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Sleep duration moderates the association between children's temperament and academic achievement

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Abstract

The primary goal of this study was to determine whether sleep duration moderated the relations of two dimensions of children's temperament, shyness and negative emotion, to academic achievement. In the autumn, parents and teachers reported on kindergarteners' and first graders' (N = 103) shyness and negative emotion and research assistants observed negative emotion in the classroom. In the spring, children wore actigraphs that measured their sleep for five consecutive school nights, and they completed the Woodcock Johnson-III standardized tests of achievement. Interactions between temperament and sleep duration predicting academic achievement were computed. Interactions of sleep duration with parent-reported shyness, teacher-reported negative emotion, and observed negative emotion indicated that the negative relations of shyness or negative emotion to academic achievement were strongest when children slept less. Results suggest that sleep duration may be an important bio-regulatory factor to consider in young children's early academic achievement.

Keywords

shyness; negative emotion; temperament; academic achievement; sleep duration

Introduction

Navigating the early school years is an important developmental task, in part because early academic achievement (AA) is important for later AA and future job attainment (Entwisle &

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Alexander, 1993; Ramey & Ramey, 1999). Identifying behaviors that either facilitate or undermine this transition may advance the understanding of individual differences in school performance and help to identify effective ways to foster high levels of AA (Rimm-Kaufman & Pianta, 2000). Based on recent research and theory (Blair, 2002; Izard, Stark, Trentacosta, & Schultz, 2008; Vaughn, Elmore-Staton, Shin, & El-Sheikh, 2015), we sought to blend two largely independent lines of literature in an effort to develop a deeper understanding of early AA. Specifically, we examined the relation of negative emotionality to early AA while also testing whether sleep duration moderated the relation between negative emotionality and AA.

Temperament typically is defined as individual differences in reactivity and regulation of emotionality (Rothbart & Bates, 2006). The present study focused on behaviors associated with the broad dimension of negative emotionality, specifically shyness, anger, and sadness. Shy children, in comparison with bolder and more outgoing children, are characterized as demonstrating passive behavior in the classroom, such as reluctance to participate in learning activities, lack of initiative in regard to problem solving, and less involvement with teachers and peers (Paulsen, Bru, & Murberg, 2006; Rubin, Coplan, & Bowker, 2009; C. M. Walker, 2011). In addition, children higher on negative emotionality tend to exhibit sadness, anger, and/or frustration at school and they may be especially prone to express these emotions in the face of academic challenges (Blair, 2002; Fredrickson, 2001; Rothbart & Bates, 2006). Anger, sadness, and shyness are thought to hinder children’s AA because they can diminish motivation, the development of cognitive skills needed for problem solving, and approach-oriented behaviors (Blair, 2002; Evans, 2010). Previous researchers have found that school-aged children’s anger and sadness are more highly related to each other than to shyness (Rothbart, Ahadi, Hershey, & Fisher, 2001). Thus, in the remaining discussion, shyness is discussed separately from anger and sadness (with the latter henceforth labelled as negative emotions).

Shyness and AA

Shy behaviors are thought to impede children's abilities to optimally engage and participate in their environment within and outside the school context (Coplan & Rubin, 2010; Kagan, Reznick, & Snidman, 1988; Valiente, Swanson, & Lemery-Chalfant, 2012). Shy children who are hesitant to engage in the classroom may miss out on critical academic opportunities such as receiving instructional feedback from teachers (i.e., asking clarification questions) and benefiting from peers through group learning tasks (Bester, Budhal, & Budhal, 2001; Evans, 2001; Liu et al., 2015).

Although there is some evidence to suggest that shy children experience greater difficulty academically compared to less shy children (Evans, 2010), the empirical association between shyness and AA is mixed (Cameron, 2009; Hughes & Coplan, 2010) and is still not well understood in early childhood. Parent- and teacher-reported shyness has been related to lower classroom engagement and participation as well as lower scores on standardized tests of AA (Coplan, Gavinski-Molina, Lagacé-Séguin, & Wichmann, 2001; Crozier & Perkins, 2002, 2002; Dobbs, Doctoroff, Fisher, & Arnold, 2006; Normandeau & Guay, 1998; Rimm-Kaufman et al., 2002; Rudasill et al., 2014; Rudasill & Konold, 2008), even after controlling

for prior verbal and literacy skill acquisition (Hall, Welsh, Bierman, & Nix, 2016). Some researchers, however, have found that parent-reported shyness in younger children (4- to 7-year olds) has no concurrent or predictive relation to literacy scores or standardized measures of reading and math achievement (Spere & Evans, 2009; Valiente, Lemery-Chalfant, & Swanson, 2010; O. L. Walker & Henderson, 2012; Zhang, Eggum-Wilkens, Eisenberg, & Spinrad, in press).

Inconsistent findings may partially be a function of who is reporting on children's shyness. Several studies have found negative associations between teacher-reported shyness and indicators of academic adjustment and AA (e.g., Crozier & Perkins, 2002; Dobbs et al., 2006), but evidence demonstrating the relation between parents' reports of children's shyness and AA is less consistent (Coplan et al., 2001; O. L. Walker & Henderson, 2012). Irrespective of the reporter, results suggest that the negative relation between shyness and AA is modest (Evans, 2010; Hall et al., 2016). Researchers have advocated for further research in order to better comprehend the role of shyness in early education and to investigate factors that elucidate the complex pattern of findings (Hughes & Coplan, 2010; Spere & Evans, 2009).

Negative Emotion Expressions and AA

Anger and sadness are thought to diminish goal achievement by inhibiting motivation for and completion of ongoing tasks (Rothbart et al., 2001). Furthermore, theory suggests that individual differences in emotionality affect cognition and school readiness (Blair, 2002; Izard et al., 2008; Raver, 2002); however, few investigators have examined the relation of negative emotional expressivity to school-related outcomes such as AA, especially during early elementary school. Children who express more negative emotions may use rigid learning strategies, while also exhibiting diminished planning or problem-solving skills and conflict in interpersonal relationships that detract from learning (Blair, 2002; Hernández et al., 2016; Linnenbrink, 2007; Pekrum, 2014). In contrast, those who can maintain a positive emotional tone might remain more actively engaged with classroom tasks (Denham, Bassett, Zinsser, & Wyatt, 2014; Graziano, Reavis, Keane, & Calkins, 2007). Thus, negative emotional expressivity, such as anger and sadness, might be expected to inhibit children's AA through cognitive, interpersonal, and motivational factors (Blair, 2002; Linnenbrink, 2007; Valiente, Swanson, & Eisenberg, 2012).

Researchers have found inconsistent empirical relations between negative emotions and AA. Teachers' and parents' reports of children's negative emotions have been negatively related to teacher-reported achievement (e.g., grades), standardized assessments of AA, and cognitive abilities (Ayoub et al., 2009; Gumora & Arsenio, 2002; Perez & Gauvain, 2009; Viljaranta et al., 2015). However, one group of researchers who used the same sample as the current study coded observations of anger and sadness in the classroom and at recess and found that kindergarteners' negative emotions were negatively related to scores on standardized tests of AA (Hernández et al., 2016). In contrast, other researchers have found that teachers' reports, parents' reports, and/or observations of anger and sadness were unrelated to standardized tests and teachers' reports of AA (Gumora & Arsenio, 2002; Perez & Gauvain, 2009; Zhou, Main, & Wang, 2010). Moreover, some researchers have found

different relations across reporters or measures of AA (Gumora & Arsenio, 2002; Perez & Gauvain, 2009), suggesting that inconsistencies in this small body of literature might be due, in part, to variations in the reporter of negative emotions (e.g., teacher, parent, observed) and measurement of AA (e.g., standardized tests and teacher-reported grade-point average).

In summary, although shyness and negative emotions have sometimes been inversely related to AA, the pattern of findings is inconsistent and the strength of the relations (even when significant) is often weak. This pattern suggests that there may be important moderating variables that impact the strength of the aforementioned relations. To advance this literature, and consistent with recent theoretical and empirical work on children's bio-regulatory processes (e.g., El-Sheikh, Hinnant, Kelly, & Erath, 2010; Rothbart & Bates, 2006; Vaughn et al., 2015), we examined whether sleep moderated the association between shyness or negative emotions and AA.

Sleep and AA

Sleep helps to facilitate optimal cognition, memory consolidation, emotion regulation, and social functioning (Gregory & Sadeh, 2012; Kopasz et al., 2010; Vriend et al., 2012; M. P. Walker, 2009). In particular, emotional processing and reactivity can be perturbed by insufficient sleep because critical connections in the Central Nervous System (CNS) between the amygdala and the medial prefrontal cortex can become disrupted. These CNS dysfunctions increase inappropriate affective reactions, such as irritability, to daytime emotional challenges (Dahl, 1996; M. P. Walker, 2009). Furthermore, longer sleep duration increases the likelihood of deep and restorative sleep (i.e., Rapid Eye Movement stage) that enables cortical processes associated with recording and consolidation of short term memories (M. P. Walker, 2009). Finally, when children arrive to school tired, they are less motivated to engage in classroom activities and may be more prone to errors in their assignments (Dahl, 1996; Gruber et al., 2010). Sleep's bio-regulatory association with emotion regulation, memory, and motivation makes sleep a potentially important variable relevant to children's AA (Blair, 2002; Eisenberg, Sadovsky, & Spinrad, 2005; Gruber, Cassoff, Frenette, Wiebe, & Carrier, 2012).

In the present study, we focused on children's sleep duration, which is the number of minutes between sleep onset (i.e., when children are in bed and movement is limited, indicating they are starting to fall asleep) and offset (i.e., when children wake up and movement indicates they are no longer asleep), because this is a bio-regulatory factor that can potentially be behaviorally modified through intervention in childhood (Buckhalt, El-Sheikh, Keller, & Kelly, 2009; Mindell et al., 2006). There is growing evidence that sleep duration is positively associated with children's AA (Chaput et al., 2016; Dewald, Meijer, Oort, Kerkhof, & Bögels, 2010; Eide & Showalter, 2012; Meijer & van den Wittenboer, 2004; Stroebele, McNally, Plog, Siegfried, & Hill, 2013; Touchette et al., 2007). Some researchers who used objective measures of sleep (i.e., actigraphy) found that when children's sleep duration was restricted, teachers reported significantly lower AA and more behavior problems (Fallone, Acebo, Seifer, & Carskadon, 2005; Vriend et al., 2013). Sleep duration was also positively related to IQ (Gruber et al., 2010), but it was unrelated to

teachers' reports of AA (Gruber et al., 2014). This body of research suggests that sleep duration may be important for understanding children's early AA.

The Moderating Role of Sleep

The psychobiological model of temperament emphasizes the need to consider environmental features as potential moderators of the relation between temperament and adjustment (Rothbart & Bates, 2006). Further clarifying the expected outcomes of such interactions, the diathesis-stress perspective suggests that certain child characteristics interact with contextual factors, thereby amplifying the negative effects of these characteristics on children's outcomes (Wachs & Kohnstamm, 2001). As was previously reviewed, certain bio-regulatory factors, such as short sleep duration, might be a risk factor for lower achievement in school. The association between shyness or negative emotions and children's AA may be amplified when other risk factors are present. In the present study, we examined short sleep duration as a possible moderating risk factor.

There is growing evidence that sleep operates as a moderator for a number of developmental outcomes. For example, multiple research teams have found that sleep duration moderated the relation between parenting and children's adjustment (Bernier, Bélanger, Tarabulsy, Simard, & Carrier, 2014; Bordeleau, Bernier, & Carrier, 2012; El-Sheikh et al., 2010). The findings in these studies suggest that longer sleep duration promotes positive associations between better parenting and adjustment, whereas shorter sleep duration might intensify negative associations between poorer parenting and adjustment.

To our knowledge, there have been only two groups of researchers who examined objective measures of sleep duration as a moderator with either child characteristics as a predictor or AA as an outcome. In their study where children's sleep was experimentally shortened, Schumacher and collegues (2016) found that sleep duration moderated the association between children's response inhibition and adaptive strategies (e.g., cognitive reappraisal, self-talk, and soliciting help) during a challenging task. Specifically, there was a positive association between children's response inhibition and adaptive strategies only for children whose normal sleep schedule was not restricted (Schumacher et al., 2016). Keller, El-Sheikh, and Buckhalt (2008) included AA as an outcome and found that the positive association between third graders' attachment security and math achievement was present only when sleep duration was short. Children who had more sleep generally had high levels of math achievement and the association between attachment security and math achievement was not significant. Collectively, these results suggest that sleep duration acts as a protective factor in the associations between child characteristics and early AA. This study adds to a small, but growing, body of literature examining objectively measured sleep duration as a moderator and was designed to clarify the association of anger, sadness, and shyness with AA.

The Present Study

We examined whether negative emotions (i.e., anger and sadness) and shyness were related to AA, as well as whether sleep duration moderated these relations. Our hypotheses were informed by previous research showing that negative emotionality is inversely related to

children's adjustment (Evans, 2001; Rothbart & Bates, 2006; Valiente, Swanson, & Eisenberg, 2012). We also responded to El-Sheikh and colleagues recommendation to examine sleep as an important bio-regulatory moderator (El-Sheikh et al., 2010; Vaughn et al., 2015). The psychobiological model of temperament as well as diathesis-stress framed our hypotheses. In line with prior research on sleep (Keller, El-Sheikh, & Buckhalt, 2008; Schumacher et al., 2016), we specifically hypothesized that the negative associations of shyness or negative emotions with AA would be strongest when sleep duration was shortest.

Method

Participants

One hundred and three (51% girls) kindergarteners ($n = 50$) and first graders ($n = 53$), their parents, and 33 teachers from 33 classrooms ($M_{students\ per\ classroom} = 3$; $SD_{students\ per\ classroom} = 2$) in southwestern U.S. city participated in this study (all percentages are rounded). Parents provided consent for themselves and their children; in addition, their children provided assent. Participants in this study were a subsample of a larger study of emotions, relationships in school, and AA (see [Hernández et al., 2016] for larger study demographics). Participants were recruited from the larger study into this subsample through mailings and phone calls. Most participants in the larger study ($N = 301$) had the opportunity to participate in the smaller study. Out of 301 participants, 103 chose to participate in the smaller study, 36 declined to participate, 133 did not respond to recruitment efforts, and 24 were not contacted (either these participants dropped out of the larger study or researchers were unable to contact these participant's parents for larger study data collection). Based on independent samples *t*-tests, those who participated in the smaller study did not significantly differ from those who did not participate (i.e., those who declined, those who did not respond, and those who were not contacted) on any of the variables used in the present study (i.e., shyness, negative emotions, AA, and all covariates listed below).

Participants in the current study were predominantly Hispanic (50%). Of those children who were non-Hispanic (45%), 83% were Caucasian, 4% were African American, 2% were Asian, 9% were American Indian, and 2% reported they were of mixed race. Six percent of participants did not report on their race or ethnicity. Children ranged in age from 5.65 to 7.51 years ($M = 6.47$ years, $SD = 0.30$). The majority of children lived in two-parent households (87%) with an average income between $60,000-$69,999, and ranging from less than $9,999 to more than $100,000. Five percent of mothers did not obtain a high school diploma, 14% had a high school diploma or some equivalent, 33% had some college education, 47% were college graduates or higher and 1% did not report on their level of education. Seven percent of fathers did not obtain a high school diploma, 19% had a high school diploma or some equivalent, 27% had some college education, 45% were college graduates or higher, and 2% did not report on their level of education.

Procedure

Multiple reporters and methods were used to measure the constructs in this study. In the fall, parents and teachers reported on children's negative emotion and shyness. Trained research assistants also recorded children's negative emotional displays in school. Children were

observed two to three times per week for nine to twelve weeks. In the spring, a separate group of research assistants brought actigraphs to children during a series of home visits. Children were instructed to wear the actigraph for a week. Parents helped children maintain compliance with the actigraph protocol. In the latter part of spring, children completed standardized tests of achievement, which were administered by another group of trained research assistants. Parents and teachers were given monetary compensation for completing surveys about their children, and children were given two small toys for their participation.

Measures

Emotion

Reported negative emotion: In the fall, parents and teachers rated (1 = *extremely false* to 7 = *extremely true*) children's negative emotions using the Anger/Frustration (11 items for teachers and 13 for parents; e.g., "Gets angry when she/he can't find something s/he wants."; αs = .94 and .90) and Sadness (12 items for teachers and 13 for parents; e.g. "Seems to feel depressed when unable to accomplish some task."; αs = .92 and .83) subscales from the Child Behavior Questionnaires (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001). The Anger/Frustration and Sadness subscales have demonstrated validity with agreement between parents and stability across time (Rothbart et al., 2001). Teacher items were modified slightly to fit with the school context (Eisenberg, Fabes, Guthrie, & Reiser, 2000). The correlations between the Anger/Frustration and Sadness subscales for teachers and parents were quite high (rs = .84 and .77, ps < .001, respectively); thus, the two subscales were averaged together within reporter and the composite scores were used as separate measures of teacher- and parent-reported negative emotions[1].

Observed negative emotion: In the fall, research assistants observed children's negative emotional expressivity in their classrooms (core classroom, art/music, library, physical education, computers), during lunch, and at recess. Observers rated negative emotional expressivity on the intensity, frequency, and duration of negative emotions such as sadness, fear, anxiety, anger, and frustration. Negative expressions were quantified as changes from the students' baseline neutral expression such as pouted lips, lips downturned in a frown, eyebrows down or arched in sadness, crying, vocal tone (e.g., whiny) and content (e.g., "S/he made me feel bad"), and vocalizations (e.g., slow, gentle sighs).

Prior to observing children in the field, research assistants participated in several weeks of training on the study observation protocols, which included watching prerecorded videos and conducting live observations in pilot preschool settings. Research assistants coded negative emotion expressions (0 = *no evidence of emotion;* 1 = *brief, small intensity emotion*; 2 = *brief, medium intensity or medium duration, small intensity emotion;* 3 = *brief, high intensity, medium duration, medium intensity, or long duration, small intensity emotion*) on prepared coding sheets after 30-seconds of observation. Two to three research assistants collected approximately 100 observations per each participating student. During two weekly 3-hour shifts, research assistants would use an ordered list of participants and

[1]Hypothesized models were also examined with Anger/Frustration and Sadness as separate constructs. The pattern of results was the same as when they were averaged into one negative emotional expression construct.

randomly select one participating student to start with and then observe, one at a time, all participating children in the class who were present. Children were generally not coded again until all present participating children were coded once. This observational method is similar to methods used in previous research (Fabes, Leonard, Kupanoff, & Martin, 2001; Spinrad et al., 2004), and more recently negative emotion observations, using this approach, have been related to teachers' reports of sadness and anger and school-related outcomes in the sample in this study (Diaz et al., 2015; Hernández et al., 2015).

To ensure compliance with the observation protocols and validity of the observed data, supervisors jointly coded with research assistants biweekly. Reliability was determined using precoded videos and randomly selected jointly coded live observations (5% of all observations) with supervisors. In this subsample, interobserver reliability (intraclass correlation [ICC]) with negative emotion was .88. Research assistants' ratings were averaged across all observations and all school settings for each student (M_{time} = 56 min, 3 seconds; SD_{time} = 29 min, 21 seconds).

Shyness: In the fall, teachers and parents rated (1 = *extremely false* to 7 = *extremely true*) children's shyness (6 items for teachers and parents; e.g., "Sometimes seems nervous when talking to adults s/he has just met."; αs = .88 and .83) using the short form of the CBQ (Putnam & Rothbart, 2006). Teacher items were modified slightly to fit with the school context. The Shyness subscale (in longer and short forms) is valid and reliable with studies showing stability across time and relations with indices of internalizing behaviors and inhibition (Eisenberg, Shepard, Fabes, Murphy, & Guthrie, 1998; Rothbart et al., 2001).

Sleep duration: Student's sleep duration was measured using actigraphy, which is a well-validated and non-invasive tool for capturing young children's sleep-wake cycles in naturalistic settings (e.g., home) (Acebo et al., 1999; Sadeh, Sharkey, & Carskadon, 1994). Children wore an actigraph (Actiwatch 2; Philips Respironics Inc) on the wrist of their non-dominant hand for five consecutive school days during the spring (January through May). A research assistant delivered the actigraph to the student's home and instructed parents and children to keep the actigraph on unless the student was partaking in activities that could damage the actigraph (e.g., showering, swimming). To promote compliance with wearing the actigraph, parents were given stickers to reward their child for each day that he or she successfully wore the actigraph. The actigraph detected sleep-wake cycles by continuously measured motion using a piezoelectric accelerometer (Weiss, Johnson, Berger, & Redline, 2010), which was set to low threshold with 40 counts per epoch and a range of 20–80 counts per epoch (Meltzer, Walsh, Traylor, & Westin, 2012). When compared with polysomnography, sleep quantity in school-aged children tends to be underestimated when actigraphs are set to a lower threshold and overestimated at a higher threshold (Meltzer et al., 2012). Activity and sleep were measured in 1-minute epochs and sleep was estimated based on at least 10 minutes of inactivity.

Sleep duration was estimated using the Phillips Actiware V5.7 program proprietary algorithm, which has been validated in children (Meltzer et al., 2012). Parent-reported sleep start and end times were used to establish the time children were in bed, which were used as indicators of the rest period in the actigraph data. Parents' reports of their child's sleep also

helped to validate the actigraphy data (Acebo et al., 1999). Actigraphy data were considered valid if the actigraphy estimated sleep start and end times were within the parent-reported bedtime and wake time. Parents recorded their child's sleep-wake times in a daily sleep diary. Parents were given the option of completing the sleep diary in English or Spanish; 13 parents completed the diary in Spanish (Spanish translations were back translated as a quality check). The software then estimated sleep onset and offset based on researchers' scoring (Respironics, 2008). In this study, sleep duration was calculated from a minimum of three weekday nights of sleep data (Acebo et al., 1999). Children had, on average, 4.88 nights (SD = .35) of valid actigraphy data. Most children had valid actigraphy data for five weekday nights (89%), some children had valid data for four nights (10%), and a few children had valid data for three nights (1%). Children may have had an invalid or missing night because the student forgot to wear the actigraph or the actigraph had technical problems.

AA: In the late spring, children completed the Applied Problems and Passage Comprehension subtests from the Woodcock Johnson Test of Achievement (WJ-III; Woodcock, McGrew, & Mather, 2001). The WJ-III is a standardized test intended to assess the academic knowledge of individuals who are 2 to 90 years of age. In children 4–7 years of age, the range reliability estimates of the Applied Problems and Passage Comprehension have been high (.88–.94 and .94–.96, respectively; Woodcock et al., 2001). The WJ-III software computes a score (e.g., W score) that allows for comparison with a normative population. W scores were used in the present study. The correlation between the Applied Problems and Passage Comprehension subtests was high (r = .58, p < .001). Therefore, in this study, an AA composite was created by using the average of the Applied Problems and Passage Comprehension subtests.

Covariates

Initial academic knowledge: In the fall of their kindergarten year, children completed the Picture Vocabulary (PV) subtest from the WJ-III. The PV subtest W scores were used in this study as a control for initial academic knowledge. Reliability estimates for the PV subtest in children 4–7 years of age ranges from .70–.81 (Woodcock et al., 2001).

Family demographic information: In the fall, parents reported on their family's annual income range (1 = $0-$9,000 to 11 = $100,000 or over), mothers', and fathers' education status (1 = less than high school diploma to 4 = college graduate or higher). Mother's and father's educational statuses were highly correlated (r = .53, p < .001), and both were highly correlated with family income (rs = .65 and .67, ps < .001, respectively). Thus, family income, mother's education, and father's education were z-scored and then averaged to create a measure of socioeconomic status (SES).

Parents also reported on their child's date of birth. Students' age was calculated as their age, in years, from the first day of September of the concurrent school year. Finally, parent reported their child's ethnicity and sex.

Medication use: In the daily sleep diary, parents reported when and if their child took any medication. Medications were reviewed on a case-by-case basis by the researchers to determine whether the medication could possibly be related to sleep. For each day that a student took medication that could be related to sleep (e.g., Melatonin, allergy and asthma, such as Zertec or Qvar, and antibiotics, such as Amoxicillin), the researcher coded a 1, whereas other medications (e.g., Ibuprophen, Acetominophin) were coded a 0. Most children did not take any medication while wearing the actigraph (78%), some children took medication 1 day (9%), 2 days (2%), 3 days (4%), 4 days (3%), and 5 days (5%). The average medication use across weekdays of available data was used as a control in this study (e.g., if the child took sleep-related medication for two nights out of five, medication use equaled .40).

Results

We conducted a series of preliminary analyses prior to testing the main hypotheses. Intra-class correlations (ICCs) were calculated to determine the independence of all focal study variables. Classroom-level variance accounted for more than 4% of the total variance in teachers' reports of negative emotion and shyness, observed negative emotion, sleep duration, and AA. In order to account for non-independence in the focal study variables, all analyses were conducted using type=complex in M*Plus* 7 with fall classroom as the cluster variable (Muthén & Muthén, 1998). Full-Information Maximum Likelihood with robust standard errors was used to handle missing data.

Correlations amongst the study variables were examined. In the regressions, all predictors, moderators, and controls were grand mean centered. Five regressions (5 emotion predictors X sleep duration) were performed to test whether the relations between negative emotions or shyness and AA were moderated by sleep duration.

Preliminary Analyses

Correlations were calculated in M*Plus* so that the Full-Information Maximum Likelihood estimator could be used to account for non-independence and missing data (see Table 1). Some covariates were related in the expected ways to the emotion predictors, sleep duration, and AA. Relations amongst the emotion predictors, sleep duration, and AA were mostly in the expected direction. Parent-reported shyness was positively related to teacher-reported shyness, observed negative emotion was positively related to teacher-reported negative emotion, and sleep duration was negatively related to parent-reported shyness. Additionally, AA was negatively related to teacher-reported shyness and observed negative emotion. However, a few relations were somewhat incongruent with previous studies. Observed negative emotion was significantly negatively related to parent-reported shyness, sleep duration was positively related to teacher-reported negative emotion, and AA was unrelated to the parent-reported shyness, parent-reported negative emotion, teacher-reported negative emotion, and sleep duration.

Emotion and AA: The Moderating Role of Sleep Duration

We conducted five regression analyses to test the focal hypotheses. All regressions included SES, students' age, WJ-III PV, Hispanic ethnicity, medication use, and students' sex as controls. In all baseline models, without the interaction term, teacher-reported shyness and observed negativity were negatively related to AA; parent- reported shyness and negativity, teacher-reported negativity, and sleep duration were unrelated to AA. Regression coefficients from teacher-reported shyness and observed negative emotion to AA were similar to those in the model with the interaction term (see Table 2).

Interactions between the temperament predictors and sleep duration are summarized in Table 2. Sleep duration significantly interacted with parent-reported shyness, teacher-reported negativity, and observed negativity in predicting AA. In each case, we tested simple slopes in M*Plus* by computing the regression coefficient for AA on each predictor at the mean of sleep duration and at one standard deviation above and below the mean (see Table 2; Aiken & West, 1991). As Figure 1a depicts, the negative relation between parent-reported shyness and AA was significant only for short sleep duration (see Table 2 for simple slope coefficients). A similar pattern was found when predicting AA from the interaction between teacher-reported negative emotion and sleep duration (see Figure 1b; Table 2 for simple slope coefficients). As shown in Figure 1c, the negative relations between observed negative emotion and AA were significant at all levels of sleep duration; however, the strength of the negative relation was strongest at short sleep duration.

Discussion

The central aim of this study was to examine the relations of shyness or negative emotion to AA, and to test if sleep duration operated as a moderator of these relations. In this cross-sectional study, we used multiple reporters and methods to assess emotion as well as objective assessments of children's sleep duration and AA in order to address the focal hypotheses. Results of this study indicate that when children's sleep duration was short, the negative association between negative emotion or shyness and AA was strongest, suggesting that long sleep duration buffers against the adverse effects of negative emotion and shyness on children's AA.

Main Effects of Teacher-Reported Shyness with AA

Teacher-reported shyness had a negative direct effect on AA beyond the covariates. Research results and theorists have suggested that children who are shyer may have more difficulty in school and lower AA than less shy children (Coplan & Rubin, 2010; Dobbs et al., 2006; Evans, 2001; Hall et al., 2016; Normandeau & Guay, 1998). Teachers' reports of shyness may be tapping into specific behaviors that shy children exhibit in the classroom, such as less interaction with the teacher and peers (Rubin et al., 2009), lack of ability to work with others (Paulsen et al., 2006), and avoidance of asking questions and academic challenges (Levin & Hart, 2003; Spere, Evans, Hendry, & Mansell, 2009) that thwart their AA.

The Moderating Role of Sleep Duration

In this study, sleep duration often functioned as a moderator of the negative relations of shyness or negative emotions to AA. Specifically, parent-reported shyness and teacher-reported negative emotions were negatively related to AA only when sleep duration was short. Additionally, although all slopes were significant, observed negative emotion was most strongly and negatively related to AA when children experienced short sleep duration. Children who do not receive sufficient sleep tend to feel tired, sluggish, and have difficulties concentrating (Epstein, Chillag, & Lavie, 1998), which may make it challenging to compensate for any negative effects of shyness and negative emotion on AA. However, when children experience more sleep, they may be better able to overcome the learning and achievement challenges believed to be associated with greater shyness and negative emotions.

Shorter sleep duration is associated with poor CNS functioning; thus, children experiencing shorter sleep may be less able to modulate behaviors often associated with negative emotional responses (Dahl, 1996; M. P. Walker, 2009). The negative association between shyness and AA may also be intensified when sleep duration is short because children may be more inhibited and their efforts and motivation for engaging in school activities may be limited or less effective (Meijer, Habekothé, & Wittenboer, 2000).

We did not find a significant interaction or main effect when parent-reported negative emotion was the predictor and we also did not find a significant interaction when teacher-reported shyness was the predictor. Parents' reports of their children's emotions likely provide a different perspective than teachers' reports because parents' reports are based on their perceptions of their child in multiple settings (e.g., home, community) as well as over a longer period of time, whereas teachers' reports are based on behavior seen for a limited amount of time and only in a school setting. Correlations amongst parent-reports, teacher-reports, and direct behavioral observations tend to be low to modest (see Table 1; Gartstein, Bridgett, & Low, 2012). In addition to context, variation in teachers' reports, parents' reports, and observations of negative emotions may be due to the different strengths in each reporter's assessment of behavior. For example, teachers and observers have the advantage of witnessing the behavior of multiple children in a classroom and may be able to judge a child's school-related behavior in comparison to other children of the same age (Rudasill et al., 2014).

It is unclear why we found that sleep duration moderated the relation between parent-reported shyness and AA, but not teacher-reported shyness and AA. The differential effects by reporter could be because teachers and parents observe shyness in different contexts. Parents most likely based their ratings on observations of their children interacting with unfamiliar individuals outside of the school context (i.e., in the home, in the grocery store or mall, on vacation, etc.) to a greater degree than did teachers. Conversely, teachers only witness students in the school context and in interactions with mostly known peers and school staff and such displays might be robustly related to AA. Indeed, we found a main effect of teachers' reports of shyness on AA, and perhaps students' sleep does not impact this main effect. Given these interesting, but unexpected findings, we urge researchers to

include multiple reporters of children's shyness in future studies and consider the mechanisms by which the results differ for teacher versus parent reported shyness.

We also found that parent-reported and teacher-reported shyness were positively correlated, as were teacher-reported negative emotionality and observed negative emotionality. Although parent and teacher-reported shyness were unrelated to reports of negative emotionality, they were unexpectedly negatively related to observed negative emotionality. Given that observed negative emotionality involved expressions of both verbal and nonverbal emotion, it is possible that shy students were rated low on this scale by observers because they were hesitant to display emotion in front of coders who they did not know very well. This unique pattern illustrates one of the many reasons why it is important to obtain a variety of assessments of emotion and to carefully consider potential contextual factors that might influence observer and reporter ratings. When key findings replicate across reporters and methods, as was the case for findings in Figure 1, we can be more confident that the main findings are not simply due to contextual factors.

Strengths and Limitations

This study had several methodological strengths. We used of an objective measure of sleep rather than parental subjective sleep reports, which is a major strength of this study. Subjective measures, such as parental report, may overestimate sleep duration by 30 to 60 minutes (Dayyat, Spruyt, Molfese, & Gozal, 2011), which is a significant amount of time that can be related to children's daytime functioning and which seriously biases models (Fallone et al., 2005). Despite this significant limitation, parental reports of sleep remain the main source of information on children's sleep (Sadeh, 2008). Additionally, few researchers examining emotionality and AA have used multiple reporters of emotion as well as standardized assessments of AA. Moreover, to our knowledge, we are the only group of researchers to empirically examine sleep duration as a potential moderator of the relations between emotionality and AA. Researchers might also consider examining indicators of sleep quality, such as wake after sleep onset or efficiency in their future studies because these may also be important aspects of sleep that have implications for children's AA. Indeed, there is very limited research on either the direct or indirect role of early emotional expressivity on children's school success (Keogh, 2003).

Although the findings advance the literature in important ways, several limitations should be noted. This study was cross-sectional and does not address the direction of causal relations. Furthermore, children's initial academic knowledge was only assessed once during the study (i.e., beginning of the child's kindergarten year). Thus, the gap between the initial assessment and the outcome of AA was different for kindergarteners and first graders, although covarying age partially controlled for this issue. Researchers should measure initial academic abilities at the beginning of each academic year so that controls are temporally the same for all participants, irrespective of cohort. Sleep researchers should also examine the longitudinal effect of prolonged sleep restrictions as well as examine the role of environmental factors such as inconsistent bedtime routines, poor parenting, and/or familial stress to further elucidate processes involved in the relation of sleep and shyness or negative emotions to children's academic performance.

Also, in this study we measured the construct of negative emotions with the sadness and anger subscales of the CBQ; however, Rothbart and Bates (2006) conceptualized negative emotions as a broader dimension of temperament, which included soothability, fear, discomfort, and shyness. In this sample, sadness and anger were very highly related, but shyness was unrelated to either construct. Researchers should consider examining the other dimensions of negative emotions as potential predictors of children's AA in future studies. Researchers should consider how other temperamental characteristics, such as self-regulation (i.e., effortful control), are related to children's sleep and AA. In a recent review, Palmer and Alfano (2017) concluded that sleep deficits in normative *adult* populations (i.e., no sleep-related health issues) often hinder individuals' abilities to control their impulses, attend and respond to stimuli, inhibit a dominant response, and express situation-appropriate emotions. Poor self-regulation is also thought to promote negative emotionality (including anger, sadness, and shyness) and subsequently hinder AA (Eisenberg et al., 2005; Rothbart & Bates, 2006). Thus, sleep, self-regulation, and negative emotionality are all likely to be related to children's AA; however, as Palmer and Alfano (2017) noted, there is a sizeable gap in the literature on normative *children's* sleep and self-regulation. In the future, researchers should consider examining the linkages between sleep, self-regulation, and other dimensions of temperament in children to further clarify how these constructs are related to children's development and adjustment.

Conclusion

In summary, we found evidence that sleep duration moderated the relation of both children's shyness and negative emotion to AA, such that negative emotion and shyness were negatively related to AA, especially when children experienced shorter sleep. These findings imply that sleep duration plays a role in children's emotions and AA. Given that less sleep may amplify any effects of negative emotion or shyness on poor school performance, encouraging optimal sleep may be especially important for children who tend to be shy and reserved as well as for those high in negative expressivity. Teachers and professionals should encourage parents to help their children get the recommended 10–11 hours of sleep each night and have consistent bedtimes (National Sleep Foundation, 2004). These findings highlight the need to consider children's sleep in future efforts to understand early AA.

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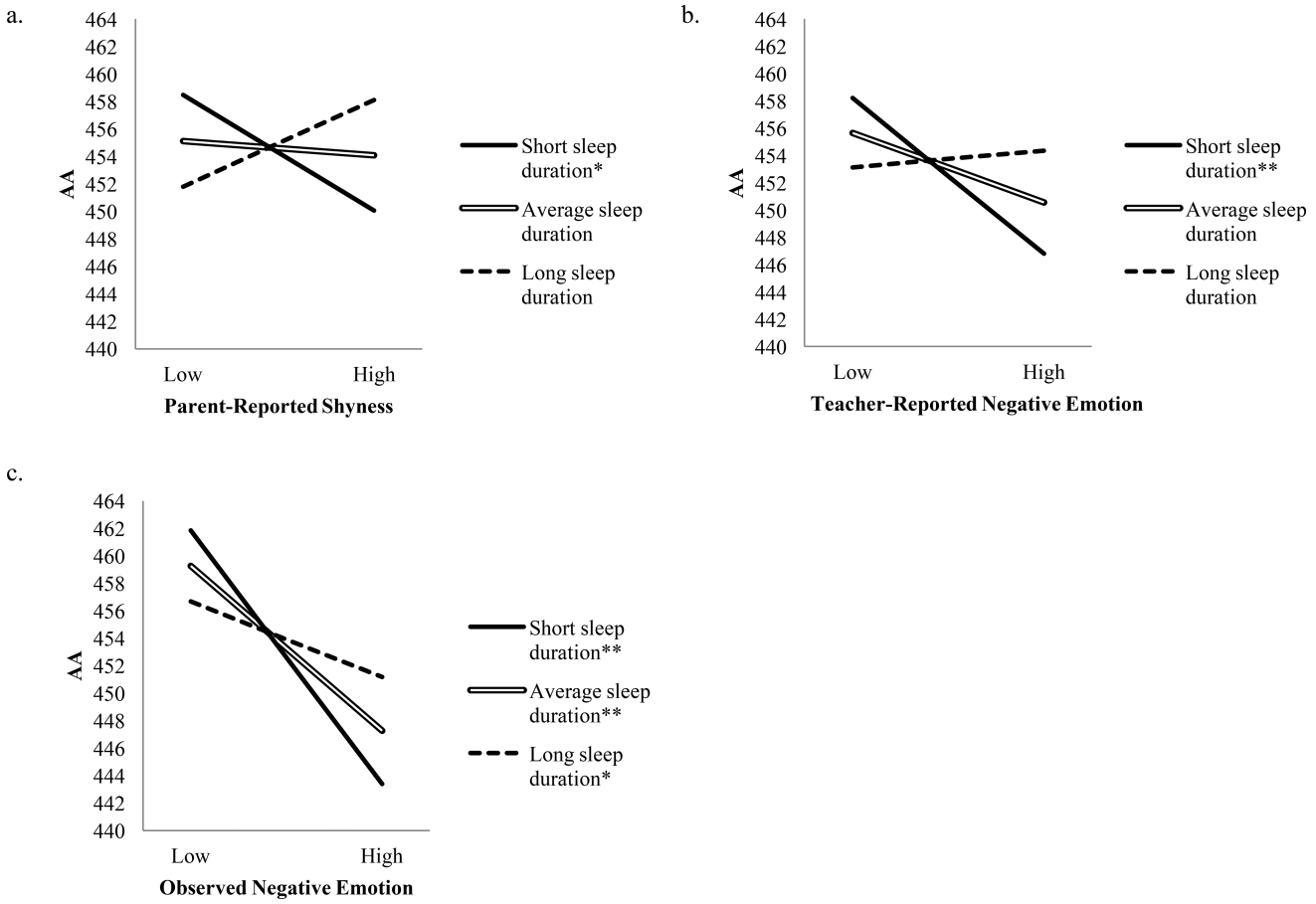

Figure 1.

The moderating effect of sleep duration on the relations of parent-reported shyness (a), teacher-reported negativity (b), and observed negative emotion (c) with AA. The figure depicts the simple slopes for short (1 *SD* below the mean), average, and long (1 *SD* above the mean) sleep duration. AA = average of the Woodcock Johnson III Passage Comprehension and Applied Problems subtests. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 1

Descriptive Statistics and Correlations for Study Variables

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. SES													
2. Age	−0.09												
3. WJ-III PV	0.60***	−0.02											
4. Hispanic	−0.38***	0.03	−0.46***										
5. Medication	0.20**	0.04	0.21*	−0.11									
6. Sex	0.20*	−0.02	0.24**	−0.27**	0.31***								
7. Neg (P)	−0.15	−0.09	−0.17	0.19*	0.09	0.04							
8. Shy (P)	−0.17†	−0.03	−0.18*	0.02	−0.06	−0.17	0.17						
9. Neg (T)	0.04	−0.19*	0.00	−0.03	0.05	0.32***	0.04	−0.10					
10. Shy (T)	−0.25*	−0.01	−0.14	0.13†	−0.03	−0.14	0.00	0.43***	−0.04				
11. Neg (O)	−0.06	−0.15*	0.00	−0.14	−0.02	0.08	0.12	−0.21*	0.34*	−0.21†			
12. Duration	0.29**	−0.24**	0.16	−0.01	−0.02	−0.05	−0.04	−0.22*	0.17*	−0.08	0.16†		
13. AA	0.34***	0.02	0.54***	−0.26**	0.06	0.11	−0.12	−0.14	−0.11	−0.29**	−0.20**	0.08	
M	−0.01	6.46	471.84	0.54	0.12	0.50	4.13	3.67	3.07	3.72	0.07	561.82	454.63
SD	0.88	0.30	10.78	0.50	0.27	0.50	1.01	1.37	1.29	1.34	0.08	30.50	19.18

Note. Child's age is in years. Child sex is coded as 0=female, 1=male; Hispanic is coded as 0=non-Hispanic, 1=Hispanic. Medication = medication use during data collection; SES=Socioeconomic status; WJ-III PV=Woodcock Johnson III Picture Vocabulary; (P) = Parent report; (T) = Teacher report; Neg = Negativity; Duration = Sleep duration; AA = Academic Achievement.

† $p<.10$.

* $p<.05$.

** $p<.01$.

*** $p<.001$.

Table 2

Interactions of Negative Emotionality or Shyness and Sleep Duration Predicting AA

	Parent-reported		Teacher-reported		Observed
Emotion predictor	**Negative**	**Shy**	**Negative**	**Shy**	**Negative**
	***B*(*SE*)**	***B*(*SE*)**	***B*(*SE*)**	***B*(*SE*)**	***B*(*SE*)**
Covariates					
SES	0.60 (2.74)	−0.26 (3.03)	0.53 (2.83)	−0.48 (2.77)	−0.30 (2.90)
Age	0.67 (4.67)	1.45 (4.22)	0.43 (4.57)	1.35 (4.60)	−0.51 (4.47)
WJ-III PV	0.86 (0.18)***	0.85 (0.17)***	0.83 (0.19)***	0.88 (0.16)***	0.85 (0.19)***
Ethnicity	0.15 (3.71)	−1.23 (3.22)	−1.94 (3.48)	−0.43 (3.58)	−2.27 (3.40)
Medication	−4.57 (5.06)	−1.59 (5.07)	−4.91 (5.69)	−3.41 (5.53)	−4.78 (5.72)
Sex	−0.39 (3.31)	0.34 (2.91)	1.66 (3.11)	−1.02 (2.87)	0.76 (3.08)
Predictors					
Temperament predictor	−1.02 (1.68)	−0.38 (1.11)	−1.97 (1.29)	−3.09 (1.19)**	−77.31 (24.30)**
Duration	0.00 (0.06)	0.01 (0.06)	0.02 (0.06)	−0.01 (0.07)	−0.16 (0.10)
Interaction					
Temperament × Duration	−0.08 (0.05)	0.09 (0.02)***	0.08 (0.03)**	0.03 (0.03)	1.38 (0.49)**
Sleep duration simple slopes for significant interactions					
Short duration		−3.08 (1.27)*	−4.40 (1.44)**		−119.30 (37.82)**
Average duration		−0.38 (1.11)	−1.97 (1.29)		−77.31 (24.30)**
Long duration		2.32 (1.37)	0.46 (1.64)		−35.32 (14.20)*

Note. "Emotion predictor" refers to negative emotion and shyness as reported by parents and teachers as well as observed negative emotion. For each model the predictor is indicated in the second row of the table. Short duration = one standard deviation below the sample mean. Average duration = sample mean. Long duration = one standard deviation above the sample mean. SES = socioeconomic status. Age is in years. WJ-III PV=Woodcock Johnson III Picture Vocabulary subtest. Ethnicity is coded 0 = non-Hispanic, 1 = Hispanic. Medication = medication use during data collection. Sex is coded 0 = female, 1 = male. B = unstandardized coefficients.

* $p < .05$.

** $p < .01$.

*** $p < .001$.