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Home Environmental and Behavioral Risk Indices for Reading Achievement

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Abstract

The goal of this study was to identify home environmental and temperament/behavior variables that best predict standardized reading comprehension scores among school-aged children. Data from 269 children aged 9–16 (M = 12.08; SD = 1.62) were used in discriminant function analyses to create the *Home* and *Behavior* indices. Family income was controlled in each index. The final *Home* and *Behavior* models each classified around 75% of cases correctly (reading comprehension at grade level vs. not). Each index was then used to predict other outcomes related to reading. Results showed that *Home* and/or *Behavior* accounted for 4–7% of the variance in reading fluency and spelling and 20–35% of the variance in parent-rated problems in math, social anxiety, and other dimensions. These metrics show promise as environmental and temperament/behavior risk scores that could be used to predict and potentially screen for further assessment of reading related problems.

Keywords

environment; temperament; behavior; reading

1. Introduction

Many people view the task of developing children's reading skills as the purview of formalized education. Yet abundant research shows that the home environment is related to reading outcomes and plays a role in fostering the development of early literacy skills (Burgess, Hecht, & Lonigan., 2002; Griffin & Morrison, 1997). The development of reading

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skills is also potentially impacted by the child's own temperament and behavior (e.g., attention problems, impulsivity; Spira & Fischel, 2005). Given the numerous child-level variables that are associated with reading skills, it would be valuable to combine them and capture their collective predictive power. Moreover, it would be particularly useful to employ a strategy that does not just combine variables but that identifies those that capture unique variance in reading performance thereby providing a set of potential targets for intervention. In this way, "risk scores" could be developed that capture salient risk factors into single scores, which may help translate research findings on risk into practice in schools and clinical settings by consolidating the array of risk variables into a single indicator that could be used in conjunction with other information to identify children who may need additional assessment or intervention. The present study was aimed at characterizing risk in terms of child-level home factors and in terms of child-level temperament and behavior dimensions into single scores that could predict an important reading outcome.

The idea of creating a single index or "risk score" to capture a complex set of variables is not new. For instance, Sameroff, Seifer, Baldwin, and Baldwin (1993) created a composite from 10 family- and child-level environmental variables in predicting IQ stability while covarying socioeconomic status (SES) and race. In 2005, the field of molecular genetics adopted a risk score model as a way to increase the power of association studies that had largely failed to identify genetic variants for phenotypes that had significant heritability (Horne et al., 2005). "Genetic risk scores" (Horne et al., p. 177) have proven useful because they combine the most salient genetic risk variants into a composite that conveys a magnitude of risk that can be detected in relation to an outcome even though each individual genetic variant comprising the risk score accounts for very little variance on its own. These prior examples of combining multiple variables into single risk scores provided some of the inspiration for the present study.

1.1 Home Environment Index

The home literacy environment is "complex and multifaceted" with many different conceptualizations (Burgess et al., 2002, p. 411) and yet it is possible to derive simple metrics of it. Two decades ago, Griffin and Morrison (1997) demonstrated the utility of a "succinct" measure of home literacy that significantly predicted reading outcomes in children. Their composite was formed from the sum of nine items on a parent questionnaire including the amount of TV watched by the child, time spent reading with the child, parents' reading habits in the home, and reading resources in the home (books, magazines). The home literacy environment score significantly predicted reading outcomes in both kindergarten and second grade while controlling for maternal education and child IQ. Griffin and Morrison's work showed that the home environment as it relates to reading outcomes could be meaningfully characterized through a single variable.

Other researchers have since characterized the home environment and their work highlights important considerations when creating a single metric. For instance, Van Steensel (2006) examined the structure of the home literacy environment and identified three profiles among children (ages 5 to 7), and Burgess et al. (2002) tested six different conceptualizations of it based on "active" (e.g., reading with a parent) versus "passive" (e.g., seeing a parent read)

behaviors in 4- and 5-year-old children. In both of these studies, home literacy environment profiles marked by active/engaged behaviors in the home such as parents reading with or to their child were best in predicting reading outcomes. Similarly, Sénéchal and LeFevre (2002) conceptualized a Home Literacy Model consisting of both informal and formal literacy experiences. Informal literacy experiences occur when a book or text is present but is not the primary focus (e.g., shared reading between a child and parent), whereas formal literacy experiences occur when attention is primarily given to the book or text (e.g., parents teaching the alphabet or reading words). Recent longitudinal research on the informal and formal literary indices suggests that they may differentially affect reading-related outcomes. For example, Sénéchal and LeFevre (2014) found that informal literacy experiences predict growth in oral language (i.e., receptive vocabulary), whereas formal literacy experiences predict growth in reading (i.e., early literacy and growth in word reading).

Thus, prior research has shown that “active” or “formal” elements in the home environment are more related to reading outcomes than “passive” or “informal” elements. As children grow and their reading skills become established, the role of the home environment is no longer one of supporting literacy development but rather supporting academic success. The active components that are salient in the environment of 4- to 7-year-olds (e.g., reading with parents) will likely get replaced with other components such as those that promote good study habits and convey expectations about academic success. The present study extends prior work by measuring aspects of the home environment as it relates to reading in a wider age range of children. Moreover, while prior studies were aimed at characterizing the structure of the home literacy environment, the present study was designed to create an index from only those variables that account for significant unique variance in an effort to increase its predictive power of reading achievement.

Other aspects of the home environment not directly related to literacy, and thus not captured by existing measures of the home literacy environment, may also account for unique variance in reading achievement (Johnson, Martin, Brooks-Gunn, Petrill, 2008). For example, household chaos, defined as an environment with high levels of crowding, background noise, and number of people coming in and out (Wachs, 1989), has been shown to have a significant but small correlation with the home literacy environment, suggesting it taps different aspects of the home environment (Johnson et al., 2008). Further, research has shown that the degree of chaos in the home is significantly inversely related to several early reading skills over and above the home literacy environment (Johnson et al., 2008). A negative relationship between chaos and reading comprehension in middle childhood has also been shown (Taylor & Hart, 2014). Additionally, parenting styles may be relevant given previous work suggesting that parental warmth, acceptance, and responsiveness are predictive of reading achievement in early and middle childhood (Bradley & Caldwell, 1984; Bradley, Corwyn, Burchinal, Pipes McAdoo, & Garcia Coll, 2001; Merlow, Bowman, & Barnett, 2007), whereas parental strictness may be negatively related to reading skills (Lee & Kim, 2012).

1.2 Behavior Index

The home environment provides an important context for supporting academic success, but aspects of a child's behavioral or psychological functioning that are related to reading comprehension may be used to create a separate index to capture additional aspects of risk that may complement or even interact with the home environment risk. For instance, one of the most widely studied behaviors in relation to reading comprehension is attention-deficit/hyperactivity disorder (ADHD; American Psychological Association, 2013), which is inversely associated with reading outcomes (Brock & Knapp, 1996; Little, Hart, Schatschneider, & Taylor, 2016; Stern & Shalev, 2013) and shares genetic underpinnings with reading (Greven, Rijsdijk, Asherson, & Plomin, 2012; Greven, Harlaar, Dale, & Plomin, 2011; Martin, Levy, Pieka, & Hay, 2006; Willcutt, Pennington, & DeFries, 2000). ADHD shows high rates of comorbidity with other behavioral problems such as conduct disorder (Biederman, Newcorn, & Sprich, 1991), which itself shows comorbidity with reading disability (Martin et al., 2006). The associations between ADHD and other common childhood behavior disorders to reading disability argue for their consideration when creating a behavior index to complement the home environment index.

The reason that ADHD is related to reading problems has to do, in part, with deficits in attention (Fergusson & Horwood, 1992; Rowe & Rowe, 1992), an executive functioning skill. Executive functioning refers to a set of processes which guide goal-directed behavior (Banich, 2009), and it includes a broad array of skills from attention to planning to shifting focus in the face of feedback. Research has demonstrated that better executive functioning longitudinally predicts higher academic performance (Bull, Espy, & Wiebe, 2008). Moreover, decreased executive functioning skills have been found among children with ADHD and conduct disorder (Moffitt, 1990; Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), suggesting the possibility that these disorders arise, in part, due to deficits in executive functioning. Thus, executive functioning dimensions such as attention would be important to consider when creating a behavior index of risk for reading problems.

Finally, achievement in school is related to individual differences in temperament, which influences thoughts, emotions, and behavior. For example, persistence (the tendency to continue a task despite obstacles), approach/withdrawal (the tendency to approach rather than withdrawal), and adaptability (the ease at which a child adjusts to new situations) all predict increased academic achievement (Bramlett, Scott, & Rowell, 2000; Martin, Nagle, & Paget, 1983). Differences in children's temperament in regard to respect for rules have recently been shown to have significant associations with reading comprehension that is explained, in part, by aspects of the home environment (Taylor & Hart, 2014). Behavioral problems and temperament traits could impact the child's environment not just at school but also at home by eliciting reactions from parents that may actually decrease the child's motivation to do well on schoolwork. As such, temperament traits are important to consider when creating a behavior index for predicting reading comprehension.

1.3 Controlling for SES

When one imagines an academically impoverished home environment, it is easy to focus on SES as a major contributing factor because it predicts academic achievement and literacy

such that children from poorer families tend to have lower achievement (Molfse, Modglin, & Molfese 2003; Sirin, 2005; Weigel, Martin, & Bennett, 2006). Meta-analyses have demonstrated that there is an average correlation of .30 between SES and achievement (Sirin, 2005; White, 1982), indicating that SES should be accounted for when predicting achievement while also cautioning that SES is inadequate as a sole measure of the home environment. In this study, SES was treated as a control variable when creating both the home environment and the behavioral index for two reasons. First, SES is a family-level factor that cannot contribute to individual differences between siblings and so did not become part of the risk indices themselves that were comprised of child-level variables. Second, like prior investigators (Griffin & Morrison, 1997; Sameroff et al., 1993), we were interested in creating composites that explained variance in an outcome measure that could not be attributed simply to economic resources in the family.

1.4 Present Study

The primary goal of the present study was to create indices that reflected salient aspects of (1) the home environment, and (2) temperament and behavior in predicting reading comprehension in school. If successful, the newly created "*Behavior"* index would appear to be the first of its kind in predicting reading performance, and the newly created "*Home"* index would consolidate a large pool of items/scales related to the home environment in a way that has not been done before. The secondary goal of the present study was to begin examining the validity and utility of the new indices in predicting other outcomes related to reading. The research questions for the present study were:

1. *Which home environment variables significantly predict problems in reading comprehension after controlling for SES?* First, it was expected that "active" variables that support school success broadly, such as amount of time doing homework, would become part of the *Home* index rather than "passive" variables (e.g., parent reading *to* the child). Further, it was expected that aspects of chaos in the home and parenting style would be retained as part of the *Home* index. Finally, SES (family income and/or parent education) were expected to be significant predictors and retained as control variables.

2. *Which temperament and behavioral variables significantly predict problems in reading comprehension after controlling for SES?* The *Behavior* index was expected to contain features of ADHD (inattention, hyperactivity/impulsivity), given its robust association to reading. Further, temperament characteristics, especially those reflecting respect for rules, were expected to be retained as part of the *Behavior* index based on prior research. Finally, similar to the home environment index, it was expected that SES would be retained as a control variable.

3. *Will the Home and/or Behavior index created to discriminate on reading comprehension performance also show utility in predicting performance on other reading and reading-related skills?* While optimized to predict reading comprehension, the *Home* and *Behavior* indices are likely to have some generalizability in their utility as risk indicators. As such, the indices were

expected to account for significant variance in other reading (e.g., fluency) and reading-related skills (e.g., spelling).

4. *Will the Home and/or Behavior index have predictive utility that extends beyond reading and reading-related skills to learning-related difficulties?* If the variables in the *Home* and *Behavior* indices have some generalization in terms of relationships to reading-related skills as hypothesized above, then it is possible that they could show utility in predicting learning-related difficulties more broadly. As such, it was expected that the *Home* and *Behavior* indices would significantly predict difficulties in reading and other areas (e.g., math).

5. *Will the Home and Behavior indices created from child-level variables predict existing measures of family-level risk associated with reading problems such as chaos and home literacy environment?* The *Home* and *Behavior* indices will be created based on their ability to predict reading comprehension performance, which has been shown to be related to family-level home chaos and home literacy environment. As such, it was expected that both the *Home* and *Behavior* indices would be significant predictors of those family-level measures of risk for reading problems.

It was expected that the *Home* and *Behavior* indices would be significantly correlated given their common goal of predicting performance in reading comprehension. However, given the different domains of individual differences captured by each index (home vs. temperament/behavior), they were each expected to significantly predict various outcomes as outlined above. Whether they interact when predicting reading and other outcomes was explored without a priori hypotheses but in line with the premise that certain combinations of risk index scores (e.g., low on both) could differentially relate to certain outcomes.

2. Materials and Methods

2.1 Sample and Procedure

Data used in the current study are part of a larger, multi-year project examining genetic and environmental influences on behavior and reading in school-aged twins. Specifically, participants in this study were twins in the Florida Twin Project on Reading, Behavior, and Environment that were recruited from the Florida Twin Project on Reading (Taylor & Schatschneider, 2010) or were new families recruited into the Florida State Twin Registry (Taylor, Hart, Mikolajewski, & Schatschneider, 2013). One of the specific aims of the Florida Twin Project on Reading, Behavior, and Environment grant was to create environmental and temperament/behavior risk indices that could be examined in genetically informative models using data from the identical and fraternal twin pairs in the sample. The first assessment in the Florida Twin Project on Reading, Behavior, and Environment was designed, in part, to get data to address the primary goal of the current study (creating the *Home* and *Behavior* indices).

The study was approved by the Institutional Review Board at Florida State University, and data were collected in accordance with guidelines and principles for human subject research. Packets were mailed to participants from fall 2012 through early fall 2013 that included a

letter about the study, consent and assent forms, and parent and child questionnaires. Parents were told that their questionnaire booklet would take up to one hour to complete and twins were told that their booklet would take up to 30 minutes to complete. Upon receipt of completed packets, families were mailed gift cards to a chosen retailer. In addition to data obtained directly from the families, achievement data were obtained from the Progress Monitoring and Reporting Network, which is a statewide educational database in Florida. In the current study, achievement data included the Florida Comprehensive Assessment of Reading 2.0 (FCAT 2.0) and the Florida Assessment for Instruction in Reading. More detailed information regarding sample recruitment and methods is described by Little and colleagues (2015).

A total of 3,343 packets were mailed to families, of which 568 families of twins in kindergarten through 9th grade participated, 106 refused and 2,334 did not respond. An additional 335 families were not able to be contacted. This resulted in 1,136 twins with parent and/or self-report data on one or more measures. The biological mother was the parent reporter in most families (493; 87.4%), followed by the biological father (47; 8.3%), and other relative such as grandmother (11; 2.0%); the remaining 2.3% of families had a step parent, adoptive parent, or other person reporting on the twins. The reading comprehension measure used in the creation of the risk indices was the FCAT 2.0. The FCAT was, until recently, the state of Florida's compulsory end-of-year achievement test for students in 3rd through 10th grade, which restricted relevant analyses to a maximum of 565 individuals ranging in age from 9 to 16 (M = 12.08; SD = 1.62) in grades 3 through 9 (approximately half of the twins in the sample). In terms of race, parents reported that 61% of the twins were White, 13% African American, 19% Hispanic, 3% mixed race, 1% Asian, 2% Other, and 1% declined to report race. The mean household income was 4.58 (SD = 2.59) rated on a 12-point scale, corresponding roughly to $60,000.

2.2 Measures

2.2.1 Reading Comprehension Outcome—The FCAT 2.0 is a group-administered exam that measures, among other domains, reading comprehension assessed through multiple choice responses that students complete after reading several narrative and expository passages. Thus, although the FCAT is a measure that is specific to Florida schools, it resembles other standardized tests in order to accomplish the goal of assessing reading comprehension proficiency. All students from grades 3 to 10 were administered the FCAT 2.0 in spring 2013 (hereafter referred to as FCAT 2013 to denote the timing of the assessment). Previous research has demonstrated high reliability of the FCAT (.90; Florida Department of Education, 2001). Scores are standardized for developmental stage (age/grade) and range from 100 to 500. The state determines the cut point for a passing FCAT score, which reflects whether reading comprehension proficiency is at grade level, and this pass/fail status was used to create the home environment and temperament/behavior indices.

2.2.2 Home Environment—To address the first study question, the responding parent/caregiver and twins age 9 and older were asked questions about the twin's home environment that were chosen based on prior research showing an association with reading.

Parent-rated items and measures are described first followed by child-rated measures. All items/measures are listed in Table 1 with their alpha reliability.

The responding parent rated each twin on the following individual items: *Level of education of parent/caregiver completing the questionnaire* (scored 1 = Grade 6 or less to 8 = Completed graduate or professional school); *Level of education of other adult caregiver* (same scale as above); *Household income of the twins* (scored 1 = Less than $10,000 to 12 = $210,000 or more); *Highest level of education parent expects twin to receive* (scored 1 = High school to 6 = Graduate/law/medical degree); *How often parent reads with child* and *How often child asks parent to read to him/her* and *How often parent helped child with English grammar* and *How often does the child amuse him/herself alone with books* (each scored 1 = More than 3 times per day to 5 = Almost never); *How often responding parent reads to child* and *How often other adult caregiver reads to child* and *How often other person reads to child* (all scored 1 = Daily; 2 = Several times a week; 3 = Weekly or less); *How much child enjoys being read to* (scored 1 = Very much to 4 = Not at all); *How many books child brings home from the library in a given month* (parent wrote in the actual number); *Hours/day child watches TV on weekdays* and *Hours/day child watches TV on weekends* (parent wrote in the actual number for each); *How often parent discusses school progress with child* (scored 1 = More than 3 times/week to 6 = Almost never); *How well parent knows what child is studying in school* (scored 1 = knows when every assignment is due and what is being studying on particular days to 4 = knows what classes child is taking but not aware of particular activities in classes); *Hours per week parent expects child to spend on homework* (parent wrote in the actual number); *How many hours per week child spends on homework* (scored 1 = 0 to 4 = 5 or more).

My Parents Scale: The My Parents Scale (Lamborn, Mounts, Stenberg, & Dornbusch, 1991) yields a *Strictness subscale* that contains 9 items that are summed to assess how late the child is allowed to stay out and how closely they are monitored. The *Warmth subscale* contains 10 items that are summed to assess the extent to which each twin feels his or her parents are loving, involved, and responsive: 5 items (e.g., “I can count on him/her to help me out if I have some kind of problem”) are rated on a 2-point scale (1 = *Usually True*, 2 = *Usually False*) and 5 items assess parental reactions to grades, amount of praise from parents, parental knowledge regarding friends, amount of time spent talking with parent, and amount of time the family spends doing pleasant activities together using different response formats for each item. The variability in response options across items on this subscale precluded accurate assessment of alpha reliability.

Confusion, Hubbub, and Order Scale (CHAOS): The CHAOS (Matheny, Wachs, Ludwig, & Phillips, 1995) has 6 items assessing environmental confusion in the home, including noise, crowding, and use of routines (e.g., “It’s a real zoo in our home”). Items are averaged and higher scores indicate increased disorganization.

2.2.3 Behavior—To address the second study question, parents rated twins on several well-known measures of behavior problems and temperament traits that had a known (e.g., ADHD) or hypothesized (e.g., respect for rules) association with reading. See Table 1 for a list of measures and alpha reliability.

Child and Adolescent Dispositions Scale (CADS): The CADS (Lahey et al., 2008) is a measure of temperament dispositions with items rated 1 (*Not at all*) to 4 (*Very much/very often*). The *Respect for Rules* subscale score was obtained by averaging 4 items derived from a previous confirmatory factor analysis (Mikolajewski, Chavarria, Moltisanti, Hart, & Taylor, 2014). It assesses a child's concerns about right and wrong and rule-abiding. The *Sympathy* subscale is comprised of the mean of 8 items (Mikolajewski et al., 2014) and measures empathy and the tendency to help others. The *Daring* subscale measures bravery and a willingness to take risks and is comprised of 5 items.

Eyberg Child Behavior Inventory (ECBI): The ECBI (Eyberg & Robinson, 1983) yields a *Behavior Problems total* score based on 36 yes/no items that require parents to rate whether specific behaviors are a problem for each twin. The *Behavior Problems Intensity* score reflects how often each of the 36 problem behaviors occurs for each twin. Items are scored on a 7-point scale ranging from 1 (*Never*) to 7 (*Always*).

Strengths and Weaknesses of ADHD-symptoms and Normal-behaviors (SWAN): The SWAN (Swanson et al., 2005) is a rating scale in which symptoms of ADHD are rated on how their child compares to other children over the past month. The *Inattention* scale includes 9 items (e.g., "Sustains attention on tasks or play activities") which are scored on a 7-point scale with anchors at 1 (Far Below Average) to 7 (Far Above Average). All items are averaged to make a total Inattention symptoms score, with lower scores indicating more attention problems. The scale has been shown to demonstrate strong psychometric properties including good internal consistency (α = .94; Young, Levy, Martin, & Hay, 2009). The *Hyperactivity/impulsivity* scale is comprised of 9 items (e.g., "Settles down and rests [controls constant activity]"), which are scored on the same 7-point scale described for the Inattention scale, with lower scores indicating increased symptoms of hyperactivity/impulsivity. Internal consistency of this scale is high in previous research (α = .94; Young et al., 2009).

Positive and Negative Affect Schedule (PANAS): The PANAS (Watson, Clark, & Tellegen, 1988) was rated by parents using a 5-point scale ranging from 1 (Very Slightly or Not at All) to 5 (Extremely). The *Negative Affectivity* (NA) scale measured the level of trait negative affect using 10 items (e.g., "distressed"). The *Positive Affectivity* (PA) scale measured trait level positive affect and was comprised of 10 items (e.g., "excited") and was scored similarly to NA.

Combined CD and ODD dimension score: The Disruptive Behavior Disorder Rating Scale (DBD; Pelham, Gnagy, Greenslade, & Milich, 1992) was used to assess CD and ODD. Items on the DBD reflect DSM-IV symptoms and are rated from 1 (*Not at All*) to 4 (*Very Much*). For ease of interpretation, the raw ratings were recoded from 0 to 3, and dimension scores were calculated by averaging items within disorder to reflect the extent to which the child had symptoms of the disorder "not at all" or "very much." To capture non-ADHD behavior disorders, the CD and ODD dimension scores were summed together into a single score ranging from a minimum of 0 (no symptoms of either disorder) to a maximum possible score of 6 (both disorders experienced "very much").

BRIEF: The Brief Inventory of Executive Functioning (BRIEF; Gioia et al., 2000) is a measure of executive functioning which includes 86 items assessing behaviors exhibited by the child during the past 6 months. Each item on the BRIEF is scored on a 3-point scale (1 = *Never*, 2 = *Sometimes*, 3 = *Often*), and items were summed for each scale, with higher scores indicating more executive functioning problems. The *Inhibition* scale score includes 10 items which assess difficulties resisting impulses. The *Shifting* scale includes 8 items measuring difficulties in changing behavior and making transitions. Ten items comprise the *Emotional Control* scale, which assesses problems modulating emotional reactions. The *Self-Monitor* scale includes 8 items measuring difficulties related to work-checking habits.

Information Sharing scale: This scale assesses the extent to which the child reports to the parent how and where the child spends his/her time and with who. These items were based on the Child Disclosure measure (Stattin & Kerr, 2000). Each item is scored on a 5-point scale ranging from 1 (*Never*) to 5 (*Often*). The Information Sharing scale is calculated by averaging each of the 5 items and higher scores reflect greater information sharing and disclosure.

2.2.4 Other Reading Measures and Learning Difficulties—To address the third and fourth study questions, additional behavior scales (not used in the formation of the home environment and behavior indices) were administered to parents. Other reading scores from spring 2013 (e.g., fluency) were taken from the aforementioned state-wide database. These scales are listed in Table 4 with their alpha reliability and descriptive statistics.

FCAT: Although the pass/fail status on FCAT 2013 (described above) was used to create the indices, it was examined in continuous form as an outcome variable as well.

Florida Assessment for Instruction in Reading (FAIR) Reading comprehension: Reading comprehension on the FAIR was assessed using a computerized test requiring students to read narrative or expository passages and answer several multiple response questions about each passage. The number of passages and questions required for each student varied, depending on ability level. *Reading fluency* on the FAIR was measured via a computerized Maze Task, which assesses a student's ability to read text quickly and efficiently. Students were instructed to read two passages in three minutes and reading fluency scores are based on the number of correct responses to items. *Spelling* on the FAIR was assessed via a computer-adapted test using a World Analysis Task, which measures knowledge of phonological and orthographic information. The Word Analysis Task consisted of 5–30 items, depending on ability level, and required students to listen to words through headphones and to respond by typing out each word. IRT reliability estimates for each FAIR scale vary by grade and range from .77 for reading fluency to .95 for spelling (http://www.fcrr.org/fair/Technical%20manual%20-%203-12-FINAL_2012.pdf).

CLDQ: The Colorado Learning Difficulties Questionnaire (CLDQ; Willcutt et al., 2011) is a screening measure used to assess learning difficulties and other problems across several domains. The 20 items are rated on a 5-point scale with anchors at 1 (*Never/Not at all*) and 5 (*Always/A great deal*). All items were summed to make a total score for each scale, including the CLDQ *Total Problems* scale, and higher scores on the CLDQ indicate greater

difficulties. Six items of the CLDQ were used to assess the *Reading Problems* scale (e.g., "does/did your child have difficulty with spelling?"). The Reading Problems scale demonstrated excellent internal consistency in the present study. The *Social Cognition Problems* scale of the CLDQ includes 4 items (e.g.," Does/did your child have poor understanding of interpersonal space?"), which assess social skill deficits. The *Social Anxiety Problems* scale, which was used to assess social isolation and anxiety, is comprised of 3 items (e.g., "Does/did your child have difficulty making or keeping friends?"). Difficulties with spatial functioning were measured with the *Spatial Problems* scale from the CLDQ, which includes 4 items (e.g., "Do/did your child's papers look disorganized or messy?"). Math difficulties for each twin were assessed using the *Math Problems* scale of the CLDQ (e.g., "Does/did your child have trouble learning new math concepts such as carrying or borrowing?").

2.2.5 Family-level Home Environment Related to Reading Problems—To address the fifth study question, parents rated the twins' home environment on widely-used measures of home literacy and chaos (see Table 4 for alpha reliability and descriptive statistics).

Home Literacy Environment: The home literacy environment (Griffin and Morrison, 1997) measure was modified to assess family-level home literacy and included a total of 6 items rated by the responding parent. It included items that reflected exposure to reading material and reading-related activities at a family-level rather than child-level (e.g., does a family member read magazines; how often does the parent read to him/herself). Due to an excess of missing values for items in this scale, scores were calculated with a minimum of 5 items.

Confusion, Hubbub, and Order Scale: The CHAOS measure (described above) was also rated by the responding parent as a family-level scale that applied to the entire household.

2.3 Data Analytic Plan

As a first step in addressing the first two research questions, significant ($p < .05$) phenotypic correlations between potential indicators and FCAT 2013 continuous scores were used to identify the initial set of variables for the discriminant functions using data from the maximum sample available (565 twins).

As the second step of addressing the first two research questions, discriminant function analyses were used to predict the outcome of the FCAT 2013 assessment (pass vs. fail). The discriminant function analyses were conducted using data from a randomly selected twin from each pair (N = 269) in order to satisfy the need for independent observations and to avoid the bias that might arise if members of the sample were highly correlated in their scores on variables used to create the indices. Discriminant function was selected because it provides a good method for weighting significant predictors in order to quantify their salience. (Another approach that could be taken is latent class analysis; however, it would not have accomplished the goal of narrowing the field of predictors down to those capturing unique variance in the outcome.) Discriminant function provides a means to predict categorical outcomes, and the pass/fail outcome on the FCAT corresponded to whether the child was deemed by the school system to be reading at grade level (passed the FCAT) or not

(failed the FCAT). In order to restrict the final function to only those variables that accounted for significant unique variance, two pieces of information were used to identify variables to retain in the model: significant ($p < .05$) values for Wilks' Lambda testing differences in group means between those who passed versus failed the FCAT in 2013 and values of the structure matrix coefficients (akin to factor loadings) above .3. This same procedure was used to create the *Home* and *Behavior* indices.

To address research questions 3–5, the *Home* and *Behavior* index scores were examined in relation to other reading and reading-related skills, learning difficulties, and widely used family-level home environment measures using regression analyses. Specifically, the *Home* and *Behavior* indices were examined in a series of hierarchical regressions predicting each of the outcomes that showed a significant simple correlation with them. For the regression analyses on continuous FCAT and other reading-related measures, scores from the prior spring (2012) were also available to be included in order to examine whether *Home* and/or *Behavior* had predictive value above and beyond prior performance (no such prior data were available for the other outcomes). The first step in each model included age (and prior year's score for reading measures) and then *Home*, *Behavior*, and *Home* x *Behavior* were entered in the second step. *Home* and *Behavior* were centered to provide a meaningful value for zero. Models with gender included in the first step and in interaction terms with *Home* and *Behavior* in the second step were examined as well. To adjust for multiple comparisons and reduce Type I error, the Benjamini-Hochberg correction (Benjamini & Hochberg, 1995) was applied within each regression analysis. This correction adjusts the critical *p*-value in a step-wise manner based on the number of significance tests included within a particular set of analyses. Notably, the inclusion of gender was significant only for the Social Cognition scale and, therefore, results with gender in the model are presented only for that scale. (Again only one twin from each pair was used to ensure independence of observations; the sample size was maximized by starting with the twins with parent- and/or twin-rated data and using the randomly designated "first twin" in each pair yielding a maximum N of 568 for these analyses.)

3. Results

To examine potential bias in the sample of twins with environment and behavioral data used for this study, those included (responders) were compared to twins in the Florida Twin Project on Reading who were recruited but did not participate (non-responders) on FCAT 2013 scores. (No data were available on new families that were unable to be reached/recruited.) The responders had significantly higher FCAT 2013 scores (n= 565; $M = 228.39$; $SD = 23.63$) than the non-responders (n = 2,136; $M = 225.30$; $SD = 24.52$), $t(2,699) = -2.71$, $p < .007$. Although significant, the difference was small in terms of effect size ($d = .13$).

The number of hours the twins watched TV on the weekends and the sum of CD and ODD symptom dimensions were both significantly skewed and required outlying values to be brought to twice the interquartile range from the median in order to improve the normality of the distributions. No other transformations were needed. The initial correlation of each of the environment and behavior measures with FCAT 2013 continuous scores served as the

starting point for the creation of the *Home* and *Behavior* indices (see Table 1). The highest correlation with FCAT 2013 was for Inattention problems (in the behavioral measures) followed by the highest level of education the parent expected for the twins (in the environmental measures). The SES variables along with Hyperactivity/Impulsivity problems showed the next highest magnitude correlations with FCAT 2013. The weakest (albeit significant) correlations with FCAT 2013 were for how much the twin enjoyed being read to, how often the parent discussed school progress with the twin, and Emotional Control. A few variables failed to significantly correlate with FCAT 2013, and those were dropped from further analysis. A table of correlations among all variables included in the discriminant function analyses, the *Home* and *Behavior* indices, and the external correlates are provided in Table S1 (supplemental online material).

3.1 Discriminant Functions to Create the *Home* and *Behavior* Indices

Table 2 presents a summary of the discriminant function analyses in the creation of the *Home* index, addressing the first research question. The initial structure matrix for the prediction of passing the FCAT 2013 from home environment measures and SES control variables showed seven variables that met criteria for retention as outlined above. When the seven variables were submitted to a new discriminant function analysis, the child-rated CHAOS score no longer met the criteria for retention, thereby leaving six variables in the final discriminant function. As expected, the final discriminant function for the *Home* index contained “active” variables such as how often the twin watched TV and how often the parent helps the child with English grammar as well as measures of SES. As evidenced in Table 2, the final *Home* discriminant function classified 76% of cases accurately (passing vs. failing FCAT 2013). To score the *Home* index, an equation was created from the final canonical discriminant function coefficients (column 3 in Table 2), with the exception of the SES variables that had been retained simply to control for the effects of SES on the other variables in the function. The resulting *Home* index was comprised of a constant and the sum of the canonical coefficient-weighted values of four environmental variables *after* SES had been partialed out. High scores on the *Home* index indicated a greater probability of passing the FCAT and reflected parent’s higher expectations for educational achievement, more time spent by the child amusing him/herself alone with books, less time spent by the parent helping the child with English grammar, and less time spent by the child watching TV on the weekends.

The discriminant function analyses for creating the *Behavior* index are summarized in Table 3, which addressed the second research question. There were eight variables that met criteria for retention, including, as predicted, both ADHD dimensions and SES measures. There were also three temperament dimensions retained including respect for rules, as predicted). The final *Behavior* discriminant function classified 72% of cases accurately. The *Behavior* index was created from the five temperament/behavior variables in the final model (column 3 in Table 3). High scores indicated greater probability of passing the FCAT and reflected lower negative affectivity, higher positive affectivity and respect for rules, and less problems with ADHD symptoms of inattention and hyperactivity/impulsivity.

The validity of each discriminant function was examined using the co-twins that had been excluded from the primary analysis. Specifically, the final set of variables in the primary *Home* discriminant function were submitted to a discriminant function using data from the excluded twins. Performance of the items (significance of Wilks' Lambda test; structure matrix function value) was examined to determine whether it was comparable to that of the primary sample. The same method was used to examine the *Behavior* index. The solutions across the two samples were comparable, so only the original discriminant function analysis on the primary sample was presented.

3.2 Prediction of Other Reading Measures and Learning Difficulties

Means and other descriptive data on the *Home* and *Behavior* indices and outcomes are given in Table 4 for the subsample of randomly selected twins from pairs (maximum N = 565). Missing data on variables used in calculating the *Home* and/or *Behavior* indices resulted in missing data on one or both indices. See Table S1 (supplemental online material) for correlations among outcomes.

As a first step in addressing research questions 3 and 4, bivariate correlations between the indices and outcomes were calculated and are summarized in Table 4. The *Home* and *Behavior* indices were found to be significantly correlated with each other, as predicted, and with most outcome measures. The *Home* index showed stronger correlations with measures of reading and reading-related skills than the *Behavior* index. For both indices, correlations with other reading-related measures were positive. The two indices showed a similar magnitude correlation with the CLDQ dimension of Reading Problems. The *Behavior* index showed stronger correlations with other CLDQ scales (e.g., Math Problems; Social Cognition) than the *Home* index.

Table 5 summarizes the hierarchical regression analyses used in addressing research questions 3 and 4 regarding prediction of other reading outcomes and learning difficulties. For the FCAT 2013 continuous scores and other reading-related measures assessed in spring 2013, the *Home* and *Behavior* indices accounted for 4–7% of the variance. Consistent with expectations, the *Home* index showed a significant positive effect for two reading measures even after accounting for the prior year's performance on those same measures, indicating that as *Home* increased so did the performance on reading comprehension and reading fluency (but, contrary to expectations, not spelling). The CLDQ scales reflect parent rated problems of their children in multiple areas associated with learning difficulties. As can be seen in Table 5, the pattern of results in the simple correlations was largely repeated in the regression analyses with the *Behavior* index showing a stronger association with CLDQ scales than the *Home* index. The regression models accounted for about 20–35% of the variance in CLDQ subscales. For all but the Social Cognition Problems scale, a decrease in *Behavior* was associated with a significant increase in problems. The *Home* index showed a similar pattern of effects, but most were non-significant after alpha correction. The *Behavior* and *Home* indices were both strong predictors of Reading Problems. Gender was a significant predictor only for Social Cognition, but the interactions that included gender were non-significant after alpha correction.

Whether the *Home* and *Behavior* indices were independent predictors of outcomes or if they might interact was explored in each regression analysis. As expected, the *Behavior* index showed a significant positive effect in predicting FCAT 2013. However, it also showed a significant interaction with *Home* in predicting both FCAT 2013 and reading fluency. The nature of the significant 2-way interaction for FCAT 2013 continuous scores was examined by plotting the mean score of that scale for groups that were above/below the mean of the *Home* and *Behavior* indices, and this is shown in Figure 1 (The sample was too small to plot the reading fluency means at the traditional +/− 1 *SD* from the *Home* and *Behavior* means as this resulted in two cells that contained 1 or 6 cases.) Twins with the "riskiest" combination of index scores (low *Home* and low *Behavior*) showed the worst performance on FCAT 2013, whereas those in the in "optimal" combination of index scores (high *Home* and high *Behavior*) had the highest FCAT 2013 scores. Likewise, Figure 2 shows the nature of the 2-way interaction predicting reading fluency. In that case, twins with the "optimal" combination of index scores were similar (and slightly lower) than the group with a better *Home* scores relative to *Behavior*. The group with better *Behavior* relative to *Home* showed reading fluency performance that was near the mean of the overall sample. These were the only significant interactions found for *Home* and *Behavior* in predicting any outcomes.

3.3 Predicting Other Measures of Home Environment Related to Reading

The *Home* and *Behavior* indices were examined as predictors of two family-level measures of the home environment to address the final research question. As indicated in Table 4, the *Behavior* index was more strongly correlated with family CHAOS than the *Home* index. Also, the home literacy environment scale was the weakest correlate of the *Behavior* index and the third weakest correlate of the *Home* index. Results of the hierarchical regression analyses predicting family-level environment measures are shown in Table 5; only *Behavior* remained significantly positively related to the home literacy environment scale after alpha correction. For CHAOS, only the *Behavior* index was significant such that decreases in *Behavior* scores (reflecting more negative affectivity, more ADHD problems, etc.) were associated with increases in CHAOS. The total variance explained in the models for home literacy environment and CHAOS was similar to the magnitude found for the reading-related measures.

4. Discussion

Various aspects of a child's home environment, temperament, and behavior are associated with reading comprehension. Prior efforts to create single scores representing multiple risk factors (Sameroff et al., 1993; Horne et al., 2005) have demonstrated the utility of such an approach and inspired the current effort to create indices from home environment and temperament and behavior variables to predict reading comprehension performance. The hypotheses were largely supported, and the newly created *Home* and *Behavior* indices appear promising as risk metrics that capture the combined influence of multiple aspects of a child's temperament, behavior, and home life.

The first two research questions in the present study asked whether a metric could be created that reflects salient aspects of the home environment and whether one could be created that

reflects salient aspects of the child's temperament and behavior in order to predict reading comprehension problems. The creation of the *Home* and *Behavior* indices involved using prior research findings to identify potential variables and transitioning to a data-driven approach that used the relationships in the data to support which variables to include in the discriminant function models. The children in the present sample were already of reading age and, as such, it was predicted that more "active" elements would be significant predictors of school-based reading comprehension performance. Consistent with this idea, the *Home* ultimately included three such elements: time spent watching TV on the weekend; time spent amusing one's self alone with books; and frequency of a parent's help with English grammar. However, the strongest element in the *Home* was not a measure of the child's actions but rather the parent's belief about the highest level of education the child would achieve. This is consistent with literature showing large effects of parent expectations for their children's reading achievement (Jeynes, 2005) and moderate correlation with other early academic skills such as numeracy (LeFevre, Polyzoi, Skwarchuk, Fast, & Sowinski, 2010).

The present data are also consistent with the idea that the parent's expectation for normative (finish high school) versus high (doctorate degree) educational achievement may set the tone in the home environment and perhaps filters through decisions on things such as how much TV to allow a child to watch on the weekend. It is also possible that the parent's expectation for educational achievement is correlated with the parent's own behaviors such as reading for pleasure or going to the library or museums that reduce time for activities such as watching TV. The present study cannot rule out the possibility that the direction of the effect is reversed and parent's expectation for educational achievement of their children is derived from what they observe (frequency of watching TV and reading for pleasure) or children's actual academic achievement. In line with evidence of bidirectional effects between parent-driven negativity and child antisocial behavior (Larsson, Viding, Rijsdijk, & Plomin, 2008), there is probably a bidirectional influence between the parent's expectation for educational achievement and the child's academic performance. What the present study can rule out is that the *Home* index simply characterizes the economic resources in the family since SES variables were controlled for in the discriminant functions to remove their effects from the coefficients of other variables.

Similarly, the *Behavior* index was created with SES controlled for in the discriminant function, thereby removing it as an explanation for those results. Given the robust association of ADHD to reading disability, ADHD features were expected to be included in the *Behavior* index and they were. However, ADHD features were not the strongest elements in the *Behavior* index. Instead, temperament traits of positive and negative affectivity had substantially larger coefficients than either of the ADHD problem dimensions. The strong bivariate correlations seen for the two dimensions of ADHD with FCAT 2013 did not account for the shared variance of those dimensions as did the discriminant function, which may help explain the smaller coefficients for the ADHD dimensions in the *Behavior* index as compared to positive and negative affectivity. The correlation between the two ADHD dimensions was .74, raising the possibility that multicollinearity may have served to suppress effects of each variable in the discriminant function. However, a sum score for ADHD was examined in a separate analysis, and its canonical discriminant function

coefficient also showed a decrease from the level seen in the structure matrix, suggesting that the pattern observed in the reported analysis did not owe to multicollinearity of the two ADHD dimensions. An additional temperament dimension, respect for rules, had a small contribution to the *Behavior* index. The target outcome in creating the *Behavior* index was performance on a school-administered reading comprehension test (pass vs. fail) that indicated whether the child read at grade level. The fact that a *Behavior* index could be created at all is telling in that it highlights the importance of considering individual differences dimensions in temperament as well as traditional behavioral features such as ADHD in accounting for some variance in a child's reading performance.

The third and fourth research questions asked whether the *Home* and *Behavior* indices would have generalized predictive utility in regard to other reading and reading-related skills as well as dimensions related to learning difficulties (e.g., math problems) with the expectation that they would. The *Home* and *Behavior* indices were themselves correlated significantly at a small to moderate magnitude. Larger magnitude significant correlations were found between *Home* and reading achievement measures and between *Behavior* and parent report on the children's learning difficulties in multiple areas (e.g., reading, math, social cognition). However, the two indices were not significantly predictive of spelling achievement, suggesting limits on the generalization of their utility in predicting academic skills. The amount of variance in FCAT 2013 continuous scores and other reading measures accounted for by *Home* and *Behavior* was 4–8% *after* controlling for prior year's scores on the same measure, which is similar to the effects shown for teacher quality on reading fluency (Taylor, Roehrig, Soden-Hensler, Connor, & Schatschneider, 2010) and the effects of instruction on reading (Connor, Morrison, Fishman, Schatschneider, & Underwood, 2007). The two indices accounted for more than a quarter of the variance in reading problems as reported by the parent. Together these results provide initial evidence of the validity and utility of the *Home* and *Behavior* indices in providing a meaningful single metric for important environmental and behavioral variables related to reading in children.

For two of the outcomes, the *Home* and *Behavior* indices showed a significant interaction. First, the *Home* and *Behavior* indices appeared to have different types of effects on reading fluency. The *Behavior* metric indexes risk such that a lower score (indicating more ADHD behaviors, less respect for rules, etc.) predicts lower reading fluency and reading comprehension, but only when coupled with a poorer *Home* score. *Behavior* level seemed to have little effect on reading fluency when *Home* was higher. Thus, a better home environment may provide some protection against the effects of poorer behavior. The positive effect of higher *Home* on reading fluency may reflect a broader positive effect of a home environment that promotes academic success. For instance, a high *Home* score may reflect greater adherence to treatment protocols for ADHD and modeling of respect for rules that promote success in school even when children have less-than-optimal behavioral and emotional control. The pattern of the interaction was similar for FCAT 2013 continuous scores except that the "optimal" combination of *Home* and *Behavior* resulted in the best performance. Future research should examine characteristics of parents that may provide some insights into what makes *Home* higher or lower. It is important not to over interpret the significant interactions found for reading fluency and FCAT reading comprehension as none

was found for the FAIR reading comprehension or spelling measures. Thus, replication of this finding will be particularly important.

It is worth commenting on some of the variables that did not make it into the *Home* or *Behavior* index. The amount of TV a child watches on weekdays came close to inclusion in the *Home* index, and other ways of characterizing this activity are defensible (e.g., summing the hours for the whole week). The final discriminant function for *Home* suggested that weekend TV watching was the weakest contributor to the score, so adding in weekday TV watching would not likely have changed the results. Surprisingly, items related to homework did not compete successfully for a place in the *Home* index. The present results supported prior findings for an association between time spent doing homework and scores on reading comprehension (e.g., Little, Hart, Schatschneider, & Taylor, 2016), but that relationship may be accounted for by other indicators in the *Home* index such as frequency of a parent's help with English grammar (which may be a proxy for parent's help with homework more generally). The *Behavior* index contained both temperament traits and externalizing behavior problems that appeared to capture the same variance as executive functioning measures, so none of the BRIEF scales were included in the final *Behavior* index. This does not mean that executive functioning is not important in understanding the development of reading. Moreover, the BRIEF is a parent report measure rather than a behavioral/clinical measure, and inclusion of the latter types of measures may have produced different results for executive functioning.

Given that there are already family-level measures of the home environment that are associated with reading outcomes, the fifth research question asked whether the newly created *Home* and *Behavior* indices would be related to those measures. The CHAOS scale and the home literacy environment scale are widely-used measures of the home environment and, as expected, they were significantly correlated with the *Home* and *Behavior* indices. However, the correlations were small in magnitude, suggesting that the newly created indices are not tapping into the same exact thing as the existing measure of the home environment. The *Home* and *Behavior* indices were designed to capture child-level risk factors, whereas the CHAOS and home literacy environment scales were rated by parents regarding the family's environment, and that may also help explain the relatively low associations that were found.

Although one of the strengths of the present study is the use of a wider age range than prior studies to examine home environment related to reading comprehension, that age range may have impacted the composition of the *Home* index. For instance, the sample was likely too old for shared reading to have an impact on the home environment. The outcome measure (FCAT) was administered starting in third grade and this restricted the sample to mid-elementary grades and above. The sample was not sufficiently sized to conduct separate discriminant function analyses by age. Therefore, it is possible that risk indices comprised of salient variables could vary across important developmental and/or academic periods (e.g., childhood vs. teens or elementary vs. high school). Future studies with sufficient numbers of children across the developmental/school ranges to afford comparisons would be useful.

The present findings need to be interpreted within the context of some important limitations. First, the variables on temperament, behavior, and home environment measures used to create the *Home* and *Behavior* indices in this study were extensive but not exhaustive. The present findings provide a starting point for confirmation and even expansion of the set of salient variables that comprise the *Home* and *Behavior* indices. Second, the canonical coefficients derived in this study were specific to this sample. This does not mean that those same values cannot be used in other samples to score the *Home* and *Behavior* indices, but such an application should be undertaken with caution. Second, the home environment was assessed only via parent, and it would have been advantageous to have multiple sources of information (e.g., home visit). Similarly, parents reported on behavior of the twins, including learning problems, and the reliability of that single informant report cannot be evaluated in relation to other sources of information (e.g., teacher rating). Third, there was no assessment of the number of siblings in the household, so effects of birth order were not evaluated. Moreover, the results may not generalize to families with single children. Finally, although the use of single metric indices to capture complex sets of risk factors can help in producing parsimonious models of the interplay between environment, temperament/behavior, and achievement, these indices may fail to account for theoretically relevant variables when using a data-driven approach as was the case here.

5. Conclusions

The context for a child's reading achievement in school includes more than classrooms and teachers. It includes temperament and behavioral characteristics of the child that interact with their environment. The present study captures some of the complexity of the numerous factors that influence reading comprehension and consolidates them into single metric indices. A parent's expectations regarding educational achievement was the strongest element of the home environment index, and it may be useful as an individual target for prevention and intervention. Parents may not realize the impact their attitudes and beliefs about their child's academic achievement could have on their success. The child's level of positive and negative emotionality were the strongest indicators in the behavioral index, suggesting that parents may be able to spot these risk factors even before the child is in school. The behavioral and environmental indices created here showed similar magnitude effects as teacher quality and instruction on predicting reading-related outcomes. This further highlights the importance of considering child-level individual differences when examining the reading performance. Finally, the creation of consolidated risk metrics could help translate research into practice by providing teachers and clinicians with another tool in screening children for intervention or further assessment of reading and reading-related problems.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Single metrics that capture risk in behavior and the environment would prove useful in understanding individual differences in achievement
- Home environment and behavior indices were created to reflect combinations of salient variables
- Home environment and behavior indices accounted for 4–7% of the variance in achievement scores after controlling for prior year performance

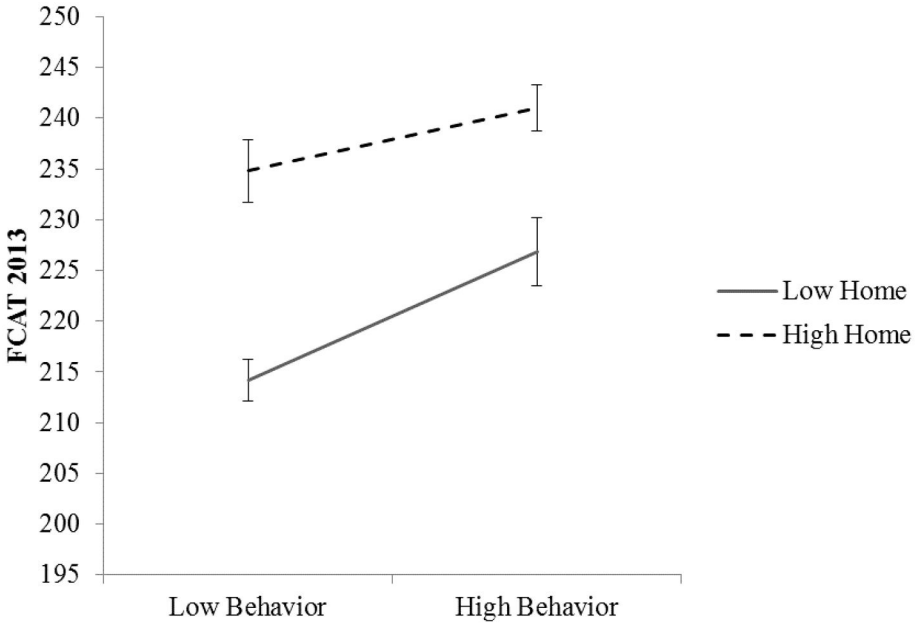

Figure 1.

Interaction between *Home* and *Behavior* in Predicting FCAT 2013 Continuous Scores. Data points are means (+/− 1 *SE*) above (High) or below (Low) the mean of the *Home* or *Behavior* index. FCAT = Florida Comprehensive Assessment Test in reading.

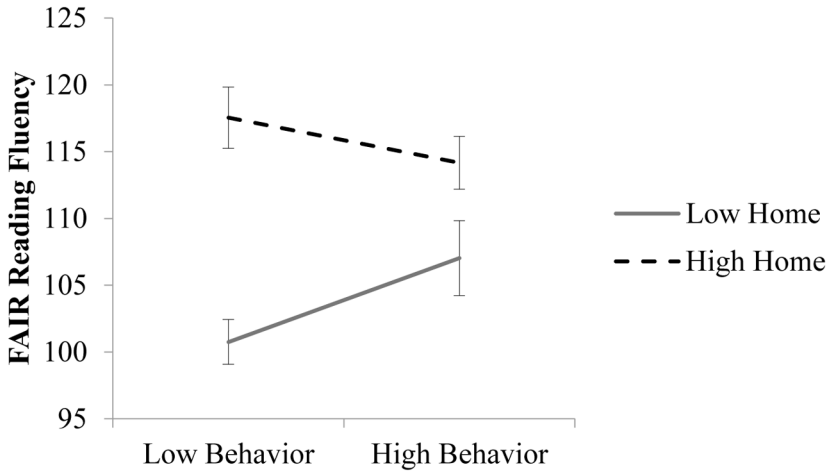

Figure 2.

Interaction between *Home* and *Behavior* in Predicting FAIR Reading Fluency 2013. Data points are means (+/− 1 *SE*) above (High) or below (Low) the mean of the *Home* or *Behavior* index. FAIR = Florida Assessment for Instruction in Reading.

Table 1

Descriptive Statistics and Correlations for Measures with FCAT in the Full Sample

Measure	N	Min	Max	Skew	Alpha	Mean (SD)	Correlation with FCAT 2013
FCAT 2013	565	152	296	−0.05	.90	228.39 (23.63)	-
Level of education of parent/caregiver	556	1	8	0.20	-	5.12 (1.87)	.35
Level of education of other adult caregiver	431	1	8	0.30	-	4.73 (1.83)	.31
Household income of the twins	536	1	12	0.89	-	4.58 (2.59)	.39
Highest level of education parent expects twin to receive	559	1	6	−1.65	-	4.96 (1.24)	.41
How often parent reads with child†	552	1	5	0.63	-	3.98 (1.13)	.25
How often child asks parent to read to him/her†	555	1	5	−1.44	-	4.35 (1.08)	.21
How often responding parent reads to child†	552	0	3	−0.54	-	1.87 (1.29)	−.04 n.s.
How often other adult caregiver reads to child†	555	0	3	0.21	-	1.33 (1.43)	.08 n.s.
How often other person reads to child†	544	0	3	1.44	-	0.62 (1.13)	−.04 n.s.
How much child enjoys being read to†	549	1	4	−0.17	-	2.63 (1.10)	.12
How many books child brings home from the library in a given month	471	0	35	2.50	-	4.64 (4.16)	−.04 n.s.
Hours/day child watches TV on weekdays	552	0	6	1.07	-	2.18 (1.47)	−.24
Hours/day child watches TV on weekends	540	0	14	0.63	-	6.73 (3.18)	−.17
How often parent helped child with English grammar†	558	1	5	−0.01	-	3.25 (1.35)	.25
How often parent discusses school progress with child†	551	1	6	1.95	-	1.53 (0.86)	−.12
How well parent knows what child is studying in school†	556	1	4	0.60	-	1.88 (0.77)	−.02 n.s.
Hours per week parent expects child to spend on homework	550	0	30	2.11	-	5.81 (3.72)	.20
How often does the child amuse him/herself alone with books†	556	1	5	0.37	-	2.88 (1.26)	−.22
How many hours per week child spends on homework	555	1	4	−0.87	-	3.38 (0.79)	.20
Strictness subscale score	483	0	25	−1.39	.64	18.51 (3.75)	.19
Warmth subscale score	500	3	19	−1.12	-	13.65 (2.55)	.08 n.s.
CHAOS (child rated)	489	1	5	0.45	.55	2.45 (0.66)	−.19
Respect for Rules	547	1	4	−0.66	.67	3.28 (0.57)	.29
Sympathy	554	1	4	−0.64	.84	3.32 (0.51)	.18
Daring	546	1	4	0.27	.74	2.43 (0.65)	−.06 n.s.
Behavior Problems Total	392	0	31	1.56	.93	4.82 (6.43)	−.18

Measure	N	Min	Max	Skew	Alpha	Mean (SD)	Correlation with FCAT 2013
Behavior Problems Intensity	552	35	217	1.45	.95	74.94 (30.89)	−.27
Inattention‡	558	1	7	0.07	.95	4.74 (1.17)	.42
Hyperactivity/impulsivity‡	555	1	7	0.09	.94	4.91 (1.16)	.36
Negative Affectivity	547	1	4	1.20	.87	1.64 (0.59)	−.20
Positive Affectivity	550	1	5	−0.34	.91	3.86 (0.74)	.23
Combined CD and ODD dimension	560	0	1.39	1.10	.90	0.37 (0.41)	−.20
Inhibition	517	10	23	1.20	.91	12.65 (2.93)	−.22
Shifting	526	8	20	0.89	.87	11.10 (3.07)	−.17
Emotional Control	510	10	25	0.84	.92	13.98 (3.66)	−.12
Self-Monitoring	524	4	12	0.84	.86	5.64 (1.81)	−.19
Information Sharing	532	10	25	−0.87	.72	21.24 (3.32)	.07 n.s.

Note: FCAT = Florida Comprehensive Assessment Test – reading comprehension; CHAOS = Confusion, Hubbub, and Order Scale; CD = conduct disorder; ODD = oppositional defiant disorder. Unless otherwise noted, all correlations were significant at $p < .05$.

†Lower scores reflect *greater* frequency/enjoyment.

‡Lower scores reflect *less* problems in the dimension.

Table 2

Discriminant Function Analysis Summary for the Home Index

Measure	Initial Structure Matrix Coefficient (N = 154)	Final Structure Matrix Coefficient (N = 242)	Final Canonical Discriminant Function Coefficient
Highest level of education parent expects twin to receive	**−.54**	**.65**	.41
How often does the child amuse him/herself alone with books†	**.50**	**−.41**	−.31
Level of education of parent/caregiver completing the questionnaire	**−.42**	**.45**	[.06]
Household income of the twins	**−.40**	**.64**	[.21]
How often parent helped child with English grammar†	**−.36**	**.33**	.33
CHAOS (child rated)	**.36**	_‡	–
Hours/day child watches TV on weekends	**.31**	**−.31**	−.04
Hours/day child watches TV on weekdays	.29	–	–
Level of education of other adult caregiver	−.24	–	–
How much child enjoys being read to†	.21	–	–
How many hours per week child spends on homework	−.19	–	–
How often parent reads with child†	−.12	–	–
How often child asks parent to read to him/her†	.12	–	–
How often parent discusses school progress with child†	−.10	–	–
Hours per week parent expects child to spend on homework	−.09	–	–
Strictness subscale score	.00	–	–
Functions and Classification	Initial	Final	–
Functions at Group Centroids			
Fail FCAT 2013	.95	−.86	–
Pass FCAT 2013	−.33	.46	–
Correct Classification	73.4%	76.4%	–

Note: Bold type in the first 2 columns indicates that the measure met both criteria for retention (structure matrix value of .30 or higher *and* significant Wilks' Lambda test between those who passed vs. failed the FCAT 2013). Final canonical discriminant function coefficients (column 3) were used to weight variables when creating the *Home* index except [bracketed] coefficients that were in the model to control for the effects of socioeconomic status. The constant in the formula for the *Home* index was −3.14. CHAOS = Confusion, Hubbub, and Order Scale; FCAT = Florida Comprehensive Assessment Test – reading comprehension.

† Lower scores reflect *greater* frequency/enjoyment.

‡ CHAOS' failed to meet the aforementioned retention criteria after the initial model and was removed from the final function.

Table 3

Discriminant Function Analysis Summary for the Behavior Index

Measure	Initial Structure Matrix Coefficient (N = 121)	Final Structure Matrix Coefficient (N = 184)	Final Canonical Discriminant Function Coefficient
Inattention†	**.55**	**.74**	.19
Positive Affectivity	**.49**	**.66**	.61
Household income of the twins	**.45**	**.55**	[.16]
Hyperactivity/impulsivity†	**.42**	**.67**	.17
Level of education of other adult caregiver	**.38**	**.40**	[−.01]
Respect for Rules	**.34**	**.52**	.09
Level of education of parent/caregiver completing the questionnaire	**.33**	**.46**	[.18]
Negative Affectivity	**−.33**	**−.46**	−.30
Sympathy	.26	–	–
Self-Monitoring	−.23	–	–
Combined CD and ODD dimension score	−.18	–	–
Behavior Problems Intensity	−.16	–	–
Shifting	−.13	–	–
Behavior Problems Total Score	−.09	–	–
Inhibition	.07	–	–
Emotional Control	.03	–	–
Functions and Classification	Initial	Final	–
Functions at Group Centroids			
Fail FCAT 2013	−.99	−.88	–
Pass FCAT 2013	.42	.37	–
Correct Classification	79.3%	72.3%	–

Note: Bold type in the first 2 columns indicates that the measure met both criteria for retention (structure matrix value of .30 or higher *and* significant Wilks' Lambda test between those who passed vs. failed the FCAT 2013). Final canonical discriminant function coefficients (column 3) were used to weight variables when creating the *Behavior* index except [bracketed] coefficients that were in the model to control for the effects of socioeconomic status. The constant in the *Behavior* index formula was −5.58. CD = conduct disorder; ODD = oppositional defiant disorder; FCAT = Florida Comprehensive Assessment Test – reading comprehension.

† Higher scores reflect *less* problems in the dimension.

Table 4

Descriptive Statistics and Correlations for Outcomes with the Home and Behavior Indices

Measure	N	Min	Max	Skew	Alpha	Mean (SD)	Correlation with *Home* (N)	Correlation with *Behavior* (N)
Home	526	−3.58	0.56	−0.51	–	−1.14 (0.80)	-	-
Behavior	532	−3.69	0.10	−0.21	–	−1.60 (0.80)	.38 (498)	-
FCAT 2013	274	153	289	−0.08	.90	228.10 (23.56)	.47 (257)	.41 (262)
FAIR Reading comprehension	219	78	148	0.49	.88–.92	104.79 (15.11)	.48 (200)	.38 (209)
FAIR Reading fluency	208	74	143	0.19	.77–.90	108.21 (15.29)	.40 (189)	.33 (196)
FAIR Spelling	203	54	138	0.21	.92–.95	100.96 (15.80)	.37 (185)	.28 (193)
Social Anxiety	556	3	14	1.44	.84	4.89 (2.42)	−*.11* (520)	−.47 (527)
Math Problems	557	3	15	1.05	.86	5.76 (3.01)	−.23 (520)	−.47 (527)
Reading Problems	551	6	30	1.33	.92	10.73 (5.10)	−.46 (516)	−.43 (522)
Social Cognition	554	4	20	1.68	.89	6.25 (3.02)	−.25 (517)	−.56 (525)
Spatial Problems	554	4	20	1.20	.86	7.47 (3.66)	−.28 (518)	−.54 (526)
Total Problems on CLDQ	559	20	83	1.15	.92	35.02 (12.66)	−.40 (522)	−.66 (530)
Home Literacy Environment	452	0	11	0.47	-	3.96 (2.49)	.17 (423)	.21 (428)
CHAOS (parent rated)	551	1	4	0.43	.56	2.23 (0.60)	−*.14* (515)	−.34 (521)

Note: Higher scores on *Home* and *Behavior* reflect greater probability of passing the FCAT. FAIR scores were from spring 2013. Florida Comprehensive Assessment Test (FCAT). FAIR = Florida Assessment for Instruction in Reading; CLDQ = Colorado Learning Disability Questionnaire; CHAOS = Confusion, Hubbub, and Order Scale. All correlations are significant at $p < .01$ except the ones in italics, which are significant at $p < .05$.

Table 5

Summary of Hierarchical Regression Models

Measure			
Predictors	**ΔR^2**	**β**	***p***
FCAT 2013			
Model 1	.73***		
Age		**.09**	.016
FCAT 2012		**.82**	.0001
Model 2	.04***		
Age		**.12**	.001
FCAT 2012		**.74**	.0001
Home		.07	.078
Behavior		**.13**	.0001
Home x *Behavior*		**−.09**	.009
Total R^2	.77***		
n	224		
FAIR Reading Comprehension 2013			
Model 1	.48***		
Age		.08	.132
FAIR Reading Comprehension 2012		**.70**	.0001
Model 2	.07***		
Age		.05	.327
FAIR Reading Comprehension 2012		**.58**	.0001
Home		**.22**	.0001
Behavior		.11	.036
Home x *Behavior*		−.01	.833
Total R^2	.55***		
n	192		
FAIR Reading fluency 2013			
Model 1	.62***		
Age		.01	.831
FAIR Reading fluency 2012		**.79**	.0001
Model 2	.08***		
Age		−.001	.982
FAIR Reading fluency 2012		**.76**	.0001
Home		**.18**	.0001
Behavior		−.03	.529
Home x *Behavior*		**−.18**	.0001
Total R^2	.70***		
n	181		
FAIR Spelling 2013			

Measure			
Predictors	**ΔR^2**	**β**	***p***
Model 1	.48***		
Age		−.02	.755
FAIR Spelling 2012		**.69**	.0001
Model 2	.04**		
Age		−.04	.496
FAIR Spelling 2012		**.63**	.0001
Home		.14	.028
Behavior		.08	.149
Home x *Behavior*		−.07	.231
Total R^2	.52***		
n	177		
Social Anxiety (CLDQ)			
Model 1	.00		
Age		.06	.177
Model 2	.23***		
Age		.06	.148
Home		.09	.043
Behavior		**−.49**	.0001
Home x *Behavior*		.06	.137
Total R^2	.23***		
n	492		
Math Problems (CLDQ)			
Model 1	.00		
Age		.04	.347
Model 2	.22***		
Age		.06	.142
Home		−.08	.073
Behavior		**−.44**	.0001
Home x *Behavior*		−.03	.467
Total R^2	.22***		
n	493		
Reading Problems (CLDQ)			
Model 1	.01		
Age		−.08	.063
Model 2	.28***		
Age		−.05	.225
Home		**−.35**	.0001
Behavior		**−.30**	.0001
Home x *Behavior*		−.04	.368

Measure Predictors	ΔR^2	β	*p*
Total R^2	.28***		
n	488		
Social Cognition Problems (CLDQ)			
Model 1	.03**		
Gender		**.17**	.0001
Age		−.01	.757
Model 2	.29**		
Gender		.07	.045
Age		−.003	.944
Home		−.04	.295
Behavior		**−.53**	.0001
Model 3	.03***		
Gender		.05	.219
Age		−.01	.752
Home		.06	.620
Behavior		−.24	.057
Home x *Behavior*		.14	.282
Gender x *Home*		−.28	.029
Gender x *Behavior*		−.07	.572
Gender x *Home* x *Behavior*		.28	.033
Total R^2	.35***		
n	490		
Spatial Problems (CLDQ)			
Model 1	.00		
Age		−.06	.204
Model 2	.30***		
Age		−.04	.314
Home		−.09	.031
Behavior		**−.51**	.0001
Home x *Behavior*		−.03	.439
Total R^2	.30***		
n	491		
Total Problems (CLDQ)			
Model 1	.00		
Age		−.04	.422
Model 2	.46***		
Age		−.01	.714
Home		**−.17**	.0001
Behavior		**−.60**	.0001
Home x *Behavior*		.01	.685

Measure Predictors	ΔR^2	β	*p*
Total R^2	.46***		
n	495		
Home Literacy Environment			
Model 1	.00		
Age		.02	.691
Model 2	.06***		
Age		.01	.910
Home		.11	.036
Behavior		**.17**	.001
Home x *Behavior*		.02	.647
Total R^2	.06***		
n	402		
CHAOS (parent rated)			
Model 1	.00		
Age		−.01	.846
Model 2	.12***		
Age		.003	.945
Home		−.03	.538
Behavior		**−.34**	.0001
Home x *Behavior*		−.05	.274
Total R^2	.12***		
n	488		

Note: Higher scores on *Home* and *Behavior* reflect greater probability of passing the Florida Comprehensive Assessment Test (FCAT). Prior year scores were available only for achievement outcomes. FAIR = Florida Assessment for Instruction in Reading; CLDQ = Colorado Learning Disability Questionnaire; CHAOS = Confusion, Hubbub, and Order Scale. Gender was coded 1 = girl, 2 = boy and was significant (and included) only for the Social Cognition outcome. Predictors in bold remained significant after Benjamini-Hochberg correction.

* $p < .05$,

** $p < .01$,

*** $p < .001$.