Abstract Title Page
Not included in page count.

Title: The Role of Executive Functions Skills and Self-Regulation Behaviors in School Readiness and Adjustment

Authors and Affiliations: Tyler R. Sasser & Karen L. Bierman, The Pennsylvania State University

Abstract Body

Background / Context:

Children growing up in poverty are particularly likely to show delays in school readiness skills, creating a substantial achievement gap between them and their middle-income peers in kindergarten that sustains and widens over time (Campbell & von Stauffenberg, 2008; NICHD Early Child Care Research Network, 2003). In part, this gap reflects delays in the acquisition of academic knowledge (e.g., emergent literacy and math skills); in part, it reflects delays in the acquisition of attention control and adaptive learning behaviors that support classroom engagement and goal-oriented learning (Shonkoff & Phillips, 2000).

Recent research suggests that the neural pathways that support attention control and adaptive learning behaviors develop rapidly between the ages of 3-6, and play a central role in supporting both academic and social-behavior readiness (Blair & Diamond, 2008). For example, during these years, children show a growing capacity to shift and control their attention, as reflected in their performance on executive function (EF) tasks that require inhibitory control and set-shifting (e.g., Peg Tapping, and Dimensional Change Card Sort tasks; Bierman et al., 2008). Teacher ratings also show corresponding improvements during the preschool years in behavioral control, including the capacity to sustain attention and complete tasks in the classroom, and the capacity to inhibit impulsive and reactive behaviors (Eisenberg & Fabes, 1992).

Theorists have speculated that individual differences in the adaptive learning behaviors that affect school readiness are a function of two processes. First, individual differences arise from variations in temperamental activity level and impulsivity, which affect the child's reactivity to stimulation and are sometimes described as "bottom up" processes (Kochanska, Murray, Jacques, Koenig, & Vendegeest, 1996; Rothbart, 2004). Conversely, EF skills and the capacity to selectively focus and sustain attention behavior are typically considered to be "top down" processes, which develop over time and allow children to modulate their impulsivity and reactivity. Although EF skills, impulsive behaviors, and attention functioning in the classroom are inter-related from a theoretical standpoint, they may each reflect some distinct aspects of children's self-regulatory skill development. Longitudinal studies that specifically assess children's EF skills, impulsive behaviors, and attention functioning in pre-kindergarten and assess individual variation and prediction to school adaptation are needed to better understand the relations between self-regulatory skill development and school adjustment.

Purpose / Objective / Research Question / Focus of Study:

The aim of this study was to examine co-variation in the development of self-regulatory skills evident in pre-kindergarten and evaluate the implications of that variation for school adjustment in kindergarten and first grade. Measures of self-regulatory skill development included: direct assessments of EF (e.g., Peg Tapping, DCCS), teacher ratings of attention functioning and impulsivity in the classroom, and observer ratings of attention functioning during academic assessments. The study utilized a person-centered approach (latent profile analysis) to determine whether subgroups of Head Start children showed variations in profiles of self- regulatory skills during the prekindergarten year. It also assessed whether those sub-groups differed in terms of their academic and social-behavioral adjustment at kindergarten and first grade. Because these analyses were exploratory, a priori hypotheses concerning the number of groups and specific profiles were not generated. However, it was anticipated that with direct assessment of EF, teacher-rated inattention and impulsivity, and assessor-rated attention included as continuous predictors, a solution of three or more distinct profiles would result, reflecting

more than just level of self-regulation (e.g., high and low), and that these profiles would differ in meaningful ways on measures of academic and social-behavioral school adjustment.

Population / Participants / Subjects:

Participants included two cohorts of four-year-old children (total N = 164, 14% Latino American, 30% African American, 56% European American; 57% girls) in 22 Head Start classrooms in three counties in Pennsylvania (York, Blair, and Huntingdon). The children were recruited as part of a larger project (Head Start REDI) but did not participate in the intervention.

All families met the requirements for participation in Head Start: 68% had incomes below the national poverty level. Forty percent of the children lived in two-parent families, 43 % lived with single mothers, and 17 % lived with relatives or foster families. Overall, 33 % of mothers had not completed high school; 46 % had a graduate equivalent degree (GED) or high school diploma; 19 % had some technical training; and 2 % had graduated from college.

Research Design:

A longitudinal research design was employed, with data collected at the start of the pre-kindergarten year of Head Start (total N= 164), at the end of the kindergarten year (N=158), and the end of the first grade year (N = 157). A multi-method, multi-informant approach was used, including direct assessments conducted with children (e.g., EF skills; literacy and numeracy outcomes), teacher ratings (e.g., attention and impulse control; social competence and aggression outcomes), and interviewer ratings (e.g., attention).

Scores on four tasks were used to assess core EF skills in the pre-kindergarten year: the *Backward Word Span* [BWS](Davis & Pratt, 1996), *Peg Tapping*[PT] (Diamond & Taylor, 1996), *Dimensional Change Card Sort* [DCCS] (Frye, Zelazo, & Palfai,1995), and walk-a-line slowly [WLS] (Kochanska et al., 1996) tasks. Teacher ratings of inattention were used to assess attention functioning, using five items from the inattention subscale of the *ADHD Rating Scale* (DuPaul, 1991) and three items from an inventory developed for the larger project. Five items from the impulsivity subscale of the ADHD Rating Scale were used to assess impulsivity. Assessor's also rated children's attention after administering the child assessment battery.

To assess rapidly developing literacy skills, the battery was adjusted at each time point to accommodate children's increasing skills; scores were standardized and averaged into a composite. The Applied Problems scale of the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather,2001) was administered at each time point to assess children's emerging numeracy skills. Teacher ratings assessed social competence (Conduct Problems Prevention Research Group [CPPRG], 2003) and aggressive-oppositional behavior problems at each time point (TOCA – R; Werthamer-Larsson, Kellam, & Wheeler, 1991).

Data Collection and Analysis:

A person-centered approach was taken to examine whether classes of children could be identified based on mean-level profiles of the self-regulation skills during the prekindergarten year. Latent profile analysis was employed (LPA; Muthen & Muthen, 1998). Pre-kindergarten levels of EF skill, teacher-rated inattention and impulsivity, and assessor-rated attention were modeled as continuous, observed indicators of categorical latent variables, which represented the different subgroups or classes. The statistical package Mplus 5.1 (Muthen & Muthen, 2008) was used to fit the LPAs. To arrive at the best-fitting model, information based indices (i.e., AIC, BIC, sample-size adjusted BIC), fit indices (e.g., VLMR), entropy, and the theoretical meaning and interpretability of solutions were considered in evaluating overall model fit (Muthen, 2003).

Findings / Results:

A model with four classes was selected. Children were assigned to groups based upon the

highest probability of group membership. Entropy for the four-class solution, which is an index of how well individuals were classified into subgroups, was excellent (.78).

To determine significant differences among the classes on the various pre-kindergarten indices of self-regulation, a series of one-way ANOVAs was computed. Table 1 shows the prevalence of the four classes, the pattern of means across the self-regulation indicators for each class, and significance levels for ANOVAs examining class differences on the self-regulation indicators and demographics. The groups did not significantly differ on age, but did differ on baseline vocabulary, $F(3, 157) = 4.90$, $p < .05$.

In the modeled solution, class 1 included 54 children, 34% of the girls and 30% of the boys in the sample. Post hoc comparisons (Bonferonni) revealed that this group was characterized by significantly higher levels of EF skill and assessor-rated attention than the other groups (with mean scores one-half SD above the sample mean), and they had significantly lower levels of teacher-rated inattention and impulsivity than the others (with mean scores over one-half SD below the sample mean). Because all four indices indicated high self-regulation, this class was labeled **"well regulated."**

Class 2 included 32 children, 17% of the girls and 23% of the boys in the sample. Bonferonni comparisons revealed that this group had significantly lower levels of EF skill and assessor-rated attention than the well- regulated group (with a group means one-fifth of a SD below the sample mean on both measures), and they had significantly higher levels of teacher-rated inattention and impulsivity (with a mean two-fifths of a SD above the sample mean on inattention, and four-fifths of a SD above the sample mean on impulsivity). This group was labeled for its most distinctive characteristic, which was elevated impulsivity: **"impulsive."**

Class 3 included 23 children (8% of the girls in the sample, 23% of the boys in the sample). Bonferonni comparisons revealed that this group had significantly lower levels of EF skill and assessor-rated attention than the well-regulated group (the EF mean was one-fifth of a SD below the sample mean; the assessor rating mean was two-thirds of a SD below the sample mean). Importantly, the group was also characterized by the highest levels of teacher-rated inattention and impulsivity (approaching two SDs above the sample mean). This group was labeled after its distinctive behavioral dysfunction in the classroom: **"dysfunctional."**

Class 4 included 55 children, including 41% of the girls in the sample and 24% of the boys in the sample. Bonferonni comparisons revealed lower EF scores and lower assessor-rated attention compared to the well-regulated group, and equivalent to the scores of children in the impulsive and dysfunctional groups. Teacher ratings of inattention and impulsivity were significantly higher than those given to children in the well-regulated group, but they were still below the sample mean, and significantly lower than levels of inattention and impulsivity exhibited by the impulsive and dysfunctional groups. This group was also significantly lower than the well-regulated group on baseline vocabulary. This group was labeled for its distinctive feature of **"low EF."** Overall, the three "problem" classes shared equivalent deficits in EF scores and assessor ratings, which distinguished them from the well-regulated group. However, these three problem classes differed substantially in terms of their teacher-rated behavior problems, ranging from no teacher-rated problems (the Low EF group), to moderate elevations, primarily in impulsivity (the Impulsive group), to extreme elevations in both inattention and impulsivity (the Dysfunctional group).

Next, univariate analyses (ANCOVAs) were conducted to investigate group differences on concurrent measures of school readiness, controlling for age, sex, and baseline vocabulary. Results are presented in Table 2, showing significant group differences on each measure of pre-

kindergarten school readiness -- literacy, numeracy, social competence, and aggression. Bonferonni comparisons revealed that all three of the problem classes had significantly lower literacy readiness than the well-regulated group, and did not differ amongst themselves. In addition, the Dysfunctional and Low EF classes both exhibited significant delays in numeracy skill development. Although the Low EF group had social competence and aggression scores that differed significantly from the well-regulated group, they were still close to the sample mean. The Impulsive and Dysfunctional groups each exhibited lower social competence and higher aggression than the well-regulated or Low EF group, with the latter group showing social competence and aggression scores that were worse than any other group, and well above the sample mean. Overall, then, children in each of these problem groups showed delays in academic skill acquisition in pre-kindergarten, with varying levels of social and behavior problems.

To examine whether the classes maintained this pattern of differences after the transition into elementary to school, ANCOVAs were conducted comparing the groups on kindergarten and first grade school outcomes. Results are presented in Table 3. Significant group differences were revealed in three of four school outcome domains: numeracy, F (3, 147) = 6.05, $p < .05$ and F (3, 146) = 3.94, $p < .05$ for kindergarten and first grade, respectively; social competence, F (3, 145) = 7.25, $p < .001$ and F (3, 146) = 6.88, $p < .05$ for kindergarten and first grade, respectively; and aggression, F (3, 145) = 9.85, $p < .001$ and F (3, 146) = 5.41, $p < .05$ for kindergarten and first grade, respectively. No significant group differences were revealed for literacy. Post hoc (Bonferonni) analyses revealed that for numeracy, the Low EF group remained significantly below the skill acquisition level of the well-regulated group at kindergarten and first grade. In addition, although not different at kindergarten, the Dysfunctional group also performed significantly below the well-regulated group on numeracy skills in first grade. In the domain of social competence, the Impulsive and Dysfunctional groups continued to show significantly lower levels of social competence than the well-regulated group in kindergarten and first grade. In addition, children in the Low EF group were significantly less socially competent than the well-regulated group by first grade. Considering the domain of aggression, only the Impulsive and Dysfunctional groups differed significantly from the well-regulated group, showing elevated rates of aggression in kindergarten and first grade. Overall, children in the Impulsive group differed from the well-regulated group only in the social-behavioral adjustment outcomes, whereas children in Dysfunctional and Low EF groups began to show cross-domain differences by first grade.

Conclusions:

The LPA analysis suggests that economically disadvantaged preschoolers are at increased risk for self-regulatory skill deficits, but that heterogeneity exists in the nature of those deficits. It is possible that differential approaches to intervention may therefore be needed. Children with isolated deficits in EF (the **low EF** class) may benefit primarily from a cognitively-focused intervention that supports EF skill development. Children with behavioral deficits (e.g., elevated impulsivity and inattention in the classroom, such as the **dysfunctional** class may require an intervention program that supports EF development and provides other environmental supports. Given these developmental links, it is possible that direct assessments of EF and teacher ratings of inattention and impulsivity (even at subclinical levels) may contribute to the identification of children in need of support or services.

Given the exploratory nature of the person-centered analyses conducted in this study, future examination is necessary to confirm the profiles that emerged. Confirmation of risk profiles may further shed light on the development of school readiness problems.

Appendices

Not included in page count.

Appendix A. References

References are to be in APA version 6 format.

Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008). Executive functions and school readiness intervention: Impact, moderation, and mediation in the Head Start REDI program. *Development and Psychopathology, 20,* 821-843. doi:10.1017/S0954579408000394

Blair, C. (2002). School readiness: Integrating cognition and emotion in a neurobiological conceptuatlization of children's functioning at school entry. *American Psychologist, 57,* 111-127. doi:10.1037/0003-066X.57.2.111

Blair, C. & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Developmental Psychopathology, 20,* 899-911. doi:10.1017/S0954579408000436

Campbell, S. B. & Stauffenberg, C. (2008). Child characteristics and family processes that predict behavioral readiness for school. In A Crouter & A. Booth (Eds.), *Early disparities in school readiness: How families contribute to transitions into school* (pp. 225-258). Mahwah, NJ: Erlbaum.

Conduct Problems Prevention Research Group (CPPRG) (2003). *Teacher social competence scale technical report*. Retrieved April 28, 2008, from The Fast Track Project Web site: http://www.fasttrackproject.org/

Davis, H. L., & Pratt, C. (1996). The development of children's theory of mind: The working memory explanation. *Australian Journal of Psychology, 47,* 25 – 31. doi:10.1080/00049539508258765

Diamond, A. & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to do as I say, not as I do. *Developmental Psychobiology, 29,* 315-334. doi:10.1002/(SICI)1098-2302(199605)29:4<315::AID-DEV2>3.0.CO;2-T

DuPaul, G. (1991). Parent and teacher ratings of ADHD symptoms: Psychometric properties in a community based sample. *Journal of Clinical Child Psychology*, 20, 245-253. doi:10.1207/s15374424jccp2003_3

Eisenberg, N., & Fabes, R. A. (1992). Emotion, regulation and the development of social competence. In M.S. Clark (Ed.). *Review of Personality and Social Psychology: Vol. 14. Emotion and social behavior.* (pp.119-150). Newburg Park, CT: Sage.

Frye, D., Zelazo, P. D., & Palfai, T. (1995). Theory of mind and rule-based reasoning. *Cognitive Development*, *10*, 483 – 527. doi:10.1016/0885-2014(95)90024-1

Kochanska, G., Murray, K. T., Jaques, T. Y., Koenig, A. L. & Vendegeest, K. A. (1996). Inhibitory control in young children and its role in emerging internalization. *Child Development, 67,* 490-507. doi:10.2307/1131828

Muthén, L.K. and Muthén, B.O. (1998). Mplus user's guide. Los Angeles, CA: Muthén & Muthén.

NICHD Early Child Care Research Network. (2003). Do children's attention processes mediate the link between family predictors and school readiness? *Developmental Psychology, 39,* 581-593. doi:10.1037/0012-1649.39.3.581

Raver, C. C. (2002). Emotions matter: Making the case for the role of young children's emotional development for early school readiness. *Social Policy Report, 16(3),* 3-24.

Rothbart, M. K. (2004). Temperament and the pursuit of an integrated developmental psychology, *Merrill-Palmer Quarterly, 50*, 492-505. doi:10.1353/mpq.2004.0035

Shonkoff, J. P., & Phillips, D. A. (Eds.). (2000). *From neurons to neighborhoods: The science of early childhood development.* Washington DC: National Academy Press.

Werthamer-Larsson, L., Kellam, S. G., & Wheeler, L. (1991). Effect of first-grade classroom environment on shy behavior, aggressive behavior, and concentration problems. *American Journal of Community Psychology*, *19*, 585–602. doi:10.1007/BF00937993

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). *Woodcock–Johnson III Tests of Achievement* (3rd ed.). Itasca, IL: Riverside.

Appendix B. Tables and Figures
Not included in page count.

Table 1
Four-class Solution for LPA with Pre-Kindergarten Self-Regulation Indices as Indicators

	Class 1 N = 54 (33%)	Class 2 N = 32 (20%)	Class 3 N = 23 (14%)	Class 4 N = 55 (34%)	F-value
Mean values					
EF	.53[a]	-.19[b]	-.18[b]	-.31[b]	23.33**
Teacher-rated inattention	-.80[a]	.42[c]	1.79[d]	-.18[b]	273.54**
Teacher-rated impulsivity	-.66[a]	.82[c]	1.79[d]	-.39[b]	256.43**
Assessor-rated attention	.70[a]	-.20[b]	-.64[b]	-.15[b]	21.68**
Demographics					
Age	.05[a]	-.10[a]	.08[a]	.00[a]	.20
Vocabulary	.34[a]	-.02[ab]	-.04[ab]	-.34[b]	4.90*
% of females	34%	17%	8%	41%	--
% of males	30%	23%	23%	24%	--

Note. Values are Z scores.
** p < .001; * p < .05

Table 2
ANCOVAs Examining Group Differences on Concurrent School Readiness Outcomes at Pre-Kindergarten

	Class 1 Well-regulated	Class 2 Impulsive	Class 3 Dysfunctional	Class 4 Low EF	F-value
Literacy	.30[a]	-.15[b]	-.20[b]	-.27[b]	10.80**
Numeracy	.21[a]	-.21[ab]	-.45[b]	-.28[b]	4.25*
Social competence	.84[a]	-.62[c]	-1.58[d]	.07[b]	73.19**
Aggression	-.67[a]	.58[c]	1.79[d]	-.17[b]	71.47**

Note. Control variables included age, sex, and baseline vocabulary.
** p < .001; * p < .05

Table 3

ANCOVAs Examining Group Differences on School Adjustment Outcomes at Kindergarten and First Grade

	Class 1 Well-regulated	Class 2 Impulsive	Class 3 Dysfunctional	Class 4 Low EF	F-value
Literacy					
Kindergarten	.21	.04	-.11	-.08	2.02
1st grade	.25	.13	-.31	-.06	2.54
Numeracy					
Kindergarten	.44[a]	.24[ab]	-.11[ab]	-.23[b]	6.05*
1st grade	.32[a]	.10[ab]	-.38[b]	-.18[b]	3.94*
Social Competence					
Kindergarten	.27[a]	-.56[b]	-.65[b]	-.10[ab]	7.25**
1st grade	.43[a]	-.39[b]	-.49[b]	-.18[b]	6.88*
Aggression					
Kindergarten	-.31[a]	.56[b]	.83[b]	.05[ab]	9.85**
1st grade	-.38[a]	.24[b]	.57[b]	.14[ab]	5.41*

Note. Control variables included age, sex, and baseline vocabulary.

** $p < .001$; * $p < .05$