Temperamental Profiles Predicting Sleep Quality and Quantity in 9- to 11-Year-Old Children

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Abstract

Sleeping difficulties have a negative influence on cognitive functioning and behavioral problems, in both children and adults (Alhola & Polo-Kantola, 2007; Astill et al., 2012). Studies have revealed that temperament might be a predictor of sleep disturbances in children. The aim of the current study was to examine the association between different temperament traits and sleep disturbances, sleep onset latency, sleep duration and subjective sleep quality in children. Participants were 113 children, aged 9 – 11 years (*M* = 10.47 years; *SD* = .72). Parents kept track of a sleep diary and both parents and children completed several questionnaires, regarding sleep and temperament. Significant associations were found between the different sleep disturbances and effortful control, high intensity pleasure/surgency, frustration, affiliation, and fear. Sleep duration was related to affiliation and fear. Subjective sleep quality was associated with affiliation and shyness. The current study provides evidence for the association between and sleep and temperament.

Keywords: Sleep, sleep disturbances, temperament, temperamental characteristics, profile, school-aged children.

Introduction

A study by the Dutch association for sleep research (NSWO, 2008) showed that approximately 30% of children in the Netherlands experience sleep problems, which corresponds with a prevalence of 25-40% found in the united states (Owens, 2005). These problems include difficulties with initiating or maintaining sleep, sleep breathing disorders, nightmares or night terrors, sleepwalking, and excessive daytime somnolence. Child sleep disturbances are often chronic. Wolke, Meyer, Ohrt, & Riegel (1995) demonstrated that infants having sleep problems at 8 months of age continued to experience difficulties at 3 and 4 years. During the past decades, a significant number of studies have shown that an adequate amount of sleep is important to be able to function optimally during the day. Sleeping difficulties and sleep deprivation have been found to have a negative influence on cognitive functioning, in both children and adults (Alhola & Polo-Kantola, 2007; Astill, van der Heijden, van IJzendoorn, and Van Someren, 2012; Deak & Stickgold, 2010). For example, one hour less sleep per night in early childhood is related to worse cognitive performance years later at school entry, even when sleep duration is normalized in the meantime (Touchette et al., 2007). Additionally, sleep disturbances and behavioral problems have been associated in many studies (Hayes, Parker, Sallinen, & Davare, 2001; Owens-Stively et al., 1997). Two recent meta-analyses have independently shown that both insufficient sleep quantity and quality (for instance, the proportion of time asleep to the total time spend in bed, or the subjective feeling of being rested upon awakening) are related to functioning at school (Astill et al., 2012). Hence, the long-term consequences of chronic sleep reduction can be serious. Therefore, it is alarming that children nowadays sleep less than they did a few decades ago (Igwlostein, Jenni, Molinari, & Largo, 2010).

From a neuropsychological perspective, there are several explanations for how sleep is related to behavior, cognitive functioning and school performance. The first assumes that sleep reduction compromises information processing by the prefrontal cortex of the brain (Drummond et al., 2000; Jones & Harrison, 2001; Choo, Lee, Venkatraman, Sheu, & Chee, 2004; Chee & Tan, 2010). This brain region is highly involved in higher order cognitive functions, such as working memory, cognitive inhibition, and planning. A second explanation is that sleep reduction decreases the period that is needed for efficient consolidation of relevant neuronal networks and downscaling of irrelevant synaptic connections (Tononi & Cirelli, 2006). Thirdly, a cognitive-energetic model states that insufficient sleep leads to increased daytime sleepiness and reduced alertness, which leads to impaired vigilance and sustained attention (Fallone, Owens, & Deane, 2002; Lim & Dinges, 2010).

Given the significant potential consequences of sleep problems in children, it is important to gain better insight in the factors that predict sleep disturbances, so that appropriate methods for

prevention or intervention can be developed and applied. Both child, parental, and environmental variables affect sleep problems. Child factors include (problem) behavior, circadian preference (evening/morning type) and cognitive functioning (Owens & Witmans, 2004). Additionally, sleep problems are common complaints in children with psychiatric disorders (Benca, Obermeyer, Thisted, & Gillin, 1992). Reduction in total sleep time en sleep efficiency is reported for various psychiatric illnesses, which is confirmed by actigraphic, polysomnographic en EEG studies (Boonstra et al., 2007; Saletu-Zyhlarz et al., 2002; De la Fuente, Bobes, Vizuete, & Mendlewicz, 2001). Associations between sleep disturbances and mood disorders are particularly strong (Peterson & Benca, 2006). Dysfunctional sleep related cognitions play an important role in this relationship (Espie, 2002; Harvey, Sharpley, Ree, Stinson, & Clark, 2007).

The child's sleep environment also influences sleep quantity and sleep quality. For example, intrusive background noise and light disturb the child's sleep (Spruyt, O'Brian, Cluydts, Verleye, & Ferri, 2005). But also the decreasing emphasis on positive sleeping habits or sleep hygiene in our 24-hour society, influences the child's sleep by affecting irregular bedtimes, lack of bedtime routines, and the constant availability of (social) media (Jan et al., 2008). Positive sleeping habits are important for both children and adults and are a crucial component of any intervention for sleep disturbances. Parenting and discipline styles are other factors often mentioned as impacting childhood sleep disturbances, since they directly influence child behavior. Furthermore, knowledge about child development is an important factor affecting sleep hygiene (Owens & Witmans, 2004). Additionally, maternal depression and family stress are variables influencing the child's sleep quantity and quality.

Several studies have revealed that temperament might also be a predictor of sleep disturbances in children. Different researchers define and measure temperament in different ways. For example, Rothbart and Bates (1998) proposed a multi-dimensional theory-driven model in which they define temperament as "constitutionally based individual differences in emotional, motor, and attentional reactivity and self-regulation". Temperament is believed to be influenced by both biological maturation and experience (Rothbart, Ellis, & Bates, 2001). Putnam, Ellis, and Rothbart (2001) examined Rothbart's model in early adolescents and demonstrated four broad dimensions of temperament: (1) Effortful control, (2) Negative affectivity, (3) Extraversion/Surgency, and (4) Affiliation. The first dimension, Effortful control, is manifested as the ability to regulate attention and behavior. It refers to the ability to inhibit a dominant response in favor of a subdominant one and includes inhibitory control, perceptual sensitivity and focused attention. Negative affectivity is the second dimension and refers to the psychological instability and proneness to experience feelings of fear, anger, frustration, and social discomfort. Negative affectivity mainly includes frustration in adolescents. In contrast, in

younger children it encompasses both fear and frustration (Putnam et al., 2001). The third dimension Extraversion/surgency denotes the orientation and exploration of novelty; it involves positive affectivity, activity level and sensation seeking. The final dimension is Affiliation, which is manifested as the desire to be close to others, independent of extraversion or shyness (Rothbart & Bates, 1998; Putnam et al., 2001).

The relationship between sleep and temperament has been extensively studied in infants. Research has shown that infants with sleeping problems are often described as having a difficult temperament. For example, Scher, Epsetin, Sadeh, Tirosh, and Lavie (1992) found that sleeping difficulties were associated with low approachability, low adaptability, and higher distractibility. Spruyt and colleagues (2008) found that infants with an easy temperament, thus obtaining high scores on measures of approachability and adaptability and low scores on distractibility, slept longer during both day and night. Infants with more difficult temperaments slept less at night. At 12 months, decreased daytime sleep duration was negatively correlated with emotional regulation.

Only few studies have examined the relationship between sleep disturbances and temperamental characteristics in school-aged children and (early) adolescents. Moore, Shane, Mindell, Burt, and Klump (2010) examined the association between self-reported temperament, according to the four-factor model by Rothbart and Bates (1998), and sleep in adolescents. They found that a higher sleep problem score was related to higher affiliativeness/sociability, negative affectivity, and lower effortful control. There were no significant associations between sleep and surgency/extraversion. Another study by El Sheikh and Buckhalt (2005) demonstrated that higher scores on sleep problems, shorter sleep duration and increased night activity were significantly related to high emotionality and low emotion regulation in 6- to 12-year-old children. In contrast, Broeren, Muris, Bouwmeester, van der Heijden, and Abee (2010) found a direct relationship between neuroticism and sleep difficulties, but no direct relation could be identified for behavioral inhibition.

From the above it can be concluded that temperamental profiles of children obtaining higher scores on measures of sleep disturbances or sleep quantity may differ from typically sleeping school-aged children. Different studies have suggested that personality characteristics might be important factors in predicting different sleep disturbances, however, surprisingly little is known about the relationship between temperament and sleep quantity and quality. Since sleep is proved to be essential for optimal daytime cognitive and behavioral functioning, it is important to determine factors that might predict sleep disturbances and other sleep parameters. The aim of the current study is to examine the association between sleep disturbances, sleep quantity- and quality variables and different temperament traits, following the multi-dimensional model proposed by Rothbart and Bates (1998). Furthermore, the current

study aims to extend the knowledge so far by examining an extensive profile of temperamental characteristics predicting sleep quantity and quality and sleep disturbances, in stead of one or just a few temperament traits. To our knowledge, the current study is also one of the first to investigate how temperament is associated with different types of sleep disturbances instead of using one single sleep problem score. It was hypothesized that temperament influences both sleep quantity and sleep quality. Based on findings discussed above it was theorized that temperamental dimensions related to distractibility/impulsivity, fear/neuroticism, negative affectivity and affiliativeness would be significantly related to sleep problems, sleep quantity, and sleep quality in 9- to 11 year old children.

Methods

Participants

Participants were 9- to 11- year old children and their parents. They were recruited through primary schools in several Dutch provinces, as well as through acquaintances of the research assistants. Exclusion criteria were: ADHD with use of medication, the use of melatonin supplements and anxiety disorders. It was also decided to exclude children older than 11 years, because during adolescence the circadian clock rhythm shifts, which may change sleep-wake rhythm and chronotype in children aged 12 years or older.

Complete records were obtained for 113 children (45 boys, 68 girls). The children had a mean age of 10.47 years (*SD* = .72, age range 9–11). Most children lived in the southwest region of the Netherlands. 88% of the children were from Dutch origin. Thirteen children had at least one parent that was born in a country other than the Netherlands. Educational level of the parents was relatively high, 50% of the mothers completed some form of higher education, 38% completed secondary education or some kind of vocational education and 10% some form of lower vocational education. 1% only completed primary school. In most cases, questionnaires were filled out by the biological mother (88%). Informed consent was obtained prior to the study. The current study was submitted for approval by the ethics committee of the Leiden Institute of Education and Child Studies (pending).

Procedure

A total of 50 primary schools were contacted and requested to participate, 12 schools (24%) agreed. 1249 parents received information and 171 parents provided informed consent (14%). Parents could express their preference about whether they wanted to receive the questionnaires in a digital form or whether they would rather fill them out on paper.

After parents had agreed to participate, they received an e-mail regarding the instructions for participating in the research project. Parents were asked to keep track of a sleep diary during the week prior to actual test date. Both parents and children completed questionnaires, which took approximately 25 minutes. The questionnaires in the current study were: a questionnaire concerning general child and parent characteristics, the *Sleep Disturbance Scale for Children (SDSC)*, a questionnaire concerning the child's sleep and sleeping habits, the *Children's Chronotype Questionnaire* (CCTQ), a questionnaire regarding the child's chronotype, the *Behavioral Inhibition Questionnaire* (BIQ) and the *Early Adolescent Temperament Questionnaire-Revised* (EATQ-R) concerning the child's temperament, and the *Strengths and Difficulties Questionnaire* (SDQ) about the child's behavior. The children were visited at school or at home to administer three computer tasks: the PVT, the PVT-GoNoGo, and Digit span (forward and backward). Afterwards, the Brus Eén-Minuut-Test and the Klepel were administered to assess reading ability. All tests were administered in the same order for every child. In the current study, only the instruments regarding sleep and temperament will be discussed.

Measures

Sleep diary

Parental sleep diaries are considered reliable and valid to assess sleep in children (Sadeh, Raviv, & Griber, 2000). The sleep diary in the current study had to be completed by the parents over eight consecutive days and seven nights. The information provided by the parent(s) concerned clock time at lights-off, sleep-onset latency, the ease to fall asleep (rated on a five-point scale), the number of night awakenings, the time of waking-up, whether the child woke up by itself or was awakened by an alarm clock or by another person, the time of getting out of bed, morning fatigue (rated on a 5-point scale), and morning temper (rated on a five-point scale).

Sleep Disturbance Scale for Children

The Sleep Disturbance Scale for Children (SDSC) is a questionnaire concerning the child's sleeping habits and particular sleep disturbances. The questionnaire contained questions regarding e.g. the child's sleeping situation, sleeping time, awakenings during the night and sleeping difficulties. This questionnaire attempts to categorize sleep disorders in children into: (1) Sleep breathing disorders, (2) Disorders in initiating or maintaining sleep, (3) Disorders of arousal/nightmares, (4) Sleep wake transition disorders, (5) Disorders of excessive somnolence, and (6) Sleep hyperhydrosis (Table 1.). The SDSC consists of 26 items that can be rated on a five-point Likert-scale, ranging from *1. Never* to *5. Always*. The internal consistency can be rated as good and the test-retest reliability is satisfactory (Bruni et al., 1996). The SDSC has been found to be a useful tool in evaluating the sleep disturbance of school-aged children in clinical and non-

clinical populations. Sleep breathing disorders and sleep hyperhydrosis are caused by physical anomalies and will therefore not be included in the analyses.

Table 1.

Scales of the SDSC.

Scale	
Sleep breathing disorders	Breathing problems, sleep apnea, snoring
Disorders in initiating or maintaining sleep	Sleep duration and latency, problems falling asleep, anxiety, night awakenings
Disorders in arousal/nightmares	Sleepwalking, sleep terrors, nightmares
Sleep wake transition disorders	Hypnic jerks, rhythmic movement disorders, hypnagogic hallucinations, nocturnal hyperkinesia, sleeptalking, bruxism
Disorders of excessive somnolence	Daytime somnolence and restless sleep, difficulty waking up, sleep paralysis
Sleep hyperhydrosis	Falling asleep and night sweating

Early Adolescent Temperament Questionnaire-Revised

The short form of the Early Adolescent Temperament Questionnaire-Revised (EATQ-R; Ellis & Rothbart, 2001; Hartman, 2000) is a self-report questionnaire based on the temperament model developed by Rothbart and collegues (Rothbart & Bates, 1998; Rothbart, Ahadi & Evans, 2000). 65 items can be rated on a five-point Likert-scale ranging from *1. Almost always untrue for you* to *5. Almost always true for you.* The EATQ-R assesses 10 different aspects of temperament that are related to self-regulation: Activation control, Affiliation, Attention, Fear, Frustration, High-intensity pleasure/Surgency, Inhibitory control, Perceptual sensitivity, Pleasure sensitivity, and Shyness (Table 2). However, three temperament scales comprising the factor Effortful control were found to be unreliable in a Dutch sample: Activation control (α = .41), Attention (α = .50), and Inhibitory control (α = .29) (Oldehinkel, Hartman, De Winter, Veenstra & Ormel, 2004). Oldehinkel and collegues (2004) constructed the scale Effortful control, reflecting activation control, attention and inhibitory control, with an internal consistency of α = .86. This Effortful control scale will be used in the current analyses, together with the 7 remaining temperament scales.

Table 2.

Subscales of the EATQ-R.

Scale	
Activation control	Capacity to perform an action when there is a strong tendency to avoid it
Affiliation	Desire for warmth and closeness to others, independent of shyness or extraversion
Attention	Capacity to focus attention and shift attention if desired
Fear	Unpleasant affect related to anticipation of distress
Frustration	Negative affect related to interruption of ongoing tasks or goal blocking
High-intensity pleasure	Pleasure derived from activities involving high intensity or novelty
Inhibitory control	Capacity to plan, and to suppress inappropriate responses
Perceptual sensitivity	Detection or perceptual awareness of slight, low-intensity stimulation in the environment
Pleasure sensitivity	Pleasure related to activities or stimuli, involving low intensity, rate, complexity, novelty, and incongruity
Shyness	Behavioral inhibition to novelty and challenge, especially social

Statistical analyses

All variables were examined for outliers and the assumptions applying to the statistical analyses. To retain extreme variations but limit adverse effects on the distribution, outliers exceeding three standard deviations from the mean were recoded into the highest value within three standard deviations from the mean (Kline, 1998). Before performing the multiple regression analyses, the correlations between the predictor variables were inspected to avoid problems with multicollinearity.

Multiple linear regression analyses were used to assess the hypotheses. The predictor variables were entered into the regression model using the backward procedure to avoid suppressor effects and to reduce the risk of type II errors (Field, 2009). In de the first step, all temperamental characteristics were entered. The variables that did not make a significant contribution to how well the model predicted the outcome variables were removed and the model was re-estimated for the remaining predictors. Gender was included as a covariate.

If problems with non-linearity of the residuals were apparent during the multiple linear regression analyses and the variables were positively skewed, the original variables were transformed using a log10 transformation. The regression models were inspected for heteroscedasticity. Graphs were made to display temperamental profiles for the different sleep disturbances and sleep parameters.

Results

Descriptive statistics

Descriptive results for all variables are reported in Table 3. All variables were examined for outliers and statistical assumptions. The EATQ-R scales effortful control, frustration, and high intensitity pleasure/surgency were normally distributed, with skewness ranging from .07 to .44. The scales affiliation, fear, pleasure sensitivity, perceptual sensitivity, and shyness were not normally distributed according to both the Shapiro-Wilk test and the Kolmogorov-Smirnov test, but transformation was not demanded by visual appearance (Field, 2009). All sleep disturbances assessed by the SDSC were positively skewed (skewness .82 to 1.62). The original variables were transformed using a log10 transformation to normalize the predictors and by doing so also the residuals, necessary for the multiple linear regression analyses. Sleep onset latency was also positively skewed, and transformed using the log10 transformation (skewness 1.68). Mean hours of sleep during the week was normally distributed, subjective sleep quality was not, but visual appearance provided no reason for transformation (skewness .16 and .019 respectively).

Table 3.

Descriptives of all variables included in the analyses.

Variable	*M.*	*SD.*	*Min.*	*Max.*
Temperamental characteristics				
Effortful control	47.02	8.62	23	64
Shyness	9.29	3.58	4	20
Affiliation	20.33	2.55	14	25
Fear	14.21	4.98	6	26
Frustration	22.29	5.42	10	35
High intensity pleasure/surgency	19.76	4.43	7	29
Pleasure sensitivity	15.95	4.47	7	25
Perceptual sensitivity	14.26	2.80	8	20
Sleep disturbances				
Disorders in initiating or maintaining sleep	12.80	380	7	24
Disorders in arousal	3.53	.89	3	6
Sleep wake transition disorders	9.09	3.01	6	18
Disorders of excessive somnolence	7.17	2.10	5	13
Total sleep problems	39.32	8.69	26	65
Sleep parameters				
Sleep onset latency (min)	21	16	4	95
Mean hours of sleep during week (min)	595	34	512	690
Subjective sleep quality	3.79	.71	2.00	5.00

Correlations

Pearson's correlation coefficients were calculated between the means of the sleep disturbance scales and temperamental characteristics, controlling for gender (Table 4). The correlations demonstrated significant associations between sleep and effortful control, affiliation, frustration, high intensity pleasure and perceptual sensitivity. Trends towards significance were demonstrated for fear and high intensity pleasure/surgency. No significant correlations were found between sleep disturbances and shyness and pleasure sensitivity. The other sleep parameters were significantly associated with affiliation, shyness and frustration. A trend towards significance was apparent for the association between the mean hours of sleep during the week and fear. All significant correlations were low to moderate, suggesting that the temperamental characteristics are part of a similar construct, but with unique contributions to each of the different sleep problem variables and sleep quality- and quantity variables (Field, 2009).

Table 4.

Pearson's correlations between sleep problems and temperamental characteristics.

	Effortful control	Shyness	Affiliation	Fear	Frustration	High Intensity pleasure	Pleasure sensitivity	Perceptual sensitivity
SDSC								
Dis. init. maint.	-.196 **	.108	-.187**	.026	.198 **	.146	.124	.203 **
Dis. Arousal	-.275 **	.028	.096	.168 *	.082	.074	.039	.026
Sleep wake tran.	-.235 **	-.098	.071	.148	.134	.154 *	.027	.000
Dis. exces. somn	-.212 **	.056	.053	.067	.160	.062	.055	.118
Sleep parameters								
Sleep onset latency	-.128	-.064	-.140	-.028	-.027	.100	-.069	.100
Mean hours of sleep week	-.081	.028	.315**	.197*	.051	-.131	.052	.003
Subjective sleep quality	.127	-.250**	.220**	-.074	-.202**	.006	.014	-.017

N=113. Sleep disturbances: Controlled for gender. Sleep parameters: controlled for gender and age. * p <.10, **p <.05

Dis. init. maint: Disorders in initiating or maintaining sleep.

Dis. arousal: Disorders in arousal.

Sleep wake tran: Sleep wake transition disorders.

Dis. exces. somn: Disorders of excessive somnolence.

Temperamental characteristics predicting sleep disturbances

To test the main hypothesis that different temperamental characteristics are predictive of the four types of sleep disturbances in children, multiple linear regression analyses were performed. However, first the correlations between the predictor variables were inspected to avoid problems with multicollinearity. Pearson's correlations between the eight different temperament scales ranged between r =.225 (p=.016) and r=.371 (p<.001), which is low enough to perform multiple linear regression analyses with the original variables. However, during the analyses possible problems with multicollinearity were suspected, so all predictor variables were centered by subtracting the mean score from each data-point (Field, 2009).

Results from the multiple linear regression analyses are shown in Table 5 (gender was entered as a covariate). The scale Disorders in initiating or maintaining sleep was significantly predicted by four of the temperamental characteristics (*Adjusted* R^2= 10.1, F(5,106)= 3.50, p<.01). High intensity pleasure/surgency, frustration, effortful control and affiliation were all moderately strong predictors, respectively accounting for 4.00%, 3.61%, 3,24, and 2.25%, of the variance. Affiliation and effortful control were both negatively associated with disorders in initiating and maintaining sleep, meaning that lower scores on these two temperamental characteristics result in more sleep disturbance. More frustration and high intensity pleasure/surgency was associated to higher sleep disturbance scores related to initiating and maintaining sleep. The regression model predicting Disorders in arousal contained three temperamental characteristics: effortful control, high intensity pleasure/surgency, and fear (*Adjusted* R^2= 10.6, F(4,107)= 4.29, p<.01). Effortful control accounted for 5.76% of the variance, high intensity pleasure/surgency for 3.24%, and fear for an additional 3.24%. Lower effortful control scores were predictive of higher sleep problem scores related to disorders in arousal. The association was positive for high intensity pleasure/surgency and fear. Sleep wake transition disorders were moderately predicted by effortful control (7.84%) and high intensity pleasure/surgency (3.24%; F(3,109)= 3.87, p<.05). Adjusted R^2 was .071, indicating that 7.1% of the model was accounted for by variations in these two temperamental scales. The final regression model predicting disorders of excessive somnolence primarily contained effortful control, explaining 5.76% of the variance (*Adjusted* R^2= .079, F(2,110)= 5.78, p<.01). Again, this association was negative. Figure 1 displays the temperamental profiles associated with different sleep disturbances.

Table 5.

Multiple linear regression table predicting sleep disturbances from temperamental characteristics.

	Disorders in initiating or maintaining sleep			**Disorders in arousal**			**Sleep wake transition disorders**			**Disorders of excessive somnolence**		
Centred predictors	*B (SE)*	*β*	*t*	*B (SE)*	*β*	*t*	*B (SE)*	*β*	*t*	*B (SE)*	*β*	*t*
Effortful control	-.003 (.001)	-.18	-1.76*	-.025 (.010)	-.24	-2.44**	-.004 (.001)	-.28	-3.05**	-.003 (.001)	-.24	-2.63**
Shyness												
Affiliation	-.007 (.004)	-.15	-1.83*									
Fear				.031 (.018)	.18	1.75*						
Frustration	.004 (.002)	.19	1.93*									
High intensity pleasure/surgency	.006 (.003)	.20	2.14**	.038 (.020)	.19	1.97*	.005 (.003)	.18	1.93*			
Pleasure sensitivity												
Perceptual sensitivity												

*p<.10

**p<.05

Note: controlled for gender.

Temperamental characteristics predicting sleep quantity and sleep quality

Multiple linear regression analyses were also used to test the relationship between temperamental characteristics and several other sleep parameters. The same procedure was followed as for sleep disturbances. Gender and age were entered as covariates. As is shown in Table 6, none of the temperamental characteristics were significant predictors of sleep onset latency. The average amount of hours the children slept during the week was significantly predicted by affiliation, which explained 5.8% of the variance (*Adjusted* R^2= .142, $F(4,90)$= 4.89). Fear showed a trend towards significance (p=.06). Both associations were positive. An average rating of subjective sleep quality was significantly predicted by shyness, explaining 4.4% of the variance (*Adjusted* R^2= .144; $F(3,91)$= 6.26, p<.01). Higher scores on shyness predicted lower scores in subjective sleep quality. A trend towards significance was observable for affiliation (p=.084), explaining 2.9% of the variance. This association was positive. Figure 2 displays the temperamental profiles related to the mean hours of sleep during the week and subjective sleep quality.

Table 6.

Multiple regression table predicting sleep parameters from temperamental characteristics

	Sleep onset latency			**Mean hours of sleep during week**			**Subjective sleep quality**		
	B (SE)	*β*	*t*	*B (SE)*	*β*	*t*	*B (SE)*	*β*	*t*
Effortful control									
Shyness							-.042 (.020)	-.21	-2.12**
Affiliation				186.92 (77.31)	.24	2.42**	.046 (.026)	.17	1.75*
Fear				77.30 (39.78)	.19	1.94*			
Frustration									
High intensity									
pleasure/surgency									
Pleasure sensitivity									
Perceptual sensitivity									

*p<.01
** p<.05
Note: Controlled for gender and age. None of the predictors were significant for sleep onset latency.

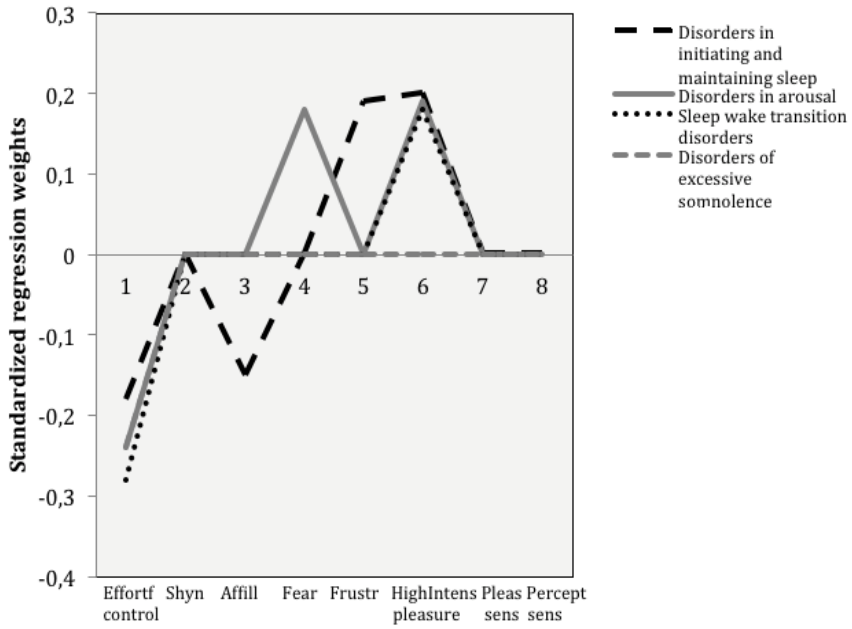

Figure 1.

Temperamental profiles for the different sleep disturbances: Standardized regression weights.

Note: controlled for gender.

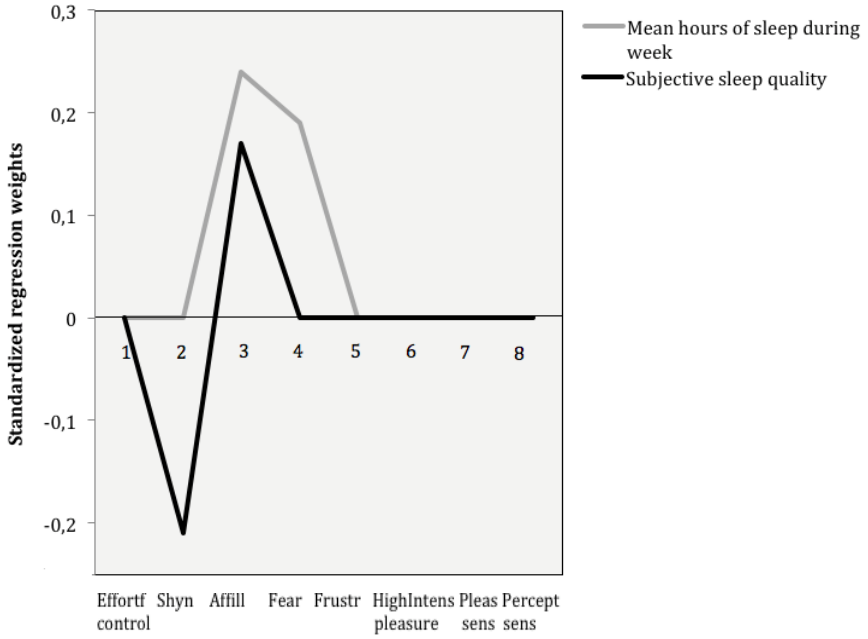

Figure 2.

Temperamental profiles for sleep quantity and sleep quality: Standardized regression weights.

Note: controlled for gender and age.

Discussion

Previous studies suggest that there might be a relationship between sleep and temperament in school-aged children. However, surprisingly little is known about the relation between temperament and sleep quantity and quality. The current study addressed this relationship between sleep and temperament in school-aged children, following the multi-dimensional model by Rothbart and Bates (1998). A second aim of the study was to extend the knowledge so far by examining a profile of temperamental characteristics predicting sleep disturbances and sleep quantity and quality. A wide range of temperamental characteristics were examined, including effortful control, shyness, affiliation, fear, frustration, high intensity pleasure, pleasure sensitivity, and perceptual sensitivity. To our knowledge, this study was one of the first to examine such an extensive profile of temperamental traits in school-aged children. Previous studies suggested that higher-sleep problem scores were associated with higher adolescent-reported affiliativeness/sociability and negative affectivity and lower effortful control (Moore et al., 2010). In addition, the relationship between sleep and temperament is extensively studied in infants and toddlers, but few studies focused on school-aged children in a non-clinical setting and on different sleep disturbances instead of one sleep problem score.

As expected, significant associations were demonstrated between sleep disturbances and temperamental characteristics in children aged 9-11 years. Effortful control turned out to be an important temperamental trait; it was significantly negatively correlated to all four different types of sleep disturbances. These findings are in accordance with previous studies in infants, toddlers, and school-aged children (Carey, 1974; Sadeh, Lavie, & Scher, 1994; Owens, 1997; Moore et al., 2010; El-Sheik & Buckhalt, 2005), in which it was shown that the ability to regulate behavior and emotion was negatively associated with sleep problems. It is possible that children obtaining low scores on measures of effortful control show more hyperactive and oppositional behavior at bedtime and become over aroused, which is unfavorable to reach the low levels in arousal important to fall asleep. Another explanation might be that children with lower scores on effortful control also have parents that are less able to regulate behavior, attention and emotions, which might cause them to be less able to provide a structured and calming bed-time routine and sleeping environment. However, it is important to note that sleep problems can also lead to problems with executive functioning. Therefore, the association between sleep problems and effortful control can be interpreted in both directions. The current study confirmed the findings by Ottoni, Lorenzi, and Lara (2011) that effortful control is not related to the number of hours a child sleeps during the week. However, Ottoni et al. did find that sleep onset latency significantly associated with effortful control, but this could not be confirmed by the present study.

Previous studies have shown that anxiety and excessive worrying are related to psychophysiological insomnia (Harvey & Greenhall, 2003; Carney et al., 2010) and fatigue (Jason, Evans, Brown, & Porter, 2010). Our results partly support these findings. Fear was not found to be a significant predictor of sleep disturbances, but trends towards significance were observed for disorders in arousal and the number of hours a child sleeps during the week. This implicates that children that are more prone to be fearful might be at risk for developing sleep problems. Furthermore, repetitive negative thoughts, such as worry and rumination, are associated with cognitive inflexibility and poor-problem solving (Watkins & Moulds, 2005). It seems plausible that these repetitive negative thoughts might also lead to feelings of frustration and depression (Rood, Roelofs, Bögels, Nolen-Hoeksma, & Schouten, 2009).

A trend towards significance was observable for the association between affiliation and disorders in initiating or maintaining sleep. A possible explanation might be that oxytocin is an important factor in the association between affiliation and sleep (Blagrove et al., 2012). Oxytocin has anxiolytic (anxiety reducing) and sedating effects and is secreted in the paraventricular nucleus of the hypothalamus, the part of the brain that is involved in regulating sleep and arousal, so it may play an important role in sleep-wake behavior. Furthermore, oxytocin is also involved in affiliative behaviors, which might explain the link between sleep and affiliation. Moore et al. (2010) also found that affiliation/sociability was an important factor in predicting sleep in (pre)adolescents. The authors argued that due to the developmental importance of social relationships during (pre)adolescence and the availability of cell phones and social media, it is not surprising that socially active (pre)adolescents have more sleep problems than those who have a less vivacious social life.. Affiliation did turn out to also be a moderately strong predictor of the mean hours of sleep a child gets each night during the week and subjective sleep quality. So, more affiliation was related to less sleep problems.

In contrast, effortful control was a significant predictor of sleep disturbances, but not of sleep quantity or sleep quality. Apparently, sleep problems are not strongly related to sleep quantity and sleep quality. Disorders in arousal and sleep-wake transition disorders are not abnormalities of the processes responsible for sleep and awake states per se but, rather, are undesirable physical phenomena that occur predominantly during sleep (ICSD). That means that these disorders are not necessarily related to reduced sleep quality or – quantity. Disorders in initiating or maintaining sleep are often related to reduced sleep quality or – quantity, however, subjective experiences of those sleep problems are not always reflected in objective sleep measures.

Among the personality characteristics in children suffering from disorders in initiating or maintaining sleep, we found low levels of effortful control and affiliation and higher levels of frustration and high intensity pleasure. Disorders in sleep-wake transition were also predicted

by low levels of effortful control and high levels of high intensity pleasure. Children with these personality traits tend to externalize their feelings. In contrast, previous studies have found that children with more internalizing temperaments suffer from insomnia (Kales, Caldwell, Soldatos, Bixler, & Kales, 1983; Park, An, Jang, Chung, 2012). Few studies report on the relation between externalizing temperaments and sleep. However, Ottoni et al. (2011) do report that the temperament trait of anger was most strongly associated with dysfunctional sleep. Higher anger scores were accompanied by increased sleep onset latency, more nightly awakenings and poorer sleep quality. The authors propose that anger is accompanied by physiological arousal and that sleep disturbance might be caused by physiological activation (Bonnet & Arand, 2003). However, further studies are necessary to clarify this association.

Disorders in arousal were characterized by low levels of effortful control en higher levels of fear and high intensity pleasure/surgency. Individuals experiencing sleepwalking, night terrors, or nightmares show heightened reactivity of the autonomic nervous system, both awake and asleep (Rogozea & Florea-Ciocoiu, 1983; Johns, Gay, Masterton, & Bruce, 1971). It seems intuitively plausible that these high levels of arousal are also reflected in the child's temperament, exhibiting higher levels of fear and anxiety. These children can be described as more introvert. It might be that these children are quickly aroused by environmental stimuli, which explains why they also obtain high scores on the dimension of high intensity pleasure.

Effortful control was found to be the only significant predictor of disorders of excessive somnolence. This seems plausible, because children with less effortful control are more susceptible to all kinds of sleeping problems and are therefore more likely to experience excessive somnolence during the day.

Several limitations should be taken into account. First, participants were not randomly drawn from the population, but through primary schools and acquaintances of the research assistants. Most children came from families with relatively high social economic status. Children from immigrant families were underrepresented in the current sample (4.4% with respect to 16.4% in the Dutch population 0-25 years; CBS, 2011). Therefore, the findings cannot be generalized to the Dutch child population. A second limitation is the cross-sectional design, which makes it impossible to demonstrate the direction of causality between temperament and sleep patterns, other than on theoretical grounds. Future research should aim to identify temperamental characteristics associated with sleep disturbances in a longitudinal approach, identifying important factors across the life span. Additionally, the amount of variance predicted by the different regression models was reasonably small. However, these findings were consistent with previous studies (Sadeh et al., 1994; Owens et al, 1997; Moore et al., 2010). Last, the sleep parameters and sleep disturbances were assessed by using parent-report measures. Most of the time, parents sleep in separate rooms from their children and might not be fully

aware of the difficulties the child experiences during the night. Objective measures of sleep might be needed to confirm the findings of the present study.

It can be concluded that an association exists between sleep (both sleep quantity and -quality and sleep disturbances) and different temperamental characteristics in school-aged children. The findings provide the opportunity to determine which temperamental features contribute to the induction or aggravation of sleep disturbances. In addition, the results may contribute to identify temperamental risk profiles of children with a susceptibility for sleep problems.

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