Published in final edited form as:
Read Writ. 2009 January 1; 22(1): 107–116. doi:10.1007/s11145-007-9111-9.

Effortful Control, Surgency, and reading skills in middle childhood

Kirby Deater-Deckard,
Psychology, Virginia Polytechnic Institute and State University, 109 Williams Hall (0436), Blacksburg, VA 24061, USA

Paula Y. Mullineaux,
Psychology, Virginia Polytechnic Institute and State University, 109 Williams Hall (0436), Blacksburg, VA 24061, USA

Stephen A. Petrill, and
Human Development and Family Science, Ohio State University, 135 Campbell Hall, 1787 Neil Avenue, Columbus, OH 43210-1295, USA

Lee A. Thompson
Psychology, Case Western Reserve University, Mather Memorial Room 103, 10900 Euclid Ave., Cleveland, OH 44106, USA

Abstract

We examined the associations between components of temperament and children's word and pseudo-word reading skills, in a school-age sample using a within-family internal-replication design. We estimated the statistical prediction of word and pseudo-word reading in separate regression equations that included the main effects of, and two-way interaction between, Surgency and Effortful Control. Children with better Effortful Control scores showed better reading skills. Surgency was unrelated to reading skills, but moderated the effect of Effortful Control. The positive association between reading skills and Effortful Control was present only for children who were low in Surgency. Thus, reading achievement in school-age children is optimized by strong Effortful Control, but these processes may be disrupted for those children who are high in Surgency.

Keywords

Effortful Control; Reading; Surgency; Temperament

Introduction

Successful mastery of reading is fundamental not only to the development of other cognitive skills but to educational outcomes, occupational success, and social-emotional development and well-being. Understanding how and why some children and adolescents excel while others fall behind in reading is critical to addressing ways to intervene and enhance achievement and maximize educational attainment. To this end, research is needed that examines individual differences in children's behaviors that pertain to the development of reading skills, when those skills are first being acquired and applied. In the current study of reading skills among early readers (grades 1 and 2), we studied potential additive and interactive effects of two aspects of temperament—Effortful Control (i.e., self-regulatory capacities) and Surgency (i.e., impulsive hedonic activation tendencies).

kirbydd@vt.edu .

Temperament and reading

In the developmental psychology literature, there have been many approaches to operationalizing temperament (Posner & Rothbart, 2006; Strelau, Zawadzki, & Piotrowska, 2001). These theories generally converge to define temperament as biologically influenced behaviors that vary widely across individuals, are readily observed from infancy, and are moderately stable over time and across settings.

In the current study, we have focused on two aspects of temperament that may be particularly important in children's reading skill development—Effortful Control (EC) and Surgency (S). In Rothbart's theory of temperament (Putnam & Rothbart,2006), the EC factor represents self-regulatory capacity and includes four facets: Attention Focusing, Inhibitory Control, Low Intensity Pleasure, and Perceptual Sensitivity. The S factor represents high-energy activation and is derived from four scales: Impulsivity, High Intensity Pleasure, Activity Level, and low levels of Shyness. These dimensions of temperament are thought to represent individual differences in brain mechanisms involved in energy/activation, response to new information (specifically, tendency to approach versus a tendency to withdraw), and regulation of arousal —mechanisms that are part and parcel of successful completion of demanding tasks and, ultimately, learning and achievement (Nęcka, 2003; Posner & Rothbart, 2006).

To our knowledge, the current study is the first to examine additive and interactive statistical effects of the EC and S factors on reading skills. Some of the component behaviors within the broader EC and S factors have been implicated in prior research on reading skill development. Foundational research by Oates (1928) and Porteus (1942) pointed to the importance of considering "behavioral styles" as fundamental contributors to scholastic achievement. More recently, Martin, Olejnik, and Gaddis (1994) found that better scholastic achievement in elementary school was predicted from greater task persistence and less distractibility—behaviors that are represented within the EC construct. Other studies using different methods and measures have found similar results (for a review see Keogh, 2003).

Behaviors that are indicative of the S factor also have been implicated, although there are far fewer studies compared to the research on EC behaviors. Several studies have shown a link between poorer reading and high motor activity, and higher impulsivity has been implicated as an impediment to reasoning and cognitive performance generally (Martin et al., 1994; Schweizer, 2002).

Aim and hypothesis

Our aim was to examine the statistical associations between the broad temperament dimensions of EC and S, and two indicators of reading skills among early readers (grades 1 and 2)—"real'' word and "pseudo" word identification (i.e., "word attack"). Based on the literature described above, we anticipated finding better reading skills to be associated with better self-regulation capacity (higher EC) and fewer impulsive activation/approach behaviors (lower S). In addition to testing this hypothesis, we conducted an exploratory analysis of the interaction between EC and S as a statistical predictor of reading performance to test for non-additive effects of temperament on reading skill development. We used an internal replication design by testing for these effects in two sub-samples: the first-born twin (Sub-sample 1) and the second-born twin (Sub-sample 2) in a sample of school-age twin pairs.

Methods

Participants

The data were from the Western Reserve Reading Project. In this on-going longitudinal twin study, the children are assessed annually (see Petrill, Deater-Deckard, Thompson, DeThorne,

& Schatschneider, 2006, for a detailed description of the study). The sample included 178 families with same-sex twins (61% of the pairs were females, 44% of the pairs were genetically identical) for whom we had complete data for the current study. Based on parents' reports at the beginning of the study, 7% of the families reported that one or both twins had, or might have, a learning disability. However, no children were excluded from analyses.

The children were 7.1 years old on average (*SD* = .88 years, from 5.3 to 8.9 years). There was a wide range of parental education that was similar for mothers and fathers: 1–2% high school or less, 39% some college, 30% bachelor's degree, 25% some post-graduate education or degree, 5% not specified. The majority was Caucasian (92%) and lived in two-parent households (6% single mothers). The total sample included 356 children in 178 families (2 children per family). For the internal replication design, we analyzed separately the 178 first-born ("sub-sample 1") and 178 second-born twins ("sub-sample 2").

Procedures

In the on-going WRRP study, we are conducting annual visits to the home to assess children's reading and cognitive skills. For the current study, we examined data from the second home visit, for which we have the most complete assessment of reading that is closest in time to the assessment of temperament. During the home visit, two testers assess each child's reading and cognitive skills using a 2.5-h assessment battery. Parents and children participated in an informed consent and assent procedure, and received honoraria for their time. All procedures were in compliance with the protocol that was approved by Institution Review Boards at the investigators' institutions.

As a separate component of the on-going longitudinal study, after this home visit parents were asked if they would be willing to complete a mailed questionnaire that included ratings of child temperament. The timing of completion of the supplemental questionnaire was not systematic, although on average these were completed 11 months after the home visit.

Measures

Reading skills—Children's reading skills were measured using two sub-tests from the Woodcock Reading Mastery Test, WRMT-R (Woodcock, 1987). We administered the Word Identification sub-test, and also assessed pseudo-word reading using the Word Attack sub-test. Word Attack was administered only to those children who demonstrated an ability to complete at least a portion of the Word Identification sub-test. All of the children in the analyses in the current study were able to complete both sub-tests.

Temperament—We used the Child Behavior Questionnaire-Short Form, CBQ-SF (Putnam & Rothbart, 2006) as a measure of temperament in middle childhood. The CBQ-SF is the most recently published instrument of child temperament. It is based on a longstanding series of studies that have established evidence for strong psychometric properties of this instrument, and for the theoretical and empirical distinctiveness of the multiple temperament dimensions that the questionnaire identifies. The measure is derived from Rothbart's theory of temperament that specifies components of behavior and affect that represent individual differences in reactivity and self-regulation.

In the current study, we focused on the Effortful Control (EC) and Surgency (S) factors in the CBQ-SF. The CBQ-SF utilizes a seven-point Likert-type scale (1 = extremely untrue of your child to 7 = extremely true of your child). The Surgency (S) scale is derived from averaging four sub-scales: Impulsivity, High-Intensity Pleasure, Activity Level, and Shyness (reversed). The Effortful Control (EC) scale is based on four sub-scales: Attentional Focusing, Inhibitory Control, Low-Intensity Pleasure, and Perceptual Sensitivity. Exploratory factor analysis

yielded strong evidence of replication of the simple-structure factor solution for the CBQ-SF (Putnam & Rothbart, 2006). The loadings for S were .62–.86, and loadings for EC ranged from .67 to .80. Mothers' and fathers' scores were substantially correlated (.72 for EC, .61 for S), so parents' reports were averaged for those children who had both mothers' and fathers' reports (93 of the 178 families).

Results

Descriptive statistics are shown in Table 1. The age standard scores for Word Identification and Word Attack were above the population mean of 100, although the standard deviations were close to population average of 15. This suggests that the children were performing above-average for their age, although there was a great deal of variability within the sample. In regard to temperament scores, mothers' and fathers' reports for EC revealed moderate negative skew, with the majority of children being rated above the middle (3.5) of the seven-point scale. Surgency was more normally distributed, with the means falling close to the middle of the scale. There was ample variability in both mothers' and fathers' reports for both temperament dimensions. The distributions were very similar across the two replication sub-samples.

We also estimated associations between the four study variables (Word Attack, Word Identification, EC, and S), and two child factors: age in years and gender (coded as 1 = female and 2 = male). Word Identification standard scores were modestly higher for older children, $r(353) = -.20$, $p < .001$. Girls were higher than boys in EC, $r(353) = -.29$, $p < .001$, and lower than boys in S, $r(353) = .18$, $p < .01$. None of the other tests was significant.

To test our hypothesis and explore potential interactions between temperament dimensions, we began by estimating bivariate Pearson correlations between study variables within the two replication sub-samples (shown as the off-diagonal elements in the correlation matrix in Table 1). The pattern of covariation among the four study variables was replicated across the two sub-samples. Word Attack and Word Identification were substantially positively correlated. There was a modest to moderate negative association between EC and S. We found modest positive associations between EC and the two reading scales (ranging across sub-samples and measures from .12, non-significant, to .20, $p < .05$), and negligible non-significant negative associations between S and the two reading scores (ranging from −.04 to −.09). Although not pertinent to the goal of the current study, for descriptive purposes we estimated twin intra-class correlations, shown in the diagonal of the correlation matrix in Table 1. Twin similarity was moderate to substantial, with the exception of negligible sibling similarity for S.

We used hierarchical regression to estimate equations predicting Word Attack and Word Identification scores. For each equation, the main effects of EC and S were included in the first step, followed by the two-way interaction between EC and S in the second step. EC and S scores were centered prior to analysis. The equations were estimated twice, once for each sub-sample (see Table 2).

We hypothesized that better reading skills would be statistically predicted by higher EC and lower S. There was partial support for this hypothesis, in that higher EC was associated significantly with better both measures of reading performance. However, the effect size was modest. Contrary to expectation, there was no evidence of an association between S and reading skills.

Exploratory analysis of the two-way interaction between EC and S revealed evidence for a negative statistical interaction for both reading outcomes that was significant in sub-sample two. Visual inspection of the interaction was conducted by creating four sub-groups of children by splitting at the means on the EC and S scores (Fig. 1). The overall pattern suggested that the positive association between EC and reading performance may only be present among

children who were lower in S. This interpretation was supported by post-hoc correlational analyses. In both sub-samples, EC and reading skills were correlated (.3 range, $p < .01$) for children who had S scores below the mean: sub-sample 1, $r = .29$ for Word Attack and .31 for Word Identification, $p < .01$; sub-sample 2, $r = .36$ for Word Attack and .34 for Word Identification, $p < .01$. In contrast, the correlations between EC and reading skills were modest and non-significant for those with S scores above the mean: sub-sample 1, $r = .01$ for Word Attack and .04 for Word Identification; sub-sample 2, $r = -.17$ for Word Attack and −.14 for Word Identification.

In supplementary analyses, we examined whether the interaction between EC and S was present for general intelligence test performance, measured as the composite sum of area scores on the Stanford-Binet. We found no evidence for this two-way interaction for general intelligence test performance in either sub-sample.

Discussion

The development of reading skills among early readers during the first half of the elementary school years appears to be optimized for children who have better self-regulation of attention, cognition and behavior—essential components of the temperament dimension of Effortful Control. In the current study the effect was modest, but it was consistent within our internal replication design, as well as replicating the literature on attention span and reading achievement in elementary school (Martin et al., 1994). This finding also is consistent with the growing literature on reading disabilities within the population of children diagnosed with attention deficit hyperactivity disorder (Spira & Fischel, 2005; Willcutt et al., 2007).

Surgency did not emerge as a statistical predictor of reading achievement. Although there is evidence in the literature that children who are highly active show poorer reading performance (Martin et al., 1994), other research suggests that the association between reading performance and impulsive hyperactivity is modest (Willcutt et al., 2007). Activity level is only one aspect of the Surgency factor, which also includes impulsivity, high-intensity pleasure and low levels of shyness. To our knowledge, ours is the first study to test directly the association between the Surgency factor and reading performance, and the results revealed essentially no association.

Although there was no main effect of Surgency, there was a significant two-way interaction between Surgency and Effortful Control scores for word and pseudo-word reading performance. The results were clear in showing that Surgency served as a moderator of the association between reading achievement and Effortful Control. One sub-group of children had higher reading scores compared to all others—those who were low in Surgency and high in Effortful Control. Post-hoc correlational analyses showed that better reading scores were associated with higher Effortful Control, but only for those children who were low in Surgency. This suggests that the processes linking Effortful Control and better reading performance may be disrupted for those children who are impulsive, overactive and sensation-seeking in their behavior.

This statistical model represents individual differences in the application of cognitive resources to the task of striving to read (and possibly even more generally as “motivation to learn”). If a child must devote considerable conscious effort to maintain motivation and control attention to perform a task, that leaves relatively little processing capacity for problem solving. Learning will take longer and be more arduous, especially if the goals and expectations surrounding a given task and its successful completion do not include some intrinsic reward for that child. On the other hand, if a child readily attends and regulates her or his attention well, and does not have competing impulses to contend with, a greater proportion of available cognitive

processing capacity can be applied to task performance in a particular situation, as well as to learning in a broad sense.

To the extent that temperament also reflects a child's coping and adaptation in the face of stressors (including the demands arising from tasks in reading and other scholastic activities), these individual differences probably affect the amount and quality of learning that occurs. Cognitive growth occurs when a child is close to the limits of her current knowledge and problem solving abilities, and learning must therefore be facilitated by others such as teachers, parents, and peers (Vygotsky, 1978). Those who are more impulsive and sensation-seeking and who have a more difficult time regulating that arousal are less likely to endure the prolonged time periods required to attempt to solve problems or carry out cognitive tasks that are even only modestly stressful or aversive. This reduces the amount of time and the number of attempts such individuals will make, resulting in less optimal learning (Strelau et al., 2001).

The implication of the current findings is that the effects of effortful self-regulation and Surgency on reading achievement are underestimated in community studies, since only main effects are tested typically. Our results also suggest that intervening to reduce impulsivity, activity level and sensation seeking behaviors is just as important as improving attention regulation or behavioral persistence, when the goal is to improve reading achievement.

There are limitations to the study that should be considered. First, the effect sizes in the current study were modest, and although the pattern of findings was replicated within the sample, we have examined only a few components of a much wider array of behaviors that are related to reading achievement. Second, the CBQ-SF is not intended to be used with children who are older than 8 years of age, but nearly half of our sample was above this threshold when the CBQ-SF was completed. Although we found no evidence of differences in means, variances, or factor structures on the CBQ-SF for children who were older or younger than 8 years of age, this remains an important caveat. Third, although we examined each twin in separate sub-samples in the current study, our findings are based on a sample of twins and the findings may not generalize to non-twin siblings or to singletons. Finally, the reading and temperament data were not collected concurrently, making attenuation of effect sizes more likely. However, reading and temperament scores are moderately to substantially stable by middle childhood, so the attenuation effect probably is minimal.

Caveats aside, the results point to the value of considering individual differences in temperament when the goal is to discern ways to improve children's reading achievement. Ultimately, this kind of research can inform practitioners—especially teachers and school administrators—about the ways in which the "fit" between particular aspects of children's individual attributes and the methods of reading instruction and intervention can be ascertained and optimized. This area of inquiry also can provide information to professionals working with parents of children who show challenging behaviors that interfere with achievement and learning. Although there is no question that individual differences in temperament and reading performance are influenced by genetic factors, these attributes are very likely modifiable through systematic changes in environments (Keogh, 2003; Posner & Rothbart, 2006).

Acknowledgments

We thank the study participants and research staff, and our collaborators on the Western Reserve Reading Project—Laura DeThorne, Christopher Schatschneider, and David Vanden-bergh. This study was supported by grants from NICHD (HD38075) and NICHD/OSERS (HD46167).

Abbreviations

CBQ-SF	Child Behavior Questionnaire-Short Form

EC	Effortful Control
S	Surgency

References

Keogh, BK. Temperament in the classroom: Understanding individual differences. Brookes; Baltimore, MD: 2003.

Martin, RP.; Olejnik, S.; Gaddis, L. Is temperament an important contributor to schooling outcomes in elementary school? Modeling the effects of temperament, scholastic ability on academic achievement. In: Carey, WB.; McDevitt, SC., editors. Prevention and early intervention: Individual differences as risk factors for the mental health of children. Brunner/Mazel; New York: 1994. p. 59-68.

Nęcka, E. Intelligence and temperament. In: Sternberg, RJ.; Lautrey, J.; Lubart, TI., editors. Models of intelligence: International perspectives. American Psychological Association; Washington, DC: 2003. p. 293-309.

Oates D. An experimental study of temperament. British Journal of Psychology 1928;19:1–30.

Petrill SA, Deater-Deckard K, Thompson L, DeThorne L, Schatschneider C. Genetic and environmental effects of serial naming and phonological awareness on early reading outcomes. Journal of Educational Psychology 2006;98:112–121. [PubMed: 19444324]

Porteus, S. Qualitative performance in the maze test. The Smith Printing House; Vineland: 1942.

Posner, MI.; Rothbart, MK. Educating the human brain. American Psychological Association; Washington, DC: 2006.

Putnam S, Rothbart MK. Development of short and very short forms of the Children's Behavior Questionnaire. Journal of Personality Assessment 2006;87:103–113.

Schweizer K. Does impulsivity influence performance in reasoning? Personality and Individual Differences 2002;33:1031–1043.

Spira EG, Fischel JE. The impact of preschool inattention, hyperactivity, and impulsivity on social and academic development: A review. Journal of Child Psychology and Psychiatry 2005;46:755–773. [PubMed: 15972069]

Strelau, J.; Zawadzki, B.; Piotrowska, A. Temperament and intelligence: A psychometric approach to the links between both phenomena. In: Collis, JM.; Messick, S., editors. Intelligence and personality: Bringing the gap in theory and measurement. Erlbaum; Mahwah, NJ: 2001. p. 61-78.

Vygotsky, LS. Mind and society: The development of higher mental processes. Harvard University Press; Cambridge, MA: 1978.

Willcutt EG, Betjemann RS, Wadsworth SJ, Samuelsson S, Corley R, DeFries JC, Byrne B, Pennington BF, Olson RK. Preschool twin study of the relation between attention-deficit/hyperactivity disorder and prereading skills. Reading and Writing 2007;20:103–125.

Woodcock, R. Woodcock reading mastery tests – revised. American Guidance Service; Circle Pines, MN: 1987.

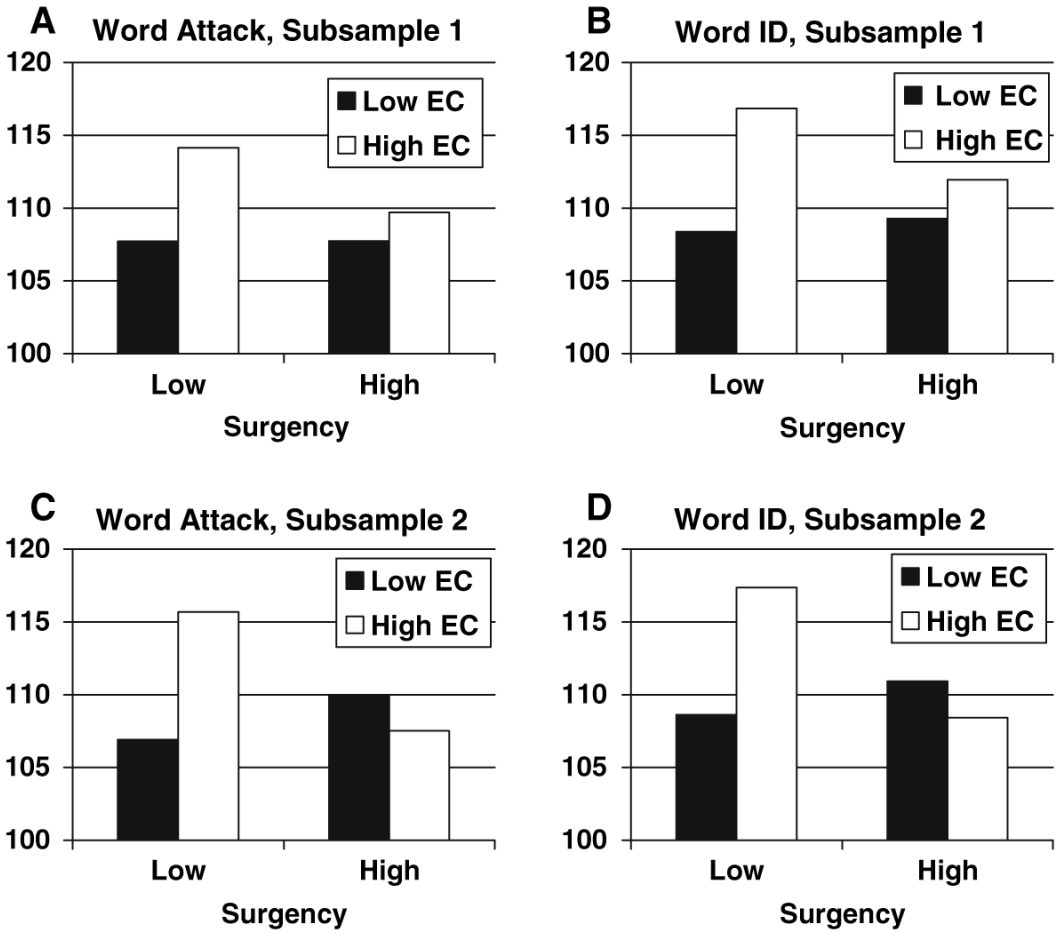

Fig. 1.

Group means for Word Attack (**a**, **c**) and Word Identification (ID, **b**, **d**) as a function of Surgency (S) and effortful control (EC) in two sub-samples. Low and High S and EC groups were created using mean splits

Table 1

Means and standard deviations with matrix of Pearson correlations: sub-sample 1 in rows and below diagonal, sub-sample 2 in columns and above diagonal, twin intra-class correlations on diagonal

		Sub-sample 2			
		Word Attack	**Word Ident.**	**Eff. Control**	**Surgency**
Sub-sample 1	*M* (*SD*)	110.7 (11.2)	112.2 (12.7)	5.34 (.68)	4.43 (.90)
Word Attack	110.1 (12.1)	.58	.82	.13^{ns}	−.07^{ns}
Word Identification	112.1 (12.8)	.78	.75	.12^{ns}	−.09^{ns}
Effortful Control	5.38 (.58)	.18	.20	.60	−.27
Surgency	4.45 (.74)	−.06^{ns}	−.04^{ns}	−.19	.09^{ns}

Note: All correlations significant at $p < .05$ (two-tailed) unless ns (non-significant). Descriptive statistics for Effortful Control and Surgency based on mothers' reports, which were not significantly different from fathers' reports. Mothers' and fathers' reports were averaged prior to estimation of correlations and for subsequent regression analyses

Table 2

Hierarchical regression models: Word Attack and Word Identification

	Word Attack	**Word Identification**
Sub-sample 1		
Model *F*(df), *p-value*	*F*(3,173) = 2.34, *p*<.08	*F*(3,173) = 2.43, *p*<.08
R^2	R^2 = .04	R^2 = .04
Betas		
Effortful Control (EC)	.16*	.20*
Surgency (S)	−.01	.01
EC × S interaction	−.09	−.03
Sub-sample 2		
F(df), *p-value*	*F*(3,174) = 3.18, *p*<.05	*F*(3,175) = 3.08, *p*<.05
R^2	R^2 = .05	R^2 = .05
Betas		
Effortful Control (EC)	.14*	.13*
Surgency (S)	−.04	−.07
EC × S interaction	−.19*	−.17*

* *p*<.05

** *p*<.01 (two-tailed)