habits predict early reading skills (e.g., Bus, 2001; Bus,

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van IJzendoorn, & Pellegrini, 1995; Bracken & Fischel, 2008; Sénéchal, LeFevre, Hudson, & Lawson, 1996). However, not all children benefit from book exposure in preschool age. It is claimed in the literature that individual variation in cognitive control may have a moderating effect on children's reactions to literacy-related experiences (e.g., Bodrova & Leong, 2006). Below we explore therefore the relationship between book exposure, cognitive control and early literacy skills.

The impact of book exposure on literacy development

Effects of book exposure on growth in expressive or receptive vocabulary have been demonstrated in a very large number of studies; see the results of several meta-analyses (e.g., Bus et al., 1995; Mol, Bus, de Jong, & Smeets, 2008; Mol, Bus, & de Jong, 2009). The literature also provides support for effects of book exposure on code-related knowledge although findings are more ambiguous (Mol et al., 2008, 2009). Frijters, Barron, and Brunello (2000), for instance, reported that the relationship between frequency of reading books to children and the acquisition of letter-name and letter-sound knowledge depends on the child's level of phonological awareness. In the same vein, Gest, Freeman, Domitrovich, and Welsh (2004) demonstrated that shared book reading was more strongly associated with language comprehension skills (measured by expressive and receptive vocabulary skills and syntax skills) than with print and decoding skills in a sample of children entering kindergarten from low to middle socioeconomic status income families. They stated that this is in line with findings indicating that when reading storybooks to preschoolers, parents comment much more frequently on the content of the story than on print concepts.

Likewise, research into the time spent on fixating print in storybooks suggests that children do look at print in storybooks, but only for a small amount of time. Evans, Williamson, and Pursoo (2008), for example, found that children aged 36–73 months spent a substantially greater percentage of time looking at the illustrations than at the text. Roughly 6 s of a 2½ min reading session was spent on looking at print. Other previous research (e.g., Justice & Ezell, 2002; Levy, Gong, Hessels, Evans, & Jared, 2006) confirms the assumption that children rarely look at print during storybook reading. Levy et al. (2006) stated therefore that storybook listening at home has little impact on children's understanding of print. According to them, literacy activities focused on print in which the children actively participate are best related to the development of orthographic knowledge, that is, knowing how words look.

Book-cover recognition

Questionnaires are often applied to assess characteristics of the Home Literacy Environment (HLE) (e.g., Farver, Xu, Eppe, & Lonigan, 2006; Hood, Conlon, & Andrews, 2008). These questionnaires cover, in addition to family demographics, parental leisure reading habits and family storybook sharing habits. A useful tool to

assess parents' exposure to adult literature is an author recognition test (Cunningham & Stanovich, 1990). In the author recognition test, subjects tick actual author names among fictitious names. The number of correct ticks (minus the incorrect ones) appears to be an indicator of parental print exposure. Children's exposure to books is another important HLE indicator (Cunningham & Stanovich, 1990). Cunningham and Stanovich (1990) used a title recognition test for young children as an indicator of book exposure at home. The more books are read to young children, the more titles they may recognize. Likewise, a book-cover recognition test completed by young children may be a proximal measure of their book sharing experiences (Sénéchal et al., 1996). We may expect that when children are more often read to, they are more familiar with the domain of books: They are more able to identify the title, character(s), and the story triggered by the book-cover. Some researchers (e.g., Cunningham & Stanovich, 1991; Sénéchal et al., 1996) have therefore suggested using this measure as an alternative for a questionnaire about family storybook reading habits completed by parents. Stainthorp (1997) however, warned for a risk of obtaining a high score on title recognition due to the fact that in the UK a considerable number of children's books are serialized on British television every year.

If the book-cover recognition test is a better indicator of book exposure, we may expect that the relationship between HLE (parent print exposure checklist and HLE questionnaire) and literacy outcomes (vocabulary and letter knowledge) disappears if we were to control for book-cover recognition. This would imply that the relationship between traditional HLE measures and literacy outcomes is mediated by book-cover recognition. To test this hypothesis, we first assessed whether the HLE questionnaire and the parent print exposure checklist are related to vocabulary and letter knowledge. Secondly, we tested whether these relationships are mediated by the book-cover recognition test.

The impact of child characteristics on literacy development

In addition to HLE, cognitive control measures like inhibition, attention, and memory are expected to have an effect on early literacy skills (Kegel, van der Kooy-Hofland, & Bus, 2009). We used the concept *cognitive control* as an umbrella term to refer to the ability to hold information in mind (*short-term memory*), to ignore distraction and to resist making one response and instead make another (*inhibition*), and to focus attention and stay focused (*sustained attention*) (e.g., Blair, Zelazo, & Greenberg, 2005; Davidson, Amso, Anderson, & Diamond, 2006; McClelland et al., 2006). To assess short-term memory we applied a digit span task, often referred to as *verbal short-term memory* or *phonological short-term memory* (e.g., Alloway et al., 2005; Anthony, Williams, McDonald, & Francis, 2007).

Cognitive control mechanisms are found to be related to vocabulary in preschool and kindergarten years (Carlson & Moses, 2001; Carlson, Moses, & Breton, 2002; Hughes, 1998). McClelland et al. (2007) found that inhibition (as the main component of their Head-To-Toes Task) predicts four-year-olds' vocabulary and print skills, after controlling for various background variables (e.g., gender, age).

In addition, they found that children who made greater gains in inhibitory control from fall to spring in their pre-kindergarten year also showed more growth in vocabulary and print skills. This might suggest that inhibition affects how much children benefit from environmental literacy input.

Lonigan et al. (1999) hypothesized that attention and literacy skills are associated prior to formal schooling and attention may be predictive of later reading ability through its effect on early literacy skills. Inattentive children may be less likely to benefit from literacy activities in the home and in (pre)school. The results of Dally's, (2006) longitudinal study are in line with this hypothesis showing that children's attention in kindergarten classrooms (as rated by teachers) had a significant direct influence on first-grade word reading and an indirect influence, through grade-one measures, on second-grade reading comprehension. Inattentive behavior at school entry may thus disrupt the acquisition of early word reading skills. However, it is relevant to note here that parent ratings of children's inattentiveness had no significant associations with reading outcomes and other cognitive control mechanisms (e.g., kindergarten short-term memory) did not have an impact on reading outcomes in grade one and two.

The literature concerning the influence of short term memory on literacy is ambiguous. Results of a study conducted by Anthony et al. (2007) are in line with Dally, (2006), who failed to demonstrate a relationship between verbal short term memory in preschoolers and letter- and print knowledge, or word reading at the end of the preschool year. In contrast, Bull, Espy, and Wiebe (2008) found that short-term memory as measured in kindergarten related to reading outcomes at the start of primary school. Likewise, phonological short-term memory scores were uniquely associated with teacher ratings of proficiency in reading measured within 6 weeks of school entry in Alloway et al. (2005). Also, Gathercole, Service, Hitch, Adams, and Martin (1999) showed that in 4-years-olds phonological short-term memory was substantially related to vocabulary ($r = .67$).

In sum, there is some evidence suggesting that cognitive control mechanisms such as short-term memory, inhibition, and attention may be associated with school success from the very start of schooling. However, there is still no explanation as to whether cognitive control is directly related to literacy outcomes, or indirectly (meaning that cognitive control is related to the input children get at home and through that to literacy outcomes). Interestingly, the National Institute of Child Health and Human Development (NICHD) Early Child Care Research Network (2003) demonstrated that family environment predicted children's ability to regulate their attention in the preschool years and that attention processes predicted academic achievement, language development, and social skills. They found that sustained attention and inhibition (as we interpret their impulsivity measure) mediated the relationship between home environment and a composite of letter knowledge and math. Sustained attention also significantly mediated effects of home environment on language skills whereas inhibition did not. In other words, lack of sustained attention and inhibitory control reduced the effect of family environment on outcome measures for school readiness. Findings were statistically significant but effect sizes and mediation statistics associated with them were rather small. In addition, the applied measures did not allow for interpreting which factors

in the home environment were mediated by child characteristics and whether mediation effects for letter knowledge were similar to those for vocabulary or math. Leseman, Scheele, Mayo, and Messer (2007), by contrast, demonstrated that high academic language input at home may compensate for negative effects of low working memory capacity of 4 year olds. Their findings showed that above median academic language input at home can compensate for below median working memory capacity.

As things are, it is still unclear whether preschool children, scoring relatively low on cognitive control, benefit optimally from literacy input in their environment. Furthermore, it is unclear whether the environment can compensate for negative effects of cognitive control variables. The third aim of the present study was therefore to test whether cognitive control moderates the effects of environmental factors on literacy outcomes. To rule out that cognitive control measures assess the same as intelligence tests and not something extra as assumed in the literature (e.g., Diamond, Barnett, Thomas, & Munro, 2007), we tested effects of cognitive control while we controlled for intelligence.

In sum, the main aim of the present study was testing the following hypotheses:

1. Home Literacy Environment (HLE) predicts literacy outcomes: vocabulary and letter knowledge.
2. The relationship between the HLE and literacy outcomes is mediated by children's knowledge of storybooks.
3. Cognitive control moderates effects of HLE on vocabulary and letter knowledge.

Method

Participants

Participants were junior kindergarten children with a native Dutch background in the age range of 4 years and 3 months to 4 years and 9 months. The sample was recruited from 22 randomly selected schools in a province in the western part of the Netherlands. Two of the initially approached schools refused to participate in the project. The schools were attended by Dutch-speaking children from low to middle socioeconomic status families. The study was carried out after parental consent was received. Eight of the children dropped out; one child refused to talk, and seven did not want to participate, resulting in a final sample of 228 participants (117 boys and 111 girls) with a mean age of 54.29 months (SD = 2.12 months). We had complete data on $N = 174$ participants (mainly because not all parents returned the questionnaire and/or the author recognition checklist).

Instruments

Spread over six sessions, the participants completed several tests to assess early literacy skills, early numeric skills, intelligence, and cognitive control. The focus in

this study was on: intelligence, short-term memory, inhibition, sustained attention, book-cover recognition, receptive vocabulary, and letter knowledge. The parents filled in a HLE questionnaire and an author recognition checklist to assess literacy practices in the home.

Intercoder reliabilities were determined for non-standardized tests. Intraclass correlations between two independent coders ranged from .78 (book-cover recognition test) to 1.00 (letter knowledge). Any disagreement was resolved through discussion.

Home literacy environment

Parents filled in a HLE questionnaire. The response rate was 85.96%. The survey contained items that related to book sharing. Forty-two parents skipped one or more items, which resulted in a much smaller *N* when we computed a composite measure for items related to book sharing. The item assessing the frequency of book sharing per week (0 = not so often, 1 = every other day, 2 = on a daily basis) was responded to most frequently ($N = 193$) and therefore used in subsequent analyses as an indicator of book sharing frequency. This item correlated significantly with other items related to book sharing: Are you able to read to your child on a daily basis? ($N = 181$; $r = .67$); If you read on a daily basis, do you do that several times a day? ($N = 163$; $r = .33$); Does your child ask you to read a story to him or her? ($N = 193$; $r = .32$). In a meta-analysis, Bus et al. (1995) found similar effect sizes for frequency of book sharing versus a composite measure including other facets of a literacy environment, which indicates that the item assessing the frequency of book sharing per week is a good indicator of book sharing exposure. Furthermore, it is common in the book reading literature to use only one question to assess frequency of shared book sharing (e.g., Farver et al., 2006; Frijters et al., 2000; Gest et al., 2004; Sénéchal et al., 1996).

Checklist on parent print exposure

Parents completed a checklist as a measure of their own exposure to adult literature (response rate 79.82%). The author recognition checklist was composed of 46 authors and 40 foils. We compiled the checklist from top 10 author lists of Stichting Collectieve Propaganda van het Nederlandse Boek (CPNB) [Collective Promotion for the Dutch Book] (CPNB, 2006) from 2004–2006 for the categories Dutch fiction, translated fiction, and crime fiction. All authors with one or more top 10 listings in these years were selected, resulting in 46 authors. Parents were instructed to tick the authors they knew and to refrain from guessing. The corrected score was obtained by subtracting the number of foils wrongly selected from the number of correctly identified items. Alpha reliability equaled .93.

Book-cover recognition

We used a storybook-cover recognition task completed by the children to account for book exposure experiences across a variety of situations (library, school, and

home). Picture story books were selected based on top 100 sales (CPNB, 2006), and library lending numbers from 1999 to 2006 (picture books that were in the top 100 most often borrowed) in the Netherlands. Books that were on both lists were included, resulting in 41 items that differed in familiarity. On a computer screen, children were shown covers of picture books one at a time. Per cover, the experimenter asked the child three questions: "Who is this/who are these?"; "What is the name of the story?", and "Can you tell what the story is about?" The experimenter coded whether a child was acquainted with the story book or not, thereby taking into account whether the child's knowledge could be the result of merchandising activities of popular book characters instead of book exposure. The maximum possible score was 41. For example, when a child replied "frog" on seeing the cover of *Kikker en het Vogeltje* [Frog and the Birdsong], but the child could not tell anything about the story, or the story that was told did not match with the one in the book, it was assumed that the child was not acquainted with the book. Frog is a highly merchandized character and just knowing the main character's proper name did not establish conclusive proof of knowing the story. Alpha reliability equaled .67.

Vocabulary

The Peabody Picture Vocabulary Test-III-NL (Schlichting, 2005), a Dutch version of the PPVT-III (Dunn & Dunn, 1997), was used as an indicator of receptive vocabulary. Participants' scores were the number of correct items.

Letter knowledge

Letter knowledge was assessed by having the participants give the name or sound of eight uppercase letters (S, M, K, P, R, O, V, A) and three lower case letters, insofar as lower case form differed from the uppercase form (m, r, a). Each letter was printed on 10 $\times$ 10 cm card and shown one at a time. Alpha reliability equaled .90. Due to technical problems in one recording, two items could not be coded; therefore, the percentage of the correctly named (or sounded out) letters was calculated.

Intelligence

The subtests Patterns (copying abstract figures that increase in complexity) and Categories (sorting a pile of 4–6 pictures into two clusters like fruits, vehicles, head gear) of the Snijders-Oomen Nonverbal Intelligence test (SON) (Tellegen, Winkel, Wijnberg-Williams, & Laros, 1998) were selected as indicators of intelligence. Compared to other subtests of the battery, categories loaded highest on the verbal factor of the SON test whereas patterns loaded highest on the nonverbal factor (Tellegen et al., 1998). Factor loadings were .74 and .82, respectively. The patterns and categories subtests correlated significantly ($r = .41$).

Cognitive control

Short-term memory

The Digit Span Forwards of the Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1983) was used as indicator of short-term memory. The experimenter says numbers, and the child has to repeat them in exactly the same order. The test started with one practice item of two numbers similar to the first level and increased with one number every next level (three items per level). The subtest was discontinued if a child made an error in two consecutive items of the same level. The score equaled the number of correct responses.

Inhibition

Peg tapping (Diamond & Taylor, 1996) was included as an indicator of inhibition. When the experimenter tapped once, the child had to tap twice and vice versa, thereby inhibiting his or her natural response to mimic the experimenter's behavior. The task consisted of 16 items. Alpha reliability equaled .85. The total score equaled the number of correct responses. Because scores were rather skewed, we performed a median split resulting in a dichotomized variable with children scoring high or low on inhibition.

Sustained attention

Sustained attention was assessed by a subtest of the computerized Amsterdam Neuropsychological Tests (De Sonneville, 2005). Animals appeared one by one in a house on the computer screen. Clicking was only allowed when a cat appeared. The task took about 10 min. Accuracy and response time were registered by mouse clicks. The total score was the number of correct responses minus the number of false alarms and missing items (items for which a child erroneously did not click). Because scores were rather skewed, we performed a median split resulting in a dichotomized variable with children scoring high or low on sustained attention.

Procedure

Parents received a pamphlet with information about the purpose of the project and the procedure (number of sessions, activities during the sessions, etc.). The phone number and e-mail address of the first author were provided in the pamphlet in case parents wished to receive additional information. Parents signed a written consent for participation.

All measures were individually administered in a separate room at school by the main researcher or one of twelve trained Bachelor's and Master's students. Testing was spread over six sessions, each lasting for about half an hour. Not all of the results are reported in this article. All sessions were videotaped with a digital camera in a fixed position. Videotaped sessions were used for data coding and for checking whether examiners had followed the scripted protocol. Session order was

counterbalanced between participants whereas the order of tasks within a session was fixed.

HLE questionnaire and author checklists were sent home including a stamped self-addressed envelope. A cover letter was added with instructions about how to complete the questionnaire and the author checklist.

Results

Descriptive statistics

Descriptive results for all measures are reported in Table 1. With two exceptions, continuous variables had a normal distribution (skewness ranging from .03 to .44). The book-cover recognition test and the author recognition checklist were slightly positively skewed (.97 and .80, respectively), but the visual appearance did not demand for transformation (Tabachnick & Fidell, 1996). On SON categories ($M = 10.88$, SD = 3.00) and patterns ($M = 9.95$, SD = 2.78), our sample's means

Table 1 Descriptive statistics for child and parent measures

Variable		*N*	Median	Range
Frequency of shared book reading				
How many times do you read to your child per week[a]		193	2.00	0–2
Variable (max. score)	*N*	*M*	SD	Range
Age[b]	228	54.29	2.12	50–59
Book-cover recognition (41)	225	2.68	2.34	0–8
Parent print exposure (47)	182	12.77	9.54	0–40
Cognitive control				
KABC short-term memory	226	6.52	1.87	2–11
Peg tapping (inhibition) (16)	225	12.36	3.60	3–16
ANT Sustained attention	228	28.96	32.47	−65–+80
Literacy outcomes				
Vocabulary	228	66.24	11.27	39–94
Vocabulary[c]	228	102.46	14.70	56–144
Letter knowledge[d]	225	27.44	31.94	0–100
Intelligence				
SON categories (15)	228	8.60	1.80	5–13
SON categories[c]	228	10.88	3.00	1–18
SON patterns (16)	228	9.03	1.35	5–13
SON patterns[c]	228	9.95	2.78	2–16

[a] 0 = not so often, 1 = every other day, 2 = on a daily basis

[b] Months

[c] Standardized scores

[d] Mean percentage correct

were similar to the standard population ($M = 10$, SD = 3), as reported by Tellegen et al. (1998).

On average, children remembered 3–4 numbers (SD = .90) of the short-term memory task ($M = 6.52$; SD = 1.87), were able to respond correctly 12.36 out of 16 times (SD = 3.60) to the inhibition task, and 28.96 out of 240 times (SD = 32.47) to the sustained attention task.

Mean score on the PPVT-III-NL ($M = 102.46$, SD = 14.70) was similar to that of the standard sample ($M = 100$, SD = 15). On average children knew two to three letters ($M = 27.44\%$, SD = 31.94).

Mostly, mothers filled in the HLE questionnaire ($n = 140$), followed by both parents ($n = 41$) and, in rare cases, by the father alone ($n = 14$) or the child's grandparents ($n = 1$). Although all parents were convinced of the importance of daily book sharing (no variance in this item), not all parents were able to read daily to their child. When asked to rate book sharing frequencies on a weekly basis, 133 parents reported reading every day, while 44 parents reported every other day, and 16 less frequently (not further specified).

On average, parents knew 12.77 authors (SD = 9.54) of the 46 on the list; they rarely checked one of the (40) foils ($M = .56$, SD = 1.22). Children recognized on average 2.68 (SD = 2.34) of 41 book-covers.

Spearman correlations in Table 2 are in line with the expectation that book-cover recognition would be related to book sharing frequency and parent print exposure. Of note is that the correlation between book sharing frequency and parent print exposure is rather small ($\rho = .18$). Furthermore, book-cover recognition was significantly correlated with SON categories, SON patterns, inhibition, memory, and sustained attention. SON categories and SON patterns correlated significantly with the cognitive control measures. As expected, vocabulary and letter knowledge were significantly related to book-cover recognition and parent print exposure. Curiously, the frequency of the book sharing item in the questionnaire was correlated with letter knowledge but not with vocabulary. Intelligence and cognitive control measures were significantly related to both vocabulary and letter knowledge (mean $\rho = .30$, SD = .06).

Spearman correlations between cognitive control measures were small to moderate at most (Cohen, 1988), ranging from .26 (short-term memory and inhibition) to .39 (sustained attention and inhibition). We decided to treat them as separate constructs in line with the literature on those measures (e.g. Davidson et al., 2006; Diamond, 2006).

Missing values

The response rate by parents to the questionnaire and parent print exposure checklist was rather high (>50%, a criterion introduced by Miller, 1991). Nevertheless the sample reduced from $N = 228$ to $N = 174$ participants. We conducted logistic regressions (McClelland, Acock, & Morrison, 2006) to see if the children that dropped out of the sample due to a missing questionnaire and/or parent print exposure checklist differed from children that were included in subsequent hierarchical regression analyses. None of the logistic regressions revealed a

Table 2 Spearman correlations between book-cover recognition, environmental factors, child characteristics and literacy outcomes (vocabulary and letter knowledge)

	1	2	3	4	5	6	7	8	9	10
1. Book- cover recognition	–	.26** (191)	.31** (180)	.29** (225)	.17* (225)	.23** (224)	.15* (222)	.13* (225)	.34** (225)	.39** (222)
2. Frequency of shared book reading per week		–	.18* (179)	−.02 (193)	.02 (193)	−.03 (191)	.02 (191)	.07 (193)	.06 (193)	.20** (192)
3. Parent print exposure			–	.22** (182)	.17* (182)	.17* (180)	.16* (180)	.08 (182)	.16* (182)	.21** (181)
4. SON categories				–	.40** (228)	.28** (226)	.21** (225)	.22** (228)	.38** (228)	.30** (225)
5. SON patterns					–	.24** (226)	.29** (225)	.12 (228)	.31** (228)	.36** (225)
6. KABC short-term memory						–	.31** (223)	.26** (226)	.43** (226)	.32** (223)
7. Peg tapping (inhibition)							–	.39** (225)	.25** (225)	.19** (224)
8. ANT sustained attention								–	.20** (228)	.25** (225)
9. Vocabulary									–	.41** (225)
10. Letter knowledge										–

Note: *N*'s are between brackets

* $p < .05$, ** $p < .01$

significant effect for missingness, indicating that those who dropped out did not differ from those included in the regression analyses.

Hierarchical regression analysis for variables predicting vocabulary

To test the three main hypotheses, we carried out a hierarchical multiple regression. In the first step, we entered home literacy environment (frequency of book sharing and parent print exposure checklist). To test whether the relationship between home literacy and vocabulary is mediated by children's knowledge of books, we entered in the second step the book-cover recognition test. In the third step, child cognitive measures (SON subtests and cognitive control measures) were entered, and in the last step the interaction terms between book-cover recognition and dummy-coded cognitive control variables were entered. Continuous predictor variables were centered. As can be seen from the results of Model 1 (see Table 3), the parent print exposure checklist was a moderately strong predictor ($\beta = .18$) and accounted for 3.24% of the variance. The frequency of book sharing was not significant. Under Model 2 in Table 3, the parent print exposure checklist test stopped being significant, but book-cover recognition was a strong predictor ($\beta = .32$). This indicates that the child's book knowledge mediates HLE. Under Model 3, the book-cover recognition test continued to be a significant, albeit weaker, predictor ($\beta = .22$). SON categories accounted for about 4% of the variance, and memory accounted for an additional 4.84%. The Model fit did not improve after interaction terms (book-cover x cognitive control measures) were entered. None of the three interaction terms caused significant effects. Evidently, children with below median scores and children with above median scores on cognitive control measures benefited equally from book exposure as indicated by the book-cover recognition test.

Table 3 Hierarchical regression analysis on vocabulary ($N = 174$)

Variable	Model 1	Model 2	Model 3
Environmental factors			
Parent print exposure	.18*	.06	−.01
Frequency of shared book reading	−.02	−.08	−.02
Book-cover recognition		.32***	.22**
Child characteristics			
SON categories			.20**
SON patterns			.10
KABC short-term memory			.22**
Peg tapping (inhibition)			.00
ANT sustained attention			.05
R^2	.03†	.12***	.26***
ΔR^2		.08***	.14***

Note: † $p = .07$; * $p < .05$; ** $p < .01$; *** $p < .001$

Table 4 Hierarchical regression analysis on letter knowledge ($N = 174$)

Variable	Model 1	Model 2	Model 3
Environmental factors			
Parent print exposure	.17*	.06	.00
Frequency of shared book reading	.15*	.10	.14
Book-cover recognition		.29***	.23**
Child characteristics			
SON categories			.03
SON patterns			.21**
KABC short-term memory			.14
Peg tapping (inhibition)			−.00
ANT sustained attention			.15
R^2	.06**	.13***	.24***
ΔR^2		.07***	.11**

Note: * $p < .05$; ** $p < .01$; *** $p < .001$

Hierarchical regression analysis for variables predicting letter knowledge

A second fixed-order hierarchical regression analysis was conducted to test the relationship between predictors and letter knowledge. We followed the same procedure as we did for vocabulary. As can be seen from the results of Model 1 (Table 4), frequency of book sharing was a significant predictor ($\beta = .15$) as well as the parent print exposure checklist ($\beta = .17$). Under Model 2, the book-cover test was a significant predictor ($\beta = .29$) and both home literacy indicators stopped being significant. The child's book knowledge evidently mediates the relationship between home literacy environment and letter knowledge. Under Model 3, the book-cover test continued to be significant. It accounted for 5.29% of the variance. SON patterns accounted for 4.41% of the total variance. Interaction terms in Model 4 did not further improve the model fit.

Discussion

Results support the first hypothesis that home literacy environment (as measured by the frequency of book sharing question and the parent print exposure checklist) predicts literacy skills. The results also corroborate the second hypothesis that children's book-cover recognition is an even better indicator of the literacy environment than home literacy variables (frequency of book sharing and parental print exposure). Third, cognitive control influences literacy outcomes, but it does not strengthen or disrupt the positive influence of book exposure. Specifically short-term memory predicts vocabulary over and above intelligence. In all, the findings support the hypothesis that the book-cover recognition score as indicator of children's literacy environment is a better predictor of literacy outcomes than cognitive measures.

To explain the advantage of the book-cover recognition score over the home literacy measures, we hypothesize that the book-cover recognition test also assesses

book sharing experiences in other settings than the home (e.g., in daycare centers, preschools, libraries, or during visits to grandparents). Furthermore, the scale may be less vulnerable to socially desirable answers (Cunningham & Stanovich, 1991; Sénéchal et al., 1996) and less sensitive to non-response and missing items.

The finding that book-cover recognition continues to be a significant, albeit weaker, predictor when intelligence is accounted for supports the suggestion of Sénéchal and colleagues (1996) that intelligence constrains scores on the book-cover recognition test. They argued that children with a better memory may remember more from storybooks than children with lower memory capacities. Therefore, the book-cover recognition test underestimates rather than overestimates children's book exposure.

The book-cover recognition test explained 6% of the variance in vocabulary. This is close to what appears from a synthesis of the research (Bus et al., 1995). According to a meta-analysis, about 8% of the variance in vocabulary was explained by preschool book exposure. As far as we know, the only previous study using a book-cover test reported effects beyond this amount: In a study by Sénéchal et al. (1996), about 15% of the variance in receptive vocabulary was explained by book exposure (Experiment 1) which is close to the variance explained in our study without correction for intelligence and cognitive control (11%).

The book-cover recognition test also predicts letter knowledge. Though there are studies that do not reveal effects of book exposure on print knowledge, our findings align with a recent meta-analysis (Mol et al., 2008) showing that print-related skills improve even when the intervention (dialogic reading) targets the story content. Mol and colleagues found that dialogic reading explains about 6.48% of the variance in print related skills which is comparable to our finding (6%). This outcome seems at odds with studies demonstrating that children hardly pay visual attention to text during storybook reading (e.g., Evans et al., 2008; Levy et al., 2006). To explain this inconsistency, we assume that a small amount of time preschool children spent on looking at print during book reading may be enough to learn about print. Even when eye fixations on print are brief, the sum total may result in growth of print knowledge (Justice, Pullen, & Pence, 2008).

Consistent with previous research (Leseman et al., 2007; Sénéchal et al., 1996), we found that short-term memory is significantly correlated with vocabulary. Evidently, this cognitive control measure assesses skills over and above intelligence (Diamond et al., 2007). It is noteworthy that none of the other cognitive control measures contributed to vocabulary after controlling for intelligence. Unlike the results of the NICHD Early Child Care Research Network study (2003) in which sustained attention explained differences in a composite measure of letter knowledge and math, we did not find effects of cognitive control on letter knowledge. It could be that cognitive control is more important in math than in letter knowledge, explaining the difference with the NICHD study.

There is no support for the hypothesis that cognitive control mechanisms, that is, short-term memory, inhibitory control, and sustained attention, moderate learning from book exposure as was suggested by McClelland et al. (2007). Our study shows, on the contrary, that all children profit from book sharing whatever their cognitive control skills. Probably because book reading sessions are highly structured,

cognitive control skills do not moderate effects of book exposure on literacy outcomes. We hypothesize that cognitive control mechanisms might gain in importance as children practice more on their own as for instance occurs when children complete computer tasks (Kegel et al., 2009).

Limitations and future directions

Because the present study is correlational in nature, prudence is called for conclusions concerning causal relationships. Book exposure may cause vocabulary growth and growth in print knowledge, but can also be the outcome of increase in vocabulary and print knowledge or reflect the interactive nature of book sharing and literacy skills (e.g. Crain-Thoreson & Dale, 1992; Justice, Chow, Capellini, Flanigan, & Colton, 2003; Raikes et al., 2006). If children have more vocabulary, or a better developed print knowledge, they might show more interest in storybooks, thereby improving vocabulary and letter knowledge.

Although we showed that variance in book-cover recognition was predicted by environmental factors, it still is the child who completed the test. We showed that intelligence and cognitive control hardly influenced performance, but we cannot rule out the possibility that child characteristics not measured in the current study may play a role.

So far, there is no evidence for differential effects of book exposure between children who differ in cognitive control. We cannot rule out that in spite of the large number of participants the sample was too homogeneous. The influence of child characteristics on school readiness should be explored in less homogeneous groups with more children scoring low on cognitive control (Kegel et al., 2009).

Due to our rather homogeneous sample, variance in the question about book sharing frequency was limited (69% reporting reading every day). This may also explain the rather low correlation between book sharing frequency and the parent print exposure checklist ($r = .16$) and the non-significant relationship between book sharing frequency and vocabulary.

It seems more plausible to hypothesize that cognitive control might gain impact when learning capitalizes more on self-regulating capacities as is the case from Grade 1 and up. Altemeier, Abbott, and Berninger (2008) for example, found that cognitive control at the beginning of Grade 1 was related to children's reading development in Grade 1. A basic skill in learning to read is decoding (mapping of letters and sounds) which strongly appeals to cognitive control skills: letters and sounds need to be connected and memorized and afterwards the sounds need to be combined in order to be able to pronounce the word. Children with weak cognitive control skills may have difficulties carrying out this series of tasks (see also: Savage, Cornish, Manly, & Hollis, 2006).

Implications

One main result of the current study is a new instrument—the book-cover recognition test—as a proximal measure of children's book exposure in research

and individual assessments of children's literacy environment. The findings are in line with the hypothesis that exposure to books is an important step in becoming literate. Book exposure correlates not only with vocabulary but with code-related knowledge as well. The results also support the hypothesis that book sharing is beneficial for all children. So far, there is no evidence for the hypothesis that effects of book exposure depend on child characteristics such as cognitive control skills.

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