

AN ABSTRACT OF THE DISSERTATION OF

Robert J. Duncan for the degree of Doctor of Philosophy in Human Development and Family Studies presented on June 10, 2015.

Title: Early Predictors of Academic Achievement and Externalizing Problems for Children in Low-Income Families

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Megan M. McClelland

Empirical studies and theory have identified many early predictors of children's academic achievement and externalizing problems. Moreover, research shows that children's early cognitive abilities and behavioral problems are strong predictors of later academic achievement and externalizing problems. The current dissertation studies extend previous work and unpack how early predictors relate to children's academic achievement and externalizing problems in a low-income sample. Both of the dissertation studies are secondary data analyses of the Early Head Start Research and Evaluation Study, which evaluated the effectiveness of Early Head Start (EHS) from 1996 through 2010. *Study I* uses inductive, sequential partitioning analyses, to explore the effects of family income and needs, child and family characteristics, child health, and early care and education (i.e., from roughly the time of the child's birth) on children's prekindergarten and 5th grade academic achievement. The study also explores subgroup effects of EHS based on sequential partitioning analyses. Study I had three key findings. First, much of the explained variance in prekindergarten academic achievement was accounted for by children's ethnicity and maternal educational attainment. However, ethnicity explained substantially more variance than maternal educational attainment for

5th grade academic achievement. Second, common-domain skills (e.g., early math for later math) explained much of the link for 5th grade math and vocabulary performance. However, early math and vocabulary skills, and not early literacy, were predictive of 5th grade literacy. Third, EHS was a selected split (in the intended direction) for a subgroup of children (i.e., Black/Hispanic, relatively lower levels of maternal educational attainment, and not in deep poverty) in the prekindergarten vocabulary model, but not a selected split in any other model. Follow up subgroup analyses of EHS effects showed mostly non-significant results on children's prekindergarten and 5th grade academic achievement.

Study II examines the effects of economic hardship, child and family characteristics, and early care and education (i.e., from roughly the time of the child's birth) and prekindergarten behavioral problems on children's externalizing problems at 5th grade. The study uses two analytical approaches to better understand these relations: a deductive, logistic regression model and an inductive, sequential partitioning model (i.e., SEARCH). Across both models, being male, maternal unemployment and not living with the husband at roughly the time of the child's birth, and high levels of prekindergarten aggression (i.e., FACES subscale) were predictive of a greater likelihood of externalizing problems at 5th grade. However, three differences in results were found between the two analytical approaches. First, variables related to economic hardship (e.g., depth of poverty, welfare receipt) were selected in the SEARCH model, but were not significant in the logistic regression model. Second, there was a significant beneficial subgroup effect of EHS (i.e., females not in deep poverty and who had mothers employed or in school at roughly the time of the child's birth) in the SEARCH model, but it was not significant in

the logistic regression model. Third, prekindergarten hyperactivity was not selected in the SEARCH model but was significant in the logistic regression model. The two dissertation studies uniquely contribute to research on early predictors of children's academic achievement and externalizing problems. Study I shows how inductive analyses can be used to connect back to previous research and guide new hypothesis driven research, whereas Study II shows the usefulness of taking deductive and inductive analytical approaches for developmental research.

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Early Predictors of Academic Achievement and Externalizing Problems for Children in
Low-Income Families

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Robert J. Duncan

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APPROVED:

Major Professor, representing Human Development and Family Studies

Co-director of the School of Social and Behavioral Health Sciences

Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below summarizes release of my dissertation to any reader upon request.

Robert J. Duncan, Author

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Early Predictors of Academic Achievement and Externalizing Problems for Children in
Low-Income Families

Early Predictors of Academic Achievement and Externalizing Problems for Children in Low-Income Families

Early life experiences have implications for development throughout an individual's life. For example, children who experience cumulative risks early in life, especially those related to poverty, are more likely to fall behind their peers in cognitive and behavioral domains (Brooks-Gunn, Duncan, & Maritato, 1997; Duncan & Brooks-Gunn, 2000; Evans, Li, & Whipple, 2013). Early predictors of children's cognitive and behavioral development are diverse, but typically interrelated, such as family income, ethnicity, maternal educational attainment, household characteristics, child and maternal health, and access to resources (Bradley & Corwyn, 2002; Duncan & Magnusson, 2005; Evans et al., 2013). Furthermore, a number of processes (e.g., home learning environment, access to high quality child care, family conflict/stress) have been theorized and empirically studied to explain the link between poverty and risk on children's cognitive and behavioral development (Conger, Rueter, & Conger, 2002; Dubow & Ippolito, 1994; Duncan, Brooks-Gunn, & Klebanov, 1994; Duncan, Yeung, Brooks-Gunn, & Smith, 1998; Evans & English, 2002; McLoyd, 1998; Son & Morrison, 2010). Although these processes have been well documented, a noticeable gap in the literature exists in exploring the influence of early life factors on children's development through inductive analyses. For scientific inquiry, inductive approaches can complement deductive approaches by learning from the raw data versus using the data to test hypotheses. In other words, inductive analyses can be used for *model discovery* versus more traditional *model testing* (Bronfenbrenner & Morris, 2006; Morgan, 2005). Information gained from inductive analyses can then be connected back to previous research and theory, and used to inform and complement deductive, hypothesis-driven,

analyses. In the current dissertation, Study I focuses on better understanding early predictors of children's academic achievement through multiple inductive analyses and Study II focuses on better understanding early predictors of children's externalizing problems by using complementary deductive and inductive analyses.

The studies in this dissertation share the unique distinction of using inductive analyses of sequentially partitioning data (i.e., SEARCH; Sonquist, Baker, & Morgan, 1974) to explore how variables collected around the time of the child's birth and prekindergarten year relate to cognitive and behavioral outcomes at 5th grade in a predominantly low-income sample of children and families. The SEARCH models do not assume that the effects of specific predictors (e.g., gender) are independently additive across the sample, but that the effects of predictors are possibly conditional on the effects of other predictors (e.g., ethnicity). Additionally, both dissertation studies were secondary data analyses of the Early Head Start Research and Evaluation Study (EHSRE), which was a randomized experiment testing for the effectiveness of Early Head Start (EHS). The EHSRE followed children and families from roughly the time of the child's birth (i.e., baseline of the study) through the child's 5th grade year, with roughly half of the sample randomly assigned to EHS.

The first study (i.e., Chapter 2) has three research objectives. First, the study identifies predictive patterns among early life factors for children's prekindergarten math, literacy, and vocabulary performance. Second, it identifies predictive patterns among early life factors and prekindergarten academic skills for children's 5th grade math, literacy, and vocabulary performance. Third, the study tests for subgroup effects of EHS on children's academic achievement created by the sequential partitioning models. The

second study (i.e., Chapter 3) uses deductive (i.e., *logistic regression model*) and inductive (i.e., *SEARCH model*) analyses to better understand how early life factors and early behavioral problems relate to children's externalizing problems at 5th grade. Both studies are rooted in common theoretical lenses and uniquely contribute to the literature on early predictors of cognitive and behavioral development for children in low-income families.

Theoretical Perspectives

Theoretical perspectives of life course sociology, life span psychology, and the bioecological model inform the current dissertation studies. Life course sociology largely focuses on understanding the influence of contexts and structure on human development (Elder, Johnson, & Crosnoe, 2003). In this perspective, individuals are considered as developing within contexts, with those contexts strongly impacting life trajectories. The contribution of contexts to development can be seen in research that focuses on the effects of early childhood poverty and family structure on later outcomes (Dubow & Ippolito, 1994; Duncan & Brooks-Gunn, 2000; Duncan et al., 1998; McLoyd, 1998). For example, children growing up in a context of poverty are more likely to experience housing that is noisier and more crowded, harsher parenting, greater stress, and fewer learning resources than children in more economically advantaged families (Duncan & Brooks-Gunn, 2000; Evans & English, 2002; McLoyd, 1998). Both of the current studies focus on better understanding the contextual influences of multiple factors on children's cognitive and behavioral development in a predominantly low-income sample.

The life span psychology perspective complements the life course perspective by putting greater emphasis on the individual characteristics that influence developmental

trajectories, and examining if those effects are the same or different across contexts (Baltes, Lindenberger, & Staudinger, 1998). For example, the dissertation studies each examine how differences in children's early cognitive skills and behavioral problems influence their development in these domains beyond the effects of early life factors (i.e., roughly the time of the child's birth). This perspective is supported by research that shows early cognitive skills are strong predictors of later academic achievement (e.g., Duncan et al., 2007; McClelland et al., 2013), and likewise, early behavioral problems are strong predictors of later externalizing problems (e.g., Bongers, Koot, Van Der Ende, & Verhulst, 2004; Vazsony & Keiley, 2007).

Finally, the bioecological model of human development informs both of the dissertation studies, which emphasizing the synergistic interdependencies between *process, person, context, and time* (Bronfenbrenner & Morris, 2006). Thus, it is important to consider that the effects of person-level predictors (e.g., prekindergarten academic skills or behavioral problems) on later successful development are likely dependent on contexts (e.g., family income, maternal educational attainment), and though not modeled, also dependent on processes (e.g., mother-child interactions) and timing. Given that developmental science is in a relatively early stage of its existence, statistical analyses using the *mode of discovery* (i.e., hypothesis-generating) versus the *mode of verification* (i.e., hypothesis-testing) are important for identifying potential context-dependent influences (Bronfenbrenner & Morris, 2006). In other words, models using hypothesis tests to obtain estimated effects for predictors by controlling for other relations are considered inadequate because of the likely dependency among predictors. The current dissertation studies use this perspective and aim to contribute to the current

literature on the effects of early life factors on children's academic achievement and externalizing problems by using a model discovery approach of sequentially partitioning the data (i.e., all predictors, except the initial partition, are conditionally dependent on previously selected splits among predictors in the model). Importantly, inductive analyses can complement previous studies that have used deductive-driven analyses (i.e., Study I) and be used to complement deductive-driven analyses in the same study (i.e., Study II).

Complementary Role of Inductive and Deductive Approaches

Similar to the ways that theoretical perspectives guide research, so too can analytical approaches. Deductive analyses use *model testing*, which includes hypothesized models and effects, and then determines whether the hypotheses were correct or not. This is commonly seen in quantitative models that determine whether or not a hypothesized effect is statistically significant. For example, examining whether or not children's ethnicity has a significant effect on academic achievement while statistically controlling for family income and maternal educational attainment would involve deductive hypothesis testing. Conversely, inductive analyses use *model discovery*, such as looking for patterns among the raw data in order to gain knowledge regarding the possible structure of influence from multiple predictors (Morgan, 2005). Both studies in the current dissertation use a sequential partitioning approach of selecting splits in the predictors that are most associated with the outcome until the model selection criteria are not met. The sequential partitioning approach allows researchers to determine which predictors are most related to the outcome, and if predictors have subgroup-specific effects that emerge in the data (based on the sequential partitioning process).

That is, once a split has been determined (e.g., gender), predictors that did not have a strong association with the outcome in the full sample could emerge as the most predictive in the resulting subgroup (e.g., males). For scientific inquiry, inductive analyses complement deductive approaches by learning from the raw data and digging into more nuances of the data, rather than using data to test hypotheses.

The current dissertation studies use inductive analyses to explore how early predictors (i.e., collected around the time of the child's birth) relate to later cognitive and behavioral development. The first study (i.e., Chapter 2) uses inductive sequential partitioning analyses based on the explained variance of predictors for children's prekindergarten and 5th grade academic achievement. The study examines three models for prekindergarten academic achievement (i.e., math, reading, vocabulary) and three models for 5th grade academic achievement (i.e., math, reading, vocabulary). Therefore, this study looks for commonalities across the models, connections to previous theory and research, and posits new testable hypotheses generated by the models. The second study (i.e., Chapter 3) uses a logistic regression model (i.e., deductive analysis) and a sequential partitioning model (i.e., inductive analysis) for predicting children's externalizing problems. This study uses two complementary, but distinct, analytical approaches to provide a deeper understanding of how early predictors and prekindergarten behavioral problems relate to children's externalizing problems at 5th grade.

Importance of Understanding Academic Achievement and Externalizing Behaviors in Childhood

Academic achievement and externalizing behaviors in childhood have a number of potential long-term implications. For instance, greater academic skills in childhood are associated with an increased likelihood of college completion (Buchmann & DiPrete,

2006; Perna, 2005). Thus for children in low-income families, boosting academic skills could help break the cycle of poverty if children become more likely to obtain a higher degree. For instance, the value of a college degree, compared to a high school degree, is worth nearly \$60,000 per year in the U.S. (Autor, 2014). Understanding what precipitates academic success for children in low-income contexts can potentially help interventions and policies become more targeted for those children most at risk. For externalizing behaviors (e.g., aggression, rule-breaking), higher rates are associated with more anger and impulsivity, and lower levels of self-regulation in early childhood (Calkins & Keane, 2009; Eisenberg et al., 2001). Furthermore, externalizing behaviors during childhood are associated with increased rates of juvenile delinquency, violence, and earlier onset of substance use (King, Lacono, & McGue, 2004; Lui, 2004). Thus, understanding early antecedents of externalizing problems is critical for potential interventions and prevention of more consequential behaviors later in life (Campbell, 1995; Campbell, Shaw, & Gilliom, 2000). Together, both of the dissertation studies contribute to the current literature on early predictors of academic achievement and externalizing behaviors for children in low-income families.

Early Predictors of Academic Achievement and Externalizing Behaviors

Previous research has identified multiple early predictors of children's later academic achievement and externalizing problems. These early predictors include variables related to family income (e.g., poverty), child and family characteristics (e.g., ethnicity, gender, maternal educational attainment), child health at birth (e.g., birth weight), and early care and education (e.g., access to EHS) (e.g., Brooks-Gunn, Duncan, & Maritato, 1997; Dubow & Ippolito, 1994; Duncan & Brooks-Gunn, 2000; Love et al.,

2005; Magnusson, Ruhm, & Waldfogel, 2007). Furthermore, early cognitive skills are predictive of future academic success and early behavioral problems are predictive of later externalizing problems (e.g., Bongers et al., 2004; Duncan et al., 2007; McClelland et al., 2013; Vazsony & Keiley, 2007). Of the early predictors in children's lives, poverty has emerged as a particularly robust predictor of later cognitive and behavioral development. The importance of understanding how poverty influences development is underscored by numerous studies that find it has significant adverse effects that persist throughout childhood (Brooks-Gunn et al., 1997; Conger et al., 2000; Dubow & Ippolito, 1994; Duncan & Brooks-Gunn, 2000; Evans & English, 2002; Evans et al., 2013; McLoyd, 1998).

Family Income. In 2013, 45% of all young children in the U.S. lived in families with incomes less than 200% of the poverty line and 40% of young black children lived in families under the poverty line (Center for Law and Social Policy, 2014). Given these disproportionately high percentages, it is important to understand how living in a low-income household affects children's development. Research suggests that poverty experienced early in life and chronically has the most deleterious effects on children's cognitive and behavioral development (Conger et al., 2000; Dubow & Ippolito, 1994; Duncan, Brooks-Gunn, & Klebanov, 1994; Duncan et al., 1998; Korenman, Miller, & Sjaastad, 1995). The disproportionately higher number of hardships that children in low-income households experience likely drives much of these relations. For example, hardships associated with poverty include lower maternal educational attainment, single or teen motherhood, parents with no or low-prestige jobs, living in low quality neighborhoods, higher numbers of siblings, residential instability, and low birth weight

(Duncan & Magnusson, 2005). However, even after accounting for many of these hardships, the overall deleterious effects of poverty often remain a significant predictor for cognitive and behavioral outcomes (Dubow & Ippolito, 1994; Duncan et al., 1994; Korenman et al., 1995; Petterson & Albers, 2001).

The current dissertation studies further explore the influence of early economic hardship (i.e., roughly at the time on the child's birth) on later academic achievement and externalizing problems by looking at the family's depth of poverty (e.g., deep poverty versus poverty), welfare receipt, and self-reported family needs (related to resource accessibility). Furthermore, the study examines the influence of these predictors within a sample of children who were born into families eligible for EHS, which serves low-income populations (US DHHS ACF, 1995). Therefore, the current study focuses on the effects of the degree of economic hardship rather than whether or not families are economically disadvantaged. Moreover, both studies attempt to further tease apart effects on children's development that are confounded with economic hardship (e.g., ethnicity, lower maternal educational attainment) (Duncan & Magnusson, 2005).

Child, Family, and Health Characteristics. Child, family, and health characteristics have been found to uniquely predict children's cognitive and behavioral development in addition to economic hardship (e.g., Evans et al., 2013; McClelland & Wanless, 2012; Obradovic et al., 2010; Sameroff et al., 1987). These characteristics are sometimes grouped into a cumulative risk index, consisting of variables such as parents without high school degrees, parents who are jobless, ethnic minority status, English Language Learner status, more than four children in the family, multiple residential moves in the past year, and teenage motherhood (Evans et al., 2013). However, when

predictors are grouped into an index it prevents determining the effects of specific predictors and if interactions exist among them (Evans et al., 2013). Still, cumulative risk indexes are found to have pervasive effects on development, including deleterious effects on IQ, achievement, language skills, and self-regulation, and increases in externalizing problems (Evans et al., 2013; McClelland & Wanless, 2012; Obradovic et al., 2010; Sameroff et al., 1987).

The current dissertation studies attempt to better understand how predictors relate to child and family characteristics (and child health at birth for study I) are associated with children's cognitive and behavioral development in a predominantly low-income sample. Low maternal educational attainment, ethnic minority status, English Language Learner status, and low birth weight are some specific predictors that have been found to be related to lower academic achievement in childhood (e.g., Anderson, Doyle, & Victorian Infant Collaborative Study Group, 2003; Aylward, 2003; Beck & Muschkin, 2012; Kieffer, 2008; McClelland & Wanless, 2012; Rauh et al., 2013). Additionally, gender (i.e., being male), economic hardship, low maternal educational attainment, and single motherhood have been found to be related to greater externalizing problems in childhood (Ackerman et al., 1999; Bongers et al., 2004; Conger et al., 2000; Criss et al., 2002; Moffitt & Caspi, 2001; Vazsony & Keiley, 2007). The current dissertation studies examine the influence of these factors early in children's lives (i.e., roughly the time of children's births) on their later academic achievement and externalizing behaviors in a low-income sample.

Early Care and Education. For children living in low-income families, federal and state programs (e.g., Early Head Start, Head Start) have been designed to address

some of the school readiness gaps related to cognitive and behavioral development. In general, there are reported beneficial effects of early care and education programs (e.g., EHS, Head Start, prekindergarten) on children's early cognitive abilities, potentially with the strongest effects in more disadvantaged populations (e.g., Ayoub, Vallotton, & Mastergeorge, 2011; Camilli, Vargas, Ryan, & Barnett, 2010; Lee et al., 2014; Magnusson et al., 2007; Zhai, Brook-Gunn, & Waldfogel, 2011). However, the effects of early care and education programs on children's early behavioral problems are mostly mixed, with some beneficial effects reported (Camilli et al., 2010; Zhai et al., 2011) and some negative effects reported (Lee et al., 2014; Magnusson et al., 2007; Zhai et al., 2011).

The current dissertation studies use data from the EHSRE, which evaluated the program effects of EHS from 1996 through 2010 (US DHHS ACF, 1996-2010). EHS is a federally funded program designed to serve low-income families with children up to three years old (Love et al., 2005; USDHHS, 1995). Programs vary in their delivery of supports, but are required to provide high-quality child development services through home visits, childcare, case management, parenting education, health care and referrals, and family supports (USDHHS, 1995). The effects of the EHS intervention on children's development at the three-year-old and five-year-old follow-ups (including cognitive and behavioral domains) have been systematically and comprehensively tested from deductive approaches (e.g., Ayoub et al., 2011; Love, Chazan-Cohen, Raikes, & Brooks-Gunn, 2013; Love et al., 2005). The impacts of EHS when children were three years old included improved cognition, vocabulary, and engagement during play, fewer aggressive behaviors, and more supportive parenting behaviors (e.g., reading more to children, less

spanking) for children in the EHS group compared to children in the control group (Love et al., 2005).

When children were five years old (i.e., prekindergarten wave), the initial beneficial effects of EHS were attenuated but maintained for some meaningful outcomes. Key significant EHS impacts included better approaches to learning and observed attention, fewer social behavioral problems, and more positive home learning environments (e.g., reading to child) for children in the EHS group compared to children in the control group (Love et al., 2013). Moreover, growth curve analyses suggest the early beneficial effects of EHS on children's cognitive abilities and lower aggressive behaviors largely persisted through age five (Love et al., 2013).

Multiple factors associated with early care and education (e.g., EHS, Head Start attendance) can influence children's academic achievement and externalizing behaviors beyond the effects of economic hardship. The current dissertation studies seek to add to this literature in two specific ways. First, the previous research on the intervention effects of EHS have not used inductive analyses, and therefore have not been able to detect unforeseen subgroup effects for EHS using a sequential partitioning approach. Second, past research has not reported on the effects of EHS on children's cognitive and behavioral outcomes at 5th grade. For Study I, the inductive models will help identify if the associations between the early care and education variables and academic achievement are conditionally dependent on other early life predictors (e.g., economic hardship, ethnicity). For Study II, the logistic regression model will test if early care and education variables have significant effects on externalizing problems at 5th grade while controlling for other predictors; whereas, the sequential partitioning model will identify if

there are subgroup specific associations between early care and education variables and externalizing problems at 5th grade.

Connections between Early Skills and Later Outcomes. In addition to economic hardship, child and family characteristics, and early care and education, there are strong associations between early cognitive skills and later academic achievement (e.g., Duncan et al., 2007; McClelland et al., 2013), and between early behavioral problems and later externalizing problems (e.g., Bongers et al., 2004; Vazsonyi & Keiley, 2007). For example, research shows that early math skills, followed by reading and attention skills, are predictive of later math and reading performance, even after accounting for effects related to socio-economic status (Duncan et al., 2007). Additionally, other work has shown strong longitudinal associations between children's early math and reading skills with their later math and reading skills (McClelland et al., 2013). Likewise, children's early aggressive, disruptive, and hyperactive behaviors are associated with later problem behaviors (Bongers et al., 2004; Campbell et al., 2000; Vazsonyi & Keiley, 2007). Therefore, for both academic achievement and externalizing problems, strong links between children's early and later abilities are expected even after accounting for effects associated with early life predictors. The importance of early skills for later skills is easily understood through the *skills beget skills* theory of human capital (Heckman, 2000). That is, children's early cognitive and behavioral skills lay the foundation for future development in these domains.

Although previous research has shown the importance of early skills for later skills, questions about which early skills are most important still remain. Study I explores which of the prekindergarten academic achievement skills (i.e., math, reading,

and vocabulary) are most related to 5th grade academic achievement (i.e., math reading, and vocabulary). Furthermore, it explores if any of the relations between prekindergarten academic skills and children's 5th grade academic achievement are different depending on the specific subgroups created by the early predictors (i.e., roughly the time of the child's birth) in the inductive analyses. Study II looks at how early behavioral problems (i.e., aggression, hyperactivity, and withdrawal) relate to children's 5th grade externalizing problems in deductive (i.e., logistic regression) and inductive (i.e., SEARCH) models. In the logistic regression model, the effects of early behavioral problems are estimated while statistically controlling for early predictors (i.e., roughly the time of the child's birth). In the SEARCH model, the effects of early behavioral problems are conditional on the previously selected splits among the early predictors. In other words, early aggression could be more closely associated with externalizing problems at 5th grade in some subgroups (e.g., males) than in other subgroups (e.g., females).

Brief Overview of Study I

The first dissertation study fills an important gap in the literature by using inductive analyses to explore how factors collected around the time of the child's birth, including family income and needs, child and family characteristics, child health, and early care and education, relate to children's academic achievement in prekindergarten and 5th grade. A number of previous studies have shown that these early predictors are associated with later academic achievement (Dubow & Ippolito, 1994; Duncan et al., 1994; Duncan et al., 1998; Evans et al., 2013; Koregnman et al., 1995; McLoyd, 1998); however, this study is the first to use inductive sequential partitioning analyses to explore how early predictors relate to later academic achievement in a low-income sample. Study

I has three complementary research objectives to further the literature. First, the study identifies predictive patterns among early life predictors (i.e., roughly the time of the child's birth) for prekindergarten math, literacy, and vocabulary performance. Second, it identifies predictive patterns among early life factors and prekindergarten academic skills for children's 5th grade math, literacy, and vocabulary. Third, it tests for subgroup effects of EHS on children's academic achievement created by the sequential partitioning analyses.

Brief Overview of Study II

The second dissertation study contributes to the current literature on how economic hardship, child and family characteristics, early care and education, and early behavioral problems relate to children's 5th grade externalizing problems. The study is rooted in previous research on how economic hardships and demographic risk factors relate to externalizing problems throughout childhood (e.g., Conger et al., 2000; Conger et al., 2002; McLoyd, 1998; Moffitt & Caspi, 2001). This study is the first to study behavioral problems with both deductive (i.e., logistic regression model) and inductive (i.e., sequential partitioning model) analyses. The analyses show how early predictors (i.e., from roughly the time of child's birth and prekindergarten year) are associated with the likelihood of externalizing problems at 5th grade from two different analytical approaches.

Taken together, these dissertation studies fill gaps in the current literature by using inductive, sequential partitioning analyses to better understand early predictors of cognitive and behavioral development for children in low-income families. Specifically, both of the studies examine how predictors from roughly the time of the child's birth and

prekindergarten year contribute to their cognitive and behavioral development. Study I uses multiple, inductive analyses to identify patterns in the raw data for children's prekindergarten and 5th grade academic achievement. Study II uses deductive and inductive analyses to better understand how early predictors relate to children's 5th grade externalizing problems. By exploring which early predictors are most related to later academic achievement and externalizing problems, and for which subgroups of children, programs and interventions can hopefully target children at greatest risk for low academic achievement and for externalizing problems.

Predictive Patterns of Academic Achievement for Children in Low-Income Families

Robert J. Duncan

Oregon State University

Author Note

Robert J. Duncan, College of Public Health and Human Sciences, Oregon State University.

Correspondence concerning this article should be addressed to Robert J. Duncan, Oregon State University, 410 Waldo Hall, Corvallis, OR 97331, E-mail: duncarob@onid.oregonstate.edu.

Abstract

Many early life factors, such as family income and needs, child and family characteristics, child health at birth, and early care and education, are predictive of children's academic achievement. Moreover, research shows that children's early academic skills are strong predictors of later academic achievement. Using inductive, sequential partitioning analyses, the current study explores the effects of early life factors (i.e., roughly the time of the child's birth) on prekindergarten and 5th grade academic achievement in a low-income sample. The study also explores subgroup effects of Early Head Start (EHS) based on the sequential partitioning analyses. The models revealed three key findings. First, much of the explained variance in prekindergarten academic achievement was accounted for by children's ethnicity and maternal educational attainment. However, by 5th grade, ethnicity explained substantially more variance than maternal educational attainment in children's academic achievement. Second, common-domain skills (e.g., early math for later math) explained much of the link for 5th grade math and vocabulary performance. However, early math and vocabulary skills, and not early literacy, were predictive of 5th grade literacy. Third, EHS was a selected split in the prekindergarten vocabulary model, where it had a beneficial effect for a subgroup of children (i.e., Black/Hispanic, relatively lower levels of maternal educational attainment, and not in deep poverty), but it was not selected in any other model. Subgroup analyses of EHS effects (i.e., based on the sequential partitioning approach) showed mostly non-significant results across all models. Findings contribute to the current literature on early predictors of academic achievement in a low-income sample through a *model discovery* approach that complements previous *model testing* approaches.

Predictive Patterns of Academic Achievement for Children in Low-Income Families

Children experiencing multiple risk factors early in life, especially those related to poverty, are more likely to fall behind their peers in academic skills and experience widening achievement gaps during the school years (Blair & Diamond, 2008; Brooks-Gunn, Duncan, & Maritato, 1997; Duncan & Brooks-Gunn, 2000; Duncan & Magnusson, 2011; Evans, Li, & Whipple, 2013; Reardon, 2011). If policies and programs hope to address academic achievement gaps related to poverty, it is critical that researchers understand early antecedents of academic success. Risk factors that have been associated with academic achievement are diverse, but typically interrelated, such as a lack of access to resources, minority ethnicity status, maternal educational attainment, single or teen motherhood, and poor mother or child health (e.g., Bradley & Corwyn, 2002; Duncan & Magnusson, 2005; Evans et al., 2013). Although the effects of many specific and cumulative risk factors have been well documented through deductive analytical approaches, a noticeable gap exists for inductively exploring predictive patterns of these factors on children's academic achievement. To address this gap, the current study uses inductive, sequentially partitioning analyses based on the explained variance of selected splits among predictors (i.e., SEARCH; Sonquist, Baker, & Morgan, 1974). This approach complements analyses of *model testing* by using the raw data for *model discovery*, which then can inform future hypothesis-driven approaches (Morgan, 2005). Using a sample of children and families who were eligible for Early Head Start (EHS), the current study uses inductive analyses to better understand how early life factors relate to children's prekindergarten and 5th grade math, literacy, and vocabulary performance.

Furthermore, subgroup effects of EHS are tested (i.e., based on the sequential partitioning models) to determine if EHS has impacts for specific subgroups of children.

The Importance of Early Experiences for Children's Academic Success

Children who experience poverty have developmental trajectories influenced by distinct, but interrelated, factors (Duncan & Brooks-Gunn, 1995; Shonkoff & Phillips, 2000). Understanding the influence of these factors on children's academic trajectories is important given that academic success can have profound impacts on their life opportunities. For instance, children with greater academic skills have an increased likelihood of college completion (Buchmann & DiPrete, 2006; Perna, 2005). For children in low-income contexts, boosting academic success and the likelihood of college completion could be one way of helping individuals break the cycle of poverty. For example, the value of a college degree, compared to a high school degree, is worth nearly \$60,000 per year in the U.S., which is almost double its value from three decades ago (Autor, 2014). Thus, it is critical that researchers understand what precipitates academic success for children in low-income contexts if programs and interventions are going to be more targeted. The current study seeks to add to the current literature on understanding early predictors of children's academic achievement by complementing previous deductive approaches with an inductive, sequential partitioning approach (i.e., *model discovery*) (Morgan, 2005). That is, the inductive models will show which predictors are most related to gaps in academic achievement and which predictors help offset gaps. The study accomplishes this by sequentially partitioning the data based on which splits among the predictors explain the most variance in children's academic achievement at prekindergarten and 5th grade.

Complementary Role of Inductive Analyses for Theoretical Development

The bioecological model, which specifies that multiple factors influence human development through the synergistic interdependencies of *process*, *person*, *context*, and *time*, informs the current study (Bronfenbrenner & Morris, 2006). In other words, the effects of person-level predictors (e.g., prekindergarten academic skills) on later success are likely dependent on contexts (e.g., family income, maternal educational attainment), and though not modeled in the current study, also dependent on processes (e.g., mother-child interactions) and timing. Given that developmental science is in a relatively early stage of its existence, statistical analyses using the *mode of discovery* (i.e., hypothesis-generating) versus the *mode of verification* (i.e., hypothesis-testing) are important for identifying potential context-dependent influences (Bronfenbrenner & Morris, 2006). That is, models using hypothesis tests to obtain estimated effects for predictors by controlling for other relations are considered inadequate because of the likelihood of dependencies among predictors. The current study uses this theoretical perspective and aims to contribute to the current literature on the effects of early life predictors on children's academic achievement through a sequential partitioning analysis (i.e., all effects, except the initial partition, are conditionally dependent on previous partitions).

Inductive analyses can be used to complement deductive analyses in order to gain a deeper understanding about human development. Deductive analyses focus on *model testing*, which includes hypothesized models and statistical testing of effects. For example, does ethnicity have a significant effect on academic achievement while statistically controlling for family income and maternal educational attainment? Conversely, inductive analyses can be used for *model discovery*, looking for patterns

among the observed data in order to gain information regarding the structure of influence from a set of predictors.

The current study uses an inductive analysis of sequentially splitting the data on a set of predictors until no substantial variance in the outcome (e.g., prekindergarten math) can be explained. Once the process is complete, the effects of the selected splits among predictors on the outcome are examined. For scientific inquiry, inductive approaches complement deductive approaches by learning from the data instead of using the data to test hypotheses. Findings are connected back to previous research and used to create new hypothesis-testing statistical models. In a review of potential mechanisms linking socio-economic status and child well-being, Bradley and Corwyn (2002) suggest that future models need to account for how multiple factors interact in order to better understand how socio-economic status contributes to children's development. The current study provides insight on this issue by exploring predictive patterns based on sequentially partitioning data of early life predictors on later academic achievement in a low-income sample.

The SEARCH Approach for Identifying Predictive Patterns. The current study uses the SEARCH method, which is an enhanced version of the original Automatic Interaction Detector (Morgan, 2005; Sonquist et al., 1974). The objective of SEARCH is to identify how multiple predictors relate to an outcome in a large dataset. This is accomplished by a sequential partitioning process of selecting the most optimal split within the predictors based on the explained variance in the outcome (Morgan, 2005). That is, the model will test all potential splits within predictors to find which is most explanatory of the outcome (e.g., prekindergarten math). Once a split has been selected,

all potential splits within predictors are then tested again to determine which is the most optimal for each subgroup created by the previous split. Through this iterative process, the final output resembles a tree, with branches that are defined by splits on the selected variables. These analyses are more generally referred to as decision trees, or classification and regression trees (CART; Hastie, Tibshirani, & Friedman, 2009).

The SEARCH analyses are simple and straightforward, yet yield complexity in the output. SEARCH is simply performing tests of variance (i.e., t-test or ANOVA) for all possible splits within the predictors, selecting the split that explains the most variance in the outcome, and repeating the process on the two new subgroups independently (for a review, see Sonquist et al., 1974). Model saturation is determined by the model constraints, which are subjectively determined by the researcher depending on the study objectives. SEARCH is particularly useful for identifying predictive patterns when multiple grouping variables exist (e.g., gender, ethnicity) as in the current study. However, in order for the models to be meaningful, theoretically important predictors need to be available for the model development.

Early Predictors of Academic Achievement

Numerous studies have found that early factors in children's lives, especially those associated with poverty, are strong predictors of later academic achievement (e.g., Brooks-Gunn et al., 1997; Dubow & Ippolito, 1994; Duncan & Brooks-Gunn, 2000). Family income has emerged as a particularly robust predictor of academic achievement and is also associated with multiple processes that can affect development (e.g., home-learning environment, access to high quality childcare) (Bradley & Corwyn, 2002; Duncan & Magnusson, 2005; McLoyd, 1998). Therefore, within a sample of children

from predominantly low-income households, the current study explores how predictors from previously identified important domains relate to children's academic achievement (i.e., family income and needs, child and family characteristics, child health at birth, and early care and education).

Family Income and Needs. The effects of family income on academic achievement are important to understand given the disproportionately high percentage of young children living in poverty. In 2013, nearly half of all young children in the U.S. lived in families with incomes less than 200% of the poverty line and 40% of young black children lived in families with incomes less than 100% of the poverty line (Center for Law and Social Policy, 2014). Research suggests that children who experience poverty early in life and chronically show the most deleterious effects of poverty on their cognitive development (Dubow & Ippolito, 1994; Duncan, Brooks-Gunn, & Klebanov, 1994; Duncan, Yeung, Brooks-Gunn, & Smith 1998). These deleterious effects are likely driven by the disproportionately higher number of hardships children in poverty experience, such as lower maternal educational attainment, single or teen motherhood, unemployed parents, low quality neighborhoods, higher numbers of siblings, residential instability, fewer children's books in the home, and poorer health (Duncan & Magnusson, 2005). However, even after accounting for many of these specific factors, the overall deleterious effects of early and chronic poverty remain significantly related to children's academic achievement (Dubow & Ippolito, 1994; Duncan et al., 1994; Korenman, Miller, & Sjaastad, 1995; Petterson & Albers, 2001).

There are multiple indicators of financial hardship beyond family income. For example, welfare receipt is a societally determined need for additional financial help.

Welfare policies that improve family income in early childhood suggest mostly positive effects on children's academic achievement (Clark-Kauffman, Duncan, & Morris, 2003; Duncan, Morris, & Rodrigues, 2011). However, when there is no manipulation of welfare receipt (i.e., randomly assigning families to improve income), it could be an indicator of higher, or more chronic, levels of financial need. It is also possible that more important than reported family income or welfare receipt is a family's perception of whether or not they have adequate access to resources to address their needs. For example, regardless of family income or welfare receipt, a family could subjectively feel as though they have inadequate access to resources such as money, food, or housing.

The current study uniquely contributes to this previous literature by inductively exploring the effects of family income and needs on children's prekindergarten and 5th grade academic achievement within a predominantly low-income sample (Clark-Kauffman et al., 2003; Dubow & Ippolito, 1994; Duncan et al., 1994; Duncan et al., 2011; Korenman et al., 1995; Petterson & Albers, 2001). Based on previous research it is unclear how different variables related to economic hardship will emerge in the inductive models predicting children's academic achievement within a low-income sample. Furthermore, the inductive analyses can complement previous findings on the effects of economic hardship by exploring how these predictors emerge in inductive models while simultaneously considering other potentially influential predictors (e.g., child and family characteristics).

Child and Family Characteristics. In addition to family income and needs, child and family characteristics have been found to have unique effects on children's cognitive development (Evans et al., 2013; McClelland & Wanless, 2012; Obradovic et

al., 2010; Sameroff et al., 1987). Child and family characteristics are sometimes grouped into cumulative risk indexes, consisting of variables such as ethnic minority status, English Language Learner status, more than four children in the family, parents with low educational attainment, multiple residential moves in the past year, teenage or single motherhood, and parents who are unemployed (Evans et al., 2013). The effects of cumulative risk indexes on aspects of cognitive development include deleterious effects on academic achievement, IQ, language skills, and self-regulation (e.g., Evans et al., 2013; McClelland & Wanless, 2012; Obradovic et al., 2010; Sameroff et al., 1987). Although cumulative risk indexes are important predictors of cognitive development, aggregating risks together can prevent determining the influence of specific predictors, and conditional effects among predictors, that comprise the cumulative risk index (Evans et al., 2013).

Ethnic minority status, maternal educational attainment, and English Language Learner status are a few specific child and family characteristics that have been consistently linked to academic achievement (e.g., Beck & Muschkin, 2012; Duncan & Magnusson, 2005; Farkas, 2003; Hill & Craft, 2003; Kieffer, 2008). For example, children who are Black or Hispanic (compared to peers who are White) are found to have significantly lower academic achievement even after accounting for other demographic and school characteristics (Beck & Muschkin, 2012; Farkas, 2003). Moreover, after accounting for socio-economic status, persistent deficits on reading performances have been found throughout elementary school for English Language Learners who enter kindergarten with limited English proficiency (Kieffer, 2008). However, it is important to consider that much of the link between ethnic minority status and academic

achievement could be driven by confounding effects related to socio-economic status (Duncan & Magnusson, 2005). For example, within a low-income sample, ethnicity was not a significant predictor of children's 3rd grade reading performance, yet single parenthood, lower maternal education, and low birth weight were all related to lower reading scores (Rauh et al., 2003). By including multiple child and family characteristics (e.g., gender, ethnicity, family size, residential mobility), the current study attempts to unpack the effects of these predictors on academic achievement for children in low-income contexts. However, it is also important to consider the effects of child's health at birth for later academic achievement (Aizer & Currie, 2014).

Child Health at Birth. A child's health at birth includes a diverse set of related factors, such as birth weight, premature birth status, and health concerns. Birth weight is a commonly used predictor of children's early health, with higher rates of low birth weight among mothers of ethnic minority status and of lower socio-economic status (Aizer & Currie, 2014; Reichman, 2005). Notably, a child's health at birth has been connected with later academic success. For example, low birth weight is associated with lower cognitive skills later in childhood (Anderson, Doyle, & Victorian Infant Collaboration Study Group, 2003; Aylward, 2003; Rauh et al., 2003). The current study explores if predictors related to children's health at birth are selected in the sequential partitioning analyses while considering the influence of other early predictors.

Early Care and Education. Federal and state programs (e.g., Early Head Start, Head Start) have been designed to address some of the school readiness gaps for children living in low-income contexts. For example, Head Start attendance is associated with improvements on children's early academic skills when using propensity score models

(Lee et al., 2014). Additionally, quality preschool programs are found to significantly improve cognitive skills, with effects potentially strongest for children from disadvantaged backgrounds (Camilli, Vargas, Ryan, & Barnett, 2010; Magnuson, Ruhm, & Waldfogel, 2007). In the earliest years of children's lives, Early Head Start enrollment has also been shown to promote both parenting and children's skills (i.e., language and self-regulation; Ayoub, Vallotton, & Mastergeorge, 2011).

Early Head Start. Early Head Start (EHS) is a federally funded program designed to serve low-income families with children up to three years old (Love et al., 2005). Programs vary in their delivery of supports, but are required to provide high-quality child development services through home visits, childcare, case management, parenting education, health care and referrals, and family supports (USDHHS, 1995). The effects of the EHS intervention study on three-year-old and five-year-old outcomes have been systematically and comprehensively tested from deductive approaches (Love, Chazan-Cohen, Raikes, & Brooks-Gunn, 2013; Love et al., 2005). When children were three-years-old, children in the EHS group performed better on cognition, vocabulary, and attention/engagement during play compared to the control group (Love et al., 2005). At age five, the beneficial effects of EHS were attenuated but maintained for some meaningful outcomes. Key significant effects included children in the EHS group having better approaches to learning and observed attention, with more positive home learning environments compared to the control group (e.g., reading to the child) (Love et al., 2013).

In addition to the main effects of EHS, group-specific effects have been studied from deductive approaches. When children were three years old, EHS programs that

implemented a mixed-based approach (combination of home- and center-based care) had more beneficial effects on children's vocabulary, parents reading to children daily, and attention/engagement during play compared to home- or center-based care alone (Love et al., 2005). However, when children were five-years-old, the program type (home-, mixed-, or center-based) did not play a moderating role for EHS effects (Love et al., 2013). At age five, EHS had generally more beneficial impacts on African American children's performance on cognitive measures (compared to Whites and Hispanics; Love et al., 2013). In sum, previous studies on the impact of EHS on prekindergarten cognitive outcomes show some evidence of subgroup-specific effects. Inductive analyses on the effects of EHS can complement this work by identifying if subgroup effects emerge based on the sequential partitioning analyses. That is, EHS can be a selected split in any model if it explains more variance than other possible splits among early life predictors and if it meets the model selection criteria. Furthermore, all final subgroups based on sequential partitioning analyses for each outcome are tested for EHS effects. Thus, the current study seeks to identify if any unforeseen subgroup effects exist for EHS on children's prekindergarten and 5th grade academic achievement. When trying to determine if Head Start has impacts on children's development, researchers have asked, "compared to what?" (Lee et al., 2014). The current study focuses on exploring the effects of EHS by asking the questions: *does EHS explain more variance in academic achievement than other early predictors? And, does EHS have a significant effect on subgroups of children defined by the sequential partitioning models?"*

Effects of Early Academic Skills on Later Academic Achievement

In addition to family income and needs, child and family characteristics, child health at birth, and early care and education, early academic skills are strong predictors of later academic achievement. For example, research shows early math skills, followed by reading and attention skills are predictive of later academic achievement, even after accounting for effects related to socio-economic status (Duncan et al., 2007). Moreover, strong longitudinal associations are found between children's early math and reading abilities with later math and reading performance (McClelland et al., 2013). Therefore, it is expected there will be strong links between children's prekindergarten academic skills and 5th grade academic achievement, even after the models account for variance related to early life predictors. The importance of early academic skills for later skills is easily understood through the *skills beget skills* theory of human capital (Heckman, 2000). That is, children's early academic skills lay a foundation for future academic achievement. The current study uses inductive analyses to explore these relations by identifying which early academic skills (i.e., the child's prekindergarten year) emerge in the 5th grade academic achievement models. Furthermore, they explore if the effects of early academic skills on 5th grade academic achievement differ for subgroups created by the sequential partitioning approach of early predictors collected around the time of the child's birth (i.e., family income and needs, child and family characteristics, child health at birth, and early care and education).

The Current Study

The current study fills an important gap that exists in the literature by using inductive, sequential partitioning analyses to explore how early life predictors (i.e., collected around the time of the child's birth) relate to children's prekindergarten and 5th

grade academic achievement. The early life predictors include family income and needs (e.g., depth of poverty), child and family characteristics (e.g., gender, ethnicity, maternal educational attainment), child health at birth (e.g., low birth weight), and early care and education (e.g., EHS), within a large sample of children in low-income families (i.e., eligible for EHS at the baseline of the study). The study has three complementary research objectives. First, it identifies predictive patterns among early life predictors for children's math, literacy, and vocabulary at prekindergarten. Second, it identifies predictive patterns among early life predictors and prekindergarten academic skills for children's math, literacy, and vocabulary at 5th grade. Third, the study tests for subgroup effects of EHS on academic achievement created by the sequential partitioning analyses. Hypotheses are not included in this type of analysis because the models are inductive (i.e., data-driven) and create potentially complex conditional effects (i.e., except for the first split, all splits among the selected predictors are conditional on previous splits).

Method

Early Head Start Research and Evaluation Study

Data were used from the Early Head Start Research and Evaluation Study (EHSRE), which are archived through the Inter-University Consortium for Political and Social Research. The EHSRE was a federally funded study through the Administration for Children and Families (ACF), within the Department of Health and Human Services (DHHS), and it evaluated the effects of Early Head Start (EHS) (data collection lasted from 1996 to 2010; US DHHS ACF, 1996-2010). Children and families were recruited from roughly the time of the child's birth and were randomly assigned to an EHS program or a comparison group. Children and families were followed through the child's

5th grade year (roughly 10 years after baseline). Data were collected from 17 different sites across the U.S. and primarily included families and children living in poverty. Although the 17 sites were not a random sample, they were chosen based on their representativeness of the types of EHS programs at the time and the ability to over-recruit enrollment by more than double (Love et al., 2005). The EHS programs were delivered to parents and children and lasted up until the child was three years old. Previously published work has provided a detailed report on the EHSRE methods and the EHS program effects through the child's prekindergarten year (ACF, 2002a; ACF, 2002b; Love et al., 2013; Love et al., 2005).

Measures

All models included twenty-four categorical variables and one continuous variable from the baseline of the study collection period (i.e., time of EHS randomization and roughly the time of the child's birth). One categorical variable (reported Head Start attendance) collected at the time of the prekindergarten wave was also included in all models. The four domains of *family income and needs*, *child and family characteristics*, *child health at birth*, and *early care and education* were represented by these 26 variables.

Family Income and Needs. At baseline, family income and needs were assessed with self-reported income, welfare receipt, and a family needs assessment. Self-reported income divided by the poverty line for the given year was used for assessing the depth of poverty the family was experiencing (coded into categories of less than 50% of the poverty line; less than 100% of the poverty line; less than 200% of the poverty line; more than 200%). Welfare receipt included two variables. First, self-reported receipt of Aid to

Families with Dependent Children (AFDC) was used. Second, a cumulative index of whether the family reported receipt of Medicaid, Food Stamps, Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Supplemental Security Income (SSI), and Public Housing (coded into categories of 0 or 1 received; 2 or 3 received; 4 or 5 received). Family needs were assessed with a cumulative index of whether the family reported having inadequate food, housing, money, medical care, transportation, and support from families and friends (0 reported; 1 reported; 2 or more reported), with higher values representing greater inadequacies in resources.

Child and Family Characteristics. At baseline, child and family characteristics included the child's gender, ethnicity, age of the child (coded as not born; first 6 month of life; older than 6 months of life), whether or not English was the primary language in the household, maternal educational attainment (coded as less than high school; high school equivalency; or more than high school), maternal occupational status (coded as employed; in school; or neither), maternal age, home living arrangements (coded as the mother living with the husband; with other adults; or single), number of adults in the household (coded as one; two; or more than two), whether or not the focus child was the first born, number of children in the household under 5 years old (coded as none; one; or more than one), number of children in the household between 6 and 17 years old (coded as none; one; or more than one), and residential moves in the past year (coded as none; one; or more than one).

Child Health at Birth. At baseline, child health indicators included whether or not the child had a low birth weight (less than 2500 grams), whether or not the child was born more than three weeks early, whether or not the child stayed in the hospital at birth,

whether or not the child was covered by health insurance, and whether or not there were concerns about the child's health and development.

Early Care and Education. At baseline, early care and education variables included whether or not the child was randomly assigned to an EHS program, the program type (coded as center care; home care; or mixed care), and whether or not the mother had previous experiences with EHS, Head Start (HS), or similar developmental program. Additionally, from the prekindergarten wave, whether or not the child ever attended Head Start was included.

Prekindergarten Academic Achievement. Three variables were used to assess children's prekindergarten academic achievement. Each of these variables were recoded into quartiles when used as independent variables in the models predicting 5th grade academic achievement. Quartiles, as opposed to continuous indicators, were used to reduce complexity for the sequential partitioning analyses, but also to provide more qualitative and substantive interpretations (e.g., child scored in the bottom 25th percentile versus the top 75th percentile). Prekindergarten math and literacy were assessed with subtests from the Woodcock-Johnson Psycho-Educational Battery-III Tests of Achievement or the Bateria III Woodcock-Muñoz (Woodcock & Johnson, 1990; Woodcock & Muñoz-Sandoval, 1996). Prekindergarten math was measured using the standard score of the Applied Problems subtest, which assesses children's ability to do basic arithmetic and counting problems. The Applied Problems subtest was parallel across English- and Spanish-speaking children and had an α of .85 in the EHSRE sample (Love et al., 2013). Prekindergarten literacy was measured using the standard score of the Letter-Word Identification subtest, which assesses children's ability to recognize

letters and words. For the Letter-Word Identification subtest, the α was .84 for English speaking children and .96 for Spanish speaking children in the EHSRE sample (Love et al., 2013). Vocabulary was measured using the standard score on the Picture Peabody Vocabulary Test-III (PPVT-III) or the Test de Vocabulario en Imagenes Peabody (TVIP) (Dunn & Dunn, 1997; Dunn, Padilla, Lugo, & Dunn, 1986), which assesses children's receptive vocabulary by pointing to a picture that represents the spoken word. The PPVT-III had an α of .96 and the TVIP had an α of .96 in the EHSRE sample (Love et al., 2013).

5th Grade Academic Achievement. Three variables were used to assess children's 5th grade academic achievement. The prekindergarten math and literacy assessments were replaced with more age appropriate assessments developed for the U.S. Department of Education's Early Childhood Longitudinal Study, Kindergarten Class of 1998-1999 (ECLS-K). Math was measured with the ECLS-K math routing score and literacy was assessed with the ECLS-K language/literacy IRT scale score (Pollack, Najarian, Rock, & Atkins-Burnett, 2005; Princiotta, Flanagan, & Germino-Hausken, 2006). The ECLS-K math routing score assesses children's ability to solve math problems, such as simple multiplication and division. The ECLS-K math routing score had a reliability of $\theta = .94$ and was correlated with teacher scores at .65 (US DHHS ACF, 1996-2010). The ECLS-K language/literacy IRT scale score assesses children's reading and comprehension skills. The ECLS-K language/literacy IRT scale score had a reliability of $\theta = .94$ and was correlated with teacher scores at .63 (US DHHS ACF, 1996-2010). Vocabulary was measured using the PPVT-III standard score, which assessed children's receptive vocabulary by pointing to a picture that represents the

spoken word (Dunn & Dunn, 1997). The PPVT-III in a norming sample had $\alpha = .95 - .96$, split half reliabilities = $.94 - .95$, and test-retest reliabilities $.88 - .89$ (US DHHS ACF, 1996-2010). Reliabilities were not provided for the current sample and item level data were not available in the public dataset.

Analytic Plan

All models used the SEARCH analytical method in Stata 12.1 (StataCorp., 2011). Each model included all of the early life predictors as possible splits for selection in the analyses. Due to the longitudinal nature of the data, variables collected at the baseline wave were given first priority in determining each split in the models (i.e., if an early life predictor satisfied the model selection criteria it was selected). For both prekindergarten and 5th grade academic achievement, reported Head Start attendance was given second priority (i.e., only selected if no baseline variable could satisfied the model selection criteria). For the 5th grade academic achievement models, prekindergarten academic skills were given the third priority (i.e., they were only selected when no early life predictor or Head Start attendance satisfied the model selection criteria). All missing values on categorical variables are coded as a category and treated as nominal. Therefore, only cases that were missing data on maternal age at the baseline of the study were deleted as a result of missingness on the predictors (less than 0.2% for all outcomes).

In the sequential partitioning analyses, splits were chosen based on which split (among all possible splits in the data) explained the most variance in the outcome. All of the prekindergarten academic achievement models employed selection criteria of each split needing to explain at least 0.40% of the variance in the dependent variable (based on

the optimal split within a predictor) and resulting in a minimum group size of at least 25 children in each group created from the split. All of the 5th grade academic achievement models employed selection criteria of at least 0.80% explained variance in the dependent variable (based on the optimal split within a predictor) and a minimum group size of at least 25. These selection criteria were chosen subjectively, but strategically, as selecting low criteria (e.g., 0.10% explained variance) results in complex models with limited interpretability and an increased probability of capitalizing on chance. P-values were not used as selection criteria, though all selected splits were significant at $p < .01$ in the prekindergarten models and at $p < .001$ for 5th grade models. All models resulted in between 9 and 13 final groups, providing a balance between potentially over-fitting the data (e.g., too many groups) and under-fitting the data (e.g., too few groups). Finally, all final subgroups from the partitioning models were tested for the effects of EHS with t-test analyses (i.e., treatment versus control for the final subgroup). This was done to test if EHS had subgroup effects created by the partitioning models. It is possible that EHS could have significant effects but would not be selected because it did not meet the selection criteria (based on explained variance and final subgroup size constraints). All models are presented as tree diagrams, displaying the selected variable and its explained variance in the top box, with two boxes below representing the split in categories for the selected predictor. Grey boxes distinguish when no predictor satisfied the selection criteria.

Results

Descriptive statistics for predictors included in the SEARCH models are presented in Table 2.1. All predictors were categorical, with the exception of maternal

age at the baseline. Descriptive statistics for each of the six outcome variables (three prekindergarten and three 5th grade) are presented in Table 2.2.

(Insert Table 2.1)

(Insert Table 2.2)

Predictive Patterns for Prekindergarten Academic Achievement

Prekindergarten Math. Early life predictors (i.e., from roughly the time of the child's birth) accounted for 13.5% of the variance in prekindergarten math and resulted in 9 final subgroups of children (see Figure 2.1). The split among the predictors explaining the most variance in the overall sample was ethnicity ($R^2 = 5.86\%$). That is, children who were White or other performed roughly 10 points better than children who were Black or Hispanic, which is equivalent to nearly half a standard deviation difference ($d = .49, p < .001$). After the initial split on ethnicity, all additional splits were conditional on ethnicity. Maternal educational attainment was the next selected split that explained the most variance in prekindergarten math for both subgroups of children ($R^2 = 1.58\%$ and 1.83%). A few unanticipated findings also emerged from the model. First, no early predictor satisfied the SEARCH criteria beyond maternal educational attainment for children who were White or other, despite sample sizes of 552 and 226 in these subgroups (i.e., no other split in an early life predictors explained more than 0.40% variance in prekindergarten math and provided subgroups of at least 25 children). Second, for a subgroup of children whose mothers had less than a high school degree, children whose mothers were younger than 22 at baseline (i.e., roughly the time of the focus child's birth) performed better on math compared to a subgroup of children whose mothers were older than 22 at baseline. Third, the cumulative family needs variable did

not split in an additive way (i.e., reporting none or multiple was worse than reporting one). Subgroup analyses testing for EHS program effects did not reveal significant results on children's prekindergarten math.

(Insert Figure 2.1)

Prekindergarten Literacy. Early life predictors accounted for 13.3% of the variance in prekindergarten literacy and resulted in 13 final subgroups of children (see Figure 2.2). Prekindergarten literacy was the only outcome where maternal educational attainment, and not ethnicity, was the first selected split ($R^2 = 3.85\%$). That is, children with mothers who had a high school degree or more performed roughly five points better than children with mothers who had less than a high school degree ($d = .39, p < .001$). Notably, for the subgroup of children with mothers who had a high school degree or more, ethnicity was not a selected predictor at all. However, ethnicity did explain the next most variance for children whose mothers had less than a high school degree ($R^2 = 1.97\%$). This model included a number of early life predictors that were each selected twice, suggesting these factors may be particularly relevant for early literacy. These predictors included the number of children in the household under the age of 6 (this was an inconsistent pattern, although more than one child was worse in both instances), gender (females performed better in both subgroups on prekindergarten literacy), and welfare receipt (inconsistent pattern, although none or one was better in both instances on prekindergarten literacy). Subgroup analyses revealed a significant negative EHS program effect for one subgroup of children on prekindergarten literacy (i.e., children of mothers with less than a high school degree, not Hispanic, focus child was the first born, and female) ($b = -4.40, t(215) = 2.39, p = .018$). In other words, for this subgroup of

children, EHS was related to lower prekindergarten literacy than compared to the control group.

(Insert Figure 2.2)

Prekindergarten Vocabulary. Early life predictors accounted for 17.3% of the variance in prekindergarten vocabulary and resulted in 11 final subgroups of children (see Figure 2.3). Of the prekindergarten outcomes, vocabulary had the most total explained variance from baseline predictors (i.e., roughly the time of the focus child's birth). Ethnicity was the first selected split explaining over half of the total explained variance ($R^2 = 9.64\%$, $d = .62$, $p < .001$). Just like prekindergarten math, maternal educational attainment explained the most variance for both subgroups created by the initial split on children's ethnicity ($R^2 = 2.01$ and 1.53%). Prekindergarten vocabulary was the only outcome with EHS assignment as a selected split in the data, where it had a beneficial effect on prekindergarten vocabulary for a subgroup of children who were Black or Hispanic, who had mothers with a high school degree or less, and who were not experiencing deep poverty ($R^2 = 0.45\%$, $d = .29$, $p < .01$). Furthermore, for the subgroup of children receiving EHS, the mother's report of previous experiences with EHS, HS, or similar child development programs showed an additional positive association with prekindergarten vocabulary ($R^2 = 0.76\%$, $d = .67$, $p < .001$). Subgroup analyses testing for EHS program effects on prekindergarten vocabulary did not reveal significant results.

(Insert Figure 2.3)

Predictive Patterns for 5th Grade Academic Achievement

5th Grade Math. Early life predictors (i.e., from roughly the time of the child's birth) and prekindergarten academic skills explained 26.0% of the variance in 5th grade

math performance and resulted in 12 final subgroups of children (see Figure 2.4). As with all 5th grade outcomes, ethnicity explained the most variance of the baseline predictors and was the first selected split ($R^2 = 6.93\%$, $d = .53$, $p < .001$). The model for 5th grade math was the only one that did not include maternal educational attainment as a selected split in the data. Instead, ethnicity again divided the data for the subgroup of children who were Black or Hispanic, with children who were Hispanic performing better ($R^2 = 1.14\%$, $d = .30$, $p < .001$). For children who were White or other, home living arrangements at roughly the time of the child's birth was the next selected split, with children of mothers who reported living with their husband performing better on 5th grade math ($R^2 = 1.20\%$, $d = .37$, $p < .001$). Only prekindergarten math performance was selected after no baseline predictor could satisfy the model selection criteria. Subgroup analyses revealed a significant negative EHS effect on 5th grade math for children who were Hispanic and in the bottom 25th percentile in prekindergarten math performance ($b = -2.01$, $t(76) = 2.41$, $p = .018$). In other words, for children in this subgroup, EHS was related to lower 5th grade math performance compared to children in the control group.

(Insert Figure 2.4)

5th Grade Literacy. Early life predictors and prekindergarten academic skills explained 27.4% of the variance in 5th grade literacy performance and resulted in 12 final subgroups of children (see Figure 2.5). Unlike prekindergarten literacy, ethnicity was the first selected split ($R^2 = 5.45\%$, $d = .47$, $p < .001$), not maternal educational attainment (which was not a selected split at all for children who were White or other). Similar to the 5th grade math model, for children who were White or other, home living arrangements at roughly the time of the child's birth was the next selected split, with

children who had mothers that reported living with their husband performing better on literacy at 5th grade ($R^2 = 1.33\%$, $d = .40$, $p < .001$). Prekindergarten literacy was not a selected split in the model, meaning that at no point did it meet the selection criteria and explain more variance than other possible splits among the predictors. Prekindergarten math and vocabulary, however, were selected splits in the model multiple times each. Subgroup analyses revealed two significant positive EHS effects for children on 5th grade literacy. First, EHS had a positive effect for a subgroup of children who were Black or Hispanic, who had mothers with more than a high school degree, and who were in the bottom 25th percentile in prekindergarten vocabulary performance ($b = 18.85$, $t(32) = -2.44$, $p = .020$). Second, EHS had a positive effect for a subgroup of children who were White or other, had mothers who reported living with her husband at roughly the time of the child's birth, and performed in the top 25th percentile in prekindergarten vocabulary performance ($b = 9.88$, $t(77) = -2.95$, $p = .004$).

(Insert Figure 2.5)

5th Grade Vocabulary. Early life predictors and prekindergarten academic skills explained 34.7% of the variance in 5th grade vocabulary performance and resulted in 11 final subgroups of children (see Figure 2.6). Similar to prekindergarten vocabulary, 5th grade vocabulary had the most total explained variance of all 5th grade outcomes. Ethnicity was the first selected split ($R^2 = 15.22\%$, $d = .79$, $p < .001$), followed by maternal educational attainment for both subgroups ($R^2 = 1.89\%$ and 2.04%). Beyond ethnicity and maternal educational attainment, only maternal age at roughly the time of the child's birth was a selected split from the early life predictors. That is, for a subgroup of children who were Black or Hispanic and who had a mother with more than a high

school degree, having a mother older than 23 was associated with better performance on 5th grade vocabulary ($R^2 = 1.05\%$, $d = .63$, $p < .001$). Other than prekindergarten vocabulary (selected five times), prekindergarten math was selected just once for a subgroup of children who were Black or Hispanic and who had mothers with a high school degree or less ($R^2 = 4.36\%$, $d = .79$, $p < .001$). Subgroup analyses revealed no significant EHS program effects on 5th grade vocabulary.

(Insert Figure 2.6)

Discussion

The current study had three research objectives. First, it explored predictive patterns among early life predictors for math, literacy, and vocabulary skills at prekindergarten. Second, it explored predictive patterns among early life predictors and prekindergarten academic skills for math, literacy, and vocabulary skills at 5th grade. And third, it conducted significance tests for EHS effects in subgroups of children created by the sequential partitioning analyses (i.e., when EHS was not a selected split in the model). It is critical to connect the results from the inductive models to previous research and theory because of the data-driven analytical approach. Furthermore, interpretations are meant to inform future research hypotheses versus making inferences or to be used as future prediction models. Overall, three general themes emerged from the models. First, for the prekindergarten models, there were relatively large overall effects associated with children's ethnicity and maternal educational attainment. However, by 5th grade the effects were substantially larger for ethnicity than maternal educational attainment on academic achievement. Moreover, certain early life predictors never met the selection criteria for inclusive in the models (e.g., child health at birth), operated in non-additive

ways (e.g., welfare receipt), or showed evidence of possible subgroup specific effects (e.g., maternal age at roughly the time of the child's birth). Second, for 5th grade literacy performance, after accounting for variance due to the early life predictors, only prekindergarten math and vocabulary were selected splits in the model, and not prekindergarten literacy. Third, only the prekindergarten vocabulary model included EHS as a selected split in the model, where it showed a positive effect for a subgroup of children (i.e., Black or Hispanic children, relatively lower maternal educational attainment, not in deep poverty). Subgroup analyses revealed mostly null effects for EHS on children's prekindergarten and 5th grade academic achievement.

Ethnicity, Maternal Educational Attainment, and Academic Achievement

For prekindergarten academic achievement, much of the explained variance was accounted for by children's ethnicity and maternal educational attainment. For instance, of the first three possible selected splits in prekindergarten math, literacy, and vocabulary models (i.e., initial split for the overall sample and the next selected split for each new subgroup), eight of the nine selected splits were on ethnicity or maternal educational attainment. Furthermore, splits in these two predictors accounted for over half of the explained variance in each of the prekindergarten model. The strong influence of ethnicity and maternal educational attainment was most noticeable in the prekindergarten math model. In that model, 68% of the total sample only included splits on ethnicity and maternal educational attainment. This was likely not a function of model selection criteria, as final subgroups comprised simply of these two variables were relatively large (e.g., $n = 552$, $n = 226$) and splits only needed to explain 0.40% variance in the outcome to be selected. Although these findings do not provide evidence for causal associations,

they are consistent with previous findings that ethnicity and maternal educational attainment have strong associations with children's early academic achievement (Beck & Muschkin, 2012; Duncan & Magnusson, 2005; Farkas, 2003; Rauh et al., 2003).

Previous research shows that cumulative risk indexes are strong predictors of children's academic achievement (Evans et al., 2013), however, these findings suggest that a few predictors could be driving much of this connection for children in low-income contexts.

For the 5th grade models, the predictive patterns changed subtly, but consistently. That is, children's ethnicity became more predictive of variance for each 5th grade outcome and generally less variance was explained by maternal educational attainment. For all 5th grade models, ethnicity was the first selected split and it explained more variance than it did in each of the prekindergarten models. In fact, when comparing the explained variance in academic achievement for the full sample at 5th grade to the explained variance in the full sample at prekindergarten, it was 18.26%, 57.06%, and 57.88% larger for math, literacy, and vocabulary (respectively). Given that widening achievement gaps that children experience during schooling could explain this effect (Blair & Diamond, 2008), a test of the change in overall explained variance associated with maternal educational attainment was also examined (which was similarly predictive of initial gaps in prekindergarten academic achievement). This analysis showed a much different pattern, with overall changes in explained variance of -44.34%, -7.27%, and 31.34% for math, literacy, and vocabulary (respectively). Again, these findings do not show causal linkages between children's ethnicity and 5th grade academic achievement. However, previous studies have shown widening achievement gaps as a function of income and socio-economic status over time (Duncan & Magnusson, 2011; Reardon,

2011), whereas these findings show that minority children may experience disproportionately widening gaps during the elementary years within a predominantly low-income sample. Moreover, previous research has suggested that much of the link between children's ethnicity and academic achievement could be confounded by socio-economic status (Duncan & Magnusson, 2005). However, the current study suggests academic achievement gaps associated with ethnicity might be more than a function of socio-economic status. That is, these findings are consistent with research showing perverse effects on ethnic minority children's academic achievement beyond the effects associated with socio-economic status (Beck & Muschkin, 2012; Farkas, 2003). For example, research shows Black children, compared to White children, are more likely to be put into lower academic tracks even after controlling for previous academic achievement, family background, and other factors, suggesting the possibility of teacher, or administrative, discrimination (Farkas, 2003). Furthermore, the current study included predictors related to economic hardship and family characteristics for possible selection in the models, but they explained relatively less variance than ethnicity in the outcomes.

The effects of other early life predictors on academic achievement. After accounting for variance due to ethnicity and maternal educational attainment for children's academic achievement, the effects of other early life predictors were generally much weaker. Predictors for children's health at birth were not selected in any model, although these findings should be interpreted cautiously. Roughly 25% of children had missing data on these variables because they had not been born at the baseline of the study (i.e., mother was pregnant with the child at baseline). Furthermore, relatively few children were reported as having poor health indicators (e.g., low birth weight), thus

satisfying the selection criteria of at least 25 children in each subgroup presents challenges. However, it could be that the effects of child health are much weaker after the model has accounted for variance due to ethnicity and maternal educational attainment, given these factors are linked to children's health at birth (Aizer & Currie, 2014; Reichman, 2005). Moreover, previous research has shown that the effects of low birth weight on reading skills become weaker after accounting for key demographic factors, such as maternal education attainment (Rauh et al., 2003).

For 5th grade math and literacy, the most explanatory split was living arrangements at the baseline of the study for children who were White or other. This variable also showed a much larger effect at 5th grade than in prekindergarten (like ethnicity), suggesting potentially stronger effects as children move through the formal schooling years. These findings fit with previous research on single motherhood having negative effects of children's academic achievement (Milne, Myers, Rosenthal, & Ginsburg, 1986; Rauh et al., 2003), although they are not directly comparable because the current study used whether the mother reported living with the husband at roughly the time of the child's birth. Still, these findings do suggest the potentially enduring negative effects of early single parenthood on math and reading skills 10 years later for some children.

Ethnicity, maternal educational attainment, and living arrangements at baseline each split in consistent and theoretically expected ways across the models, however welfare receipt did not. Welfare receipt emerged as an important predictor twice for prekindergarten literacy and once for 5th grade literacy with instances where each category (i.e., low, medium, or high receipt) was either predictive of higher or lower

literacy skills. This could be indicative of a potentially influential variable that takes different meanings depending on the context. Previous research suggests that welfare receipt is beneficial for children's academic achievement when improving a family's relative financial standing (Clark-Kauffman et al., 2003; Duncan et al., 2011). However, previous research has also showed no significant effects of moving onto or off welfare on children's early cognitive abilities, although moving onto welfare receipt was negatively related to adolescents reading skills (Chase-Lansdale et al., 2003). Importantly, these findings suggest that different levels of welfare receipt likely carry different meanings depending on the context.

Profiles of Children. Overall, results suggest that ethnicity and maternal educational attainment were most closely associated with prekindergarten academic achievement for children in low-income families. That is, Black and Hispanic children and children of mothers with less than a high school degree performed significantly, worse on prekindergarten academic achievement than their low-income peers. For early math and vocabulary, few other early life factors explained much of children's prekindergarten academic achievement once ethnicity and maternal educational attainment were taken into account. For early literacy, child and family characteristics (i.e., gender, number of children under six in the household) and economic hardship (i.e., welfare receipt, depth of poverty) were significant predictors in the model although the associations were strongest for maternal educational attainment and ethnicity status.

For 5th grade academic achievement, the effects associated with ethnicity status appeared to be substantially larger than any other early life factor, although maternal educational attainment and mother's living arrangements (i.e., single, with the husband,

with other adults) at birth also emerged as important predictors. That is, Black and Hispanic children performed significantly worse on average for 5th grade academic achievement than their low-income peers, with the effects larger than for prekindergarten academic achievement. However, early success in prekindergarten math and vocabulary (e.g., scoring in the top 25th percentile) helped offset some of the initial gaps associated with ethnicity status. Therefore, this study shows that although risk can be considered through a complex lens of how many interrelated factors influence children's development, a few factors explain much of children's academic performance at school entry and five years later.

In general, these analyses and findings need to be interpreted within a larger context of how the effects of many traditional risk factors are modeled and tested. The current study attempts to provide a deeper understanding of how early predictors relate children's academic achievement by exploring potential conditional effects within a predominantly low-income sample (Bradley & Corwyn, 2002; Bronfenbrenner & Morris, 2006). The early predictors that explained the majority of the variance in prekindergarten academic achievement are ethnicity and maternal educational attainment, with ethnicity explaining the most variance for academic achievement at 5th grade. Findings also suggest that variables such as maternal age at child's birth and welfare receipt might be conditional of other contexts and ill-suited for cumulative risk indexes (Evans et al., 2013).

Prekindergarten Math and Vocabulary, Not Prekindergarten Literacy, Predicted 5th Grade Literacy

For the effects of prekindergarten academic skills on 5th grade academic achievement, findings were mostly consistent with previous research (Duncan et al.,

2007; McClelland et al., 2013). For instance, of the prekindergarten academic skills, 5th grade math was explained principally by early math skills and 5th grade vocabulary was explained principally by early vocabulary skills. This is consistent with the *skills beget skills* framework of human capital (Heckman, 2000), and previous research that children who enter school with advantages in academic skills will likely maintain these advantages throughout schooling (e.g., Duncan et al., 2007; McClelland et al., 2013). However, prekindergarten literacy was not a selected predictor in the model for 5th grade literacy. This finding suggests that after accounting for early life predictors, prekindergarten math and vocabulary skills have a stronger association with 5th grade literacy performance than prekindergarten literacy. This is consistent with previous work that has shown early math skills to be the strongest predictor of later literacy skills while controlling for socio-economic status (Duncan et al., 2007). Yet, these findings complement the previous work by showing that in addition to the importance of early math skills, early vocabulary skills may also be more predictive of later literacy than early literacy. Moreover, these models show that once accounting for the effects associated with early predictors and prekindergarten math and vocabulary skills, prekindergarten literacy did not contribute substantially to the explained variance (i.e., $R^2 \geq 0.80\%$) for this low-income sample.

Null and Mixed Effects of EHS

EHS program assignment emerged as a selected split in only the prekindergarten vocabulary model. That is, EHS had a beneficial effect on children's prekindergarten vocabulary performance and explained more variance than any other possible split for a subgroup of children who were Black or Hispanic, had mothers with relatively lower

levels of educational attainment, and were not in deep poverty. For this subgroup, the EHS program effects were larger in children who had a mother that reported previous experiences with a developmental program (e.g., Early Head Start, Head Start). In fact, this subgroup of children scored over 11 points better than the conditional control subgroup, an effect size of over three quarters of a standard deviation on prekindergarten vocabulary. Overall, this effect of EHS is in part consistent with previous research that has found larger effects on prekindergarten cognitive skills for children who are Black (Love et al., 2013), but shows a more nuanced subgroup effect (i.e., a subgroup not in deep poverty and for families with relatively lower maternal educational attainment). Furthermore, it suggests that benefits may be larger for EHS programs when mothers have previous experience with these types of developmental programs. This finding is in part consistent with previous research that shows mothers who were in Head Start as children had children with larger beneficial effects of Head Start on early academic achievement than children of mothers who were not in Head Start as children (Chor, 2015). Together, these findings suggest a need to further explore intervention and program effects on children as parents have increased exposure and familiarity with them. Despite EHS emerging as a split in the prekindergarten vocabulary model, it did not emerge and did not have a significant effect for any subgroup of children in the 5th grade vocabulary model.

The subgroup analyses of EHS showed mostly non-significant effects for each of the outcomes. For the 28 final subgroups that were not conditional on EHS in the prekindergarten models, only one subgroup had a significant negative EHS effect on literacy (i.e., relatively lower maternal educational attainment, non-Hispanic, first born,

females). For the 35 final subgroups in 5th grade models, there was one significant negative effect for a subgroup in math (i.e., Hispanic, relatively low prekindergarten math) and two significant positive effects for subgroups in literacy (i.e., White or other, mother lived with husband at baseline, relatively high prekindergarten vocabulary; Black or Hispanic, relatively high maternal educational attainment, relatively low prekindergarten vocabulary). Although the study design was a randomized trial of the EHS effects, it is challenging to interpret the few significant subgroup effects that emerged as anything more than potentially chance findings given the large number of non-significant findings (i.e., 59). However, it is imperative that researchers continue to evaluate the effects of early care and education programs, which should consist of subgroup analyses from both deductive and inductive approaches. Although it is possible the effects of EHS were due to chance, the two beneficial EHS effects on subgroups for 5th grade literacy could carry potentially important implications for later school success (Buchmann & DiPrete, 2006; Perna, 2005). Furthermore, EHS had a beneficial effect for a subgroup in the prekindergarten vocabulary, where it was the optimal split and met selection criteria. This finding is encouraging because prekindergarten vocabulary had large predictive effects on 5th grade vocabulary and literacy skills.

Limitations and Future Directions

The study used inductive, sequential partitioning analyses to search for patterns among early predictors of children's prekindergarten and 5th grade academic achievement within a predominantly low-income sample. A few limitations and future directions emerge from the current study. First, the specific patterns are not meant to be inferential, but are descriptive of the observed data. Thus, replication becomes paramount for the

validity of themes that emerged from the models. Replication should include inductively exploring models in similar low-income populations to see if common patterns exist and hypothesis testing of the common themes on independent samples. Second, at times two predictors may have explained similar amounts of variance in the outcome, but when one predictor is selected the other appears to have not been meaningful, which could be misleading. That is, once the model is conditional on one variable (e.g., ethnicity), other variables that share common variance with that variable (e.g., economic hardship, maternal educational attainment) are being accounted for without being selected in the model. Therefore, future studies should consider combining deductive and inductive models to better estimate the effects of early predictors. Third, all associations are correlational in nature and not causal, with the exception of some of the EHS effects (due to the random assignment at baseline). Although the data suggest relatively large effects of children's ethnicity on 5th grade academic achievement, reasons for why this occurs are still left unanswered. Future studies should continue to explore how ethnicity and socio-economic status each contribute to academic achievement and if there are differential effects depending on early childhood years compared to the schooling years. And finally, due to the secondary analysis of publically accessible data, numerous potentially important early predictors (e.g., self-regulation; Blair & Diamond, 2008) and processes (e.g., home learning environment; Son & Morrison, 2010) for children's academic achievement were not included in the analyses. Future studies should examine inductive models with other previously identified important predictors to better understanding children's academic achievement.

Implications and Conclusions

The current study has a number of important implications. First, it attempts to better understand individual and contextual interactions and dependencies through a model discovery approach consistent with modern theoretical perspectives (Bronfenbrenner & Morris, 2006). That is, it shows the utility of using sequential partitioning analyses to identify predictive patterns for children's prekindergarten and 5th grade academic achievement in a predominantly low-income sample. Within the predictive patterns, findings suggest that both maternal education attainment and ethnicity are key early predictors of prekindergarten academic achievement. However, for 5th grade academic achievement the effects of ethnicity become substantially larger. Second, it shows that there are potentially stronger links between early math and vocabulary skills with 5th grade literacy than there is with early literacy. Thus, in part consistent with previous research on the importance of early math skills for school success (Duncan et al., 2007), the study also highlights the importance of early vocabulary skills. Third, the sequential partitioning analyses show mostly non-significant effects for EHS on children's academic achievement. However, there were a few subgroups in which EHS did have beneficial effects and a few where it had iatrogenic effects. Future work needs to continue to explore for which groups of children early care and education programs are most effective, and ineffective, and attempt to understand why. Children's academic performance is important for researchers to understand, especially for children in families facing economic hardship and cumulative risk, given the potential impact of academic success on lifetime earnings (Autor, 2014).

References

- Anderson, P., Doyle, L. W., & Victorian Infant Collaborative Study Group. (2003). Neurobehavioral outcomes of school-age children born extremely low birth weight or very preterm in the 1990s. *Jama*, *289*(24), 3264-3272.
- Administration for Children and Families. (2002a). *Making a difference in the lives of children and families: The impacts of Early Head Start programs on infants and toddlers and their families*. Washington, DC: U. S. Department of Health and Human Services.
- Administration for Children and Families. (2002b). *Pathways to quality and full implementation in Early Head Start Programs*. Washington, DC: U. S. Department of Health and Human Services.
- Aizer, A., & Currie, J. (2014). The intergenerational transmission of inequality: Maternal disadvantage and health at birth. *science*, *344*(6186), 856-861.
- Autor, D. H. (2014). Skills, education, and the rise of earnings inequality among the "other 99 percent". *Science*, *344*(6186), 843-851.
- Aylward, G. P. (2003). Cognitive function in preterm infants: no simple answers. *Jama*, *289*(6), 752-753.
- Ayoub, C., Vallotton, C. D., & Mastergeorge, A. M. (2011). Developmental pathways to integrated social skills: The roles of parenting and early intervention. *Child Development*, *82*, 583 – 600. doi: 10.1111/j.1467-8624.2010.01549.x
- Beck, A. N., & Muschkin, C. G. (2012). The Enduring Impact of Race: Understanding Disparities in Student Disciplinary Infractions and Achievement. *Sociological Perspectives*, *55*(4), 637-662.
- 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.
- Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, *53*(1), 371-399.
- Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. *Handbook of child psychology*.
- Brooks-Gunn, J., Duncan, G. J., & Maritato, N. (1997). Poor families, poor outcomes: The well-being of children and youth. *Consequences of growing up poor*, 1-17.
- Buchmann, C., & DiPrete, T. A. (2006). The growing female advantage in college completion: The role of family background and academic achievement. *American sociological review*, *71*(4), 515-541.
- Camilli, G., Vargas, S., Ryan, S., & Barnett, W. S. (2010). Meta-analysis of the effects of early education interventions on cognitive and social development. *The Teachers College Record*, *112*(3).
- Center for Law and Social Policy (2014). New census data tell us that poverty fell in 2013. Retrieved from <http://www.clasp.org/issues/child-care-and-early-education/in-focus/2013-poverty-data-a-glimpse-of-good-news-for-children-but-we-can-do-better> on November 17, 2014.

- Chase-Lansdale, P. L., Moffitt, R. A., Lohman, B. J., Cherlin, A. J., Coley, R. L., Pittman, L. D., et al. (2003). Mothers' transitions from welfare to work and the well-being of preschoolers and adolescents. *Science*, 299(5612), 1548-1552.
- Chor, E. (2015, March). Head Start's broken promise? Multigenerational poverty, multigenerational participation. Presented at the biennial meeting of the Society for Research in Child Development, Philadelphia, PA.
- Clark-Kauffman, E., Duncan, G. J., & Morris, P. (2003). How welfare policies affect child and adolescent achievement. *American Economic Review*, 299-303.
- Dubow, E. F., & Ippolito, M. F. (1994). Effects of poverty and quality of the home environment on changes in the academic and behavioral adjustment of elementary school-age children. *Journal of Clinical Child Psychology*, 23(4), 401-412.
- Duncan, G. J., & Brooks-Gunn, J. (Eds.). (1995). *Consequences of growing up poor*. Russell Sage Foundation.
- Duncan, G. J., & Brooks-Gunn, J. (2000). Family poverty, welfare reform, and child development. *Child development*, 71(1), 188-196.
- Duncan, G. J., Brooks-Gunn, J., & Klebanov, P. K. (1994). Economic deprivation and early childhood development. *Child development*, 65(2), 296-318.
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental psychology*, 43(6), 1428.
- Duncan, G. J., & Magnuson, K. A. (2005). Can family socioeconomic resources account for racial and ethnic test score gaps?. *The future of children*, 15(1), 35-54.
- Duncan, G. J., Yeung, W. J., Brooks-Gunn, J., & Smith, J. R. (1998). How much does childhood poverty affect the life chances of children?. *American sociological review*, 406-423.
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P. et al. (2007). School readiness and later achievement. *Developmental Psychology*, 43(6), 1428-1446. doi: 10.1037/0012-1649.43.6.1428
- Duncan, G. J., & Magnuson, K. (2011). The nature and impact of early achievement skills, attention skills, and behavior problems. *Whither opportunity*, 47-69.
- Duncan, G. J., Morris, P. A., & Rodrigues, C. (2011). Does money really matter? Estimating impacts of family income on young children's achievement with data from random-assignment experiments. *Developmental psychology*, 47(5), 1263.
- Dunn, L. M. & Dunn, L. M. (1997). Peabody Picture Vocabulary Test-Third Edition. Circle Pines, MN: American Guidance Service, Inc.
- Dunn, L. M., Padilla, E. R., Lugo, D. E., & Dunn, L. M. (1986). Examiner's manual for the Test de Vocabulario en Images Peabody (Peabody Picture Vocabulary Test) Adaptacion Hispanoamericana (Hispanic American adaptation). *Circle Pines, MN: American Guidance Service*.
- Evans, G. W., Li, D., & Whipple, S. S. (2013). Cumulative Risk and Child Development. *Psychological Bulletin*, doi: 10.1037/a0031808
- Farkas, G. (2003). Racial disparities and discrimination in education: What do we know, how do we know it, and what do we need to know?. *The Teachers College Record*, 105(6), 1119-1146.
- Hastie, T., Tibshirani, R., Friedman, J., (2009). *The elements of statistical learning* (Vol. 2, No. 1). New York: Springer.

- Heckman, J. J. (2000). Policies to foster human capital. *Research in economics*, 54(1), 3-56.
- Hill, N. E., & Craft, S. A. (2003). Parent-school involvement and school performance: Mediated pathways among socioeconomically comparable African American and Euro-American families. *Journal of Educational Psychology*, 95(1), 74.
- Kieffer, M. J. (2008). Catching up or falling behind? Initial English proficiency, concentrated poverty, and the reading growth of language minority learners in the United States. *Journal of Educational Psychology*, 100(4), 851.
- Korenman, S., Miller, J. E., & Sjaastad, J. E. (1995). Long-term poverty and child development in the United States: Results from the NLSY. *Children and Youth Services Review*, 17(1), 127-155.
- Lee, R., Zhai, F., Brooks-Gunn, J., Han, W. J., & Waldfogel, J. (2014). Head start participation and school readiness: Evidence from the early childhood longitudinal study–birth cohort. *Developmental psychology*, 50(1), 202.
- Love, J. M., Kisker, E. E., Ross, C., Raikes, H., Constantine, J., Boller, K., et al. (2005). The effectiveness of early head start for 3-year-old children and their parents: lessons for policy and programs. *Developmental psychology*, 41(6), 885.
- Love, J. M., Chazan-Cohen, R., Raikes, H., & Brooks-Gunn, J. (2013). What makes a difference: Early Head Start evaluation findings in a developmental context. *Monographs of the Society for Research in Child Development*, 78(1), 1-173.
- Magnuson, K. A., Ruhm, C., & Waldfogel, J. (2007). Does prekindergarten improve school preparation and performance?. *Economics of Education Review*, 26(1), 33-51.
- McClelland, M.M., Acock, A. C., Piccinin A., Rhea, S. A., & Stalling, M. C. (2013). Relations between preschool attention and sociability and later achievement outcomes. *Early Childhood Research Quarterly*, 28, 314 – 324.
doi:10.1016/j.ecreq.2012.07.008
- McClelland, M. M., & Wanless, S. B. (2012). Growing up with assets and risks: The importance of self-regulation for academic achievement. *Research in Human Development*, 9(4), 278-297.
- McLoyd, V. C. (1998). Socioeconomic disadvantage and child development. *American Psychologist*, 53(2), 185.
- Milne, A. M., Myers, D. E., Rosenthal, A. S., & Ginsburg, A. (1986). Single parents, working mothers, and the educational achievement of school children. *Sociology of Education*, 125-139.
- Morgan, J. N. (2005). History and potential of binary segmentation for exploratory data analysis. *Journal of Data Science*, 3, 123 – 136.
- Obradović, J., Bush, N. R., Stamperdahl, J., Adler, N. E., & Boyce, W. T. (2010). Biological sensitivity to context: The interactive effects of stress reactivity and family adversity on socioemotional behavior and school readiness. *Child development*, 81(1), 270-289.
- Perna, L. W. (2005). The key to college access: Rigorous academic preparation. In W. G. Tierney, Z. B. Corwin & J. E. Colyar (Eds.), *Preparing for college: Nine elements of effective outreach* (pp. 113-134). United States of America: State University of New York.

- Petterson, S. M., & Albers, A. B. (2001). Effects of poverty and maternal depression on early child development. *Child development*, 72(6), 1794-1813.
- Pollack, J. M., Najarian, M., Rock, D. A., & Atkins-Burnett, S. (2005). Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K). Psychometric Report for the Fifth Grade. *National Center for Education Statistics*.
- Princiotta, D., Flanagan, K. D., & Germino-Hausken, E. (2006). *Fifth grade: Findings from the fifth-grade follow-up of the early childhood longitudinal study, kindergarten class of 1998-99 (ECLS-K)*. US Department of Education, Institute of Education Sciences, National Center for Education Statistics.
- Rauh, V. A., Parker, F. L., Garfinkel, R. S., Perry, J., & Andrews, H. F. (2003). Biological, social, and community influences on third-grade reading levels of minority Head Start children: A multilevel approach. *Journal of Community Psychology*, 31(3), 255-278.
- Reardon, S. F. (2011). The widening academic achievement gap between the rich and the poor: New evidence and possible explanations. *Whither opportunity*, 91-116.
- Reichman, N. E. (2005). Low birth weight and school readiness. *The Future of Children*, 15(1), 91-116.
- Sameroff, A. J., Seifer, R., Barocas, R., Zax, M., & Greenspan, S. (1987). Intelligence quotient scores of 4-year-old children: Social-environmental risk factors.
- Shonkoff, J. P., & Phillips, D. A. (2000). *From neurons to neighborhoods: The science of early childhood development*. Washington, DC: National Academy Press.
- Sonquist, J. A., Baker, E. L., & Morgan, J. N. (1974). Searching for structure: an approach to analysis of substantial bodies of micro-data and documentation for a computer program.
- StataCorp, L. P. College Station, TX: 2011. *Stata statistical software: release, 12*.
- United States Department of Health and Human Services, Administration for Children and Families. (1995). Early Head Start program grant availability: Notice. *Federal Register*, 60, 14548-14578.
- United States Department of Health and Human Services. Administration for Children and Families. Early Head Start Research and Evaluation (EHSRE) Study, 1996-2010: [United States]. ICPSR03804-v5. Ann Arbor, MI: Inter-university Consortium for Political and Social Research[distributor], 2011-09-22. <http://doi.org/10.3886/ICPSR03804.v5>
- Woodcock, R. W., & Johnson, M. B. (1990). Tests of achievement, WJ-R: Examiner's manual. *Allen, TX: DLM Teaching Resources*.
- Woodcock, R. W., & Muñoz-Sandoval, A. F. (1996). *Bateria Woodcock-muñoz: pruebas de aprovechamiento revisada*. Riverside Publishing Company.

Table 2.1. Descriptive Statistics for Predictors included in the Models ($N = 2977$)

Early Life Factors	% Yes	% No	% Missing
<i>Depth of Poverty</i>			
Deep Poverty (below 50% of poverty line)	39.60	42.73	17.67
Poverty (below 100% of poverty line)	31.41	50.92	17.67
Low-Income (below 200% of poverty line)	10.08	72.25	17.67
Non Low-Income (above 200% of poverty line)	1.24	81.09	17.67
<i>Welfare Receipt</i>			
None or One	22.27	72.96	4.77
Two or Three	63.96	31.27	4.77
More than Three	9.00	86.23	4.77
AFDC	28.12	51.83	20.05
<i>Needs Assessment</i>			
None	47.46	46.06	6.48
One	24.45	69.07	6.48
More than One	21.60	71.92	6.48
<i>Demographic and Family Characteristics</i>			
Male	50.45	48.57	0.97
White	36.48	61.77	1.75
Black	34.06	64.19	1.75
Hispanic	23.24	75.01	1.75
Other	4.47	93.78	1.75
Child Not Born at Baseline	23.38	76.62	0
Child less than 6 Months Old at Baseline	50.45	49.55	0
Child Older than 6 Months Old at Baseline	26.17	73.83	0
Primarily Language is English in Home	76.02	20.59	3.39
Mother has Less than 12 Years of Education	45.92	50.49	3.59
Mother has High School Degree or GED	27.61	68.80	3.59
Mother has More than 12 years of Education	22.88	73.53	3.59
Mother is Employed	22.61	74.23	3.16

Mother is In School/Training	21.13	75.71	3.16
Mother is Neither Employed or in School/Training	53.11	43.73	3.16
Teenage Mother at Baseline ^a	35.95	63.85	0.20
1 Adult in the Household	36.85	62.85	0.30
2 Adults in the Household	50.32	49.38	0.30
3 Adults or More in the Household	12.53	87.17	0.30
Mother Lives with Husband	25.19	74.54	0.27
Mother Lives with Other Adults	38.76	60.97	0.27
Mother Lives Alone with Children	35.77	63.96	0.27
Focus Child was the First Born	62.08	37.35	0.57
No Children under 6 in Household	64.49	35.24	0.27
1 Child under 6 in Household	26.81	72.92	0.27
2 or more Children under 6 in Household	8.43	91.30	0.27
No Children between 6 and 17 in Household	64.93	34.80	0.27
1 Child between 6 and 17 in Household	22.30	77.43	0.27
2 or more Children between 6 and 17 in Household	12.50	87.23	0.27
No Residential Moves in Past Year	45.05	45.75	9.20
1 Residential Move in Past Year	25.93	64.87	9.20
2 or More Residential Moves in Past Year	19.82	70.98	9.20
<i>Early Care and Education</i>			
Early Head Start assignment	50.49	49.51	0
Center-Based Care	20.49	79.51	0
Home-Based Care	45.95	54.05	0
Mixed Approach	33.56	66.44	0
Previous Experience with Childcare program	12.56	83.64	3.80
Head Start Attendance	36.55	34.97	28.49
<i>Child Health</i>			
Low Birth Weight (less than 2500 grams)	7.52	77.06	15.42
Stayed in Hospital at Birth	11.76	57.95	31.21
Child Covered by Health Insurance	61.81	6.92	31.27
Concerns about Health and Development	8.87	59.52	31.61

Prekindergarten Academic Achievement^b

Bottom 25 th Percentile in Math	18.16	58.73	23.11
25 th -50 th Percentile in Math	19.96	56.93	23.11
50 th -75 th Percentile in Math	19.64	57.25	23.11
Top 25 th Percentile in Math	19.13	57.76	23.11
Bottom 25 th Percentile in Literacy	19.13	57.70	23.17
25 th -50 th Percentile in Literacy	20.54	56.29	23.17
50 th -75 th Percentile in Literacy	19.06	57.77	23.17
Top 25 th Percentile in Literacy	18.10	58.73	23.17
Bottom 25 th Percentile in Vocabulary	18.61	54.62	26.77
25 th -50 th Percentile in Vocabulary	17.07	56.16	26.77
50 th -75 th Percentile in Vocabulary	18.93	54.30	26.77
Top 25 th Percentile in Vocabulary	18.61	54.62	26.77

Note. ^aMother's age was treated as a continuous variable in models.

^bThis categorical breakdown is for children that had data on at least one 5th grade outcome ($n = 1558$)

Table 2.2. Descriptive Statistics for Prekindergarten and 5th Grade Outcomes

	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>Min.</i>	<i>Max</i>
<i>Prekindergarten Achievement</i>					
Math	1755	88.31	20.08	0	136
Literacy	1754	89.32	13.66	44	136
Vocabulary	1674	91.50	15.16	40	152
<i>5th Grade Achievement</i>					
Math	1552	8.37	4.66	0	18
Literacy	1554	127.57	27.90	31.51	180.65
Vocabulary	1544	93.97	15.74	40	138

Figure 2.1. Predictive Pattern for Prekindergarten Math ($N = 1752$, $M = 88.29$, $SD = 20.08$)

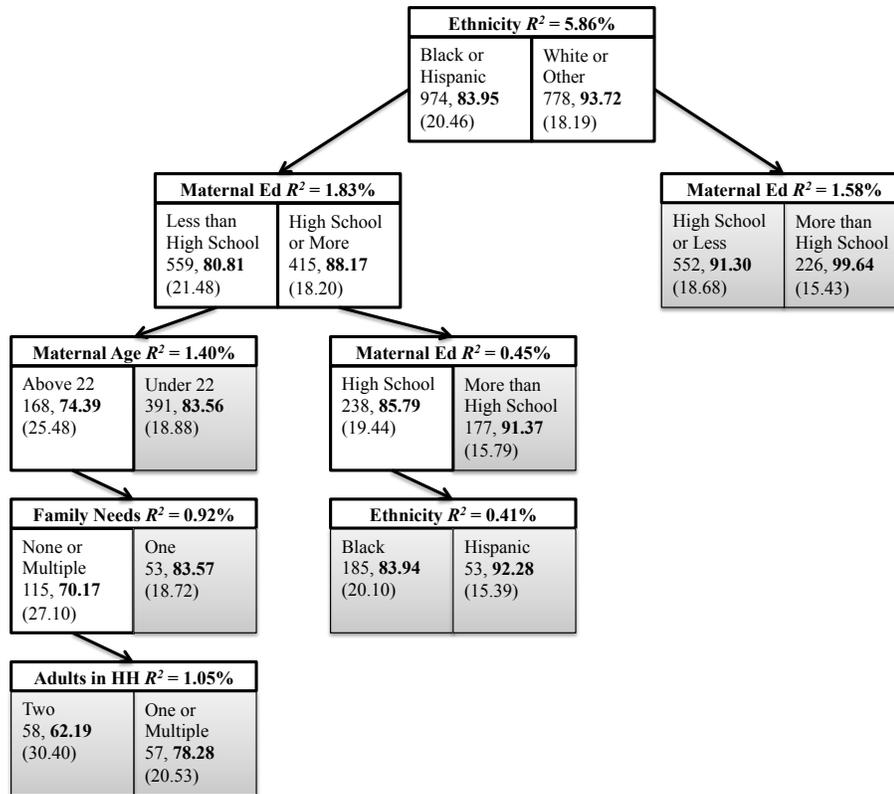


Figure 2.1. Each split is displayed with a box that has the variable that is being divided and the two new groups created. The boxes for the two groups created from the split display the sample size, mean, and standard deviation for that conditional subgroup. All splits are significant at $p < .01$. “Adult in HH” are the number of adults in the household.

Figure 2.2. Predictive Pattern for Prekindergarten Literacy ($N = 1751$, $M = 89.30$, $SD = 13.67$)

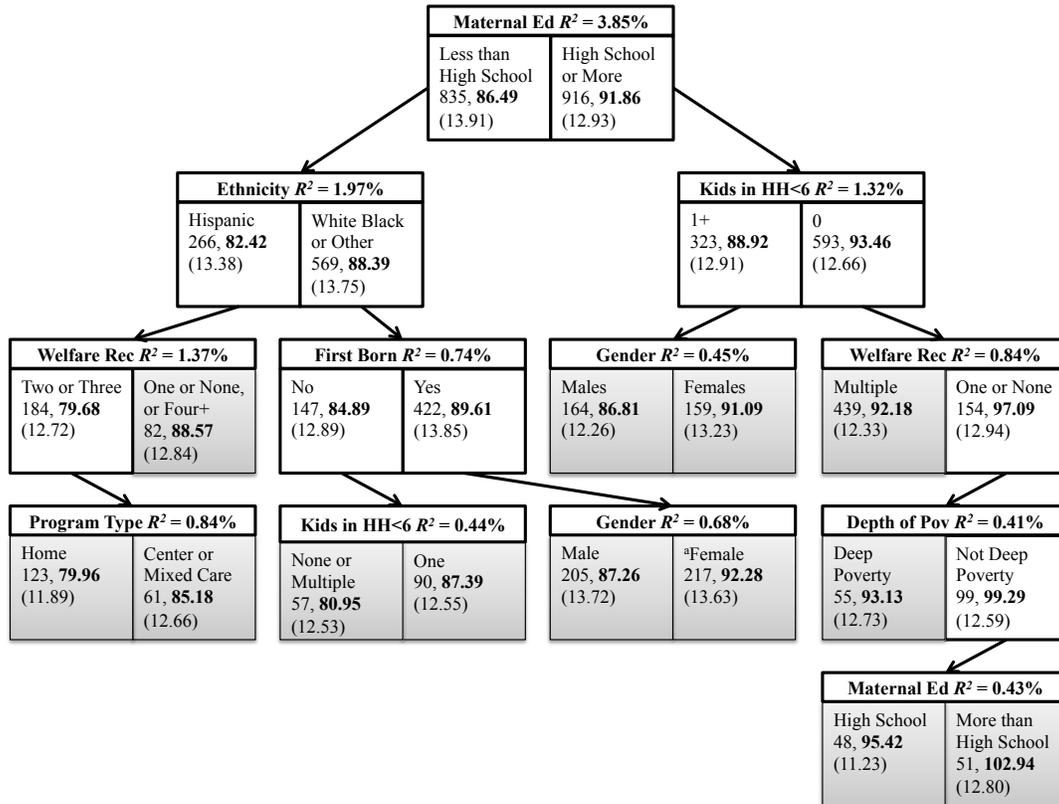


Figure 2.2. Each split is displayed with a box that has the variable that is being divided and the two new groups created. The boxes for the two groups created from the split display the sample size, mean, and standard deviation for that conditional subgroup. All splits are significant at $p < .01$. “Kids in HH < 6” are the number of children in the household under 6 other than the focus child.

^aSignificant negative EHS effect

Figure 2.3. Predictive Pattern for Prekindergarten Vocabulary ($N = 1671$, $M = 91.47$, $SD = 15.15$)

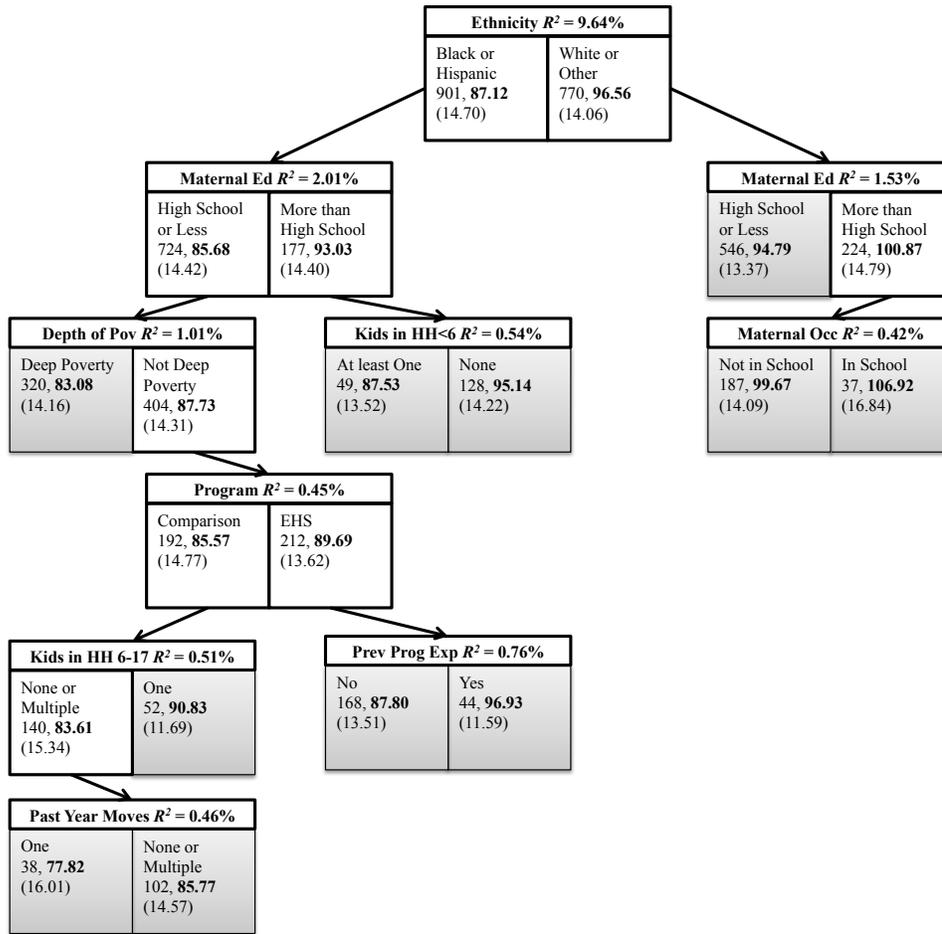


Figure 2.3. Each split is displayed with a box that has the variable that is being divided and the two new groups created. The boxes for the two groups created from the split display the sample size, mean, and standard deviation for that conditional subgroup. All splits are significant at $p < .01$. “Kids in HH < 6” are the number of children in the household under 6 other than the focus child. “Kids in HH 6-17” are the number of children in the household between 6 and 17.

Figure 2.4. Predictive Pattern for 5th Grade Math ($N = 1549$, $M = 8.37$, $SD = 4.66$)

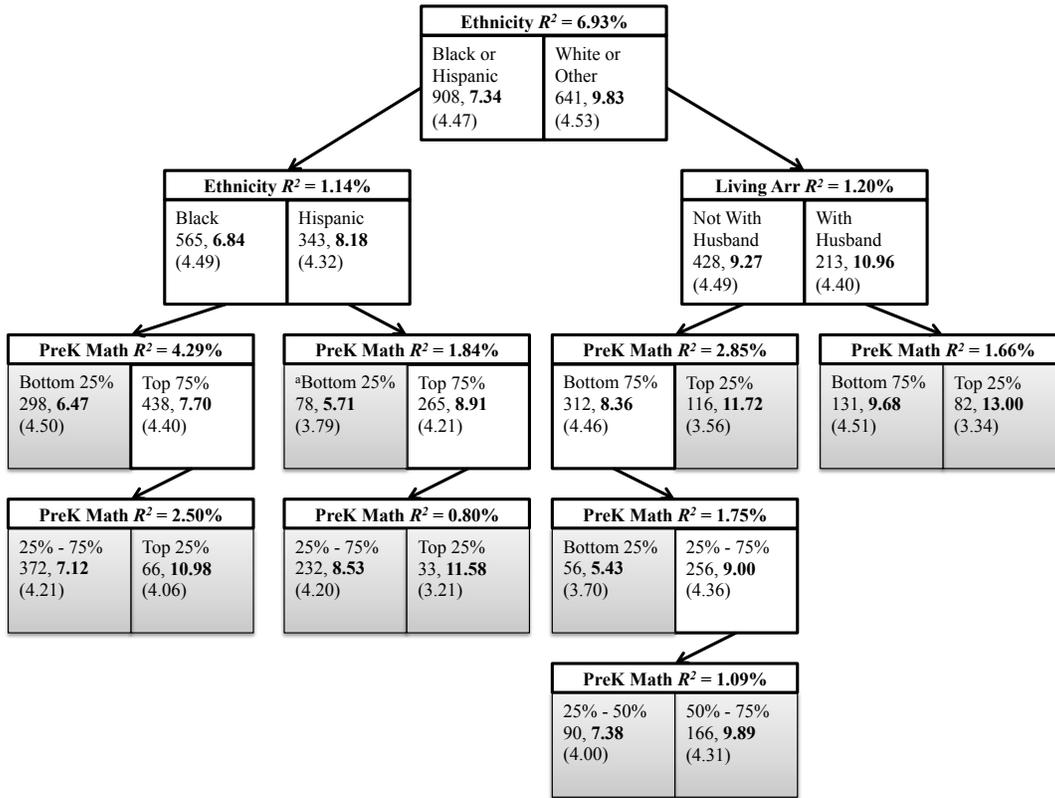


Figure 2.4. Each split is displayed with a box that has the variable that is being divided and the two new groups created. The boxes for the two groups created from the split display the sample size, mean, and standard deviation for that conditional subgroup. All splits are significant at $p < .001$.
^aSignificant negative EHS effect.

Figure 2.5. Predictive Pattern for 5th Grade Literacy ($N = 1551$, $M = 127.56$, $SD = 27.92$)

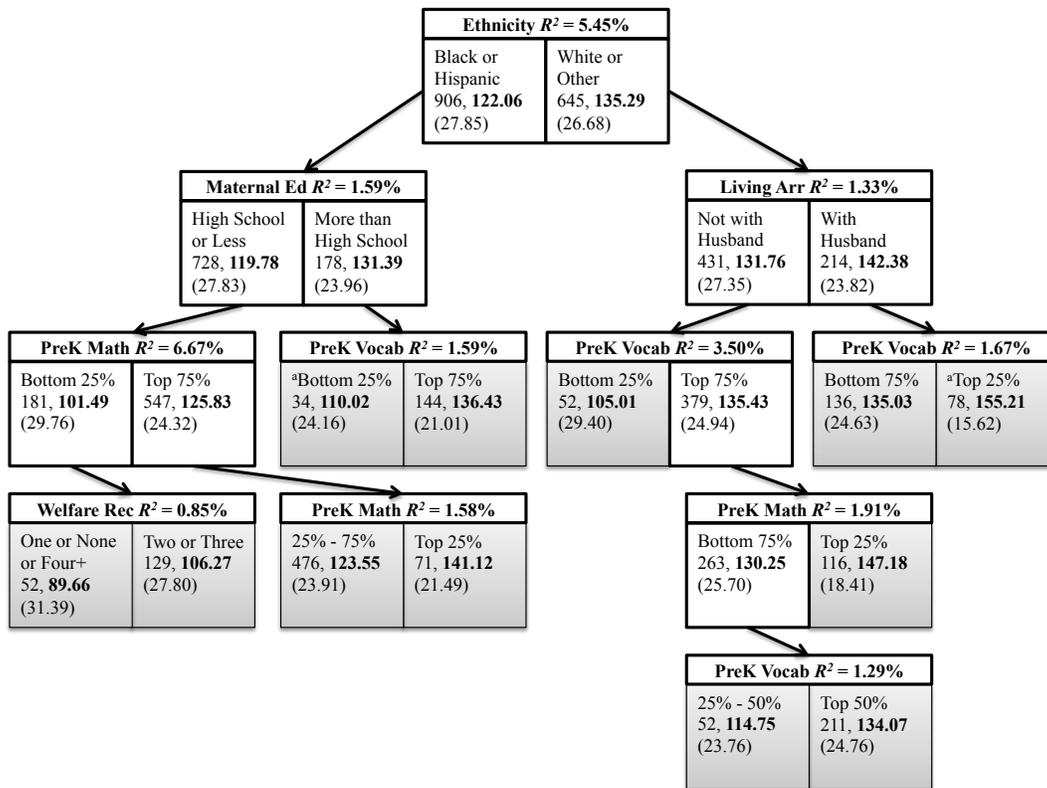


Figure 2.5. Each split is displayed with a box that has the variable that is being divided and the two new groups created. The boxes for the two groups created from the split display the sample size, mean, and standard deviation for that conditional subgroup. All splits are significant at $p < .001$.

^aSignificant beneficial EHS effect.

Figure 2.6. Predictive Pattern for 5th Grade Vocabulary ($N = 1541$, $M = 93.97$, $SD = 15.75$)

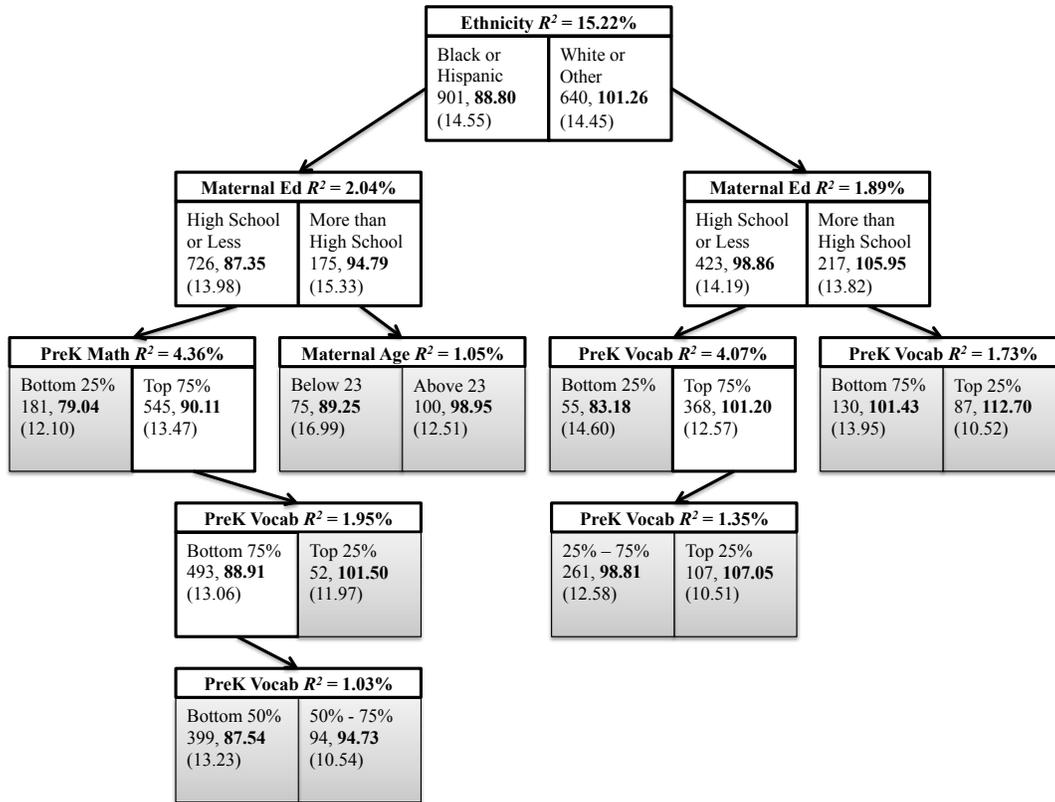


Figure 2.6. Each split is displayed with a box that has the variable that is being divided and the two new groups created. The boxes for the two groups created from the split display the sample size, mean, and standard deviation for that conditional group. All splits are significant at $p < .001$.

Predicting Externalizing Problems for Children in Low-Income Families: A Dual-Analytical Approach

Robert J. Duncan

Oregon State University

Author Note

Robert J. Duncan, College of Public Health and Human Sciences, Oregon State University.

Correspondence concerning this article should be addressed to Robert J. Duncan, Oregon State University, 410 Waldo Hall, Corvallis, OR 97331, E-mail: duncarob@onid.oregonstate.edu.

Abstract

Externalizing problems in childhood are important to understand given their connections to more consequential problem behaviors later in life (e.g., substance use, violence). Research shows that multiple early risk factors and early behaviors are predictive of later externalizing problems. In a low-income sample, the current study examines the effects of economic hardship, child and family characteristics, and early care and education (i.e., from roughly the time of the child's birth) and prekindergarten behavioral problems on children's externalizing problems at 5th grade. The study uses two analytical approaches to understand these relations: a deductive, logistic regression model and an inductive, sequential partitioning model (i.e., SEARCH). Across both models, being male, maternal unemployment and not living with the husband at roughly the time of the child's birth, and higher levels of prekindergarten aggression were predictive of a greater likelihood of externalizing problems at 5th grade. However, three differences in results were found between the two analytic strategies. First, variables related to economic hardship were selected (e.g., depth of poverty, welfare receipt) in the SEARCH model, but not significant in the logistic regression model. Second, there was a significant beneficial subgroup effect of Early Head Start in the SEARCH model (i.e., females not in deep poverty and who had mothers employed or in school at roughly the time of the child's birth), but it was not significant in the logistic regression model. Third, prekindergarten hyperactivity was not selected in the SEARCH model but was significantly related to 5th grade externalizing problems in the logistic regression model. The study contributes to research on early predictors of children's externalizing problems and shows the usefulness of taking complementary analytical approaches for developmental research.

Predicting Externalizing Problems for Children in Low-Income Families: A Dual-Analytical Approach

Children experiencing multiple risk factors early in life, especially those related to poverty, are at increased risk of behavioral problems later in childhood (Duncan, Brooks-Gunn, & Klebanov, 1994; Evans, Li, & Whipple, 2013; Moffitt & Caspi, 2001). There are a number of interrelated processes that likely contribute to the negative effects of poverty on children's behavioral problems (McLoyd, 1998). For instance, the Family Stress Model suggests that a family's financial hardships can lead to negative mental health effects on the caregiver, negative effects on the caregiver-child relationship, and, ultimately, increases in the child's behavioral problems (Conger, Rueter, & Conger, 2000; Conger et al., 2002). The current study builds on research focused on how early economic hardship, child and family characteristics, early care and education, and early behavioral problems are associated with later externalizing problems (e.g., Conger et al., 2000; Conger et al., 2002; Duncan et al., 1994; Evans et al., 2013, Love et al., 2005; Moffitt & Caspi, 2001). The current study utilizes dual analytical approaches to complement previous research on theoretical processes that lead to children's behavioral problems (e.g., Calkins & Keane, 2009; Conger et al., 2000; Moffitt & Caspi, 2001). Specifically, the current study uses both deductive (i.e., logistic regression model) and inductive (i.e., SEARCH model) analyses to better understand how early predictors, collected around the time of the child's birth and prekindergarten year, predict children's externalizing problems at 5th grade in a predominantly low-income sample.

Theoretical Perspectives

Two theoretical perspectives inform the current study: the Family Stress Model (Conger et al., 2000) and the bioecological model of human development

(Bronfenbrenner & Morris, 2006). First, the Family Stress Model explains the link between economic hardship and children's problem behaviors through the effects of poverty on the caregiver and the caregiver-child relationship (Conger et al., 2000, Conger et al., 2002). That is, economic hardship is shown to increase economic pressure and strain, lead to increases in parental distress and conflict, and thus increases in disruptive and harsh parenting (Conger et al., 2000). This model has been shown to hold across ethnically diverse samples (Conger et al., 2000; Conger et al., 200) and is important for conceptually framing how early predictors, including economic hardship, relate to later externalizing problems for a predominantly low-income sample of children and families.

Second, the bioecological model of human development focuses on the synergistic interdependencies of *process, person, context, and time* (Bronfenbrenner & Morris, 2006). This perspective emphasizes the importance of analytical approaches that use the *mode of discovery* (i.e., hypothesis-generating) versus the *mode of verification* (i.e., hypothesis-testing) (Bronfenbrenner & Morris, 2006). The current study uses an inductive, sequential partitioning analysis (i.e., SEARCH) that identifies which early predictors are most related to children's externalizing problems at 5th grade, and which predictors are most related to externalizing problems for subgroups of children created by the data partitioning. Therefore, the current study attempts to better understand how early predictors, collected around the time of the child's birth and prekindergarten year, relate to externalizing problems at 5th grade through both deductive and inductive analyses.

Externalizing Problems in Childhood

Externalizing behaviors are the negative outward actions of children on their environments, including aggression, disruption, and hyperactivity (Achenbach, 1978; Achenbach & Edelbrock, 1978). Higher rates of externalizing behaviors are correlated with more anger and impulsivity, and lower levels of self-regulation in early childhood (Calkins & Keane, 2009; Eisenberg et al., 2001). Of importance from a public health perspective, externalizing problems during childhood are associated with increased rates of juvenile delinquency, violence, and earlier onset of substance use (King, Lacono, & McGue, 2004; Lui, 2004). Moreover, children who show persistent and non-normative behavioral problems when coupled with other risk factors (e.g., stressful home environments, negative parenting) face the greatest risks for more consequential behavioral problems later in life (Aguilar, Sroufe, Egeland, & Carlson, 2000; Campbell, Shaw, & Gilliom, 2000; McLoyd, 1998; Moffitt, 1993; Moffitt & Caspi, 2001). Therefore, understanding the early antecedents of children's externalizing problems is critical for interventions and potential prevention of these more consequential behaviors (e.g., violence, substance use; Campbell, 1995; Campbell et al., 2000; King et al., 2004). Given the negative implications of externalizing problems in childhood, the current study seeks to better understand early predictors of 5th grade externalizing problems through dual analytical approaches. Furthermore, the current study uses a dichotomous variable to represent whether or not children exhibit clinically-relevant levels of externalizing problems in order to differentiate these problems from more normative levels of misbehavior that occur in childhood (Moffitt & Caspi, 2001).

Early Predictors of Externalizing Problems

Multiple factors that are present early in children's lives are predictive of later externalizing problems. For instance, research shows that economic hardship (e.g., depth of poverty), child and family characteristics (e.g., gender, maternal employment), early care and education (e.g., Early Head Start; EHS), and early behavioral problems (e.g., aggression) are predictive of later externalizing problems (Conger et al., 2002; Conger et al., 2002; Duncan et al., 1994; Evans et al., 2013; McLoyd, 1998; Moffitt & Caspi, 2001). Within a predominantly low-income sample, the current study examines the effects of these predictors collected at roughly the time of the child's birth and the child's prekindergarten year for externalizing problems at 5th grade.

Economic Hardship. Experiencing poverty early in life and chronically is associated with greater levels of behavioral problems in childhood beyond the influence of other risk factors (Dubow & Ippolito, 1994; Duncan et al., 1994; Korenman, Miller, & Sjaastad, 1995). In addition to the main effects of poverty on behavioral problems, changes in family income are also related to children's behavioral problems (Dearing, McCartney, & Taylor, 2006; Zachrisson & Dearing, 2014). That is, decreases in family income are related to increases in children's externalizing behaviors, while controlling for all time-invariant factors, such as changes in parental employment status and single motherhood status (Dearing et al., 2006; Zachrisson & Dearing, 2014).

The current study focuses on the role of early economic hardship in children who were in families that were eligible for EHS around the time of their birth (serves low-income children and families). Predictors, related to the depth of poverty, family needs, and welfare receipt, distinguish the degree of economic hardship families experienced in the study. Family needs are operationalized as whether the family subjectively feels they

have adequate access to resources such as money, food, or housing. Additionally, the number of different forms of federal supports the family receives (i.e., welfare receipt) could indicate greater, or more chronic, levels of poverty or could offset some of the negative effects of poverty. For instance, research has shown that mothers' transitions on and off of welfare has no significant effects on preschool or adolescent externalizing behavior, though transitioning out of employment is associated with increases in externalizing behaviors during adolescence (Chase-Lansdale et al., 2003). This research suggests that the effects of welfare receipt are likely less related to externalizing problems compared to changes in family income and maternal employment (Chase-Lansdale et al., 2003; Dearing et al., 2006; Zachrisson & Dearing, 2014). It is possible that the influence of different types of economic hardship manifest in different ways for the two analytical approaches. For example, effects of welfare receipt on externalizing problems may be conditional on other predictors and emerge in the sequential partitioning analyses for subgroups of children, but not have additive and independent effects in the logistic regression model. Conversely, effects of depth of poverty on externalizing problems may be independent and additive across the sample, thus significant in the logistic regression model, but not be the strongest predictor for any subgroup of children in the sequential partitioning model.

Child and Family Characteristics. Independent of a family's economic hardship, child and family characteristics are also related to children's externalizing problems. For instance, males show significantly higher rates of externalizing problems than females (e.g., Bongers, Koot, van der Ende, & Verhulst, 2004; Criss et al., 2002; Moffitt & Caspi, 2001). Although some aspects of externalizing behaviors show

narrowing gaps between males and females throughout adolescence, males show significantly higher rates throughout childhood (Bongers et al., 2004; Moffitt & Caspi, 2001). Additionally, previous research shows that gender does not moderate the effects of risk on later behavioral problems, simply that males show higher rates of problem behaviors throughout childhood (Moffitt & Caspi, 2001). In other words, the effects of other early predictors (e.g., economic hardship, maternal employment) are expected to relate to externalizing problems in similar ways for males and females. Although the logistic regression model will not test for the moderation of gender, if gender is selected in the sequential partitioning model (i.e., SEARCH) then all following splits would be conditional on gender. For instance, some predictors (e.g., early behavioral problems) might be more closely related to externalizing problems in males, though they could have relatively similar effects in females as well.

In addition to gender, a number of factors related to children's families are associated with externalizing problems in childhood. For example, single motherhood and change in family structure that leads to single motherhood are associated with more externalizing problems beyond the influence of family income (Criss et al., 2002; Duncan et al., 1994; Korenman et al., 1995). That is, children of single mothers are more likely to have externalizing problems than children from non-single mothers. Maternal employment is also shown to influence children's externalizing problems. In fixed effects analyses, changes in maternal employment predicted changes in externalizing problems beyond the influence of changes in family income (Zachrisson & Dearing, 2014). In other words, mothers who went from employed to unemployed had children who were more likely to have increases in behavioral problems. Furthermore, lower

maternal education, job status, and ethnic minority status predict greater externalizing behaviors in childhood, though the effects of ethnic minority status are possibly confounded with socio-economic status (Criss et al., 2002).

Child and family characteristics are sometimes grouped into cumulative risk indexes consisting of indicators such as ethnic minority status, English Language Learner status, having more than four children in the family, maternal educational attainment, multiple residential moves in the past year, teenage motherhood, and maternal employment status (Evans et al., 2013). Furthermore, cumulative risk indexes can also represent the number of environmental stressors that children experience (Evans & English, 2012). These cumulative risk indexes have consistently been linked to children's externalizing behaviors in both cross-sectional and longitudinal studies (Ackerman et al., 1999; Evans & English, 2012; Evans et al., 2013). As children face greater cumulative risk, they are more likely to have behavioral problems. However, grouping risk factors together prevents researchers from determining the influence of specific risk factors and if risk factors are conditional on other influences (Evans et al., 2013). Thus, the current study seeks to understand the separate contributions of child and family characteristics to children's externalizing problems in the logistic regression model, and if specific risk factors are conditional on other predictors in the SEARCH model.

Early Care and Education. Early care and education can potentially influence externalizing behaviors in childhood beyond the effects of other early life predictors. The influence of attending different forms of early care and education programs have revealed mixed findings on children's later behavioral problems. One specific form of early care

and education is EHS, with its effects evaluated in previously published work using the EHSRE (e.g., Ayoub, Vallotton, & Mastergeorge, 2011; Love et al., 2013; Love et al., 2005). Children in the EHS program, compared to controls, showed fewer aggressive behaviors and their parents showed more supportive parenting behaviors (e.g., less spanking) when the children were three years old (Love et al., 2005). When the children were five years old, children in the EHS program showed significantly fewer behavioral problems (i.e., aggression, hyperactivity, withdrawn behaviors) compared to controls, though not significantly different levels of aggressive behaviors (Love et al., 2013). However, growth curve analyses suggested the early beneficial effects of EHS (at the child's two- and three-year-old time points) on aggressive behaviors largely persisted through age five (Love et al., 2013). Finally, other work has found that the EHS program is associated with small improvements in self-regulation when the child was three years old (Ayoub et al., 2011), a key component in helping children avoid behavioral problems in favor of more adaptive behaviors (Calkins & Keane, 2009).

Head Start and prekindergarten programs have shown more mixed effects. In a meta-analysis on the intervention effects of attending preschool programs, there were small, beneficial effects of preschool attendance on children's social skills (Camilli, Vargas, Ryan, & Barnett, 2010). However, other work has indicated that attending prekindergarten, preschool, or Head Start is associated with increases in externalizing behaviors and decreases in self-control when compared to children in parental care or other forms of non-parental care (Magnuson, Ruhm, & Waldfogel, 2007). These negative effects of prekindergarten, preschool, and Head Start persisted through the end of first grade, although the initial cognitive benefits of these forms of early education had

faded. Other work shows Head Start participation improves aspects of children's social competence (Zhai, Brook-Gunn, & Waldfogel, 2011), though there were negative effects of Head Start on children's externalizing problems (Lee et al., 2014; Zhai et al., 2011). In sum, the effects of early care and education on children's behavioral problems are mostly mixed. The current study seeks to better understand the effects of early care and education on children's externalizing problems at 5th grade by examining the influence of EHS (randomly assigned), EHS program type (home, center, or mixed), mother's previous experience with child development programs, and Head Start attendance (not randomly assigned) in two different analytical approaches. The logistic regression approach examines the effects of early care and education variables while holding all other early predictors constant and the SEARCH model explores subgroup effects by sequentially partitioning the data.

Early Problem Behaviors. In addition to factors related to economic hardship, child and family characteristics, and early care and education, there are strong associations between children's early behavioral problems and later externalizing problems. For example, aggressive and disruptive behaviors in early childhood predict later externalizing behaviors (Bongers et al., 2004; Vazsonyi & Keiley, 2007). In other words, children who enter school with higher levels of externalizing behaviors are more likely to maintain these higher levels throughout childhood. Studies have also shown that early aggression and hyperactivity are most related to children's later externalizing problems, especially when coupled with cumulative risk (Campbell et al., 2000). Therefore, the current study examines how behavioral problem prior to formal school entry, consisting of aggression, hyperactivity, and withdrawn behaviors, relate to

externalizing problems in 5th grade beyond the influence of economic hardship, child and family characteristics, and early care and education. The study utilizes two analytical approaches to more comprehensively examine this research question. That is, the logistical regression model will test for additive effects of early behavioral problems across the full sample, whereas the SEARCH model will explore if early behavioral problems have different effects for specific subgroups on later externalizing problems.

Dual Analytical Approaches

The current study uses two distinct, yet complementary, analytical approaches to better understand how early predictors relate to children's externalizing problems at 5th grade: a logistic regression model and a sequential partitioning model (i.e., SEARCH). The two approaches are generally complementary, such that the logistic regression model is more deductive and focuses on the additive and independent effects of early predictors on later externalizing problems, whereas the SEARCH model is inductive and focuses mostly on subgroup specific effects.

Logistic Regression. The logistic regression approach allows researchers to make inferences about an observed effect for the sample population. Therefore, the estimated effect sizes of the different predictors and confidence intervals are of primary interest. This model estimates the effect of variables while statistically controlling for the effects of other predictors included in the model. In other words, logistic regression allows for the interpretation of predictors while holding all of the other variables constant. Although the logistic regression model is useful and appropriate for the current study, it makes important assumptions about the relation between the predictors and outcome. Principally, it assumes that the each predictor has an independent and additive effect

(unless interactions are hypothesized). Therefore, the assumption is that a variable related to economic hardship (e.g., depth of poverty) and a variable related to early care and education (e.g., EHS assignment) would each contribute uniquely and additively to a children's likelihood of later externalizing problems. Although interactions and subgroup effects can be tested in logistic regression, they are a priori and need theoretical justification. Given that previous research has shown that the effects between risk and externalizing problems are not moderated by gender (Moffitt & Caspi, 2001), it is expected that early predictors should relate similarly to later externalizing problems for boys and girls. The SEARCH model can complement the logistic regression model by identifying predictors that are most related to externalizing problems, and for which subgroups of children, and does not assume predictors have effects that are independent and additive across the full sample.

SEARCH. The SEARCH method was developed to identify complex interactions among variables in large data sets and was originally called the Automatic Interaction Detector (Sonquist, Baker, & Morgan, 1974). The SEARCH method is useful for finding patterns in the raw data and is an inductive, data-driven analysis. The patterns are developed using a sequential partitioning process of selecting an optimal split among the predictors on an outcome (Morgan, 2005). That is, the model will test all predictors (and all possible splits within each predictor) to find the split that is most related to the outcome (e.g., externalizing problems). The split among the predictors that produces the largest likelihood ratio chi-squared statistic is the one determined to be optimal with a dichotomous outcome. The process is sequential; therefore once a split has been determined, two new subgroups are created and all predictors (and possible splits) are

tested again (Sonquist et al., 1974). In other words, the first split is made on the most optimal predictor for the full sample and then each additional split is conditionally the most optimal predictor based on the previous splits in the model. The model constraints are subjectively determined, but the current study uses significance level of $p < .01$ for the log likelihood chi-squared statistic and subgroup sizes of $n \geq 25$.

Through this iterative process, the final output resembles a tree, with branches that are defined by splits on selected predictors. This technique is similar to other classification and regression tree methods (CART), or also known as decision trees (Hastie, Tibshirani, & Friedman, 2009). This analysis is useful when numerous grouping variables exist, as in the current study (e.g., depth of poverty, gender, maternal education attainment, EHS assignment). However, important limitations include that the process is primarily descriptive (not necessarily inferential) and little is learned about the strength of the association for splits not selected in the model. Furthermore, all effects are conditional on previous splits, which present strengths in identifying subgroup effects, yet weaknesses for interpretability and generalizability. Most importantly, the logistic regression and SEARCH models provide complementary, but distinct, information for how economic hardships, child and family characteristics, early care and education, and early behavior problems relate to externalizing problems at 5th grade.

The Current Study

The current study seeks to better understand how early predictors collected at roughly the time of the child's birth (i.e., economic hardship, child and family characteristics, early care and education) and prekindergarten year (i.e., problem behaviors) are associated with externalizing problems at 5th grade in a predominantly

low-income sample. The rationale for the study is based on previous research and theories that show economic hardship and cumulative risk are associated with children's behavioral maladjustment (e.g., Conger et al., 2000; Conger et al., 2002; Evans et al., 2013; McLoyd, 1998; Moffitt & Caspi, 2001). The study adds to the current literature on externalizing problems by showing how dual analytical approaches provide complementary, but distinct, information. The analyses include a hypothesis-testing, logistic regression model and a hypothesis-generating, sequential partitioning model. Both models provide information on the central research question: *how do early predictors relate to the likelihood of later externalizing problems in a low-income sample?* Externalizing problems are treated as a dichotomous variable to represent clinical or near-clinical levels versus relatively lower (normative) levels because children with non-normative levels of externalizing problems have a greater likelihood of later consequential behaviors (Campbell et al., 2000; King et al., 2004; Lui, 2004; Moffitt & Caspi, 2001). Based on previous research, it is hypothesized that children who are male, come from families with greater levels of economic hardship, maternal unemployment, single motherhood, and show early aggressive behaviors will have significantly higher likelihoods of 5th grade externalizing problems in the logistic regression model (e.g., Ackerman et al., 1999; Bongers et al., 2004; Campbell et al., 2000; Conger et al., 2002; Criss et al., 2002; Moffitt & Caspi, 2001; Vazsony & Keiley, 2007). Specific hypotheses about the subgroup effects in the SEARCH model are not made because of the inductive nature of the analyses, though it is expected that selected splits will be mostly consistent with the significant predictors in the logistic regression model.

Method

Early Head Start Research and Evaluation Study

The current study was a secondary data analysis of the Early Head Start Research and Evaluation Study (EHSRE). The Administration for Children and Families (ACF), within the Department of Health and Human Services (DHHS), funded the EHSRE, which evaluated the effects of Early Head Start (EHS) (lasting from 1996 to 2010; US DHHS ACF, 1996-2010). Data were collected from 17 different sites across the U.S. and included children and families eligible for EHS at the baseline of the study. The 17 sites were not a random sample, but were representative of EHS programs at the time (Love et al., 2005). Eligibility for involvement in the EHSRE required that EHS programs could over-recruit eligible families at the baseline of the study in order for half of the families to be randomly assigned to the EHS program or a control group (randomization was done by Mathematica Policy Research). The eligible families were mostly living in poverty, with the mother either pregnant or had just given birth at the baseline of the study. The current study uses three waves of data from the EHSRE: the baseline wave (roughly the time of the child's birth and the time of EHS randomization), prekindergarten wave (roughly 5 years after the baseline), and 5th grade wave (roughly 10 years after the baseline). Previously published work provides detailed information on the EHSRE methods and EHS effects through children's prekindergarten year (for reviews see Love et al., 2013; Love et al., 2005).

Measures

Twenty-four predictor variables were used in the analyses. Twenty of the variables (measuring *economic hardship, child and family characteristics, early care and education*) were collected at the baseline wave of the study (e.g., roughly the time of the

child's birth) and four (measuring children's *early problem behaviors* and *Head Start attendance*) were collected during the child's prekindergarten wave of the study. Of the 24 variables, 23 were categorical and one was continuous (maternal age at baseline). For the 23 categorical variables, "missingness" was coded as a category. This strategy was used, as opposed to multiple imputation or full information maximum likelihood, because it was more amendable to the SEARCH method and kept variables consistent across both models. Furthermore, estimates were not biased due to listwise deletion of observations because very few cases were dropped due to missingness on predictors ($n = 2$ on maternal age at baseline).

Economic Hardship. At baseline, economic hardship was assessed with self-reported family income, welfare receipt, and a needs assessment. Self-reported income divided by the poverty line for the given year was used for assessing the family's depth of poverty. Depth of poverty included four categories: deep poverty (less than 50% of the poverty line), poverty (less than 100% of poverty line), low-income (less than 200% of the poverty line), and not low-income (more than 200%). Self-reported welfare receipt included two variables: self-reported receipt of Aid to Families with Dependent Children (AFDC) and a cumulative index of the number of services families reported receiving: Medicaid, Food Stamps, Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Supplemental Security Income (SSI), and Public Housing (coded into categories of 0 or 1 received; 2 or 3 received; 4 or 5 received). Family needs were assessed with a measure of self-reported adequacy of resources. This measure was a cumulative index of the number of resources parents reported having insufficient amounts: food, housing, money, medical care, transportation, and support from families

and friends (0 reported; 1 reported; 2 or more reported), with higher values representing greater inadequacies in access to resources.

Child and Family Characteristics. Child characteristics included gender, ethnicity, and the child's age at the baseline of the study (coded as not born; first 6 month of life; older than 6 months of life). At the baseline of the study, family characteristics included whether the primary language in the household was English (coded as English or non-English), maternal educational attainment (coded as less than high school; high school equivalency; or more than high school), maternal occupational status (coded as employed; in school; or neither), maternal age, home living arrangements (coded as the mother living with the husband; with other adults; or single), number of adults in the household (coded as one; two; or more than two), if the focus child was the first born, number of children in the household under 5 (coded as none; one; or more than one), number of children in the household between 6 and 17 (coded as none; one; or more than one), and number of residential moves in the past year (coded as none; one; or more than one).

Early Care and Education. At the baseline of the study, early care and education included whether or not the child was randomly assigned to the EHS program (coded as program group or comparison group), the EHS program type at the site (coded as center care; home care; or mixed care), and whether or not the mother had previous experiences with EHS, Head Start (HS), or similar development program (coded as yes, has experience or no, has no experience). Additionally, whether or not the child attended Head Start (not randomized) was included from the prekindergarten-aged wave of the study.

Early Problem Behaviors. The early problem behaviors included subscales from the FACES Social Behavior Problems measure (ACF, 2006; Love et al., 2013), which were collected during the prekindergarten wave of the study. For this measure, parents rate their child on 12 total items, consisting of 3 subscales: aggressive behaviors (4 items), hyperactive behaviors (4 items), and withdrawn behaviors as “0 = not true”, “1 = somewhat true or sometimes true”, and “2 = very true or often true”. The FACES Social Behavior Problems scale has been found to be reliable and valid in this sample and in other national studies (ACF, 2006; Love et al., 2013). For this sample, the internal consistency of the 12 items was $\alpha = .76$ ($n = 2,029$) (Love et al., 2013), subscale specific internal consistencies are not presented because the item level data was not available in the public dataset.

The three subscales were coded into a low, medium, or high level for each behavior. The categories were created using the percentile command (i.e., *xtile*) and missing observations were coded as a fourth category. The percentile command created three roughly equivalent groups consisting of one-third of the values, although with only 4 items per subscale and highly skewed distributions, the values were not perfectly distributed into thirds. This was done for three reasons: first, all measures showed highly skewed distributions; second, a greater focus was on the qualitative (e.g., low versus high) instead of quantitative (e.g., estimated change based on a one-unit difference in the measure) effects of early problem behaviors; and third, in the SEARCH models it allows the inclusion of variables that have missingness (coded as a category), and therefore children with missing data on the variable were not dropped from the analyses.

The *xtile* command was run for each subscale separately, meaning each variable was recoded into thirds based on its distribution. For the FACES aggression subscale, the categories were low aggression (raw scores of 2 or less), medium aggression (raw scores of 3), and high aggression (raw scores of 4 or higher). For the FACES hyperactivity subscale, the categories were low hyperactivity (raw scores of 1 or less), medium hyperactivity (raw scores of 2), and high hyperactivity (raw scores of 3 or higher). For the FACES withdrawn subscale, the categories were low withdrawn (raw scores of 0), medium withdrawn (raw scores of 1), and high withdrawn (raw scores of 2 or higher).

5th Grade Externalizing Problems. The Child Behavior Checklist (CBCL) was used to assess externalizing problems at 5th grade (Achenbach & Rescorla, 2001). For this measure, parents rate children on multiple aspects of externalizing behaviors. Parent ratings are “0 = not true (as far as you know)”, “1 = somewhat true or sometimes true”, and “2 = very true or often true” for each item. The Externalizing scale consists of 35 total items and is an average of two subscales: the Rule-Breaking Behavior subscale and the Aggressive Behavior subscale. The Rule-Breaking Behavior subscale is assessed with 17 items, with items such as “Breaks rules at home, school, or elsewhere”. The Aggressive Behavior subscale is assessed with 18 items, with items such as “Cruelty, bullying, or meanness to others”. Although item level data were not publicly available to calculate the alpha in this sample, nor reported in the 5th grade user guide (US DHHS ACF, 1996-2010), the CBCL has been shown to be a reliable and valid measure of children’s externalizing behaviors (Achenbach & Edelbrock, 1978; Achenbach & Rescorla, 2001). Per request, Mathematica Policy Research provided the data for the cut-scores on the CBCL Externalizing scale (i.e., clinical, near-clinical, neither) with the

current study using the clinical and near-clinical codes to indicate a child has externalizing problems. To create the clinical level values, the CBCL raw scores were transferred into a T-score, with T-scores values greater than 60 (i.e., both clinical and near-clinical) indicating externalizing problems. In terms of the CBCL raw score, clinical and near-clinical values corresponded to a raw score of 12 or higher on the 35 total items at 5th grade.

Analytic Plan

All analyses were run in Stata 12.1 (StataCorp, 2011). Two models were estimated for predicting children's externalizing problems at 5th grade: logistic regression and SEARCH. The predictors were predominantly categorically coded, with the one exception of maternal age at the study baseline (i.e., roughly the time of the child's birth). All categorical variables were treated as nominal in both analyses. For the categorical predictors in the logistic regression model, significant differences between codes within a predictor were of focus (i.e., do males and females significantly differ on externalizing problems). When there were more than two categories being compared within a predictor (e.g., ethnicity), all group differences were estimated with the post-estimation command *lincom*. This allows for significance tests between categorical codes that did not include the reference group in the logistic regression. To simplify interpretations, only significant group differences at $p < .05$ are presented in the results.

The SEARCH model was estimated (principally descriptive) to complement the information gained from the logistic regression (principally inferential). Given that externalizing problems was a dichotomous variable (clinical and near-clinical values compared to neither clinical nor near-clinical values) the selected splits in the SEARCH

model were determined based on the likelihood ratio chi-squared statistic. Thus, the split among the predictors that provided the largest likelihood ratio chi-squared statistic (and thus, significance level) was determined to be the most optimal split for externalizing problems. The model selection criteria, or model constraints, were that a split had to be significant at $p < .01$ and create two subgroups of $n \geq 25$. The selection criteria were chosen strategically. That is, selecting low criteria results in complex models with limited interpretability and an increased probability of identifying variables due to chance alone. Thus, $p < .01$ was selected as a criteria rather than $p < .05$ in order to reduce the likelihood of capitalizing on potential chance differences. Further, subgroups of at least 25 were used to eliminate splits that could be selected based on relatively small sample sizes, again to reduce the likelihood of capitalizing on chance findings. Due to the longitudinal nature of the data, variables collected at the baseline wave were given first priority in determining each split in the model. Therefore, if a variable from the baseline wave satisfied the model constraints, it was selected. Head Start attendance was given second priority because it preceded the prekindergarten problem behaviors assessment, but also occurred after the baseline variables. Prekindergarten problem behaviors were given the third priority. Therefore, they are selected conditional on the baseline variables and Head Start attendance not meeting the selection criteria.

Although the same predictors were candidates for inclusion in SEARCH models as used in the logistic regression, one important distinction existed. For the logistic regression, each code is compared to another code within the categorical variable (e.g., White children compared to Black children). In the SEARCH model, a variable is split into two subgroups (e.g., White children compared to all Non-White children). For

dichotomous variables this makes no difference (e.g., males compared to females). For both models, missing values on categorical variables were coded as a “missing” category. Significant differences between a group (e.g., low welfare receipt) and missingness in the logistic regression is noted in the text, but not presented in the table. For the SEARCH models, the grouping of children coded as missing on a variable are not presented in the figure. This information is omitted because the reasons for coding missingness in this way is to avoid listwise deletion based on missingness on predictors in the model, not to understand how missing data patterns relate to later externalizing problems.

One table of the significant effects from the logistic regression model and one figure of the SEARCH model are presented. For the table, all groups that are predictive of a higher likelihood of externalizing problems are presented first for consistency (i.e., positive b-coefficients and relative risk ratios larger than one). Relative risk ratios are easily interpreted as the relative increase in probability of externalizing problems at 5th grade. In other words, a relative risk ratio of “2.00” would indicate twice the probability of being at the *clinical* or *near-clinical* level in externalizing problems. For the SEARCH figure, the tree shows the selected split followed by the relative risk ratio. The relative risk ratios are descriptive of the observed data and are not inferential. Additionally for the SEARCH figure, within each box the two splits are presented with the sample size and the percentage of children in the data that were classified as being at the *clinical* or *near-clinical* level in externalizing problems at 5th grade. A grey box distinguishes the final splits where no predictor met the selection criteria (i.e., $p < .01$ and $n \geq 25$ for each subgroup).

Results

Descriptive statistics for all variables included in the models ($N = 1377$) are presented in Table 3.1, except for maternal age at the study baseline ($M = 22.69$, $SD = 5.62$, $Range = 14 - 40$). Although missing data are presented in a separate column, missing codes for each variable were included in the models. Correlations are not presented because all variables, except one, were categorical and not continuous.

(Insert Table 3.1)

Logistic Regression Model. The significant effects in the logistic regression model for 5th grade externalizing problems are presented in Table 3.2. In total, five predictors from the baseline of the study (i.e., roughly the time of the child's birth) and five early problem behaviors (i.e., child's prekindergarten year) were significantly related to 5th grade externalizing problems (i.e., $p < .05$), while statistically controlling for all other variables. Of the baseline predictors, gender was the most statistically significant effect (i.e., least likely due to chance alone), where males were 66% more likely than females to have externalizing problems at 5th grade. However, the largest point estimate of the baseline predictors was whether the child came from a home that spoke English, with children in these homes 82% more likely than children in non English-speaking homes to have externalizing problems (notably, as rated by the caregiver). Three other significant effects for the baseline predictors (i.e., roughly the time of the child's birth) were: 1) children in families where the mother lived with other adults (i.e., not single), compared to the living with the husband, were more likely to have externalizing problems at 5th grade; 2) children of mothers who were unemployed and not in school, compared to mothers who were employed, were more likely to have externalizing problems at 5th grade; and finally, 3) children in the first six months of life at baseline, compared to

children older than six months at baseline, were more likely to have externalizing problems at 5th grade. Furthermore, coded as missing on welfare receipt was predictive of a significantly lower likelihood of externalizing problems at 5th grade compared to codes of receiving welfare receipt. All other comparisons not shown were non-significant. For instance, no variable related to early care and education (e.g., EHS, Head Start attendance) or economic hardships (e.g., depth of poverty, family needs) had a significant effect on children's externalizing problems at 5th grade.

For the child's prekindergarten problem behaviors, early aggression and hyperactivity were each significantly associated with children's likelihood of externalizing problems at 5th grade, but withdrawn behaviors were not. The difference between children with high aggression and low aggression in prekindergarten was the strongest predictor in the model, with high levels of aggression, compared to low levels of aggression, predictive of 270% greater likelihood of externalizing problems at 5th grade. High levels of hyperactivity in prekindergarten were predictive of 81% and 62% greater likelihood of externalizing problems at 5th grade compared to levels of low and medium hyperactivity (respectively).

(Insert Table 3.2).

SEARCH Model. The SEARCH model for externalizing problems at 5th grade is presented in Figure 3.1. The first split in the tree was gender, with males showing 55% greater likelihood of externalizing problems. In other words, of the baseline predictors (i.e., roughly the time of the child's birth) gender had the largest likelihood ratio chi-squared statistic of possible splits in the data. This finding is consistent with the logistic regression model that showed gender to be the most statistically significant effect of the

baseline predictors. However, unique from the logistic regression model, each further split in the model is now conditional on the child's gender.

For males, the next selected split was welfare receipt (i.e., the largest likelihood ratio chi-squared statistic of the baseline predictors and met selection criteria), with relatively higher levels of welfare receipt related to 60% greater likelihood of externalizing problems at 5th grade. For males, in families receiving none or one form of welfare receipt, past year residential moves at baseline was the next selected split with multiple moves associated with over twice the likelihood of having externalizing problems at 5th grade. For this subgroup, prekindergarten aggression was next selected split (no baseline predictor met the model selection criteria), with medium and high aggression related to three times the likelihood of externalizing problems at 5th grade compared to the low aggression subgroup. In other words, welfare receipt provided the most optimal split of the baseline factors for males. When welfare receipt was low, males in families that had multiple moves around the time of their birth were more likely to have externalizing problems at 5th grade. When males were not in families with multiple moves, prekindergarten aggression was the final split with no other predictor meeting the selection criteria.

For males in families receiving multiple forms of welfare, early aggression was the next selected predictor (no baseline predictor met the model selection criteria), with higher levels of prekindergarten aggression, compared to low or medium levels of prekindergarten aggression, associated with over twice the likelihood externalizing problems at 5th grade. Among the subgroup of children with low or medium levels of aggression, home living arrangement was the next most optimal split in the data (i.e.,

baseline predictor now met the model selection criteria), with children from families where the mother was not living with the husband showing nearly twice the likelihood of externalizing problems at 5th grade. The final split along this pathway was prekindergarten aggression, with medium levels compared to low levels of aggression (i.e., early high aggression had already been partitioned out) associated with nearly twice the likelihood of externalizing problems at 5th grade. In summary, for predicting 5th grade externalizing problems using sequential partitioning, males were further differentiated in the model based on family welfare receipt, past year residential moves, and mothers living arrangements around the time of the child's birth (i.e., baseline of the study), and prekindergarten aggression levels.

For females, the most optimal split was depth of poverty (i.e., the largest likelihood ratio chi-squared statistic of the baseline predictors and met selection criteria), with females in deep poverty, compared to females not in deep poverty, showing 85% greater likelihood of externalizing problems at 5th grade. For females in deep poverty, none or one form of welfare receipt, compared to multiple forms of welfare receipt, was predictive of 91% greater likelihood of externalizing problems at 5th grade. This effect of welfare receipt is in the opposite direction than the split for males, suggesting a potential interaction effect between depth of poverty and welfare receipt on externalizing problems at 5th grade. For females in deep poverty and with none or one form of welfare receipt, prekindergarten aggression was the next most optimal split, with medium and high levels of aggression, compared to low levels, predictive of over twice the likelihood of externalizing problems at 5th grade. For females in deep poverty, with fewer forms of welfare receipt, and low levels of aggression, maternal educational attainment at baseline

was the next selected split with higher likelihoods of externalizing problems at 5th grade in children with mothers that had a high school degree compared to others (63% had less than a high school degree and 37% had more). For females in deep poverty, with lower levels of welfare receipt, and medium or high levels of prekindergarten aggression, maternal age at baseline was the next selected split with children of mothers 21 or older associated with higher likelihoods of externalizing problems. In summary, for predicting 5th grade externalizing problems using sequential partitioning and for females in deep poverty, the tree further differentiated children based on family welfare receipt, maternal educational attainment, and maternal age at baseline of the study (i.e., roughly the time of the child's birth), and prekindergarten aggression levels.

Maternal occupation status was the most optimal split for females not in deep poverty, with children of mothers who were unemployed and not in school, compared to children of mothers who were in school or employed, showing roughly twice the likelihood of externalizing problems at 5th grade. For the females not in deep poverty and who had mothers who were in school or employed, the next selected split was EHS assignment, with the children assigned to the comparison group, compared to children in the EHS group, showing over three times the likelihood of externalizing problems at 5th grade. For the subgroup of females not in deep poverty and who had a mother unemployed and not in school, the next most optimal split was primary language in the home, with children from homes that spoke English associated with over three times greater likelihood of externalizing problems at 5th grade. For the subgroup of females not in deep poverty, who had a mother unemployed and not in school, and the primary

language in the home was English, children who were the first born had over twice the likelihood of externalizing problems at 5th grade.

Overall, selected splits in the SEARCH model were largely consistent with significant predictors in the logistic regression model (e.g., gender, living arrangements at baseline, prekindergarten aggression), but also some different predictors emerged as well (e.g., EHS, past year residential moves). Moreover, prekindergarten hyperactivity was not a selected split in the SEARCH model meaning that at no point did it meet with selection criteria and have a likelihood ratio chi-squared statistic larger than other possible splits in the data. Although EHS was not selected in the logistic regression model, it did show a beneficial subgroup effect for externalizing problems at 5th grade (i.e., females not in deep poverty, who had mothers that were employed or in school at roughly the time of the child's birth).

(Insert Figure 3.1).

Discussion

The current study examines the effects of predictors from roughly the time of the child's birth (i.e., economic hardship, child and family characteristics, and early care and education) and prekindergarten problem behaviors on children's externalizing problems at 5th grade in a low-income sample. The study builds on previous research by taking a dual analytical approach for understanding these relations. The logistic regression estimates significant differences for predictors while statistically controlling for other predictors in the model. These findings are meant to be inferential (generalize to other similar low-income populations), with predictors interpreted as having independent and additive effects on children's externalizing problems at 5th grade. The SEARCH

approach inductively identifies patterns in the data through a sequential partitioning analysis. In other words, it identifies which predictors are most related to children's externalizing problems at 5th grade through partitioning the data based on the splits that provide the largest likelihood ratio chi-squared statistic. Key findings across both models are mostly consistent with previous research and theories, showing significant effects of gender, maternal employment and mothers living with the husband (i.e., partner status) at roughly the time of the child's birth, and prekindergarten aggression on later externalizing problems (Bongers et al., 2004; Campbell et al., 2000; Moffitt & Caspi, 2001; Vazsony & Keiley, 2007). However, a few key differences in the models also emerged. First, economic hardship predictors (i.e., welfare receipt, depth of poverty) were selected splits in the SEARCH model, but not significant in the logistic regression model. Second, the SEARCH model identified potential subgroup effects that were unobserved in the logistic regression (e.g., beneficial EHS effect for a subgroup of females). Third, prekindergarten hyperactivity did not emerge as a selected split in the SEARCH model, although it was highly significant in the logistic regression model (i.e., $p < .01$).

Consistencies across Models for Early Predictors of Externalizing Problems

The findings from the current study further previous research by exploring the effects of early predictors, related to economic hardship, child and family characteristics, and early care and education, on children's externalizing problems at 5th grade in a low-income sample of children. Data were used from roughly the time of the child's birth to predict children's 5th grade externalizing problems roughly 10 years later. A number of early predictors emerged consistently across the two types of analyses. Consistent with

previous research, gender was a strong predictor in both models (e.g., Bongers et al., 2004; Moffitt & Caspi, 2001). However, the interpretation is slightly different for each model. In the logistic regression model, males showed significantly greater likelihood of externalizing problems at 5th grade while controlling for other predictors (including prekindergarten aggression and hyperactivity). In the SEARCH model, gender had the largest likelihood ratio chi-squared statistics of all baseline predictors. Therefore, in the SEARCH model, all additional splits were conditional on gender and it allowed for the possibility of gender-specific effects. Regardless, both models show that males were roughly 60% more likely to have externalizing problems at 5th grade.

Three other predictors from roughly the time of the child's birth were significant in the logistic regression model and selected as optimal splits in the SEARCH model: maternal occupational status, home living arrangements, and language spoken in the household. Maternal occupational status and living arrangements (whether the mother lived with the husband) were both associated with externalizing problems in expected directions and consistent with previous research (Criss et al., 2002; Duncan et al., 1994; Korenman et al., 1995; Zachrisson & Dearing, 2014). In the logistic regression model, children who had mothers living with husbands at baseline showed lower likelihoods of externalizing problems at 5th grade, compared to children who had mothers living with other adults. Furthermore, children with mothers who were unemployed and not in school showed greater likelihoods of externalizing problems at 5th grade, compared to children with mothers who were employed. In the SEARCH model, these variables emerged for subgroups of children and were conditional on previous splits in the model (e.g., gender), but were in expected directions. In general, these variables are likely

related to financial security and parental stress (Duncan & Magnusson, 2005; McLoyd, 1998), which likely influence the caregiver-child relationship (Conger et al., 2000; Conger et al., 2002).

The influence of language spoken in the home is more challenging to interpret, as children in English-speaking homes were predicted to be more likely to show externalizing problems across both types of analyses. This finding is inconsistent with studies using cumulative risk indexes, which sometime uses English Language Learner status as an indicator of risk, with cumulative risk associated with more externalizing problems (Evans et al., 2013). However, the SEARCH model helps possibly shed light on the logistic regression finding, by selecting this predictor only for a subgroup of females, not in deep poverty, whose mothers were unemployed and not in school. For this specific subgroup of children ($n = 202$), those children in English-speaking homes showed more than three times the likelihood of externalizing problems at 5th grade. In summary, there could be a subgroup specific effect that is driving the significant finding in the logistic regression model. Previous research has suggested that many of the observed links between ethnic minority status and poorer academic achievement are possibly confounded by socio-economic status (Duncan & Magnusson, 2005), which has also been suggested as a possibility for the link between ethnic minority status and problem behaviors (Criss et al., 2002). Regardless, these findings suggest that the effects of English Language Learner status on externalizing problems could be conditional on other influences.

Inconsistencies across Models for Early Predictors of Externalizing Problems

Only one variable emerged as having a significant effect in the logistic regression model that was not selected in the SEARCH model: age of the child at baseline of the study. That is, at the baseline of the study and time of EHS randomization, children in the first six months of life (45.32% of the sample), compared to children older than six months (27.23% of the sample), showed a significantly higher likelihood of externalizing problems at 5th grade. Based on previous research and the study design, it is unclear why children's age at the baseline of the study could have influenced externalizing problems at 5th grade. Because research shows that experiencing poverty early in life is most deleterious on development (e.g., Dubow & Ippolito, 1994; Duncan et al., 1994), it is possible that the older children in the sample showed less economic hardship during an earlier sensitive period in development (i.e., first 6 months of life). The effect of child age at baseline did not emerge in the SEARCH model, suggesting that it was not a result of a specific subgroup and once accounting for more optimal splits in the data it never met the selection criteria.

After accounting for gender, the two most optimal splits in the SEARCH model were for two variables that did not have significant effects in the logistic regression model: *depth of poverty* and *welfare receipt*. For males, families receiving multiple forms of welfare receipt at the baseline had significantly higher likelihoods of externalizing problems at 5th grade. For females, experiencing deep poverty was associated with a significantly higher likelihood of externalizing problems at 5th grade. Notably, only conditional on gender, these splits had the largest likelihood ratio chi-squared statistic (i.e., least likely due to chance), yet were not significant predictors in the logistic regression model. Within a predominantly low-income sample, these findings

are consistent with the previous research on the pervasive influence of economic hardship on children's externalizing problems (i.e., Conger et al., 2000; Conger et al., 2002; McLoyd, 1998; Moffitt & Caspi, 2001).

Interpreting the observed splits in the SEARCH model must be done cautiously given the inductive, data driven nature of the analyses. Still, the model showed a potentially important interaction related to economic hardship, such that the effect of welfare receipt on externalizing problems was in the opposite direction once conditional on depth of poverty. That is, females in deep poverty showed fewer externalizing behaviors if their families were receiving multiple forms of welfare receipt. This finding could shed light on why previous research has failed to find consistent patterns between welfare receipt and externalizing behaviors in childhood (Chase-Lansdale et al., 2003), which is that it is possibly conditional on family income. Two important differences when comparing the effects of depth of poverty and welfare receipt between the two models are worth noting. First, the SEARCH model selected a split among baseline predictors if it satisfied the model constraints (prior to prekindergarten behaviors), which was not true in the logistic regression model. In other words, if welfare receipt and depth of poverty are influencing other predictors in the model (e.g., prekindergarten aggression), their effects could be suppressed in the logistic regression model. Additionally, the splits on depth of poverty and welfare receipt were optimal, dichotomous splits in the SEARCH model and not comparisons within the variables (e.g., deep poverty versus poverty) as with the logistic regression model.

Two other theoretically relevant variables emerged in the SEARCH model that did not emerge in the logistic regression model: past year residential moves and EHS

assignment. For males with none or one form of welfare receipt, past year residential moves was the next most optimal split, with multiple moves associated with increases in externalizing behaviors at 5th grade. This finding is consistent with research that has documented negative effects of residential instability in early childhood (Leventhal & Brooks-Gunn, 2000; Schmitt, Finders, & McClelland, 2014), as well as research that suggests high mobility presents risks for children's development (Duncan & Magnusson, 2005; Evans et al., 2013).

The EHS program showed a beneficial effect for a subgroup of females not in deep poverty and whose mothers were employed or in school at the baseline of the study. For this subgroup, EHS assignment was associated with a relatively large decrease (one-third of the likelihood) in externalizing problems at 5th grade. Although this is unique from research that has focused on overall EHS program effects and interactions through deductive processes (e.g., parenting behaviors, self-regulation) (Ayoub et al., 2011; Love et al., 2013; Love et al., 2005), it does suggest EHS could impact 5th grade externalizing behaviors for some subgroups of children. Moreover, despite this subgroup (i.e., females not in deep poverty with mothers either working or in school) presenting relatively low risk compared to the full sample, it should not be minimized considering the potential harmful effects of externalizing problems on developmental trajectories (e.g., King et al., 2004; Lui, 2004; Moffitt & Caspi, 2001). Head Start attendance did not emerge as a significant or selected predictor of externalizing problems at 5th grade in either model. This finding is in part consistent with previously reported mixed effects associated with Head Start and preschool attendance on children's behavioral problems (Camilli et al., 2010; Lee et al., 2014; Magnusson et al., 2007; Zhai et al., 2011). It is worth noting that

it is possible that Head Start does influence early behavioral problems, though the effects have largely washed out by the time children are in 5th grade.

Finally, although maternal educational attainment, maternal age, and if the child was the first-born emerged in the SEARCH model, they were each conditional on four previous splits in the data and represented relatively small subgroups of children, thus making them more challenging to interpret. Moreover, their connections to previous research are less clear. For example, maternal educational attainment did not split in an additive way, such that children who had mothers with a High School degree at baseline showed more externalizing problems than children who had mothers with less than, or more than, a High School degree. Maternal age also did not split in a way consistent with risk research, as children of relatively younger mothers at baseline (under 21) showed fewer externalizing problems at 5th grade than children of relatively older mothers; this pattern of associations is opposite of what would be expected based on prior research (e.g., Duncan & Magnusson, 2005; Evans et al., 2013). In summary, maternal educational attainment, maternal age, and birth order could all present subgroup specific effects on children's externalizing problems at 5th grade, but need to be further examined to draw conclusions and could simply be products of error in the data driven model.

Early Problem Behaviors

Both analytic approaches identified associations between prekindergarten aggressive behaviors and 5th grade externalizing problems. These findings are consistent with research that shows high levels of aggressive behaviors are maintained through children's elementary years (Bongers et al., 200; Vazsony & Keiley, 2007). However, there are two notable differences between the two models: the interpretation of the effect

of early aggression and the effect of hyperactivity on children's externalizing problems at 5th grade. In the logistic regression model, the effect of early aggression is assumed to be independent and additive across the sample. Yet, in the SEARCH model, early aggressive behaviors did not satisfy the selection criteria for splitting the data in over a third of the full sample (38.34%). This is likely in part a function of baseline factors explaining much of 5th grade externalizing problems until small subgroups remained in the SEARCH model. However, it also suggests that the effect of early aggression may not be the same across the full sample, as it is assumed in the logistic regression model. In other words, early aggression might be very predictive of 5th grade externalizing problems for some subgroups of children (e.g., males; selected for 95.63% of males in the sample) but have less of a relation in other subgroups of children (e.g., females; selected for 26.03% of females in the sample).

The other key difference that emerged between the two models related to prekindergarten hyperactive behaviors and 5th grade externalizing problems. In the logistic regression model, high levels of early hyperactivity were associated with more externalizing problems at 5th grade (compared to medium and low levels), yet early hyperactivity levels were never a selected split in the SEARCH model. This is likely a function of the connection between children's early hyperactive and aggressive behaviors (e.g., Achenbach, 1978; Achenbach & Edelbrock, 1978; Hinshaw, 1987). For example, in the SEARCH models when no baseline predictor satisfied the selection criteria, prekindergarten aggression was always more closely associated with 5th grade externalizing problems than was prekindergarten hyperactivity. Once the SEARCH model was conditional on prekindergarten aggression, prekindergarten hyperactivity

added little in explanatory power beyond that which was explained by differences in early aggression. This finding is inconsistent with conceptualizing both early aggression and hyperactivity as risk factors for later externalizing problems (e.g., Campbell et al., 2000), but suggests early hyperactivity is possibly confounded with early aggression and its effects are potentially spurious with later externalizing problems. It is important to note that this conclusion could be in part dependent on how the early behaviors were coded (low, medium, and high levels), and future work would need to further examine this question in an independent sample.

SEARCH Profiles of Children. For the SEARCH models, results indicated that males experiencing economic hardship, multiple residential moves, and who do not have a mother and father living together at the time of their birth are most likely to have externalizing problems at 5th grade. The negative associations of these early life factors are further exacerbated if children also show prekindergarten aggressive behaviors. Just like with males, economic hardship at birth is also related to externalizing problems at 5th grade for females, though the pattern is less clear otherwise. For instance, the effects of early aggression do not appear to be as related to 5th grade externalizing problems in females as with males. Therefore, early interventions and programs may be most successful for reducing future externalizing problems if they target males who experience early risk and show early aggressive behaviors.

Limitations and Future Directions

Although this study is unique by using dual analytical approaches for understanding early predictors of 5th grade externalizing problems, a number of limitations exist. First, a number of potentially key variables were not available for the

analyses because of the secondary data analysis constraints of using a pre-existing dataset. Variables such as maternal depression (Pettersson & Albers, 2001), childhood neighborhood quality (Duncan et al., 1994; Leventhal & Brooks-Gunn, 2000), and self-regulation (Calkins & Keane, 2009) could be meaningful early predictors of later externalizing problems, but were not examined in the current study. Future work should consider including the significant predictors from the current study as well as other previously identified key predictors for understanding early antecedents of externalizing problems for children in low-income families. Relatedly, although theoretical perspectives guided the study, it was not a test of them. For example, the links in the Family Stress Model (e.g., caregiver-child relation) were not examined (Conger et al., 2000), nor were potential *processes* discussed in the bioecological model (Bronfenbrenner & Morris, 2006). Future work should consider taking dual analytical approaches to address the processes of these models to see if they hold in both deductive and inductive analyses.

Implications and Conclusions

Although limitations exist, there are also a number of important implications. First, the current study found a number of strong links between predictors from roughly the time of the child's birth to externalizing problems 10 years later. It replicates findings of the importance of maternal employment, living arrangements (or partner status), and gender in a predominantly low-income sample (Bongers et al., 2004; Criss et al., 2002; Duncan et al., 1994; Korenman et al., 1995 Zachrisson & Dearing, 2014). In other words, the link between these early predictors and later externalizing problems are likely unique from the overall effects associated with economic hardship. The current study

also shows the utility of a sequential partitioning analysis (i.e., SEARCH) for complementing findings from a logistic regression (e.g., interpreting the effect of household spoken language on 5th grade externalizing problems). Furthermore, the SEARCH model potentially more accurately captured the role of economic hardship within this low-income sample (e.g., depth of poverty, welfare receipt), consistent with theory of it as a cause of behavioral problems in childhood (Conger et al., 2000; Conger et al., 2002; McLoyd, 1998). Finally, the SEARCH model also identified a beneficial subgroup effect for EHS on children's externalizing problems. Although these findings are dependent on replication given the exploratory nature of the model, it does suggest that EHS is protecting some children from later externalizing problems. Moreover, considering that externalizing problems in childhood present increased risks for more consequential behaviors later in life (Campbell et al., 2000; King et al., 2004; Lui, 2004), this could have meaningful implications for those children. Future work should continue to explore the influences of multiple, early predictors on children's behavioral development through dual analytical approaches to further developmental research.

References

- Achenbach, T. M. (1978). The child behavior profile: An empirically based system for assessing children's behavioral problems and competencies. *International Journal of Mental Health, 24*, 4-42.
- Achenbach, T. M., & Edelbrock, C. S. (1978). The classification of child psychopathology: a review and analysis of empirical efforts. *Psychological bulletin, 85*(6), 1275.
- Achenbach, T. M., & Rescorla, L. (2001). *ASEBA school-age forms & profiles*. Burlington, VT: Aseba.
- Ackerman, B. P., Schoff, K., Levinson, K., Youngstrom, E., & Izard, C. E. (1999). Therelations between cluster indexes of risk and promotion and the problem behaviors of 6-and 7-year old children from economically disadvantaged families. *Developmental Psychology, 35*(6), 1355.
- Aguilar, B., Sroufe, L., Egeland, B., & Carlson, E. (2000). Distinguishing the early-onset/persistent and adolescence-onset antisocial behavior types: From birth to 16 years. *Development and Psychopathology, 12*(02), 109-132.
- Administration for Children and Families. (2002a). *Making a difference in the lives of children and families: The impacts of Early Head Start programs on infants and toddlers and their families*. Washington, DC: U. S. Department of Health and Human Services.
- Administration for Children and Families. (2002b). *Pathways to quality and full implementation in Early Head Start Programs*. Washington, DC: U. S. Department of Health and Human Services.
- Administration on Children, Youth and Families. (2006). Head Start Performance Measures Center Family and Child Experiences Survey (FACES 2000): Technical Report. Washington, DC: U.S. Department of Health and Human Services
- Ayoub, C., Vallotton, C. D., & Mastergeorge, A. M. (2011). Developmental pathways to integrated social skills: The roles of parenting and early intervention. *Child Development, 82*, 583 – 600. doi: 10.1111/j.1467-8624.2010.01549.x
- Bongers, I. L., Koot, H. M., Van Der Ende, J., & Verhulst, F. C. (2004). Developmental trajectories of externalizing behaviors in childhood and adolescence. *Child development, 75*(5), 1523-1537.
- Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. *Handbook of child psychology*.
- Calkins, S. D., & Keane, S. P. (2009). Developmental origins of early antisocial behavior. *Development and psychopathology, 21*(04), 1095-1109.
- Camilli, G., Vargas, S., Ryan, S., & Barnett, W. S. (2010). Meta-analysis of the effects of early education interventions on cognitive and social development. *The Teachers College Record, 112*(3).
- Campbell, S. B. (1995). Behavior problems in preschool children: A review of recent research. *Journal of child Psychology and Psychiatry, 36*(1), 113-149.
- Campbell, S. B., Shaw, D. S., & Gilliom, M. (2000). Early externalizing behavior problems: Toddlers and preschoolers at risk for later maladjustment. *Development and psychopathology, 12*(03), 467-488.

- Chase-Lansdale, P. L., Moffitt, R. A., Lohman, B. J., Cherlin, A. J., Coley, R. L., Pittman, L. D., et al. (2003). Mothers' transitions from welfare to work and the well-being of preschoolers and adolescents. *Science*, *299*(5612), 1548-1552.
- Conger, K. J., Rueter, M. A., & Conger, R. D. (2000). The role of economic pressure in the lives of parents and their adolescents: The Family Stress Model.
- Conger, R. D., Wallace, L. E., Sun, Y., Simons, R. L., McLoyd, V. C., & Brody, G. H. (2002). Economic pressure in African American families: a replication and extension of the family stress model. *Developmental psychology*, *38*(2), 179.
- Criss, M. M., Pettit, G. S., Bates, J. E., Dodge, K. A., & Lapp, A. L. (2002). Family adversity, positive peer relationships, and children's externalizing behavior: A longitudinal perspective on risk and resilience. *Child development*, *73*(4), 1220-1237.
- Dearing, E., McCartney, K., & Taylor, B. A. (2006). Within-child associations between family income and externalizing and internalizing problems. *Developmental Psychology*, *42*(2), 237.
- Dubow, E. F., & Ippolito, M. F. (1994). Effects of poverty and quality of the home environment on changes in the academic and behavioral adjustment of elementary school-age children. *Journal of Clinical Child Psychology*, *23*(4), 401-412.
- Duncan, G. J., Brooks-Gunn, J., & Klebanov, P. K. (1994). Economic deprivation and early childhood development. *Child development*, *65*(2), 296-318.
- Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., et al. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child development*, *72*(4), 1112-1134.
- Evans, G. W., & English, K. (2002). The environment of poverty: Multiple stressor exposure, psychophysiological stress, and socioemotional adjustment. *Child development*, *73*(4), 1238-1248.
- Evans, G. W., Li, D., & Whipple, S. S. (2013). Cumulative Risk and Child Development. *Psychological Bulletin*, doi: 10.1037/a0031808
- Hinshaw, S. P. (1987). On the distinction between attentional deficits/hyperactivity and conduct problems/aggression in child psychopathology. *Psychological bulletin*, *101*(3), 443.
- King, S. M., Iacono, W. G., & McGue, M. (2004). Childhood externalizing and internalizing psychopathology in the prediction of early substance use. *Addiction*, *99*(12), 1548-1559.
- Korenman, S., Miller, J. E., & Sjaastad, J. E. (1995). Long-term poverty and child development in the United States: Results from the NLSY. *Children and Youth Services Review*, *17*(1), 127-155.
- Lee, R., Zhai, F., Brooks-Gunn, J., Han, W. J., & Waldfogel, J. (2014). Head start participation and school readiness: Evidence from the early childhood longitudinal study–birth cohort. *Developmental psychology*, *50*(1), 202.
- Leventhal, T., & Brooks-Gunn, J. (2000). The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. *Psychological bulletin*, *126*(2), 309.
- Liu, J. (2004). Childhood externalizing behavior: theory and implications. *Journal of child and adolescent psychiatric nursing*, *17*(3), 93-103.

- Love, J. M., Kisker, E. E., Ross, C., Raikes, H., Constantine, J., Boller, K., et al. (2005). The effectiveness of early head start for 3-year-old children and their parents: lessons for policy and programs. *Developmental psychology*, 41(6), 885.
- Love, J. M., Chazan-Cohen, R., Raikes, H., & Brooks-Gunn, J. (2013). What makes a difference: Early Head Start evaluation findings in a developmental context. *Monographs of the Society for Research in Child Development*, 78(1), 1-173.
- Magnuson, K. A., Ruhm, C., & Waldfogel, J. (2007). Does prekindergarten improve school preparation and performance?. *Economics of Education Review*, 26(1), 33-51.
- McLoyd, V. C. (1998). Socioeconomic disadvantage and child development. *American Psychologist*, 53(2), 185.
- Moffitt, T. E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: a developmental taxonomy. *Psychological review*, 100(4), 674.
- Moffitt, T. E., & Caspi, A. (2001). Childhood predictors differentiate life-course persistent and adolescence-limited antisocial pathways among males and females. *Development and psychopathology*, 13(02), 355-375.
- Morgan, J. N. (2005). History and potential of binary segmentation for exploratory data analysis. *Journal of Data Science*, 3, 123 – 136.
- Petterson, S. M., & Albers, A. B. (2001). Effects of poverty and maternal depression on early child development. *Child development*, 72(6), 1794-1813.
- Schmitt, S. A., Finders, J. K., & McClelland, M. M. (2014). Residential Mobility, Inhibitory Control, and Academic Achievement in Preschool. *Early Education and Development*, (ahead-of-print), 1-20.
- Sonquist, J. A., Baker, E. L., & Morgan, J. N. (1974). Searching for structure: an approach to analysis of substantial bodies of micro-data and documentation for a computer program.
- StataCorp, L. P. College Station, TX: 2011. *Stata statistical software: release, 12*.
- United States Department of Health and Human Services. Administration for Children and Families. Early Head Start Research and Evaluation (EHSRE) Study, 1996-2010: [United States]. ICPSR03804-v5. Ann Arbor, MI: Inter-university Consortium for Political and Social Research[distributor], 2011-09-22. <http://doi.org/10.3886/ICPSR03804.v5>
- Vazsonyi, A. T., & Keiley, M. K. (2007). Normative developmental trajectories of aggressive behaviors in African American, American Indian, Asian American, Caucasian, and Hispanic children and early adolescents. *Journal of abnormal child psychology*, 35(6), 1047-1062.
- Zachrisson, H. D., & Dearing, E. (2014). Family Income Dynamics, Early Childhood Education and Care, and Early Child Behavior Problems in Norway. *Child development*.
- Zhai, F., Brooks-Gunn, J., & Waldfogel, J. (2011). Head Start and urban children's school readiness: a birth cohort study in 18 cities. *Developmental psychology*, 47(1), 134.

Table 3.1. Descriptive Statistics for included Predictors and 5th Grade Externalizing Problems

Predictors	% Yes	% No	% Missing
<i>Economic Hardship</i>			
<i>Depth of Poverty</i>			
Deep Poverty (below 50% of poverty line)	39.14	44.30	16.56
Poverty (below 100% of poverty line)	31.74	51.70	16.56
Low-Income (below 200% of poverty line)	10.89	72.55	16.59
Non Low-Income (above 200% of poverty line)	1.67	81.77	16.59
<i>Family Welfare Receipt</i>			
None or One	22.22	72.70	5.08
Two or Three	63.54	31.38	5.08
More than Three	9.15	85.77	5.08
AFDC	25.64	51.42	22.95
<i>Family Needs Assessment</i>			
None	49.31	43.36	7.33
One	23.46	69.21	7.33
More than One	19.90	72.77	7.33
<i>Child and Family Characteristics</i>			
Male	50.91	49.09	0
White	40.16	58.31	1.53
Black	33.19	65.28	1.53
Hispanic	20.92	77.55	1.53
Other	4.21	94.26	1.53
Child Not Born at Baseline	27.45	72.55	0
Child less than 6 Months Old at Baseline	45.32	54.68	0
Child Older than 6 Months Old at Baseline	27.23	72.77	0
Primarily Language is English in Home	78.43	18.45	3.12
Mother has Less than 12 Years of Education	42.19	54.61	3.20
Mother has High School Degree or GED	28.61	68.19	3.20
Mother has More than 12 years of Education	26.00	70.80	3.20

Mother is Employed	25.27	71.53	3.20
Mother is In School/Training	21.28	75.52	3.20
Mother is Neither Employed or in School/Training	50.25	46.55	3.20
Child Unborn at Baseline	27.45	72.55	0
Child less than 6 Months Old at Baseline	45.32	56.68	0
Child older than 6 Months Old at Baseline	27.23	72.77	0
One Adult in the Household	35.58	64.27	0.15
Two Adults in the Household	50.54	49.31	0.15
Three Adults or More in the Household	13.73	86.12	0.15
Mother Lives with Husband	25.78	74.07	0.15
Mother Lives with Other Adults	39.51	60.34	0.15
Mother Lives Alone with Children	34.57	65.28	0.15
Focus Child was the First Born	62.24	37.47	0.29
No Children under 6 in Household	64.20	35.65	0.15
One Child under 6 in Household	27.45	72.40	0.15
Two or more Children under 6 in Household	8.21	91.64	0.15
No Children between 6 and 17 in Household	65.72	34.13	0.15
One Child between 6 and 17 in Household	21.42	78.43	0.15
Two or more Children between 6 and 17 in Household	12.71	87.14	0.15
No Residential Moves in Past Year	47.28	42.99	9.73
One Residential Move in Past Year	24.40	65.87	9.73
Two or More Residential Moves in Past Year	18.59	71.68	9.73
<i>Early Care and Education</i>			
Early Head Start assignment	51.13	48.87	0
Center-Based Care	17.94	82.06	0
Home-Based Care	47.35	52.65	0
Mixed Approach	34.71	65.29	0
Previous Experience with Childcare program	13.80	82.79	3.41
Ever in Head Start	42.63	44.88	12.49
<i>Prekindergarten Problem Behaviors</i>			

Aggressive Behaviors

Low	40.52	44.08	15.40
Medium	21.13	63.47	15.40
High	22.95	61.65	15.40

Hyperactive Behaviors

Low	41.03	43.79	15.18
Medium	20.84	63.98	15.18
High	22.95	61.87	15.18

Withdrawn Behaviors

Low	44.37	40.45	15.18
Medium	24.18	60.64	15.18
High	16.27	68.55	15.18

5th Grade Externalizing Problems

Clinical/Near-Clinical Levels in Externalizing	26.94	73.06	
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Table 3.2. Significant Differences for Predicting Externalizing Problems using Logistic Regression ($N = 1377$)

<i>Significant Comparisons</i>	<i>B</i>	<i>SE</i>	<i>p</i>	<i>RR (95% CI)</i>
<i>Baseline Factors</i>				
Male vs. Female	0.55	0.14	.000	1.66 (1.29, 2.12)
Younger children vs. Older children	0.36	0.18	.040	1.40 (1.02, 1.92)
English speaking vs. Not English speaking	0.65	0.31	.038	1.82 (1.04, 3.08)
Live with other adults vs. Live with husband	0.49	0.21	.021	1.57 (1.07, 2.27)
Unemployed/Not in School vs. Employed	0.47	0.18	.011	1.54 (1.10, 2.12)
<i>Prekindergarten Behaviors</i>				
High Aggression vs. Low Aggression	1.50	0.19	.000	3.70 (2.72, 4.90)
High Aggression vs. Medium Aggression	0.58	0.19	.003	1.70 (1.21, 2.37)
Medium Aggression vs. Low Aggression	0.92	0.19	.000	2.30 (1.65, 3.16)
High Hyperactivity vs. Low Hyperactivity	0.64	0.19	.001	1.81 (1.28, 2.52)
High Hyperactivity vs. Medium Hyperactivity	0.52	0.20	.009	1.62 (1.13, 2.29)

Note. All predictors were included in the model, but non-significant findings not shown in the table. Coded as “missing” on welfare receipt is significantly related to lower likelihood of externalizing problems compared to each code of welfare receipt.

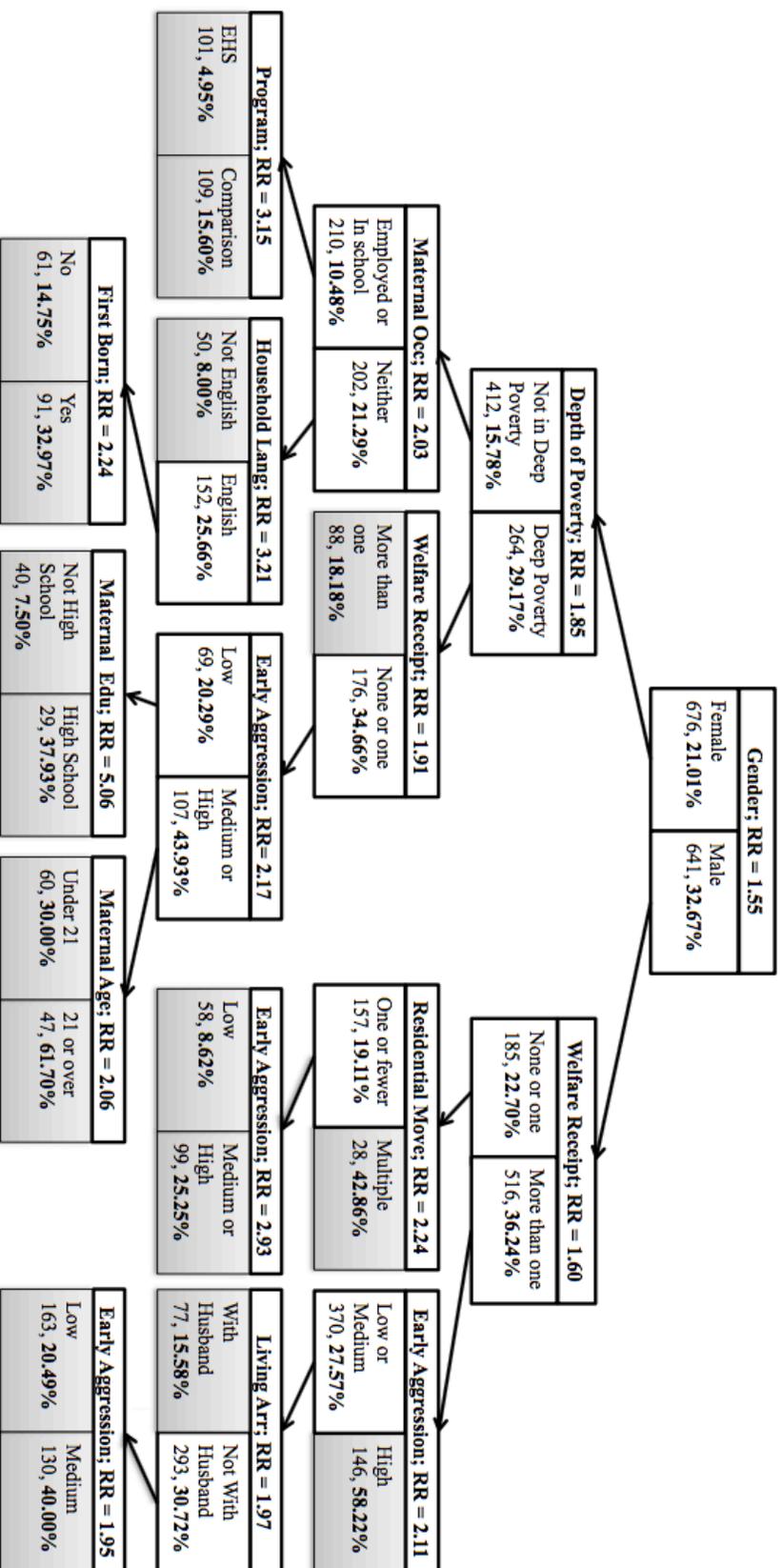


Figure 3.1. Predictive Pattern for 5th Grade Externalizing Problems (N = 1377, Clinical/Near-Clinical = 26.94% in Overall Sample)

Note. Each split is displayed with a box that has the variable that is being divided and the two new subgroups created. “RR” is the Relative Risk Ratio. All splits are significant at p < .01. The boxes for the two groups created from the split display the sample size and percentage coded as having externalizing problems for that conditional subgroup.

CONCLUSION

The current dissertation studies each uniquely contribute to a large literature exploring the effects of early economic hardship and risk on children's cognitive and behavioral development (e.g., Bradley & Corwyn, 2002; Conger et al., 2000; Conger et al., 2002; Dubow & Ippolito, 1994; Duncan & Brooks-Gunn, 2000; Evans et al., 2013; McLoyd, 1998). Understanding the effects of early poverty on development are important as relatively high numbers of young children, especially ethnic minorities, experience these contexts (Center for Law and Social Policy, 2014). Overall, both studies were rooted in a theoretical perspective of using inductive, sequential partitioning analyses to complement deductive analyses on children's cognitive and behavioral development (i.e., *model discovery*; Bronfenbrenner & Morris, 2006; Morgan, 2005). In Study I, *Predictive Patterns of Academic Achievement for Children in Low-Income Families*, sequential partitioning analyses (i.e., SEARCH) were used to understand how early predictors related to children's prekindergarten and 5th grade academic achievement. These analyses were used to identify common themes across the models, make connections back to previous research and theory, and to generate new hypothesis-driven research questions. In Study II, *Predicting Externalizing Problems for Children in Low-Income Families: A Dual-Analytical Approach*, deductive and inductive analyses were used for complementary purposes to understand the effects of early predictors on children's externalizing problems at 5th grade.

Overview of Study Findings

Study I. Study I had three complementary research objectives related to early predictors of academic achievement for children in low-income families. First, it

identified predictive patterns among early life predictors (i.e., family income and needs, child and family characteristics, child health at birth, and early care and education) for prekindergarten math, literacy, and vocabulary skills. Second, it identified predictive patterns among early life predictors and prekindergarten academic skills for math, literacy, and vocabulary skills at 5th grade. And third, it tested for effects of Early Head Start (EHS) in subgroups created by sequential partitioning models. Findings from the inductive models were then connected back to theory and previous research, in order to inform future research hypotheses. Overall, three themes emerged from the analyses. First, for the prekindergarten models, there were relatively large overall effects associated with ethnicity and maternal educational attainment, but by 5th grade the effects were substantially larger for ethnicity. Relatedly, other early life predictors never met the selection criteria for inclusive in the models (e.g., child health at birth), operated in non-additive ways (e.g., welfare receipt), or showed evidence of possible subgroup specific effects (e.g., maternal age at baseline). Second, for 5th grade literacy performance, after accounting for variance due to the early life predictors, only prekindergarten math and vocabulary were selected splits in the model, and not prekindergarten literacy. Third, EHS was a selected split in only one of the sequential partitioning models, where it showed a beneficial effect on prekindergarten vocabulary for a subgroup of children who were Black or Hispanic, whose mothers had a High School degree or less, and were not in deep poverty. Analyses for the subgroups created by the partitioning models revealed mostly null effects for EHS on children's prekindergarten and 5th grade academic achievement. Together, the analyses contribute to previous research and theories on how early predictors and EHS are associated with academic achievement for children from

low-income contexts (Duncan & Brooks-Gunn, 2000; Duncan & Magnusson, 2005; Evans et al., 2013; Love et al., 2013).

Study II. Study II examined the influence of economic hardship, child and family characteristics, early care and education, and early behavioral problems on children's externalizing problems at 5th grade in a low-income sample. The study built off previous research on connections between economic hardship, risk, and children's behavioral maladjustment (e.g., Conger et al., 2002; McLoyd, 1998; Moffitt & Caspi, 2001), but took dual analytical approaches for understanding these relations. The first approach, the logistic regression model, estimated significant differences for predictors while statistically controlling for other predictors in the model. These findings were meant to be inferential (generalize to other low-income populations), with significant predictors interpreted as having independent and additive effects on children's externalizing problems at 5th grade. The second approach (i.e., SEARCH) inductively showed patterns in the raw data by using a sequential partitioning analysis. In other words, it identified which splits among the predictors were most associated with children's externalizing problems at 5th grade by partitioning the data based on the selection criteria. Findings across both models were mostly consistent with previous research and theories, showing significant effects associated with gender, maternal employment and living arrangements (i.e., partner status), and early aggression on children's externalizing problems (Bongers et al., 2004; Campbell et al., 2000; Moffitt & Caspi, 2001; Vazsony & Keiley, 2007). However, the two analytic strategies are complementary, but provide distinct information and three key differences were found. First, variables related to economic hardship were selected (e.g., depth of poverty, welfare receipt) in the SEARCH model, but were not

significant in the logistic regression model. Second, there was a significant beneficial subgroup effect of EHS in the SEARCH model (i.e., females not in deep poverty and who had mothers employed or in school at roughly the time of the child's birth), but EHS was not significant in the logistic regression model. Third, prekindergarten hyperactivity was not selected in the SEARCH model but was significant in the logistic regression model. Taken together, the findings contribute to the literature by showing how dual analytical approaches are beneficial for addressing developmental questions.

Commonalities between the Two Studies. Both studies shared a number of commonalities. They were secondary data analyses of the Early Head Start Research and Evaluation Study (EHSRE; US DHHS ACF, 1996-2010), meaning families were eligible for EHS at the baseline of the study. In other words, the majority of the families were living below the poverty line and mothers either recently had a baby or were expecting. EHS was randomly assigned to roughly half of the sample, and therefore both studies further examined the effects of EHS on children's cognitive and behavioral development. Moreover, both studies used data from the baseline of the EHSRE (roughly the time of the child's birth), the prekindergarten year (roughly five years later), and the 5th grade year (roughly 10 years later). The longitudinal nature allowed for the examination of early predictors on later academic achievement and externalizing problems in childhood. Finally, each study used inductive, sequential partitioning approaches (i.e., SEARCH). These models are useful for complementing previous research and theories, as in Study I, and useful for complementing deductive analyses in the same study, as in Study II. Importantly, both studies contribute to literature on early predictors of cognitive and behavioral development in low-income populations. The SEARCH models allowed for

both studies to examine profiles of children that face the greatest risk of poor academic performance and externalizing problems. Although the models create complexity with the sequential portioning approach, the selected splits among the predictors that were most related to the outcome emerged creating profiles of risk and success.

Understanding Early Predictors of Cognitive and Behavioral Development in Low-Income Populations

The current dissertation studies contribute to a broad literature of both empirical and theoretical work on how economic hardship and risk influence children's cognitive and behavioral development (Dubow & Ippolito, 1994; Duncan et al., 1994; Duncan et al., 1998; Conger et al., 2002; Evans & English, 2002; McLoyd, 1998). However, understanding the influence of economic hardship presents a number of challenges to researchers given its disproportionate association with other types of hardships (Duncan & Magnusson, 2005). For instance, socio-economic status is hypothesized to explain previously reported links between ethnic minority status (confounded with socio-economic status) and academic achievement (Duncan & Magnusson, 2005). However, Study I found that ethnicity was the strongest predictor of 5th grade academic achievement in a low-income sample, while including the possibility of selecting predictors related to economic hardship, maternal occupational status and educational attainment. This is concerning as the effects of ethnicity grew stronger during the elementary school years than did the effects of maternal educational attainment, though both were similarly predictive of initial gaps. Thus, the argument that widening gaps are a function of entry-level differences was not supported (Blair & Diamond, 2008), as widening gaps were disproportionately associated with ethnicity. In general, these

findings are consistent with theories of possible racial discrimination during the school years beyond the effects of socio-economic status (Farkas, 2003).

In Study II, the effects of economic hardship on children's later externalizing problems showed different patterns across the two analytical approaches (i.e., logistic regression and SEARCH models). For example, in the logistic regression model, variables related to maternal employment and partner status emerged (Criss et al., 2002; Duncan et al., 1994; Korenman et al., 1995 Zachrisson & Dearing, 2014), but not variables related to depth of poverty, welfare receipt, or family needs. In the SEARCH model, after splitting the data on gender (the optimal split among baseline predictors), the next most optimal split for each gender was related to economic hardship (i.e., depth of poverty for females and welfare receipt for males). The strong association between economic hardship and externalizing problems in the SEARCH model is consistent with previous theories (Conger et al., 2000; McLoyd, 1998; Moffitt & Caspi, 2001), but furthers this work by showing its close association to externalizing problems 10 years later within a low-income sample.

Impacts of Early Head Start (EHS) on Cognitive and Behavioral Development

Both of the current dissertation studies were secondary analyses of the EHSRE on the effects of EHS programs. Previous research has identified a number of positive impacts for EHS on children's early cognitive and behavioral development (Ayoub et al., 2011; Love et al., 2013; Love et al., 2005). Each of the current studies furthered this research in two ways. One, the studies looked at connections between EHS and 5th grade outcomes, which have not been comprehensively studied yet. Second, they looked at potential subgroup effects based on the sequential partitioning analyses.

Study I. In Study I, the effects of EHS manifested in the prekindergarten vocabulary model (though not in any other models) for a subgroup of children who were Black or Hispanic, had mothers with a high school degree or less, and were not in deep poverty. For this subgroup, children who received EHS, compared to children in the control group, did significantly better on prekindergarten vocabulary. Furthermore, for the subgroup of children who received EHS, if the mother had previous experiences with a child development program (e.g., EHS or HS), the effects were significantly larger. These findings are consistent with previous deductive models that have shown stronger beneficial EHS effects on prekindergarten cognitive skills for Black children compared to White or Hispanic children (Love et al., 2013). It is also partially consistent with research that has shown mothers with prior Head Start attendance had children that benefitted more on cognitive skills from attending Head Start compared to children in Head Start whose mothers did not attend Head Start themselves (Chor, 2015).

Study II. In Study II, the effects of EHS on externalizing problems were selected for a subgroup of children, although EHS was not significant in the logistic regression model. For females not in deep poverty and who had a mother employed or in school at the baseline of the study (roughly the time of the child's birth), the EHS program significantly reduced the likelihood of 5th grade externalizing problems. Although previous studies have identified early behaviors and processes (i.e., self-regulation, parenting skills, lower aggressive behaviors) that could influence later externalizing problems (Ayoub et al., 2011; Love et al., 2012; Love et al., 2005), this is the first study to identify a specific subgroup that EHS could be working for in terms of 5th grade externalizing problems. Though these findings are promising, it is important that the

inductive findings are replicated in independent samples because of the exploratory nature of the model.

Practical Implications. Each study contributes in unique and important ways to understanding potential subgroup effects of EHS on children's cognitive and behavioral development. Programs and interventions need to not only ask what are they being compared to (Lee et al., 2014), but for which subgroups of children are programs most, or least, effective? Inductive, sequential partitioning analyses present one form for answering this question and can help in generating future hypothesis driven questions. Both studies identified subgroups of children that benefited from the EHS program, which had not been found in previous research on EHS effects for prekindergarten vocabulary (e.g., Love et al., 2013) or would have been undetected in deductive analyses (e.g., logistic regression in Study II).

Using Inductive and Deductive Analyses to Further Developmental Science

An important common theme across both studies in this dissertation is the use of inductive models to further the current literature on children's cognitive and behavioral development. Study I used multiple inductive analyses (i.e., *discovery models*; Bronfenbrenner and Morris, 2006; Morgan, 2005), in order to better understand how early person and context predictors related to children's math, reading, and vocabulary at prekindergarten and 5th grade. In Study I, common themes across the models were connected back to previous research and theory, and new hypotheses were generated. Study II used deductive (i.e., *model testing*) and inductive (i.e., *discovery model*) analyses to provide complementary information on how early predictors related to children's externalizing problems at 5th grade. Together, the deductive and inductive models were

able to offset the limitations of using either analysis alone to answer the research question of how early predictors relate to children's later externalizing problems.

Limitations and Future Directions

A few common limitations and future directions emerged from the dissertation studies. First, the specific splits among predictors selected in the sequential partitioning analyses used in both studies were not necessarily meant to be inferential, but were descriptive of the data. Thus, replication becomes paramount for the validity of all the findings in the current dissertation studies from the inductive models. Relatedly, in the sequential partitioning analyses two splits among predictors may have been similarly optimal, but when one split was selected the other split could appear to have not been meaningful, which is likely misleading. That is, once the model is conditional on one predictor (e.g., ethnicity), other predictors (e.g., economic hardship) that share common variance with that variable are being accounted for without being selected in the model. Study I would have benefitted from combining the inductive analyses with deductive analyses in order to gain a deeper understanding of the relations in the data, as done in Study II. Furthermore, the predictors available in the public dataset and the methods of the EHSRE limited both of the dissertation studies. In Study I, variables related to children's self-regulation and executive function would have likely helped to explain further variance in 5th grade outcomes, considering their connections to later school success (e.g., Blair & Diamond, 2008; McClelland et al., 2013). In Study II, variables related to caregiver stress and child-caregiver relationship would have added to the models considering the theoretical mediating roles they play between economic hardship and behavioral maladjustment (Conger et al., 2000; Conger et al., 2002; McLoyd, 1998).

Finally, most of the associations that were observed in both studies were correlational and not causal, with the exception of some of the EHS effects (due to random assignment at baseline). In general, future studies should continue to try to better understand causal and correlational relations between early predictors and later cognitive and behavioral development in low-income samples with diverse analytical methods.

Implications and Conclusions

The current dissertation studies have a few potentially important implications. Both studies show the utility of using a sequential partitioning analysis to identify key early predictors of cognitive and behavioral development in a sample of predominantly low-income children and families. Study I showed how multiple inductive models can be connected back to previous research and theories, whereas Study II showed how inductive and deductive models can provide complementary information. The findings from the inductive models in both studies were largely consistent with previous research and theories (Bongers et al., 2004; Conger et al., 2000; Conger et al., 2002; Criss et al., 2002; Duncan et al., 1994; Duncan et al., 2007; Korenman et al., 1995 Zachrisson & Dearing, 2014), yet contributed unique information to previous research. Importantly, both studies highlight beneficial subgroup effects of EHS on cognitive and behavioral outcomes in 5th grade that have not been previously reported. Finally, the outcomes of each study representative key domains for children's wellbeing. Academic success in childhood is associated with a greater probability of college success (Buchmann & DiPrete, 2006; Perna, 2005). Furthermore, college success has major implications on expected lifetime earnings (Autor, 2014). Similarly, behavioral problems in childhood are associated with much more consequential behaviors in adolescence (e.g., substance

use) and young adulthood (e.g., violence) (King et al., 2004; Lui, 2004; Moffitt & Caspi, 2001). Thus, it is critical to understand the early predictors of children's cognitive and behavioral trajectories, especially when children are in low-income contexts.

BIBLIOGRAPHY

- Achenbach, T. M. (1978). The child behavior profile: An empirically based system for assessing children's behavioral problems and competencies. *International Journal of Mental Health, 24*, 4-42.
- Achenbach, T. M., & Edelbrock, C. S. (1978). The classification of child psychopathology: a review and analysis of empirical efforts. *Psychological bulletin, 85*(6), 1275.
- Achenbach, T. M., & Rescorla, L. (2001). *ASEBA school-age forms & profiles*. Burlington, VT: Aseba.
- Ackerman, B. P., Schoff, K., Levinson, K., Youngstrom, E., & Izard, C. E. (1999). Therelations between cluster indexes of risk and promotion and the problem behaviors of 6-and 7-year old children from economically disadvantaged families. *Developmental Psychology, 35*(6), 1355.
- Administration for Children and Families. (2002a). *Making a difference in the lives of children and families: The impacts of Early Head Start programs on infants and toddlers and their families*. Washington, DC: U. S. Department of Health and Human Services.
- Administration for Children and Families. (2002b). *Pathways to quality and full implementation in Early Head Start Programs*. Washington, DC: U. S. Department of Health and Human Services.
- Administration on Children, Youth and Families. (2006). Head Start Performance Measures Center Family and Child Experiences Survey (FACES 2000): Technical Report. Washington, DC: U.S. Department of Health and Human Services
- Aguilar, B., Sroufe, L., Egeland, B., & Carlson, E. (2000). Distinguishing the early-onset/persistent and adolescence-onset antisocial behavior types: From birth to 16 years. *Development and Psychopathology, 12*(02), 109-132.
- Aizer, A., & Currie, J. (2014). The intergenerational transmission of inequality: Maternal disadvantage and health at birth. *science, 344*(6186), 856-861.
- Anderson, P., Doyle, L. W., & Victorian Infant Collaborative Study Group. (2003). Neurobehavioral outcomes of school-age children born extremely low birth weight or very preterm in the 1990s. *Jama, 289*(24), 3264-3272.
- Autor, D. H. (2014). Skills, education, and the rise of earnings inequality among the "other 99 percent". *Science, 344*(6186), 843-851.
- Aylward, G. P. (2003). Cognitive function in preterm infants: no simple answers. *Jama, 289*(6), 752-753.
- Ayoub, C., Vallotton, C. D., & Mastergeorge, A. M. (2011). Developmental pathways to integrated social skills: The roles of parenting and early intervention. *Child Development, 82*, 583 – 600. doi: 10.1111/j.1467-8624.2010.01549.x
- Baltes, P. B., Lindenberger, U., & Staudinger, U. M. (1998). *Life span theory in developmental psychology*. John Wiley & Sons, Inc.
- Beck, A. N., & Muschkin, C. G. (2012). The Enduring Impact of Race: Understanding Disparities in Student Disciplinary Infractions and Achievement. *Sociological Perspectives, 55*(4), 637-662.
- 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.
- Bongers, I. L., Koot, H. M., Van Der Ende, J., & Verhulst, F. C. (2004). Developmental trajectories of externalizing behaviors in childhood and adolescence. *Child development*, 75(5), 1523-1537.
- Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, 53(1), 371-399.
- Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. *Handbook of child psychology*.
- Brooks-Gunn, J., Duncan, G. J., & Maritato, N. (1997). Poor families, poor outcomes: The well-being of children and youth. *Consequences of growing up poor*, 1-17.
- Buchmann, C., & DiPrete, T. A. (2006). The growing female advantage in college completion: The role of family background and academic achievement. *American sociological review*, 71(4), 515-541.
- Calkins, S. D., & Keane, S. P. (2009). Developmental origins of early antisocial behavior. *Development and psychopathology*, 21(04), 1095-1109.
- Camilli, G., Vargas, S., Ryan, S., & Barnett, W. S. (2010). Meta-analysis of the effects of early education interventions on cognitive and social development. *The Teachers College Record*, 112(3).
- Campbell, S. B. (1995). Behavior problems in preschool children: A review of recent research. *Journal of child Psychology and Psychiatry*, 36(1), 113-149.
- Campbell, S. B., Shaw, D. S., & Gilliom, M. (2000). Early externalizing behavior problems: Toddlers and preschoolers at risk for later maladjustment. *Development and psychopathology*, 12(03), 467-488.
- Center for Law and Social Policy (2014). New census data tell us that poverty fell in 2013. Retrieved from <http://www.clasp.org/issues/child-care-and-early-education/in-focus/2013-poverty-data-a-glimpse-of-good-news-for-children-but-we-can-do-better> on November 17, 2014.
- Chase-Lansdale, P. L., Moffitt, R. A., Lohman, B. J., Cherlin, A. J., Coley, R. L., Pittman, L. D., et al. (2003). Mothers' transitions from welfare to work and the well-being of preschoolers and adolescents. *Science*, 299(5612), 1548-1552.
- Chor, E. (2015, March). Head Start's broken promise? Multigenerational poverty, multigenerational participation. Presented at the biennial meeting of the Society for Research in Child Development, Philadelphia, PA.
- Clark-Kauffman, E., Duncan, G. J., & Morris, P. (2003). How welfare policies affect child and adolescent achievement. *American Economic Review*, 299-303.
- Conger, K. J., Rueter, M. A., & Conger, R. D. (2000). The role of economic pressure in the lives of parents and their adolescents: The Family Stress Model.
- Conger, R. D., Wallace, L. E., Sun, Y., Simons, R. L., McLoyd, V. C., & Brody, G. H. (2002). Economic pressure in African American families: a replication and extension of the family stress model. *Developmental psychology*, 38(2), 179.
- Criss, M. M., Pettit, G. S., Bates, J. E., Dodge, K. A., & Lapp, A. L. (2002). Family adversity, positive peer relationships, and children's externalizing behavior: A longitudinal perspective on risk and resilience. *Child development*, 73(4), 1220-1237.

- Dearing, E., McCartney, K., & Taylor, B. A. (2006). Within-child associations between family income and externalizing and internalizing problems. *Developmental Psychology, 42*(2), 237.
- Dubow, E. F., & Ippolito, M. F. (1994). Effects of poverty and quality of the home environment on changes in the academic and behavioral adjustment of elementary school-age children. *Journal of Clinical Child Psychology, 23*(4), 401-412.
- Duncan, G. J., & Brooks-Gunn, J. (Eds.). (1995). *Consequences of growing up poor*. Russell Sage Foundation.
- Duncan, G. J., & Brooks-Gunn, J. (2000). Family poverty, welfare reform, and child development. *Child development, 71*(1), 188-196.
- Duncan, G. J., Brooks-Gunn, J., & Klebanov, P. K. (1994). Economic deprivation and early childhood development. *Child development, 65*(2), 296-318.
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental psychology, 43*(6), 1428.
- Duncan, G. J., & Magnuson, K. A. (2005). Can family socioeconomic resources account for racial and ethnic test score gaps?. *The future of children, 15*(1), 35-54.
- Duncan, G. J., Yeung, W. J., Brooks-Gunn, J., & Smith, J. R. (1998). How much does childhood poverty affect the life chances of children?. *American sociological review, 40*6-423.
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., et al. (2007). School readiness and later achievement. *Developmental Psychology, 43*(6), 1428-1446. doi: 10.1037/0012-1649.43.6.1428
- Duncan, G. J., & Magnuson, K. (2011). The nature and impact of early achievement skills, attention skills, and behavior problems. *Whither opportunity, 47*-69.
- Duncan, G. J., Morris, P. A., & Rodrigues, C. (2011). Does money really matter? Estimating impacts of family income on young children's achievement with data from random-assignment experiments. *Developmental psychology, 47*(5), 1263.
- Dunn, L. M. & Dunn, L. M. (1997). Peabody Picture Vocabulary Test-Third Edition. Circle Pines, MN: American Guidance Service, Inc.
- Dunn, L. M., Padilla, E. R., Lugo, D. E., & Dunn, L. M. (1986). Examiner's manual for the Test de Vocabulario en Images Peabody (Peabody Picture Vocabulary Test) Adaptacion Hispanoamericana (Hispanic American adaptation). *Circle Pines, MN: American Guidance Service*.
- Eisenberg, N., Cumberland, A., Spinrad, T. L., Fabes, R. A., Shepard, S. A., Reiser, M., et al. (2001). The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child development, 72*(4), 1112-1134.
- Elder, G. H., Johnson, M. K., & Crosnoe, R. (2003). *The emergence and development of life course theory* (pp. 3-19). Springer US.
- Evans, G. W., & English, K. (2002). The environment of poverty: Multiple stressor exposure, psychophysiological stress, and socioemotional adjustment. *Child development, 73*(4), 1238-1248.
- Evans, G. W., Li, D., & Whipple, S. S. (2013). Cumulative Risk and Child Development. *Psychological Bulletin*, doi: 10.1037/a0031808

- Farkas, G. (2003). Racial disparities and discrimination in education: What do we know, how do we know it, and what do we need to know?. *The Teachers College Record*, 105(6), 1119-1146.
- Hastie, T., Tibshirani, R., Friedman, J., (2009). *The elements of statistical learning* (Vol. 2, No. 1). New York: Springer.
- Heckman, J. J. (2000). Policies to foster human capital. *Research in economics*, 54(1), 3-56.
- Hill, N. E., & Craft, S. A. (2003). Parent-school involvement and school performance: Mediated pathways among socioeconomically comparable African American and Euro-American families. *Journal of Educational Psychology*, 95(1), 74.
- Hinshaw, S. P. (1987). On the distinction between attentional deficits/hyperactivity and conduct problems/aggression in child psychopathology. *Psychological bulletin*, 101(3), 443.
- Kieffer, M. J. (2008). Catching up or falling behind? Initial English proficiency, concentrated poverty, and the reading growth of language minority learners in the United States. *Journal of Educational Psychology*, 100(4), 851.
- King, S. M., Iacono, W. G., & McGue, M. (2004). Childhood externalizing and internalizing psychopathology in the prediction of early substance use. *Addiction*, 99(12), 1548-1559.
- Korenman, S., Miller, J. E., & Sjaastad, J. E. (1995). Long-term poverty and child development in the United States: Results from the NLSY. *Children and Youth Services Review*, 17(1), 127-155.
- Lee, R., Zhai, F., Brooks-Gunn, J., Han, W. J., & Waldfogel, J. (2014). Head start participation and school readiness: Evidence from the early childhood longitudinal study–birth cohort. *Developmental psychology*, 50(1), 202.
- Leventhal, T., & Brooks-Gunn, J. (2000). The neighborhoods they live in: the effects of neighborhood residence on child and adolescent outcomes. *Psychological bulletin*, 126(2), 309.
- Liu, J. (2004). Childhood externalizing behavior: theory and implications. *Journal of child and adolescent psychiatric nursing*, 17(3), 93-103.
- Love, J. M., Chazan-Cohen, R., Raikes, H., & Brooks-Gunn, J. (2013). What makes a difference: Early Head Start evaluation findings in a developmental context. *Monographs of the Society for Research in Child Development*, 78(1), 1-173.
- Love, J. M., Kisker, E. E., Ross, C., Raikes, H., Constantine, J., Boller, K., et al. (2005). The effectiveness of early head start for 3-year-old children and their parents: lessons for policy and programs. *Developmental psychology*, 41(6), 885.
- Magnuson, K. A., Ruhm, C., & Waldfogel, J. (2007). Does prekindergarten improve school preparation and performance?. *Economics of Education Review*, 26(1), 33-51.
- McClelland, M.M., Acock, A. C., Piccinin A., Rhea, S. A., & Stalling, M. C. (2013). Relations between preschool attention and sociability and later achievement outcomes. *Early Childhood Research Quarterly*, 28, 314 – 324. doi:10.1016/j.ecreq.2012.07.008
- McClelland, M. M., & Wanless, S. B. (2012). Growing up with assets and risks: The importance of self-regulation for academic achievement. *Research in Human Development*, 9(4), 278-297.

- McLoyd, V. C. (1998). Socioeconomic disadvantage and child development. *American Psychologist*, 53(2), 185.
- Milne, A. M., Myers, D. E., Rosenthal, A. S., & Ginsburg, A. (1986). Single parents, working mothers, and the educational achievement of school children. *Sociology of Education*, 125-139.
- Moffitt, T. E. (1993). Adolescence-limited and life-course-persistent antisocial behavior: a developmental taxonomy. *Psychological review*, 100(4), 674.
- Moffitt, T. E., & Caspi, A. (2001). Childhood predictors differentiate life-course persistent and adolescence-limited antisocial pathways among males and females. *Development and psychopathology*, 13(02), 355-375.
- Morgan, J. N. (2005). History and potential of binary segmentation for exploratory data analysis. *Journal of Data Science*, 3, 123 – 136.
- Obradović, J., Bush, N. R., Stamperdahl, J., Adler, N. E., & Boyce, W. T. (2010). Biological sensitivity to context: The interactive effects of stress reactivity and family adversity on socioemotional behavior and school readiness. *Child development*, 81(1), 270-289.
- Perna, L. W. (2005). The key to college access: Rigorous academic preparation. In W. G. Tierney, Z. B. Corwin & J. E. Colyar (Eds.), *Preparing for college: Nine elements of effective outreach* (pp. 113-134). United States of America: State University of New York.
- Petterson, S. M., & Albers, A. B. (2001). Effects of poverty and maternal depression on early child development. *Child development*, 72(6), 1794-1813.
- Pollack, J. M., Najarian, M., Rock, D. A., & Atkins-Burnett, S. (2005). Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K). Psychometric Report for the Fifth Grade. *National Center for Education Statistics*.
- Princiotta, D., Flanagan, K. D., & Germino-Hausken, E. (2006). *Fifth grade: Findings from the fifth-grade follow-up of the early childhood longitudinal study, kindergarten class of 1998-99 (ECLS-K)*. US Department of Education, Institute of Education Sciences, National Center for Education Statistics.
- Rauh, V. A., Parker, F. L., Garfinkel, R. S., Perry, J., & Andrews, H. F. (2003). Biological, social, and community influences on third-grade reading levels of minority Head Start children: A multilevel approach. *Journal of Community Psychology*, 31(3), 255-278.
- Reardon, S. F. (2011). The widening academic achievement gap between the rich and the poor: New evidence and possible explanations. *Whither opportunity*, 91-116.
- Reichman, N. E. (2005). Low birth weight and school readiness. *The Future of Children*, 15(1), 91-116.
- Sameroff, A. J., Seifer, R., Barocas, R., Zax, M., & Greenspan, S. (1987). Intelligence quotient scores of 4-year-old children: Social-environmental risk factors.
- Schmitt, S. A., Finders, J. K., & McClelland, M. M. (2014). Residential Mobility, Inhibitory Control, and Academic Achievement in Preschool. *Early Education and Development*, (ahead-of-print), 1-20.
- Shonkoff, J. P., & Phillips, D. A. (2000). *From neurons to neighborhoods: The science of early childhood development*. Washington, DC: National Academy Press.

- Son, S. H., & Morrison, F. J. (2010). The nature and impact of changes in home learning environment on development of language and academic skills in preschool children. *Developmental psychology, 46*(5), 1103.
- Sonquist, J. A., Baker, E. L., & Morgan, J. N. (1974). Searching for structure: an approach to analysis of substantial bodies of micro-data and documentation for a computer program.
- StataCorp, L. P. College Station, TX: 2011. *Stata statistical software: release, 12*.
- United States Department of Health and Human Services, Administration for Children and Families. (1995). Early Head Start program grant availability: Notice. *Federal Register, 60*, 14548–14578.
- United States Department of Health and Human Services. Administration for Children and Families. Early Head Start Research and Evaluation (EHSRE) Study, 1996-2010: [United States]. ICPSR03804-v5. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2011-09-22. <http://doi.org/10.3886/ICPSR03804.v5>
- Vazsonyi, A. T., & Keiley, M. K. (2007). Normative developmental trajectories of aggressive behaviors in African American, American Indian, Asian American, Caucasian, and Hispanic children and early adolescents. *Journal of abnormal child psychology, 35*(6), 1047-1062.
- Woodcock, R. W., & Johnson, M. B. (1990). Tests of achievement, WJ-R: Examiner's manual. *Allen, TX: DLM Teaching Resources*.
- Woodcock, R. W., & Muñoz-Sandoval, A. F. (1996). *Bateria Woodcock-muñoz: pruebas de aprovechamiento revisada*. Riverside Publishing Company.
- Zachrisson, H. D., & Dearing, E. (2014). Family Income Dynamics, Early Childhood Education and Care, and Early Child Behavior Problems in Norway. *Child development*.
- Zhai, F., Brooks-Gunn, J., & Waldfogel, J. (2011). Head Start and urban children's school readiness: a birth cohort study in 18 cities. *Developmental psychology, 47*(1), 134.