Published in final edited form as:
Learn Individ Differ. 2011 February 1; 21(1): 96–108. doi:10.1016/j.lindif.2010.10.006.

Self-Regulation Mediates the Relationship between Learner Typology and Achievement in At - Risk Children

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Abstract

A person-centered approach was used to explore the mediating role of self-regulation between learner typology at age 8 and academic achievement at age 14while controlling for domain-specific achievement in a longitudinal sample of 113 children born to adolescent mothers. Children were classified into one of 5 learner typologies at age 8based on interactive patterns of intellectual, achievement, and adaptive abilities. Typology classification explained significant variance in both reading and mathematics achievement at age 14. A bootstrapping approach confirmed that self-regulation mediated the relationship between typology and reading and mathematical achievement for children from all typologies except those classified as Cognitively and Adaptively Challenged. Implications of person-centered approaches for understanding processes involved with achievement are discussed.

Keywords

self -regulation; achievement; person-centered; cognitive and intellectual disabilities

1. Introduction

Learning abilities and disabilities demonstrate considerable stability during middle childhood despite attempts by educators and others to remediate deficits and to enhance age-appropriate competencies (Kovas, Haworth, Dale, & Plomin, 2007). Remediation strategies are based on the acknowledgment that not all children learn at the same pace or even by the same methods, and that the identification of children who show atypical learning processes may allow for more effective individualized instructional methods. Despite the general acceptance of this assumption, evidence for aptitude-by-treatment interactions in educational contexts has been limited (Pashler, McDaniel, Rohrer, & Bjork, 2008) and research has

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failed to substantiate differential success of specific techniques with children who have different learning styles (Mayer, 2008). However, a growing body of research has identified self-regulation as a promising focus for intervention and remediation of academic delays for students with a variety of learning styles and aptitudes (Blair & Razza, 2007; Borkowski et al., 2004; Martinez-Pons, 2002; McClelland, Cameron, Connor, Farris, Jewkes, & Morrison, 2007; Pintrich, 2000; Zimmerman, 1989; 1990).

The current study used data from the Notre Dame Adolescent Parenting Project (NDAPP; Borkowski, Farris, Whitman, Carothers, Weed, & Keogh, 2007; Whitman, Borkowski, Keogh, & Weed, 2001), an on-going longitudinal research study of children born to adolescent mothers, to explore the mediating role of self-regulation for reading and mathematical achievement from a person-centered approach. Three primary goals of the current research were to identify meaningful classifications, or typologies, of cognitive abilities during the early elementary years as an alternative to traditional diagnostic classifications, to determine the extent to which these learner typologies predicted reading and math achievement in early adolescence, and to examine the mediating role of self-regulation between learner typologies and achievement outcomes. Longitudinal studies have repeatedly found children born to adolescent mothers to score in the average range cognitively during infancy but by early childhood to show signs of cognitive delay (Broman, 1981; Whitman, et al., 2001). By the time these children reach high school, they frequently demonstrate low intelligence, grade retention, poor literacy, restricted educational aspirations, delinquent behavior, and have increased risk for dropping out of school(Brooks-Gunn & Furstenburg, 1986; Brooks-Gunn, Guo, & Furstenberg, 1993;Moore, Morrison, & Greene, 1997). Prior research from the NDAPP found children born to adolescent mothers likely to have learning difficulties relative to community expectations (Whitman et al., 2001). Despite the increased risk of academic difficulties associated with birth to an adolescent mother, individual achievement outcomes varied substantially, with some children in this sample demonstrating typical or even above average achievement(Borkowski et al., 2007). Therefore, this sample is conducive to investigations of classification of children into meaningful typologies that may inform educators about differential response to remediation strategies.

1.1. Person-centered approach to learner typologies

In contrast to typical variable-centered approaches that seek to identify associations between variables, person-centered approaches focus on groups of people with similar characteristics. Person-centered approaches are particularly useful in investigating questions related to group differences in patterns of development (Laursen & Hoff, 2006), and have gained acceptance in research on social and personality development in attempts to explain differences in developmental trajectories (Hoff, 2006). Despite the acceptance of person-centered approaches in some domains of psychology, Hoff reported that studies of cognitive and language development have typically relied on variable-centered approaches, and suggested that reading research, and cognitive research more generally, may benefit from person-centered approaches to identify distinct patterns of abilities rather than more typical general linear models used to determine which abilities explain the most unique variance. Laursen and Hoff (2006) cautioned that variable-centered analytic models assume not only that populations are homogeneous, but that homogeneity exists with respect to how the predictors operate on the outcomes. The current study adopts a person-centered approach to investigate patterns of cognitive and adaptive abilities in a sample at-risk for cognitive delay associated with their birth to adolescent mothers.

Person-centered approaches to educational research have typically adopted educationally based classifications to explore differential learning processes of children from distinct diagnostic categories (e.g., educable mentally disabled, learning disabled). However, these

traditional diagnostic classifications have provided little guidance on which to base educational interventions, leading professionals to establish alternative criteria (Luckasson et al., 2002; Zirkel, 2006). The American Association on Intellectual and Developmental Disabilities (AAIDD) led the field in calling for a system of definitions and intervention based on amount of supports currently needed in contrast to a psychometric strategy (Luckasson et al., 2002). Relatedly, in October 2006 the U.S. Department of Education allowed a "responsiveness to intervention" (RTI) standard to replace the severe discrepancy standard for classification of learning disabilities (Zirkel, 2006). The current ambiguous status of classification poses a dilemma for educators, researchers, and policy makers. Ideally, classification criteria should result in meaningful groupings of children that benefit from specific remediation or educational strategies and that are flexible enough to accommodate to academic changes over time.

Despite a general paucity of person-centered approaches in research on cognitive development, several recent studies have used this methodology (Francis, Shaywitz, Stuebing, Shaywitz, & Fletcher, 1996; Konold & Pianta, 2005). For instance, research conducted by Francis et al. (1996) used a person-centered approach to investigate different types of problem readers. Three groups of first grade students from the Connecticut Longitudinal Study were identified based on ability patterns: those with reading scores lower than expected based on IQ expectations, those with low reading scores consistent with lower IQ scores, and those without reading problems. No significant differences were found in the two groups of poor readers suggesting that children identified as learning disabled by a discrepancy model followed a similar developmental trajectory to those identified on the basis of low reading skills only.

As another example of a person-centered approach, Konold and Pianta (2005) applied cluster analytic techniques to a national sample of 4-year-old children based on three measures of cognitive ability and three measures of social functioning in order to derive meaningful profiles of school readiness. The validity of the profiles was assessed longitudinally based on their success in predicting first grade achievement. Six distinct profiles were identified by Konold and Pianta. Twenty-four percent of the children were classified as "High Social Competence" based on average scores on cognitive measures and above average social functioning; these children tended to come from homes with above average SES. Twenty-two percent of the children were classified as "High Cognitive Ability and Mild Externalizing". Children with this profile scored highest on cognitive measures, but also evidenced somewhat higher levels of behavior problems. They were significantly more likely to be white and came from high SES families. Another 20% of the children were considered "Low to Average Social and Cognitive Skills" and demonstrated consistent, but slightly lower scores on all measures. Seventeen percent of children were classified with "Social and Externalizing Problems" and with somewhat lower levels of cognitive attentiveness. A fifth subgroup was identified based on low levels of cognitive attentiveness, with all other measures in the average range. The final subgroup included only 7% of the sample, and was labeled "Low Cognitive Ability". This subgroup was distinguished by relatively average social functioning, but relatively low performance on the ability measures. Results suggested that children with profiles indicative of strengths in both cognitive and social areas performed better in first grade in comparison to profiles showing similar cognitive ability, but lower social functioning. The authors concluded that multiple pathways to success exist, and that strengths in one area (e.g., social functioning or academic readiness) may have compensated for weaknesses in other areas.

As evidenced by Konold and Pianta (2005), cluster analysis can provide an objective framework to identify learner typologies without constraints based on a priori expectations (e.g., that IQ scores below 70 signify a qualitative difference in ability). Cluster analysis is

particularly relevant to person-centered approaches as it seeks to identify heterogeneous subgroups of cases in a population. A set of groups is differentiated by minimizing within-group variation and maximizing between-group variation (Garson, 2008). In the current study five intellectual, achievement, and adaptive abilities provided the input for the typologies. These constituent variables were chosen to reflect assessments typically included in algorithms to classify children with an intellectual or developmental disorder, or a learning disorder. Cluster analysis was then used to create typologies based on the identification of subgroups that minimized variance within the typologies on these measures, but maximized the variance between the typologies.

Traditional diagnostic approaches were appropriate in the past as both theory and technology limited alternative views. However, advances in computational resources have provided a basis for more complex, dynamic accounts of development (Elman, Karmiloff-Smith, Bates, Johnson, Parisi, & Plunkett, 1996; Ferrer, McArdle, Shaywitz, Holahan, Marchione, & Shaywitz, 2007; Smith & Samuelson, 2003; Thelen & Smith, 1994). Dynamic systems theory would suggest that children s abilities and skills would combine to create a limited number of patterns that would be adaptive for the specific challenges inherent in any age-specific environment (Thelen & Smith, 1994). These ability patterns, or learner typologies, would be meaningful to the extent the future environment continued to present related challenges, but may diminish in importance as alternative tasks and challenges become increasingly relevant in the lives of children. For example, typologies formed during periods of transition from preschool to elementary school may emphasize adaptive skills, in contrast to typologies formed during the early elementary years when learning-related strategies become paramount. Predictability of typologies from middle childhood to early adolescence may be enhanced through genetic factors operating through endogenous characteristics (Kovac et al., 2007) and through the stability of environmental affordances and adversities. As environmental demands change, corresponding changes in classifications would be expected.

1.2. Predicting reading and mathematics achievement from learner typologies

The predictive validity of the emergent typologies may be substantiated by their success in explaining individual differences in reading and mathematics achievement over time. The years between middle childhood and early adolescence are fraught with physical, cognitive, and psychosocial development creating both challenges and opportunities. Educators, ever aware of requirements imposed by NCLB legislation, strive to take advantages of developmental opportunities to remediate deficits in learning difficulties and instill academic proficiency in all students. Thus, if educational goals are being achieved, some of the initial differences between learner typologies in middle childhood should diminish by early adolescence as those with learning difficulties have caught up to their more successful peers. Despite potential for remediation, however, genetic (Kovacs et al., 2007) and environmental constraints may impose limits on the degree of remediation possible.

Children born to adolescent mothers may beat academic risk due to a number of environmental constraints (Furstenburg et al., 1987; Lefever, Nicholson, & Noria, 2007; Whitman et al., 2001). For instance, cognitive readiness of teen moms in the NDAPP assessed prior to the birth of their children, along with other measures of parenting, predicted both reading and math achievement of children at age 8 (Noria, Borkowski, & Whitman, 2008), and at age 10(Smith, Borkowski, & Whitman, 2008). Other research has confirmed that poor academic outcomes are associated with multiple risk factors that tend to occur frequently in the lives of teen moms (Seitz, 1996). Children of adolescent mothers are likely to be raised in single parent homes where the young mother often has inadequate education, is underemployed, and poorly equipped to foster cognitive and metacognitive development (Seitz, 1996), magnifying the number of children classified into low achieving

typologies. Stability of these risk factors in the lives of children over time may enhance the predictability of early learner typologies f or later achievement.

1.3. Self-regulation as a mediator of achievement outcomes

Self-regulation, however, may allow children to deviate from expected trajectories and demonstrate successful achievement despite adverse environments. Self-regulation is a broad construct that has been researched from a variety of theoretical perspectives. Recently, Blair and Razza (2007) suggested that the development of inhibitory control is central to self-regulation, and that "the ability to inhibit prepotent response tendencies in the face of irrelevant or distracting information, such as in the context of a math problem or when discriminating letters or phonemes, is a unique contributor to developing academic ability over and above that of specific knowledge of problem elements or solutions" (pg. 658). Further, Blair and Razza suggested that neurological maturation may underlie advances in both self -regulation and numerical ability or quantitative reasoning. Evidence to support their suppositions was obtained from observational measures of inhibitory control and teacher reports of effortful control in a study of 170 Head Start children that uniquely predicted kindergarten math skills, and to a lesser extent letter knowledge (Blair & Razza, 2007).

In the current study, the inhibitory control aspect of self-regulation included inhibition of inappropriate classroom behaviors (e.g., disruption), inhibition of negative emotions (e.g., coping with failures, frustrations), as well as being able to focus attention in the face of distractions. Our approach to self -regulation included aspects of both cognitive and emotional regulation. Although some researchers have argued that emotional, or hot, regulation is conceptually distinct from cognitive, or cool, regulation (Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009), others suggest that emotional and cognitive regulation are intertwined, especially in early development(Bell & Wolfe, 2004 ; Posner, Rothbart, Sheese, & Tang, 2007). A recent review of research on the neurodevelopment of the prefrontal cortex concluded that the neurological foundation of executive processes may become progressively differentiated with development. Although research has yet to specify the time line associated with this differentiation, Tsujimoto (2008) reported that children before the ages of 5 or 6 tended to respond to regulation challenges with activation of the entire prefrontal cortex, whereas activation areas became increasingly distinct by early adolescence.

The meditational role of a unified approach to self-regulation between reading readiness at age 5 and reading competence at age 14 in children from the NDAPP was substantiated by Smith et al. (2008) who found at-risk children of adolescent mothers to lack important prereading skills at age 5 and reading competence at age 14, with self-regulation serving as a partial mediator of the relationship between early and later reading competencies. Noria et al. (2008) also found a unified measure of cognitive and emotional self-regulation to be significantly related to academic achievement in the second grade. Children who were more task-oriented and had at least adequate learning skills demonstrated better adjustment and academic skills.

Borkowski et al. (2004) discussed the role of self-regulation in the academic development of children of adolescent mothers. To the extent that adolescent mothers lack self-regulatory skills, their ability to model or teach these skills to their children may be limited. Research by Martinez-Pons (2002), based on a social cognitive perspective, confirmed that parents use of modeling, encouraging, facilitating, and rewarding self-regulation was associated with children s self-regulation, that in turn, predicted academic competence. Furthermore, children s failure to learn self -regulatory skills was suggested to negatively impact their academic skills.

Research has typically relied on variable-centered approaches to predict achievement, often assessing the mediating and moderating roles of child and family related variables with longitudinal samples (Ferrer et al., 2007; McClelland et al., 2007; McClelland, Sektnan, & Morrison, 2009; Razza, Martin, & Brooks-Gunn, 2009). For instance, McClelland et al. (2007) examined relationships among behavioral regulation, emergent literacy, and vocabulary and math skills as they developed during the prekindergarten year. Children s ability to regulate their behavior generally improved from fall to spring during prekindergarten. Emergent literacy during the spring was significantly predicted by both fall literacy scores and by behavioral regulation scores during the spring semester. Behavioral regulation also emerged as an important protective factor in the context of early family risk in a sample of over 1,300 children from the NICHD Early Child Care and Youth study (McClelland et al., 2009). Similarly, sustained attention, one aspect of self-regulation, was found to mediate between parenting and academic competence in a large, geographically diverse sample of children from the Fragile Families data set (Razza et al., 2009). Consistent with variable-centered approaches, the relationship of self-regulation to achievement outcomes was assumed to operate similarly for all children in these studies. In contrast to variable-centered approaches that assume homogeneity with respect to processes linking predictor and outcome variables, person-centered approaches suggest that subgroups may exist where self-regulation may be differentially associated with learning outcomes. The current research allowed for differential longitudinal processes by creating subgroups based on patterns of abilities and then examined the mediating role of self -regulation for each subgroup.

1.4. The current study

The primary goal of the current study was to identify meaningful patterns of cognitive and adaptive abilities in this sample at-risk for academic difficulties. Community or school samples typically used in developmental research evidence relatively low frequencies of learning difficulties, reducing their power to detect meaningful associations between predictor and outcome variables. In contrast, the NDAPP provided data on children at increased risk for cognitive and academic difficulties, providing greater diversity with respect to learning difficulties. A second aim was to substantiate the predictive validity of the patterns by accessing how well the typologies generated at age 8 were able to account for individual differences in reading and mathematics achievement at age 14. Establishment of typologies at age 8 provides for inclusion of children’s response to learning-related challenges encountered during first grade. Some children, presented with educational opportunities, may have overcome their lack of readiness for school and flourished with skilled instruction. Other children, with similar opportunities, may be less able to take advantage of the opportunities provided, falling behind age-appropriate standards. Thus, typologies reflect individual differences after children have encountered learning-related challenges and had a chance to learn appropriate strategies to master these challenges. Further, assessment of outcomes at age 14 is an age when reading skills have started to plateau (Francis et al., 1996) following a steep learning curve. In addition, neurodevelopmental research has indicated that executive skills, including self-regulation, have become increasing distinct by age 14 (Tsujimoto, 2008). Our third aim was to investigate the meditational role of self-regulation between 8-year learner typologies and 14-year reading and math achievement while controlling for variance associated with 10-year achievement. This provides a conservative test of the role of self-regulation since much of the individual variations in self-regulation may manifest as achievement-related differences. Our person -centered approach allowed us to account for potential heterogeneity within our sample with respect to the meditational role of self-regulation; that is, it allowed us to look at the role of self-regulation with respect to different learner typologies.

2. Method

2.1. Participants

The sample included 113first -born children of adolescent mothers drawn from an ongoing longitudinal study of adolescent parenting and child development (Whitman et al., 2001). Mothers of the children were recruited as pregnant adolescents through local hospitals, health departments, and school -aged mothers programs in a medium-sized Midwestern city (n = 93) and in a small town in the Southeast(n = 20). Mother s average age at the time of childbirth was 17.1 (SD= 1.27, Range = 14.0 –19.5). Children were born between fall 1985 and summer 1992; slightly over one -half (54%)of the sample was male.

At the time of the 8-year assessment, most of the children were in second grade, although five children, who were in first grade, had been retained in either kindergarten or first grade. The majority of the sample was African American (67.2%) with 24.8% European American and 8% Latino. Of the113 children who were tested at age 8, 102 participated at age10, and 88 at age 14 for an attrition rate of 22% over the 6-year period. Attrition was unrelated to learner typology(χ^2 (4) = 2.41, p > .10), SES (t (109) = 1.30, p > .10), race (χ^2(2) = 1.36, p > .10), or child s sex (χ^2 (1) = 2.53, p > .10). At age 14, 93%of the children lived with their biological mothers, but only 11.6% lived with their biological fathers. Approximately 36% of the children s mothers were married and an additional 22% were living with a partner. Close to 84%of the mothers had completed high school and over 28% had some post-secondary education.

2.2. Design and Procedures

Children were seen in a university laboratory setting at ages 8 (M= 8.03, SD = .24, Range = 6.99 to 8.99), 10 (M= 10.02, SD = .18, Range = 9.68 to 10.77) and 14 (M = 14.23, SD = .51, Range = 13.41 to 16.33). Children were most often accompanied by their mothers, but occasionally were brought by alternative primary caregivers (e.g., grandparents, fathers, foster parents). Assessment periods lasted approximately 3hours and included assessments of cognitive, academic, and psychosocial functioning, as well as observations of interactions between mothers and their children. Mothers were paid $75 for their participation and children received gifts appropriate for their age (e.g., university t-shirts, choice of toy).

Multiple methods were used to ascertain information about the children. Intelligence and academic achievement scores were obtained through direct testing of the children by trained psychology graduate students or faculty. Information on adaptive skills was gathered through maternal interviews. When children were 8 and 10 years old teachers were contacted and asked to provide reports on academic status, self-regulation, and achievement. Data from teachers was available for 85% of the children at age 8 (n = 96) and 73.5% at age 10 (n = 83). Measures utilized in the current study are described below. A complete description of all measures from the NDAPP may be found in Whitman et al. (2001).

2.3. Measures

2.3.1. Academic Achievement—The Reading Recognition, Reading Comprehension and Mathematics subtests of the Peabody Individual Achievement Test-Revised (PIAT -R; Markwardt, 1989) were administered to measure academic ability at ages 8 and 10. Total Reading includes both Reading Recognition (word reading) and Reading Comprehension which consists of having the child read silently and then select one of four pictures illustrating the passage. The Mathematics subtest uses a multiple choice format to test knowledge and application of mathematical concepts and facts. Standard scores, based on age norms, with a mean of 100 and standard deviation of 15, were derived for each subtest. Split-half reliabilities for these subtests were reported to range from .92– .97 (Markwardt,

1989), with test-retest reliabilities at age 8 (10 in parentheses) of .94 (.93) for Total Reading and .79 (.73) for Mathematics (Markwardt, 1989). Since scores for Total Reading were highly correlated (r= .72) with Mathematics for the current sample at age 8, the average of the two subtests scores was included as a constituent variable in the creation of typologies.

When children were 14 years of age, three scales from the Wechsler Individual Achievement Test (1992) were administered to assess academic achievement. Basic Reading and Reading Comprehension were combined for a total reading score while the Mathematics Reasoning subtest was used as a single measure of math achievement. Basic Reading assessed decoding and word-reading ability while Reading Comprehension involved a series of printed passages and oral questions designed to tap skills such as recognizing stated detail and making inferences. Mathematics reasoning was based on a series of problems, with visual and oral presentations to assess children s ability to reason mathematically. Split -half reliabilities for 14-year-olds were reported to be .92 for the Reading Composite and .90 for Mathematics Reasoning.

2.3.2. Intelligence—The Wechsler Intelligence Scale for Children-III (WISC-III; Wechsler, 1991) assessed intellectual development at age 8. Four subscales, Picture Completion, Information, Block Design, and Vocabulary were administered to obtain an estimated IQ, standardized to a mean of 100 and standard deviation of 15. This short form has been reported to correlate highly (r= .94) with the Full Scale WISC -III(Sattler, 1992).

2.3.3. Adaptive Behavior—The Vineland Adaptive Behavior Scale-Survey form (VABS; Sparrow, Balla, & Cicchetti, 1984) assessed children s adaptive behavior in communication, daily living, and socialization domains. Administration involved a semi-structured parental interview conducted when children were 8 years of age. Raw scores for each of the three domains were converted to standard scores, based on age-related norms, with a mean of 100 and a standard deviation of 15. Split -half reliabilities were reported to be .89 for Communication, .90 for Daily Living Skills, and .86 for Socialization (Sparrow et al., 1984).

2.3.4. Self-Regulation—Teachers completed the Teacher-Child Rating Scale (T-CRS; Hightower, Spinell, & Lotyczewski, 1989) as a measure of self-regulation in the class room when children were ages 8 and 10. The T-CRS includes one section on problematic school behaviors and a second section on children s strengths. In the 18-item problem section, teachers indicated on a 5-point Likert-type scale the degree to which children s behaviors were problematic in the classroom. In the 20-item strengths section, teachers assessed on a similar scale how well children engaged in typical classroom tasks such as completing work and coping with failure. The T-CRS has previously been found to be a reliable and valid measure of children s socioemotional functioning in the classroom (Hightower et al., 1989) and has been utilized as an indicator of self-control (Fantuzzo, Rohrbeck, & Hightower, 1989) and self-regulation (Smith et al., 2008; Noria et al., 2008).

In the current study, the Acting Out and Learning Skills subscales from the problem behavior section and the Frustration Tolerance and Task Orientation subscales from the strengths sections were considered to reflect self-regulatory behaviors in the classroom . All 22 items from these four subscales are listed in Appendix A. Cronbach’s alpha of the 22 self-regulation items for the current sample was .96 (.95at age 8) with an intraclass correlation of .51 (.45at age 8). Alpha reliability of the 4 subscale scores was .88 (.81 at age 8) with an intraclass correlation of .65 (.52 at age 8), supporting a unified cognitive and emotional approach to self-regulation. The correlation between children s scores at age 8 and at age 10 was .43($p < .001$). In order to maximize the number of children for whom teacher data was available, the average self-regulation score for ages 8 and 10 was used in all analyses. If data was only available at one time period then that score substituted for the

average. Data was unavailable for 9 children (8%) at both ages 8 and 10. In summary, children s self-regulation score consisted of the average rating given by teachers on 22items from the T-CRS at both ages 8 and 10.

2.3.5. Educational services and supports—When children were age 8 teachers also completed the Teacher Report Form (TRF; Achenbach, 1991) for each child. In addition to responding to 113 items that may be symptoms of internalizing and externalizing difficulties, teachers were also requested to provide information about the education background of each child (e.g., “Has he/she been referred for special class placement, services, or tutoring?” and “Has he/she ever repeated a grade?”).

2.3.6. Socioeconomic status—Socioeconomic status (SES), calculated when children were age 8, was estimated based on maternal education and occupational status following the approach detailed b y Hollingshead in 1965.

2.4. Analytic strategy

Two-step cluster analysis was used to identify heterogeneous groups within the current sample. The first of the two-steps reveals pre-clusters based on a sequential clustering method, with cases sorted based on maximum likelihood estimates. The second of the two-steps used the pre -clusters as a start for further hierarchical clustering. The Akaike Information Criterion (AIC) was examined to determine the optimal number of clusters. The AIC provides information about residual variations remaining in the data following grouping into clusters. At some point the reduction in error associated with the creation of additional clusters becomes negligible and suggests an optimal number of clusters to capture the maximum variations within the data. The internal cohesion of clusters was assessed with the H coefficient (Tryon & Bailey, 1970) that compares the variability of constituent variables within clusters to overall variability within the sample.

A bootstrapping approach was used to test for multiple mediation following the recommendation of Shrout and Bolger (2002), and using the methodology as described by Preacher and Hayes (2008). Bootstrapping provides distinct advantages over the more traditional approach to mediation analysis proposed by Baron and Kenny (1986). Specifically, advocates of bootstrapping argue that mediation does not require a significant correlation between the independent and dependent variables. Perhaps more importantly, bootstrapping does not assume that the sampling distributions of the indirect effects are normal. Instead, sampling distributions are estimated from actual random samples taken from the data provided. Simulations by MacKinnon, Lockwood, Hoffman, West, and Sheets (2002) compared several mediation models and concluded that bootstrapping has greater power to detect significant relationships among the variables than the Baron and Kenny approach, yet retains appropriate controls for spurious results.

Preacher and Hayes (2008) provided an enhancement of simple bootstrapping mediation models, by allowing for the simultaneous testing of multiple mediators. Multiple mediation analyses includes algorithms for testing hypotheses regarding overall mediation effects, for hypotheses about specific mediators after controlling for variance accounted for by other mediators, and to determine the relative strength of the proposed mediators. Multiple mediation analysis avoids biased parameter estimates that may occur when mediators are assessed in isolation. The relative magnitude of each indirect effect compared to the total meditational effect may be considered an estimate of effect size (McKinnon, 2008), although there is currently no generally accepted effect size statistic for multiple mediator models (Preacher & Kelley, 2010).

The current study used multiple mediation analysis to test the specific mediation effect of self-regulation when included in models along with intervening levels of ability-specific achievement, a known robust mediator between early and later ability. Early ability was operationalized as learner typology at age 8, and later ability -specific achievement was determined by standardized achievement testing at age 14. Inclusion of both self-regulation and ability-specific achievement at age 10 as potential mediators provided a conservative test of the incremental role of self-regulation while accounting for variance due to possible concurrent relationships with achievement. In summary, we used a multiple mediation bootstrapping model to test whether self-regulation mediated the relationship between learner typology at age 8 and achievement at age 14 while controlling for the meditational effect of ability-specific achievement, and then compared the two potential mediators to determine the unique significance and strength of each.

Mplus 5.21 software was used to estimate multiple mediation effects based on syntax provided by Preacher and Hayes (2008). Mplus uses maximum likelihood (ML) estimation based on all available data allowing participants with missing data to be included in the mediation models. Distributions of scores were examined within learner typology to check for outliers that could potentially skew results, especially in relatively small sample sizes. Only two extreme outliers were identified; one IDD child had an exceptionally high math score at age 10, and one Typical child had an extremely high reading score at age 14. Multiple mediation models were conducted with and without these children to check for consistency of results.

3. Results

3.1. Cluster analyses

Means, standard deviations, and correlations of the five constituent variables used to classify children into typologies are shown in Table 1. As indicated, scores for each of the variables averaged approximately 1 *SD* below age based norms. Two-step cluster analysis using SPSS classified 8 -year-old children into learner typologies based on patterns of intelligence, achievement and adaptive behavior. The reduction in AIC fit statistic, based on maximum likelihood estimation, associated with the creation of each new cluster was used to determine the optimal number of clusters. A 5-cluster solution provided the most parsimonious model of the data (AIC = 294.31, $\chi^2(1) = 4.47$, $p < .05$), and also satisfied add it ional criteria provided by Garson (2008) to determine cluster validity. Specifically, Garson suggested that clusters need to have a sufficient number of cases to be meaningful, and that the meaning should be readily intuited by inspection of the constituent variables.

Table 2 provides means, standard deviations (*SD*), and 95% confidence intervals of the constituent variables by typology. In addition, results of one-way ANOVA, with Games-Howell post-hoc comparisons, used to confirm differences between clusters on each of the constituent variables, are reported in Table 2. The Games-Howell test is a modified HSD test designed for unequal variances and unequal sample sizes, recommended when group sample sizes are greater than 5. Partial eta squared (η_P^2) statistics are also included as a measure of effect size. Results confirmed that each of the constituent variables was significantly related to learner typology with effect sizes that ranged from .46 for Daily Living Skills to .69 for Achievement.

The cluster that included the most children (31.0% of the sample) was characterized by scores approximately 1 *SD* below the mean in intellectual, achievement, and adaptive domains, and was given the label of Cognitively and Adaptively Challenged (hereinafter referred to as simply Challenged) to acknowledge the consistency of low scores across domains. The H coefficient of .81 indicates tight internal cohesion for this typology with

low variability on all constituent variables. The second largest typology included 22.1% of the sample, and included children with intellectual and achievement scores close to 2 *SDs* below the mean, paired with adaptive behavior scores averaging between 1 and 1½ *SD* below the mean. This typology was labeled Very Low IQ and Academic Skills with Moderately Low Adaptive Behavior (hereafter referred to as simply Adaptive) to reflect the sparing of some adaptive skills despite generally low cognitive functioning. The H coefficient associated with the Adaptive typology was .84 indicating high internal cohesion. Another 21.2% of the children also averaged between 1 and 1½ *SD* below the mean on Daily Living and Socialization skills, but these were coupled with strong achievement skills, moderate intelligence, and moderate adaptive communication skills. This typology was labeled Achievement Focused to denote the above average scores on math and reading assessments, relative to intellectual or adaptive measures. An H coefficient of .72 indicates good internal cohesion.

Only about 13.3% of the children exhibited a congruent pattern of average (e.g., within 1 *SD*) scores in domains of intelligence, adaptive behavior, and achievement suggesting a label of Typical. Although the H coefficient for this typology was only .39, inspection of the standard deviations reported in Table 2 revealed low variability on all variables except for Socialization; the variance of the socialization measure was greater within the Typical typology relative to the total variance reducing the internal cohesion. The fifth typology included only 12.4% of the children, and was characterized by scores in all domains approximately 2 standard deviations below average. Since the average scores included both significantly sub average intelligence and adaptive behavior scores, the typology was labeled Intellectual and Developmental Disability (IDD). The relatively low H coefficient (.53) for the IDD typology was due to greater within cluster variance for Daily Living Skills (DLS) compared to total variance. In summary, the Typical, Challenged, and IDD typologies included children whose scores in intellectual, achievement, and adaptive areas were relatively congruent. In contrast, the Achievement Focused children exhibited less congruence between domains with relatively high achievement, moderate intelligence, and moderately low adaptive skills, and children in the Adaptive typology exhibited an opposite pattern with higher adaptive skills relative to intelligence and achievement.

The external validity of clusters may be established through verification that typologies differ significantly on variables not used to create the groups(Garson, 2008; von Eye & Bogat, 2006). Teacher reports of attention problems, grade retention and educational supports from the TRF when children were 8 years of age were used to establish this external validity. Results of one-way ANOVA confirmed that learner typology was significantly related to teacher reports of attention problems, $F(4, 91) = 7.94$, $p < .001$, $\eta_p^2 = .26$. Games-Howell post hoc comparisons indicated that Achievement Focused children had significantly fewer attention problems ($M = 5.17$, $SE = 1.61$) than Challenged ($M = 11.38$, $SE = 1.43$), Adaptive, ($M = 16.95$, $SE = 1.69$) and IDD children ($M = 13.67$, $SE = 2.58$), and that Adaptive children had significantly more attention problems than both Achievement Focused and Typical ($M = 6.21$, $SE = 2.07$), children, but differences between the other typologies were not significant.

Learner typology was also significantly associated with grade retention, $\chi^2(4) = 22.53$, $p < .001$, with placement in Special Education classes, $\chi^2(4) = 44.84$, $p < .001$, and with provision of educational support services, $\chi^2(4) = 30.77$, $p < .001$. Children classified as IDD had the highest rate of grade retention at 67%, compared to 20% of children classified as Adaptive, and only 11% of Challenged children. None of the children from Typical or Achievement Focused typologies had been held back. In addition, 100% of IDD children received educational supports beyond typical classroom instruction, and over 70% had been determined eligible for special education services. The majority (73.7%) of children

classified as Adaptive also received supplemental educational supports, but only 20% had been placed in special education classes. Approximately 42% of Challenged students received educational supports, as did 31% of Typical students.

Cluster placement did not differ significantly for boys and girls, $\chi^2(4) = 4.18$, $p > .10$. Girls were most likely to be classified as Challenged(32.7%) and Achievement Focused (25%), with 23.1% classified as Adaptive, 13.5% as Typical and only 5.8% as IDD. Boys were also most likely to be classified as Challenged (29.5%), with 21.3% classified as Adaptive, 18% as Achievement Focused, 18% as IDD and 13.1 % as Typical. Cluster placement did not differ significantly based on minority background, although there was a marginally significant trend with European American students most likely to be included in Achievement Focused (32.1%) or Typical (25%) typologies and minority students most likely to be included in Challenged (34.1%) or Adaptive (24.7%), $\chi^2(8) = 8.90$, $p < .10$. Maternal SES when children were 8 years of age was significantly related to learner typology, $F(4, 106) = 3.64$, $p < .01$, $\eta_p^2 = .12$. The Games-Howell post hoc comparisons indicated that children classified in the IDD typology were from homes with lower SES than children classified in Achievement Focused, Typical, or Challenged typologies, but differences between the other typologies were not significant.

3.2. Preliminary analyses

One-way ANOVA was used to examine relationships between learner typology at age 8 and scores on mediators (i.e., self-regulation and domain-specific achievement) at age 10and achievement at age 14. As indicated in the top one-half of Table 3, all mediators were significantly related to learner typology at age 8. Effect sizes, indicated by η_p^2in Table 3, were large for reading and math achievement at age 10, and smaller for self-regulation. The correlation between10 -year math and reading achievement was significant, $r = .71$, $p < .001$. Self-regulation was also significantly correlated with reading achievement, $r = .45$, $p < .001$, and with math achievement, $r = .44$, $p < .001$. In addition, as indicated in the bottom half of Table 3, learner typology at age 8 was significantly related to reading and math achievement at age 14. Further, reading achievement at age 14 was associated with 10-year mediators including reading skills($r = .88$, $p < .001$), math ($r = .74$, $p < .001$) and self-regulation ($r = .51$, $p < .001$). Math achievement at age 14 was similarly associated with reading skills ($r = .71$, $p < .001$), math ($r = .73$, $p < .001$) and self-regulation ($r = .48$, $p < .001$) at age 10.

3.3. Multiple meditational analyses

To explore heterogeneity within the sample that may allow for differential mediation effects based on learner typology, separate meditational models were analyzed for each learner typology. Five dummy variables were created indicating belongingness to each of the typologies (i.e., either Achievement Focused, 1, or not, 0; either Typical, 1, or not, 0, etc.). The full sample was used in each analysis to increase power. Therefore, each analysis isolated one specific typology in contrast to children from all other typologies. Since the Challenged typology included children approximately at the median on many of the constituent variables, mediational analyses isolating the Challenged typology were conducted using only children in the High Achieving and Typical typologies as the contrast group. Self-regulation and ability-specific achievement at age 10 were tested as mediators in all models.

The first five models explored mediators of 14-year WIAT reading composite scores for children dependent upon their typology at age 8. Table 4 provides parameter estimates and their standard errors, associated with total mediation effects, with domain-specific achievement, self-regulation, and finally estimates of the comparison between mediators.

Confidence intervals for these estimates are based on accelerated bootstrapping techniques that accounts for any deviations from normal distributions within the current data. Estimates are significant (i.e., $p < .05$) if the 95% confidence intervals do not include 0. As expected, the meditational role of reading ability at age 10 was significant and strong for all typologies, confirming that typologies at age 8 were related to 14-year reading outcomes through reading skills assessed at age 10. Self-regulation was also a significant mediator for all models except for the Challenged typology. Further, comparison of the strength of the indirect effects of the two mediators revealed that the pathway through 10-year reading achievement was stronger than the path through self-regulation for all typologies. Calculation of the relative magnitude of the size of the indirect effects indicated that between 85%and 93 % of the total indirect effect was accounted for by the mediated path through 10-year reading scores and between 7% and 15% by the mediated path through self-regulation. Adjusted r^2values revealed that model variables accounted for between 70% (for Challenged typology) and 80% (for IDD typology) of the variance in 14-year reading achievement.

Unstandardized and standardized (in parentheses) path coefficients for both direct and indirect effects models further explain the relationships among predictor, mediator, and outcome variables and are presented for Typical, Challenged and IDD typologies in Figure 1. As indicated in Figure 1a, classification in the Typical typology was associated with an 12.02-point increase in 10-yearreading achievement and a 12.79 increase in self -regulation compared to children in other typologies. Further, a difference of one point on 10-year reading scores was associated with a .65 point increase on 14-year WIAT reading composite scores. A difference of one point on self-regulation was associated with a .11point increase on 14 -year WIAT reading composite scores. The direct path to 14-year reading from the Typical typology accounted for a 10.42-point difference in achievement scores, and was reduced to nonsignificance when mediators were included in the model. Path models isolating Achievement Focused and Adaptive typologies suggested patterns similar to the Typical typology, except that the magnitude and direction of the coefficients varied, and are therefore not shown. For instance, classification in the Adaptive typology was associated with a 21.29-point decrement in 10-year reading achievement and a 13.94-point decrement in self-regulation compared to other typologies.

Direct effects of typology on 14-year WIAT reading composite scores were reduced to nonsignificance for models that included Achievement Focused, Typical, and Adaptive typologies. However, the direct effect of typology on reading achievement remained significant in models isolating the Challenged and IDD typologies even after including mediators. Figure 1b shows path coefficients isolating the Challenged typology and Figure 1c shows coefficients associated with the IDD typology. Children classified as Challenged continued to have lower reading skills at age 10, and were also evaluated by teachers to have significantly lower self -regulation skills than Typical or Achievement Focused children. Reading skills at age 14 were partially mediated by reading achievement at age 10, but the meditational role of self-regulation was non-significant. Further, the significant direct path to 14 -year reading scores indicated that learner typology at age 8 retained a direct link to 14-year reading scores over and above the indirect link through 10-year math achievement. The direct effect of typology on 14-year reading achievement also remained significant for children classified as IDD at age 8 despite controls for the meditational effects of both self-regulation and 10-year reading skills.

An additional five models examine d mediators between 8-year learner typology and 14 -year WIAT math scores. Separate meditational models were analyzed isolating each typology. Parameter estimates associated with total mediation effects, with 10-year math achievement, with self-regulation, and of the comparison between mediators are shown in

Table 5. Consistent with results from the reading models, the meditational role of math achievement at age 10 was significant and strong for all typologies, confirming that typologies at age 8 were related to 14-year mathematical outcomes through math skills assessed at age 10. Self-regulation also significantly mediated between all typologies except Challenged and math achievement. Further, comparison of the strength of the indirect effects of the two mediators revealed that the pathway through 10-year reading achievement was stronger than the path through self-regulation for all typologies other than Challenged. Calculation of the relative magnitude of the size of the indirect effects indicated that between 76% and 86% of the total indirect effect was accounted for by the mediated path through 10-year reading scores and between 14% and 19% by the mediated path through self-regulation. Adjusted r^2values revealed that model variables accounted for between 37% (for Challenged typology) and 59% (for Adaptive typology) of the variance in 14-year math achievement.

Three different patterns of mediation were obtained, with examples provided in Figure 2. The first pattern is exemplified by membership in the Typical typology as shown in Figure 2a. As indicated, unstandardized path coefficients reveal that membership in the Typical typology was associated with a 13.64-point advantage in 10 -year math scores and a 12.96-point advantage in self-regulation compared to children in all other typologies. The direct path from the Typical typology to 14-year math achievement was reduced from 12.57 to 4.44 when variance associated with the mediators was accounted for. Similar to the meditational pattern for IDD children (not shown), the direct effect of typology on 14-year mathematics achievement was reduced to nonsignificance after controlling for meditational effects.

Models isolating Adaptive and Achievement Focused typologies indicated that classification at age 8 retained a significant direct effect in additional to significant indirect effects, as shown for the Adaptive typology in Figure 2b. As indicated, membership in the Adaptive typology was associated with an 18.43-point decrement in 10-year math scores and a 13.41-point decrement in self-regulation compared to children in all other typologies. The direct path from typology to 14-year math achievement was reduced from −17.22 to −5.66 when variance associated with the mediators was accounted for. Despite significant mediation effects, the Adaptive typology retained a significant direct effect on 14-year mathematics achievement. The pattern of meditational for Achievement Focused children was similar to the pattern found for the Adaptive typology, but with the direction of effects reversed. A third pattern was found for Challenged children, as shown in Figure 2c. The model isolating this typology showed the total meditational effects to be significant in addition to the unique effect of 10-year math ability, but self-regulation was not found to significantly mediate 14-year math achievement for Challenged children, nor was the difference between the strength of 10-year math and self-regulation significantly different.

4. Discussion

A person-centered approach was used to identify patterns of learning abilities and disabilities based on interactions among important markers of intelligence, achievement, and adaptive behaviors during middle childhood. In contrast to classification based on traditional definitions of disability, scores on assessments typically used to diagnose children were subjected to cluster analysis. Five distinctive typologies of abilities emerged: Three typologies included different patterns of learning difficulties, one reflected academic strengths, and one cluster was comprised of students with scores in the average range.

Our main goal was to identify meaningful patterns or typologies of cognitive abilities during the early elementary years in an at-risk sample of children. The risk status of the current

sample was confirmed based on the percentage of children classified in a typology characterized by learning difficulties. Approximately 34% of the children were categorized in one of two typologies that averaged close to 2*SD*below the mean in intelligence and achievement, with the groups differentiated on adaptive behavior. Cluster analysis supported traditional definitions of intellectual and developmental disabilities that require adaptive behaviors deficits in addition to intellectual deficits (Luckasson et al., 2002). For instance, children from the Adaptive and IDD typologies did not differ on intelligenceo r achievement variables, but children in the Adaptive typology had higher adaptive behavior scores. Despite support for the traditional definition of intellectual and developmental disabilities that includes adaptive behavior deficits, a distinct typology showing impaired achievement relative to intelligence was not found. Lack of a typology characterized by a discrepancy between achievement and intelligence is consistent with current perspectives on learning disabilities that emphasize low reading skills within the context of a normal distribution (Shaywitz, Escobar, Shaywitz, Fletcher, & Makuch, 1992).

The emergence of typologies that overlapped on achievement but differed on adaptive behavior, and that overlapped on adaptive behavior but differed on achievement, provided a unique opportunity to explore the meaningfulness of each pattern on subsequent achievement. Results of both analyses of variance and the multiple mediation analyses confirmed substantial predictability over the six year period from age 8 to age 14. Despite an initial academic advantage for children classified as Achievement Focused, reading and math scores for these children were indistinguishable from those classified as Typical by age 10. It is possible that the initial advantage of Achievement Focused children may not have been a meaningful difference, and subsequent lower scores may reflect regression toward the mean. Alternatively, it is possible that the difference was initially meaningful, but the lower daily living scores eventually undermined strengths in achievement domains. Inclusion of children with greater variance in the upper ends of the academic distribution would help clarify this issue. For instance, comparison of Achievement Focused children to those in a typology characterized by high intellectual, achievement, and adaptive skills would allow inferences to be made about the importance of adaptive skills on subsequent achievement. Initial differences between children in Adaptive and IDD typologies also failed to differentially predict 14-year reading and math achievement, suggesting that the spared adaptive skills did not confer achievement-related advantages.

Another aim of the current study was to examine the mediating role of self -regulation between learner typologies and achievement outcomes. Identification and analyses based on distinct typologies revealed that self-regulation served as an important mediator of both reading and mathematical achievement for all typologies except for children classified as Challenged. Despite the relatively consistent meditational effect, differences between predictors and outcomes varied in important ways across groups. Self-regulation and 10-year reading skills fully mediated the relationship between typology and 14-year reading outcomes for children in the Achievement Focused, Typical and Adaptive typologies. In contrast, the relationship between the Challenged and IDD typologies at age 8 and 14 -year reading was only partially mediated, with initial status accounting for significant variance over and above variance attributed to mediators.

The maintenance of significant direct paths from typology to reading ability for both the Challenged and IDD typologies suggests the existence of a dynamic quality present at age 8 that led to continued reading deficits despite supplemental educational services and supports. Recent research (Ferrer, Shaywitz, Holahan, Marchione, & Shaywitz, 2010) suggested an alternative perspective on understanding dyslexic readers that involved a disconnection, or uncoupling, between intelligence and reading skills for some poor readers. Average readers and those that improved their reading skills between early elementary

school and high school demonstrated a causal path from intelligence to reading whereas intelligence and reading were less causally related for persistently poor readers. Conversely, reading led to improved intelligence for typical readers, but not for either group of poor readers (Ferrer et al., 2010). Therefore, the dynamic relationship between constituent variables may vary between typologies, resulting in different meditational strengths. Further, a similar uncoupling between self-regulation and reading for some children may explain the lack of a meditational effect of self-regulation for children classified as Challenged.

Slightly different meditational patterns were obtained between typologies and mathematical outcomes compared to reading outcomes. For example, self-regulation and 10-year achievement fully mediated the relationship between typology and 14 -year math achievement for children in the Typical and IDD typologies, with maintenance of a significant direct effect for Achievement Focused and Adaptive learners suggesting only partial mediation. Self-regulation was not found to mediate for Challenged children, and learner typology retained a significant direct effect on 14-year math achievement. Although heterogeneous patterns were identified between predictor and outcome variables, it is important to more fully understand the mechanisms that underlie these patterns before recommending educational interventions based on typologies. For example, recent conclusions about the uncoupling of reading and intelligence over time (Ferrer et al., 2010) may be extended to an understanding of mathematics achievement with self -regulation uncoupled from achievement for children classified as Challenged. Further, inclusion of self-regulation into longitudinal models may aid in understanding the dynamic interplay of cognitive variables during middle childhood, and provide further foundation to support groupings based on learner typologies.

In contrast to prior research with this sample of children born to adolescent mothers (Smith et al., 2008), self-regulation emerged as an important predictor even after controlling for concurrent measures of achievement, eliminating potential confounding due to shared variance between self-regulation and concurrent measures of achievement. Omission of intermediate achievement scores in longitudinal models may yield significant meditational effects of self-regulation that are actually attributable to the overlap in variance between self-regulation and concurrent achievement. Inclusion of both self-regulation and achievement in the same analysis strongly supports the independent contribution of self-regulation.

In many respects, the typologies identified in the current sample were consistent with findings of Konold and Pianta (2005), despite different age groups, measures, and risk status. For instance, children were classified as Typical based on scores close to average on intelligence and achievement measures, but significantly higher than other typologies on daily living skills, a pattern similar to Konold and Pianta s High Social Competence group. Children from the NDAPP classified in the Challenged typology demonstrated consistency across measures with scores averaging approximately one standard deviation below normal, a pattern similar to Konold and Pianta s Low to Average Social and Cognitive Skills cluster. Children in the Adaptive typology evidenced distributions of scores that overlapped considerably with children from the Challenged typology on socialization and daily living skills, yet scored distinctly lower than Challenged children on measures of intelligence, achievement, and adaptive communication. Adaptive children in our sample were consistent with children identified by Konold and Pianta as Low Cognitive Ability, but who retained skills in adaptive functioning. Over 12% of the children were classified in the IDD typology. These children scored similarly to Adaptive children on intelligence and achievement measures, but significantly lower than all other typologies in adaptive behavior. A parallel distinction was not found in the sample studied by Konold and Pianta (2005), perhaps due to the younger age of their sample or the greater degree of risk in the NDAPP sample. The only

classification associated with cognitive strengths was the High Achieving typology (21%). Children were assigned to this typology primarily on the basis of relatively high scores on intelligence and achievement.

The at-risk nature of the current sample provided for a greater percentage of children experiencing meaningful levels of learning difficulties and increased the power of the analyses to detect significant associations. However, despite the relatively high percentage of children who were classified in one of the atypical typologies, the sample size remained somewhat smaller than desirable for meditational analyses. Small samples can be problematic for two important reasons. First, small samples may limit the ability to detect significant associations that may be relatively weak, leading researchers to accept the null hypothesis when an important relationship actually exists. In the current data, statistically significant associations were identified despite the small sample size, reducing the impact of the small sample. A second reason small samples are problematic is that one or two extreme scores may have an inflated influence on outcomes with smaller samples. Only two extreme outlier s were identified within the current data set, and analyses were generally consistent when conducted with and without these children. For these reasons, results may be accepted as valid despite the sample size.

Results of the current study have an important implication for remediation and intervention with young students given the mediating role of domain specific achievement and self-regulation between 8-year learner typology and 14-year achievement. The strong meditational role of achievement at age 10 suggests an important window of opportunity between the ages of 8 and 10 to remediate critical learning deficits. However, within the current sample considerable stability was found over this two year period, with typology at age 8 highly predictive of achievement at age 10. The significant mediating role for self -regulation for children from most typologies implies that despite the considerable stability of reading and mathematics skills over time, improvement of self -regulation skills may have a positive impact on later academic ability. Children who were able to tolerate frustration, had good work habits, and who were able to inhibit their disruptive tendencies had relatively higher achievement at age 14 than children who were unable to regulate their classroom behaviors in these ways. Further, self-regulatory skills appeared to benefit children with serious deficits in addition to those with age-appropriate achievement levels.

Although our results confirm the importance of self-regulatory abilities for academic success, specific mechanisms linking self -regulation to competence remain opaque. Valiente, Lemery-Chalfant, Swanson, and Reiser (2008) offered data to suggest that children who engaged in greater effortful control behaviors developed more positive relationships with teachers, were more socially competent and were appropriately engaged in the classroom. Further, these process variables partially mediated the relationship between effortful control and school grades. Since the direct relationship between effortful control and grades remained significant, Valiente et al. inferred that other aspects of self -regulation (e.g., planning or attention allocation) may add to the predictive utility of the construct of self-regulation. For instance, Duncan et al. (2007) suggested that attention skills increase the overall time children are engaged and participating in academic tasks. Important goals of future research are to substantiate the incremental value of self-regulation for atypical children and to provide evidence for the mechanisms linking self - regulation to academic competence.

Future research also needs to substantiate the validity of the learner typologies. As computational strategies have become more sophisticated, several alternatives to basic cluster analytic approach may be useful. For example, model-based cluster analysis was recently used to classify two types of alcohol users and then to relate these clusters to

distinct self-regulatory processes (Mun, von Eye, Bates, & Vaschillo, 2008). Use of these mixture models may provide a more reliable grouping of ability typologies than the data-based procedure used to generate clusters in the current study.

4.1. Conclusions

Results from the current study cast doubt on the assumption that children from school-based samples represent a homogeneous population. Heterogeneity was apparent in the current sample in both patterns of learning abilities and disabilities and in the meditational processes of self-regulation on academic outcomes. Despite the heterogeneity, self-regulation skills provided incremental benefits to many very low achieving children with respect to reading and mathematics achievement. In conclusion, we believe that a person-centered approach to classification that involves important cognitive and adaptive domains and that synthesizes abilities in these domains in an interactive fashion has greater potential to provide direction for educational intervention than traditional rule-based heuristic approaches.

Acknowledgments

This longitudinal study was supported in part by an NIH grant (HD26456) and was previously presented as part of a symposium on *Longitudinal Perspectives on the Nature of Intellectual Disabilities* at the Gatlinburg Conference on Research and Theory in Mental Retardation and Developmental Disabilities in New Orleans, LA. Prior related research has been published in the books, *Interwoven Lives: Adolescent Mothers and their Children* and *Risk and Resilience: Adolescent Mothers and their Children Grow Up*.

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Appendix: Self - regulation items from the Teacher – Child Rating Scale (T - CRS)

1. Disruptive in class
2. Underachieving
3. Fidgety, difficulty sitting still
4. Poor work habits
5. Disturbs others while they are working
6. Poor concentration, limited attention span
7. Constantly seeks attention
8. Difficulty following directions
9. Overly aggressive to peers
10. Poorly motivated to achieve
11. Defiant, obstinate, stubborn
12. Learning academic subjects
13. Accepts things not going his/her way
14. Completes work
15. Ignores teasing
16. Well organized
17. Accepts imposed limits
18. Functions well even with distractions
19. Copes well with failure
20. Works well without adult support
21. Tolerates frustration
22. A self-starter

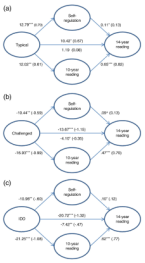

Figure 1.
Path model of (a) Typical typology, (b) Challenged typology, and (c) IDD typology on 14-year reading achievement as mediated by self-regulation and 10-year reading achievement.

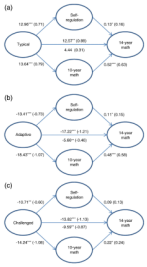

Figure 2.
Path model of (a) Typical typology, and (b) Adaptive typology, and (c) Challenged typology on 14 -year mathematics achievement as mediated by self-regulation and 10-year math achievement.

Table 1

Intercorrelations, Means, and Standard Deviations of Constituent Variables used to Create Learner Typologies at Age 8

Constituent variables	1	2	3	4	5
1. Intelligence	---				
2. Achievement	.70***	---			
3. Adaptive Communication	.54***	.65***	---		
4. Daily Living Skills	.29**	.27**	.40***	---	
5. Socialization	.31**	.31**	.42***	.49***	---
M	87.47	87.53	86.42	85.35	79.28
SD	15.16	15.56	10.39	11.18	9.44
Range	56 – 124	62 – 127	63 – 116	51 – 120	59 – 126

Note. $N = 113$.

** $p < .01$.

*** $p < .001$.

Learn Individ Differ. Author manuscript; available in PMC 2012 February 1.

Table 2

Comparison of Constituent Variables by Learner Typology

Constituent variables		Learner typology: Ach_Focus *n* = 24	Typical *n* = 15	Challenged *n* = 35	Adaptive *n* = 25	IDD *n* = 14	*F*(4,108)
Intelligence	*M*	103.25[a]	100.40[a]	87.20[b]	72.12[c]	74.64[c]	49.69*
	SD	11.75	8.68	7.53	6.60	11.97	η_p^2 = .65
	95% *CI*	99.54 – 106.96	95.71 – 105.09	84.13 – 90.27	68.49 – 75.75	69.79 – 79.50	
Achievement	*M*	108.23[a]	95.70[b]	85.00[c]	73.56[d]	74.57[cd]	60.30*
	SD	8.73	11.57	7.74	5.12	12.70	η_p^2 = .69
	95% *CI*	104.66 – 111.80	91.19 – 100.21	82.05 – 87.95	70.07 – 77.05	69.90 – 79.24	
Adaptive Communication	*M*	95.46[a]	94.13[a]	87.29[b]	80.12[c]	71.79[d]	35.55*
	SD	8.21	6.15	6.10	6.87	7.55	η_p^2 = .57
	95% *CI*	92.65 – 98.27	90.58 – 97.69	84.96 – 89.62	77.36 – 82.88	68.10 – 75.47	
Daily Living Skills	*M*	83.46[b]	99.20[a]	86.23[b]	86.44[b]	69.64[c]	23.23*
	SD	7.92	7.17	7.80	8.27	11.27	η_p^2 = .46
	95% *CI*	80.08 – 86.84	94.93 – 103.47	83.43 – 89.03	83.13 – 89.75	65.22 – 74.07	
Socialization	*M*	79.13[ab]	90.60[a]	80.94[ab]	78.20[b]	65.2[c]	25.16*
	SD	5.58	13.99	5.84	3.75	4.08	η_p^2 = .48
	95% *CI*	76.33 – 81.93	87.06 – 94.14	78.63 – 83.26	75.46 – 80.94	61.55 – 68.88	

Note. CI = confidence interval. η_p^2 = partial eta squared. Means sharing a common superscript are not statistically different at α = .05 according to the Games Howell procedure.

*p <.001.

Table 3

Comparison of Mediating Variables and 14-year Achievement by Learner Typology

		Learner typology					
		Ach Focus	**Typical**	**Challenged**	**Adaptive**	**IDD**	***F*(4,74)**
		n = 18	**n = 9**	**n = 25**	**n = 18**	**n = 9**	
Mediating Variables							
Reading	*M*	111.00[a]	103.56[a]	87.52[b]	72.17[c]	70.89[c]	27.41*
Achievement	*SD*	17.34	9.34	12.02	11.66	8.45	η_p^2 =
	95%	104.86 –	94.88 –	82.31 –	66.03 –	62.21 –	.60
	CI	117.14	112.24	92.73	78.30	79.57	
Math	*M*	104.61[a]	100.33[ab]	87.52[bc]	71.33[d]	73.56[cd]	22.04*
Achievement	*SD*	7.69	10.18	13.66	9.12	15.78	η_p^2 =
	95%	98.86 –	92.20 –	82.64 –	65.59 –	65.43 –	.54
	CI	110.36	108.46	92.40	77.08	81.68	
Self-Regulation	*M*	87.99[b]	90.17[ab]	76.46[bc]	65.34[c]	66.25[c]	7.32*
	SD	16.49	15.07	17.45	19.33	8.92	η_p^2 =
	95%	80.61 –	79.73 –	70.20 –	57.96 –	55.81 –	.28
	CI	95.37	100.60	82.73	72.72	76.69	
14-year Achievement							
Reading	*M*	104.94[a]	100.22[a]	87.36[b]	73.72[c]	68.22[c]	40.91*
Achievement	*SD*	10.07	10.74	10.56	9.96	12.04	η_p^2 =
	95%	100.65 –	94.15 –	83.71 –	69.43 –	62.15 –	.69
	CI	109.24	106.30	91.01	78.02	74.30	
Math	*M*	105.83[a]	106.00[a]	89.96[b]	77.78[c]	85.00[bc]	25.16*
Achievement	*SD*	9.27	13.88	11.36	11.09	12.01	η_p^2 =
	95%	101.30 –	99.58 –	86.11 –	73.24 –	78.58 –	.58
	CI	110.37	112.42	93.81	82.32	91.42	

Note. CI = confidence interval. η_p^2 = partial eta squared. Means sharing a common superscript are not statistically different at α = .05 according to the Games Howell procedure.

* $p < .001$.

Table 4

Mediation of Learning Typology at Age 8 on Reading Achievement at Age 14 Through Self- Regulation and Reading Ability at Age 10

			95% CI		
Mediator	**β**	**SE**	**Lower**	**Upper**	r^2
Achievement Focused Typology					.79
Total mediation	18.05*	2.95	13.08	24.69	
Reading ability at age 10	16.78*	2.87	12.27	23.11	
Self-regulation	1.27*	0.70	0.26	3.09	
Reading v self-regulation	15.51*	2.95	10.66	21.89	
Typical Typology					.78
Total mediation	9.16*	3.20	2.84	15.28	
Reading ability at age 10	7.78*	3.17	1.31	13.83	
Self-regulation	1.37*	0.76	0.25	3.48	
Reading v self-regulation	6.41*	3.33	1.35	15.21	
Challenged Typology[a]					.70
Total mediation	−8.92*	1.76	−12.96	−5.79	
Reading ability at age 10	−8.03*	1.68	−12.01	−5.07	
Self-regulation	−0.90	0.67	−2.67	0.15	
Reading v self-regulation	−7.13*	1.84	−11.22	−3.79	
Adaptive Typology					.78
Total mediation	−14.93*	2.31	−19.70	−10.44	
Reading ability at age 10	−13.55*	2.03	−17.86	−9.75	
Self-regulation	−1.37*	0.86	−3.69	−0.15	
Reading v self-regulation	−12.18*	2.09	−16.60	−8.34	
IDD Typology					.80
Total mediation	−14.19*	2.44	−19.15	−9.32	

Mediator	β	SE	95% CI Lower	95% CI Upper	r^2
Reading ability at age 10	−13.09*	2.27	−17.52	−8.53	
Self-regulation	−1.10*	0.72	−3.01	−0.11	
Reading v self-regulation	−11.98*	2.31	−16.14	−7.49	

Note. *N*= 113. CI = confidence interval.

[a] $n = 74$.

* $p < .05$.

Table 5

Mediation of Learner Typology at Age 8 on Mathematics Achievement at Age 14 through Self-Regulation and Math Ability at Age 10

			95% CI		
Mediator	**β**	**SE**	**Lower**	**Upper**	r^2
Achievement Focused Typology					.58
Total mediation	11.26*	2.22	7.09	15.99	
Math ability at age 10	9.65*	2.24	5.68	14.62	
Self-regulation	1.61*	.93	.27	4.25	
Math v self-regulation	8.04*	2.61	3.09	13.36	
Typical Typology					.57
Total mediation	8.71*	2.11	4.61	13.07	
Math ability at age 10	7.06*	2.11	3.35	11.55	
Self-regulation	1.65*	1.08	.17	4.40	
Math v self-regulation	5.41*	2.61	.76	10.99	
Challenged Typology[a]					.37
Total mediation	−4.10*	2.15	−9.14	−.40	
Math ability at age 10	−3.13*	1.88	−7.76	−.13	
Self-regulation	−0.97	.99	−3.15	.72	
Math v self-regulation	−2.16	2.09	−6.82	1.50	
Adaptive Typology					.59
Total mediation	−11.60*	2.34	−16.42	−7.29	
Math ability at age 10	−9.67*	2.31	−14.68	−5.50	
Self-regulation	−1.92*	1.15	−4.65	−.01	
Math v self-regulation	−7.75*	2.80	−13.60	−2.57	
IDD Typology					.56
Total mediation	−12.20*	2.97	−18.23	−6.42	
Math ability at age 10	−10.40*	3.00	−16.17	−4.39	

			95% CI		
Mediator	**β**	**SE**	**Lower**	**Upper**	r^2
Self-regulation	−1.80*	1.05	−4.55	−.37	
Math v self-regulation	−8.61*	3.30	−15.28	−2.08	

Note. *N*= 113. CI = confidence interval.

[a] *n* = 74.

* *p* < .05.