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Decomposing the Microsystem: An Etiological Approach

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DECOMPOSING THE MICROSYSTEM: AN ETIOLOGICAL APPROACH

By

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This work is dedicated to my flower child.

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ABSTRACT

Various environments were examined under an etiological scope in an effort to better understand the influence of genes on these environmental contexts for the present study. Using the Bioecological theoretical framework by Bronfenbrenner and Ceci (1994) the environment is explained as nested layers comprised of individuals, environments, systems, or ideals that either directly impact the individual or indirectly impact the individual. This Bioecological model also takes into account a bidirectional relationship between the individual and their environment, in that the individual has the ability to influence the environment and the environment has the potential to influence the individual. For the present study the focus was on the microsystem, which is comprised of interpersonal relationships and environments, such as the home, the school, and the neighborhood. From this inner most layer of the Bioecological model, four environments were identified and chosen for further exploration; the home, classroom, school, and neighborhood. Experiences of these environments were assessed using a twin design and child-level reports. The study involved 536 twin pairs (107 female-female MZ pairs, 101male-male MZ pairs, 131 female-female DZ pairs, 98 male-male DZ pairs, and 96 opposite-sex DZ pairs). The sample was representative of the Florida population (73% White, 13% Black, 2% Asian, 8% Mixed, less than 1% Native American or Alaska native, and approximately 4% "Other"; 29% of the sample identified as Hispanic). The twins were aged 9 to 15 (M=11.4, SD=1.4). Structural equation modeling techniques were used to assess univariate genetic and environmental estimates of the environmental measures. The results from this study indicated environmental influences (shared and non-shared) on home chaos, while the experiences of the classroom and school environments appear to indicate genetic, shared, and non-shared environmental influences with some differences depending on the sex of the individual. The

neighborhood environment also appears to indicate genetic and environmental influences depending on the sex of the individual. Finding differential influences of genetic and environmental factors on the environments of the microsystem reveal the importance of probing environments for genetic influences, in that samples potentially vary in the degree that certain environments are under genetic influence. In order to properly measure the environment it is important to use environmental measures assessing individual experiences either in addition to or as opposed to family-level assessments.

INTRODUCTION

Many efforts have been made to understand the extent to which the environment informs lifespan development, behavioral outcomes, and achievement outcomes. In doing so, it has become increasingly important to understand just what makes up an environment, as this construct can be quite broad and ambiguous. In Bronfenbrenner's ecological systems theory, the environment is described as various systems nested within one another: the microsystem, the mesosystem, the exosystem, the macrosystem, and the chronosystem (Bronfenbrenner, 1992). The microsystem is the inner most layer of the overall system; it is the setting that is closest to the individual and made up of interpersonal relationships and environments, such as the home, the school, and the neighborhood. The mesosystem is the next layer of this model, and is described as a system of microsystems, linking processes that take place between two or more settings. The exosystem is the third layer in the ecological system and is comprised of elements that do not directly involve the developing individual, but may be impactful, like parental employment status or socioeconomic status (SES). The macrosystem is the fourth layer and is comprised of cultural and social beliefs, customs, and ideologies. The chronosystem is the most distal layer from the individual and is concerned with time, more specifically, the era/time in which the individual is developing. Bronfenbrenner and Ceci went on to further develop this ecological systems theory into the bioecological model, which also emphasizes the individual, heritability, and the bidirectional relationship between the environment and the individual (Bronfenbrenner & Ceci, 1994). Bronfenbrenner explains that human development occurs through proximal processes that are defined as interacting with one's environment: with objects, symbols, other individuals, and various elements that elicit attention on a regular basis and over an extended amount of time (Bronfenbrenner, 1999). Furthermore, Bronfenbrenner and Ceci propose that environmental conditions and processes can influence variation in heritability (Bronfenbrenner & Ceci, 1994). The researchers posit that more stable and enriched environments allow for greater influences of heritability on various phenotypes (Bronfenbrenner & Ceci, 1994). Whereas, less stable and more tumultuous environments lead to a decrease in the influence of heritability on phenotypes, and the variance accounted for in these phenotypes is due to a larger extent to environmental factors (Bronfenbrenner & Ceci, 1994).

In examining only the most proximal layer to the individual of the bioecological model, the microsystem, there are various environmental contexts to explore. The microsystem encompasses environments such as the home environment, the classroom environment, the overall school environment, and the neighborhood environment. The individual interacts directly with each of these environments, and each of these environments have been linked phenotypically with outcomes relating to cognitive ability and achievement in students (Gottfried, 1984; Bradley, 1993; Molfese, DiLalla, & Lovelace, 1995; Baker et al., 1998; Molfese, Modglin, & Molfese, 2003; Pianta et al., 2002; Brody, Dorsey, Forehand, & Armistead, 2003; Ceci, 1991; Mashburn et al., 2008; Evans, 2006).

The home environment is critically important in relation to various developmental outcomes in children and has been examined at length phenotypically. Activities in the home and home characteristics have been linked with intellectual and reading abilities in children (Molfese, Modglin, & Molfese, 2003). Studies show that children from more organized and quieter homes with routines perform better in school (Evans, 2006). While other studies reveal that more chaotic, deprived, and unstable homes are associated with having lower expectations, poorer cognitive functioning, and withdrawal from academic challenges (Brown & Low, 2008; Bradley & Caldwell, 1980; Feinstein & Bynner, 2004). In addition, more chaotic homes tend to be associated with low levels of socioeconomic status, and greater conduct problems (SES; Evans et al., 2005; Coldwell, Pike, & Dunn, 2006; Deater-Deckard et al., 2009; Dumas et al., 2005). Noise in the home has been linked to intellectual deficits in male 12- to 14-month olds, but not female (Wachs, 1978). Noise not only affects children in the home, but adults as well. Adults in noisier homes are reportedly less responsive to children (Corapci &Wachs, 2005; Matheny et al., 1995; Wachs, 1989; Wachs & Camli, 1991). Chaos in the home is linked with higher levels of stress, difficulty accomplishing tasks, and conflict (Weisner, 2010). This environment has been a reliable link to childhood outcomes. Studies show home environment measures to be stable important predictors of group differences in intelligence in children aged 3 to 8 years of age (Molfese, DiLalla, & Bunce, 1997; Espy, Molfese, & DiLalla, 2001). The home environment is the most proximal environment to the individual, and typically the environment that the child spends the most time in, therefore it is an important environment to measure and explore.

The classroom environment is an additional environmental context of the microsystem that research suggests is impactful for academic success and achievement in children. Phenotypic studies show that by creating stimulating, safer, happier, and more challenging environments in the classroom leads to improvements in students socially and academically (Brock et al., 2007). Classroom size and density have been identified as elements of the classroom environment that may be impactful for learning (Gifford, 1987; Martin, 2006). High-density classrooms have been linked with higher levels of aggression, hostility, decreased social interactions (Moore & Lackney, 1994), lower academic performance and more distractions in the classroom (Evans, Saegert, & Harris, 2001; Lackney, 1994; Martin, 2006). Moreover, classroom social adjustment and engagement within the classroom environment have been linked with success in school (Birch & Ladd, 1997; Wentzel, 1996). The teacher is also an important component in creating the classroom environment, shaping the child's experience in school, and has been linked with child outcomes as well. In the primary grades, classroom social adjustment has been linked with the relationship the student develops with the adult in the classroom (Pianta, 1999). Positive relationships between the teacher and child may protect the student against poor performance in school (Cicchetti & Lynch, 1993). Teacher and child conflict has been correlated positively with school avoidance and negative feelings toward school (Birch & Ladd, 1997). These studies reveal the importance of the relationship between the teacher and the student and the environment that the teacher creates in the classroom for the students. If children develop negative feelings toward teachers and begin to avoid and feel negatively toward school, it can be assumed that their academic performance will be impacted negatively. In a study of teacher-child relationships in kindergarten on later academic performance, negative relationships were related to poorer academic performance (Hamre & Pianta, 2001).

The school environment is also a proximal environment for the individual in the microsystem related to various achievement outcomes for children. Much like the classroom environment, school density is a topic that has been examined by numerous researchers and has been related to academic performance in children. Schools with larger populations tend to perform worse on standardized tests (Greenwald et al., 1996; Schneider, 2002; Lackney, 2004). Additionally, lower income students attending smaller schools potentially benefit even more than more well off contemporaries academically (Cotton, 1996; Howley et al., 2000). Smaller schools are also linked consistently with more positive attitudes in students, better attendance rates, more involvement in extracurricular activities, less issues surrounding behavioral problems in students, and a greater feeling of connectedness (Cotton, 1996). School quality and environment are factors that impact the attrition and retention of teachers (Buckley, Schneider, & Shang, 2004), who help to shape the environment of both the classroom and the overall school. Violence in the school is an additional factor that influences the overall school environment. The threat of violence in the school has been linked with teaching effectiveness in a sample of 7^{th} through 12^{th} graders (Harris et al., 1996), which in turn affects the academic performance of students. Additionally, students have reported that the threat of crime or violence in the school environment caused them to miss school (Harris et al., 1995; Bowen & Bowen, 1999).

Neighborhood influences on children's outcomes have been studied for many years. Findings show that high-SES neighborhoods have a positive effect on school readiness and achievement outcomes (Leventhal & Brooks-Gunn, 2000). Crime rates and neighborhood safety are also related to neighborhood SES and children's outcomes, in that crime rates appear to be higher in lower SES neighborhoods and achievement outcomes are dampened for students from lower SES neighborhoods when compared to students from more affluent communities (Brooks-Gunn, Duncan, & Mariato 1997; Leventhal & Brooks-Gunn 2000; Rankin & Quane, 2002). It can also be argued that less stable and less safe neighborhoods have negative effects on student academic success (Berliner, 2009). Correlations between witnessing neighborhood violence and trouble in school have been discovered in a sample of African American male and female students (Jenkins & Bell, 1994). Moreover, students from at-risk neighborhoods attributed school-related problems to crime or the threat of crime in their neighborhoods (Harris et al., 1995). Bowen and Bowen (1999) found that violence in the neighborhood had a greater unique impact on school outcomes than did danger in the school environment.

In addition to phenotypic studies of these environments aforementioned, etiological studies using quantitative genetic methods have also been conducted in an attempt to better understand the impact of the environment on numerous outcomes. Quantitative genetic modeling allows researchers to explore the genetic and environmental etiology of various phenotypes. By using twin studies researchers are able to examine the proportion of variance in an outcome that is attributed to genetic influences (or heritability; h^2), shared environmental influences (non-genetic influences that act to make siblings more similar; c^2), and non-shared environmental influences (non-genetic influences that act to make siblings more different, along with error; e^2). These variance components are typically modeled by A (additive genetics), C (common shared environment), and E (unique environment and error), or the ACE model. There are situations in which the genetic influences on a phenotype are due to dominance genetic effects (D; the presence of a dominant allele affects/trumps the expression of an allele on a complimentary chromosome) as opposed to or in addition to additive genetic effects. Dominance genetic effects typically reduce the additive genetic variation in a phenotype. In the case that D is implicated, an ADE model is utilized instead of an ACE model. Twin data are not sufficient to simultaneously model C and D, which is why separate models are necessary.

Numerous researchers have examined the impact of environments in the microsystem on achievement outcomes utilizing quantitative genetic methods. In a study of 3 and 4 year old twins, researchers found that socioeconomic status (SES) and chaos in the home partially mediated the shared environmental variance associated with cognitive functioning (Petrill et al., 2004). From that study researchers also indicated that SES and chaos were significant mediators of the stability of verbal and nonverbal cognitive skills from age 3 to 4, and that chaos in the home was a significant mediator of cognitive abilities even when controlling for SES (Petrill et al., 2004). In an additional study of elementary school-aged twins, chaos in the home and SES were examined as mediators of shared environmental influences on the longitudinal stability of general cognitive ability (Hart et al., 2007). Hart and colleagues found that SES and chaos in the home accounted for both independent sources of shared environmental influences on cognitive ability at specific measurement occasions as well as a portion of the longitudinal stability of cognitive ability in the early childhood years (Hart et al., 2007). In addition to the home environment, the classroom environment has been assessed in genetically sensitive models as well. As previously stated, the teacher is a major component of the classroom environment, shaping this environment for children. Teacher quality has been associated with reading performance in such a way that greater portions of variance in reading was accounted for by genetic factors for children with better quality teachers, and environmental factors accounted for greater portions of variance in reading for children with poorer quality teachers (Taylor et al., 2010). Twin studies have also suggested that poor teacher quality is associated with poor reading outcomes in children (Hart, Taylor, & Schatschneider, 2013). Furthermore, the school environment has been assessed etiologically, linking SES and reading comprehension; Hart et al., found that lower SES schools allowed for greater genetic influences on reading comprehension, while higher SES schools allowed for greater environmental influences on reading comprehension (Hart et al., 2013). Finally, researchers found that neighborhood-level SES influences the heritability and environmental influences on some early literacy skills in a sample of kindergarten and first grade twins (Taylor & Schatschneider, 2010).

While the phenotypic and behavioral genetic literatures suggest the importance of these different environmental contexts and how they impact individual outcomes, the literatures disregard the influence and contribution of the individual to the experience of these environments. Studies linking environmental influences to cognitive and achievement outcomes primarily use family-level, classroom-level, school-level, or neighborhood-level data to measure the environment. In using environmental variables that are not measured at the individual-level, the report of the environment is common across twins, and by definition represents the shared environment only. In order to properly account for the potential of genetic and environmental influences on a phenotype, behavioral genetics modeling needs individual-level data. The usage of "group-level" data in behavioral genetics treats the environment as purely "environmental," absent of any potential individual influence, specifically in the estimations of genetic and/or non-shared environmental influences on environmental measures. In ignoring the potential genetic and non-shared environmental effects that would be accounted for at the individual level, important information is possibly missing from these models. In the Bioecological model, the importance of the individual is emphasized in that there is a bidirectional relationship between the environment and the individual that needs to be accounted for (Bronfenbrenner & Ceci's, 1994). The fact is individuals are not just at the whim of the environment, there is an interaction between the individual and the environment. There are cases however, in which the use of family-level data are unavoidable, for instance when examining the impact of SES on a phenotype.

Various researchers have examined the ways individuals interact with their environments (Scarr & McCartney, 1983; Plomin & Bergeman, 1991; Hanscombe et al., 2010). Researchers have proposed that the environment is not independent of the person (Hanscombe et al., 2010). The behavioral genetics field is moving toward understanding the extent to which these environments are influenced by genetic factors—that is, how are our genes influencing how we approach and experience different environments? Researchers argue that the environment is shaped by the genes individuals carry; it is argued that environments are under genetic influence (Scarr & McCartney, 1983; Plomin & Bergeman, 1991; Kendler & Karkowski-Shuman, 1997). It is also noted that from conception, development involves the interaction of the environment and the individual; the individual shapes and changes its environment from the very beginning creating a bidirectional relationship between the individual and the environment (Bronfenbrenner & Ceci, 1994). The researchers describe this bidirectional relationship as the internal becoming the external—the individual influencing the surrounding environment (Bronfenbrenner & Ceci, 1994). Plomin and Bergeman (1991) describe environments under genetic influence as the *nature of nurture*. These researchers note that in the quest to measure the environment, individual traits and characteristics are unintentionally tapped as well (Plomin & Bergeman, 1991). For example, parental education, occupation, and number of books in the home are often used to measure the environment, and while these factors give us an idea of what the home and family environments are like, they also measure parental characteristics like IQ (Plomin & Bergeman, 1991). Environmental influences outside of the home are also potentially under the influence of the individual, in that we select, modify, and create our environments (Bronfenbrenner & Ceci, 1994; Plomin & Bergeman, 1991). Plomin and Bergeman also note that genetic factors contributing to differences in child behavior may also contribute to differences in the experiences of the children (1991).

Etiological studies have overwhelmingly examined more distal layers of Bronfenbrenner's ecological system. The studies cited above almost all include assessments of SES in relation to various environments and outcomes. SES is accounted for in the exosystem of Bronfenbrenner's model and affects the child; however the child has no direct influence on the SES of the family, school, or neighborhood. SES is a more distal environmental variable that impacts the child; however an environment that the individual child can influence is of interest presently, and would be accounted for in more proximal layers of the bioecological model, like the microsystem. Hanscombe and colleagues were one of the first groups to study chaos in the home from the child perspective, in effect assessing the microsystem (Hanscombe et al., 2010). Hanscombe and colleagues examined chaos in the home as measured by twins aged 9 and 12, and 22% of the variance in chaos was due to genetic factors, while the rest of the variance was due to environmental factors and error (Hanscombe et al., 2010). Finding genetic influences on chaos in the home was important because this reinforced theories from Plomin as well as Bronfenbrenner and Ceci, in that the individual acts on the environment in addition to the environment acting on the individual. Finding genetic influences on home chaos also suggests that the environment is not absent of individual influences, it is not purely "environmental," and therefore individual-level measures should be used to assess this environment.

Furthermore, moderate and pervasive genetic influences, with an average heritability of 27%, were found on a host of environments in a review relating to psychopathology (Kendler & Baker, 2007). The aforementioned review further reinforces the importance of collecting individual-level data to properly account for individual differences (genetic and non-shared environmental) in the experience of various environments. These studies (Hanscombe et al., 2010; Kendler &Baker, 2007) have established the likelihood of genetic influences on the environment. It is important now to examine the potential for these genetic influences on environmental experiences in different samples. Like the Hanscombe study, this study also assess chaos in the home as reported by the child in a genetically sensitive design, in addition to child-level reports of the classroom, school, and neighborhood environments, similar to the array of environments outlined in the review by Kendler and Baker (2007). A missing element in the literature has been child-level reports of environmental measures, and an understanding of the influence of genetics on these environments—an objective of this study was to add to that gap in the literature. The design of this study was chosen to follow a similar format as Hanscombe et al., (2010) while expanding the environments involved and utilizing a more racially, ethnically, and socioeconomically diverse sample. The intent was to first establish if there were genetic influences on various levels of the environment before moving forward toward more complicated and elaborate designs. This study was to serve as a foundation for future studies to potentially link achievement outcomes with these environments using child-level data.

Studies suggest that children growing up in the same home and same family may experience environments differently (Daniels et al., 1985; Hanscombe et al., 2010). Examining the various layers of the environment at the child-level allows for a clearer picture of genetic and environmental influences on environmental experiences and perceptions. The bioecologial model groups all of these environments into one system, the microsystem, leading to the question of how different the experiences of these environments are by individuals. A goal of the present study was to examine more numerous environmental contexts in one study. It is important to understand the etiology of various levels of the environment because this gives insight into the extent to which genes account for the experiences individuals have. The potential finding of genetic influences on the experience and perception of different environments is likely to reflect some genetic characteristics of the children or the possibility of actual differences in the experience and perception of the environment. The purpose of this study was to assess the degree (if any) of genetic influence on the environments in the microsystem: the home environment, the classroom environment, the school environment, and the neighborhood environment. It was hypothesized that there would be genetic influences on each environmental context outlined. The rationale for this hypothesis concerns theoretical frameworks that suggest the presence of genetic influences on the shaping and experience of the environment (Plomin & Bergeman, 1991; Bronfenbrenner & Ceci, 1994). Moreover, findings of genetic influences on home chaos

(Hanscombe et al., 2010) and other environmental contexts relating to psychopathology (Kendler & Baker, 2007) would suggest the potential for finding genetic influences on the environments in the microsystem for this study.

METHODS

Participants

Participants for this study were drawn from the Florida Twin Project on Reading, Behavior, and Environment (Taylor, Hart, Mikolajewski, Schatschneider, 2012), an ongoing cohort-sequential twin project. The Florida Twin project collects achievement data on reading for students in the state of Florida from the statewide educational database, the Progress Monitoring and Reporting Network (PMRN). The project also collects data on twin behavior and environments using child and parent questionnaires, questionnaires were sent out in the summer of 2012. For the current study, 536 twin pairs (107 female-female MZ pairs, 101 male-male MZ pairs, 131 female-female DZ pairs, 98 male-male DZ pairs, and 96 opposite-sex DZ pairs) were drawn from the Twin project. The sample was almost split evenly between male and female participants (54% female). The twins were between the ages of 9 and 15 (M=11.4, SD=1.4). The racial and ethnic makeup of the sample was diverse and representative of Florida (73% White, 13% Black, 2% Asian, 8% Mixed, less than 1% Native American or Alaska native, and approximately 4% “Other”; approximately 29% of the sample identified as Hispanic) according to the Census Bureau for the state of Florida (http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk).

Procedures and Measures

Secondary data were used in this study, obtained from a larger project. For the larger project, the Florida Twin Project, a packet of questionnaires with instructions included was sent out to twin families. These packets included various scales collecting demographic data on the twin families, behavioral data, as well as environmental data, including: the Confusion, Hubbub and Order Scale (CHAOS; Matheny, Wachs, Ludwig, & Phillips, 1995), a measure of Class

Time (NICHD, 2004), a measure of the school environment (What My School is Like; NICHD, 2005), and the Neighborhood Environment Scale (Bass & Lambert, 2004). The zygosity of twin pairs was assessed using a five-item questionnaire measuring physical similarities between twins (Lykken, Bouchard, McGue, & Tellegen, 1990) completed by parents. All measures for this study, aside from zygosity reports, were administered to children who were at least 9 years of age or older in the summer of 2012. Parents of all twin participants completed informed consents which were approved by the Florida State University IRB (appendix B), allowing the usage of the questionnaire data in the current study. The twin participants also gave assent to participate.

Confusion, Hubbub, and Order Scale (CHAOS). The chaos measures environmental confusion, routine, and noise in the home. The short version of this measure was utilized for this study, a six-item measure on a five-point scale, answers ranging from “Definitely Untrue” given a point of 1, to “Definitely True” which is worth 5 points. The assessment was given as a ‘pencil and paper’ task. Chaos is measured in a way that larger scores indicate more chaos in the home, and the total score for the assessment is calculated by averaging the individual item scores. Three of the items on this measure were reverse coded (items 1, 4, and 6). Reliability for this scale can be found in Table 1 (Appendix A). A copy of this measure can be found in Appendix C.

Class Time. This measure assessed the classroom environment and children’s perception of the teaching style of instructors. This classroom environment measure is based on the Perception of Teaching Styles scale (Eccles et al., 1993), which was designed to draw out information about the students’ perceptions of teacher fairness and friendliness, competition and social comparison amongst the students, and cooperative learning opportunities for the students. The class time measure was composed of ten items measured on a 5 point scale, answers ranging from “Not at All” worth 1 point, to “Very True” worth 5 points. This measure is scored in a way that higher scores are equated with better classroom practices. Four of the items on this measure were reverse scored (items 6, 7, 8, and 9). The measure as a whole represents a measure of how supportive the classroom is (average of items 1-10), and also includes two subscales: class cooperation/autonomy (average of items 1, 2, 3, 4, 5, and 10) and class competition (average of items 6, 7, 8, and 9. For this study the total scale was used for analyses, as the total scale gave a more complete picture of the classroom environment compared to the other subscales. Reliability for this scale can be found in Table 1 (Appendix A). A copy of this measure can also be found in Appendix C.

What My School is Like. This measure was based on the School Attachment and Environment Scale (Huston et al., 2010). This was a 19 item measure that assessed the school environment. The measure was scored on a 4 point scale, with answers ranging from “Not at All True”, worth 1 point to “Very True”, worth 4 points. This measure contains four subscales; school attachment (items 2, 8, 10, 13, and 19), teacher bonding (items 3, 4, and 16), school activity participation (items 7 and 18), and negative attitudes towards school (items 6, 9, 11, 12, 14, and 15). The score for each subscale is the average of the items that correspond to the given subscale. For analyses all four subscales were utilized. Reliability for this total scale and subscales can be found in Table 1 (Appendix A) and a copy of this measure can be found in Appendix C.

Neighborhood Environment. The Neighborhood Environment scale is a ten item measure of neighborhood disorder and disadvantage (Bass & Lambert, 2004). The items capture the participants’ feelings about neighborhood safety and security. The ten item measure is scored on a 4 point scale, answers ranging from “Not at all true”, worth 1 point to “Very true”, worth 4 points. The measure is scored so that lower scores indicate the feelings of a safer neighborhood environment. Four of the items on the measure are reverse scored (items 1, 6, 7, and 9). The scale has been shown to be reliable (Table 1, Appendix A). A copy of this scale can be found in Appendix C.

Analyses

The Twin Method. This study utilized the twin method to gain insight into the genetic and environmental influences on each environmental context of the microsystem assessed. The twin method is a quantitative genetic model that assesses twins raised together to estimate genetic and environmental influences on a given outcome. By comparing the phenotypic differences between monozygotic (MZ) twins who are genetically identical, and dizygotic (DZ) twins who share on average 50% of their genes, scientists are able to estimate the relative contributions of genes and environmental influences on a trait. The twin design partitions the variance in a phenotype into additive genetic (A) factors, shared environmental (C) factors, and non-shared environmental (E) factors (which also includes error). Because MZ twins are genetically identical, differences seen between them are typically attributed to environmental factors. A greater similarity between MZ twins suggests genetic influences as well as shared environmental influences, similar relationships between MZ and DZ twin pairs suggests shared environmental influences, and differences in MZ twins suggest non-shared environmental influences. There are also cases in which genetic influences on a trait are due to non-additive genetic effects or dominance effects (D). Dominance is exhibited when dominant genes are expressed over recessive genes, or as opposed to an additive effect of genes. Dominance effects can be observed through intraclass correlations when the correlations between MZ twins are more than twice as large as DZ correlations. Shared environmental factors and dominance genetic effects cannot be modeled simultaneously, therefore either A,C, and E are modeled or A, D, and E are modeled. Intraclass correlations were generated for the environmental measures calculated by zygosity and used to compare these MZ and DZ relationships to determine if an ACE or an ADE model was appropriate for analyses.

DZ twins were split between same-sex pairs and opposite-sex pairs, the opposite-sex DZ twins were included in the intraclass correlations to evaluate the presence of potential sex differences in the etiological factors related to the environmental measures. If opposite-sex DZ correlations are less than the average of same-sex DZ correlations, then qualitative differences are implied. Qualitative sex differences indicate a difference in the nature of etiological factors influencing males and females. Qualitative sex differences lead to different genetic and environmental factors influencing individual differences in males and females on the given trait. Quantitative sex differences are implied if the same-sex DZ correlations differ in magnitude between males and females. Quantitative sex differences suggest that the same genetic or environmental factors influence a trait in males and females, but the magnitude of influence differs by sex.

Sex-limitation Model Fitting. The data were analyzed to test for sex differences between twins on each environmental measure prior to running further univariate genetic analyses due to the presence of opposite-sex DZ twins. Intraclass correlations were probed for explicit differences between male and female twins, as well as differences between MZ and DZ twins that might suggest potential dominance effects. Multi-group analyses using structural equation modeling were performed to explore sex differences by fitting various constrained and unconstrained models to five different groups; MZ female-female twins, MZ male-male twins, DZ female-female twins, DZ male-male twins, and opposite-sex DZ twins. For each environmental measure, univariate ACE or ADE components of variance were estimated by gender subgroup. The fully varying model (the fully unconstrained model), where ACE or ADE estimates were allowed to vary by gender subgroup was subsequently compared to a model where the ACE or ADE estimates were invariant (the constrained model), or not allowed to vary across gender subgroups. If a chi-square difference test between these two models was non-significant, the constrained model was accepted and model testing stopped there. If a chi-square difference test indicated that there was a significant reduction in model fit after constraining across subgroups, it was determined that there were gender subgroup differences in A, C/D, and/or E components of variance. To determine the best model fit, sub-models that represented varying combinations of A, C/ D, and/or E estimates were set to be invariant across subgroups (e.g., A and C/D allowed to vary across gender, and E set to be invariant) and compared to the fully unconstrained model. The best fitting model was chosen based on whether it was significantly different from the fully unconstrained model, as indicated by chi square difference testing, and the lowest Akaike's information Criterion (AIC; Akaike, 1987). If all sub-models differed significantly from the fully unconstrained model, the fully unconstrained model was chosen as the final model. Once the best fitting model was chosen pathway estimates for each latent factor (A, C/D, and E) were produced, and significance was determined by 95% confidence intervals which did not bound zero. Structural equation modeling was conducted using Mx (Neale et al., 2003) with maximum likelihood estimation. All data analyses were conducted using raw data with age and age squared partialed out and subsequently z-scored. Because twin pairs are perfectly correlated on age it can artificially inflate the shared environmental estimate, therefore it is standard practice in twin studies to control for variables like this (McGue & Bouchard, 1984).

RESULTS

The means and standard deviations for each environmental measure are presented in Table 1 for the full sample and in Table 2 by gender. Table 2 also contains t-test results for gender differences on each environmental variable, Levene's test of equal variances results, and the reliability coefficients for each environmental measure can be found in Table 1 (see Appendix A). T-test results indicated significant differences between males and females for the classroom environment, teacher bonding, and negative attitudes toward school. Levene's test results indicated unequal variances between male and female participants for the classroom environment measure, the school attachment subscale, and the teacher bonding subscale.

Pearson correlation coefficients for each of the environmental measures are presented in Table 3 (Appendix A). All correlations were significant except the correlation between negative attitudes toward school and CHOAS and the correlation between negative attitudes toward schools and the neighborhood environment. Twin intra-class correlations are presented in Table 4 by gender and twin zygosity (Appendix A). Female MZ twins were significantly correlated on all environmental measures; male MZ twins were also significantly correlated on each environmental measure. The results indicated variable significance in correlations for DZ twin-pairs. Female DZ twin-pairs were significantly correlated for all measures except the classroom environment measure. Male DZ twin-pairs were significantly correlated on chaos, school attachment, school activity participation, and neighborhood environment; but not classroom environment, teacher bonding, or negative attitudes toward school. Opposite-sex DZ twin-pairs were significantly correlated on chaos, school attachment, teacher bonding, and neighborhood environment; but were not significantly correlated on the classroom environment, school activity participation, or negative attitudes toward school. The results from intraclass correlations, overall, indicated differences in the magnitude of correlations between MZ and DZ twins. The intraclass correlations also suggested some qualitative sex differences for negative attitudes toward school as well as school activity participation. In addition to these qualitative differences, the intraclass correlations indicated quantitative sex differences for the classroom environment, teacher bonding, and negative attitudes toward school. The potential for dominance genetic effects are suggested when MZ intraclass correlations are more than two times the magnitude of DZ intraclass correlations; this relationship was exhibited for the classroom environment, teacher bonding, and negative attitudes toward school. Therefore, ADE models were examined for these scales, for all others, ACE models were examined.

Following the results of the intra-class correlations, sex-limitation ACE/ADE model fitting was conducted on each environmental measure; results from these analyses are presented in Table 5 (Appendix A). When MZ and DZ intraclass correlations were compared by gender, chaos, school attachment, school activity participation, and neighborhood environment coefficients did not indicate dominance. The MZ intraclass correlations for these scales were no more than twice the magnitude of the DZ correlations and were subsequently analyzed by fitting ACE models. Dominance genetic effects were suggested for classroom environment, teacher bonding, and negative attitudes toward school scales due to MZ intraclass correlation coefficients being greater than twice the magnitude of DZ intraclass correlation coefficients. Interestingly, it was only the male participant intraclass correlation coefficients that resulted in this magnitude difference suggesting dominance effects. However, because of these differences between male MZ and DZ twins, the data for classroom environment, teacher bonding, and negative attitudes toward school scales were analyzed by fitting ADE models.

The chaos, classroom environment scale, and the school attachment subscale did not result in significant differences in model fit between the unconstrained model and the fully constrained model, indicating no significant sex differences for these environments. The model-fitting results indicated sex differences for teacher bonding, school activity participation, negative attitudes toward school, and the neighborhood environment. The model that best fit the data for teacher bonding was a model where the D parameter was constrained while A and E were allowed to vary. The model that best fit the data for school activity participation was the fully unconstrained ACE model. The model best fitting negative attitudes toward school data constrained the D and E parameters, while allowing A to vary. Finally, the neighborhood environment scale was best fit by the fully unconstrained ACE model.

Furthermore, univariate ACE/ADE decomposition results are presented in Table 6 for each environmental measure by gender (see Appendix A). The results indicated significant influences of shared and non-shared environmental factors for chaos. The classroom environment scale results indicated significant dominance genetic influences and non-shared environmental influences on the classroom environment. The school attachment subscale and the negative attitudes toward school subscale both resulted in significant additive genetic influences and non-shared environmental influences for male and female twins on these aspects of the school environment. The teacher bonding subscale and the school activity participation subscale both resulted in significant additive genetic influences and non-shared environmental influences for female participants. The results indicated significant shared environmental and non-shared environmental influences on school activity participation for male twin participants. Finally, the neighborhood environment scale resulted in significant additive genetic influences for female twin participants, significant shared environmental influences for male twin participants, and significant non-shared environmental influences for both male and female twins.

DISCUSSION

The purpose of this study was to assess the degree (if any) of genetic influences on the environments of the microsystem, which it was hypothesized that there would be. The motivation behind the present study lied in theories supporting the notion that the individual is important to the experience of as well as the shaping of the environment (Plomin & Bergeman, 1991; Bronfenbrenner & Ceci, 1994). Moreover, previous findings of genetic influences on home chaos (Hanscombe et al., 2010) and other environments relating to psychopathology (Kendler & Baker, 2007) suggested the potential to find genetic influences on environments of the microsystem.

Various phenotypic and etiological studies have explored the important role that the environment plays in the development of children. However the overwhelming majority of research conducted on environmental influences on childhood outcomes has explored the environment in such a way that the individual was ignored. Previous studies have used family-level data to explore the environment and researchers have treated the environment as though it were “purely environmental.” By doing this researchers have potentially missed important information. Using measures that are common for twins inflates the measure of the shared environment, and measures of genetic and non-shared environmental influences have potentially been inaccurately estimated. In the case of behavioral genetic modeling, individual-level data is important to properly measure the genetic and environmental influences on phenotypes. Hanscombe and colleagues (2010) were one of the first groups to actually treat home chaos as a phenotype and explore the etiology of that environment using child-level data. In that study Hanscombe et al., found indications of genetic influences on chaos in the home environment (2010). This finding was important because it supported theories highlighting the importance of the individual when accounting for the environment (Plomin & Bergeman, 1991; Bronfenbrenner & Ceci, 1994). The study from Hanscombe et al. (2010) acted to continue a conversation concerning the measurement of the environment, and the importance of testing environmental contexts at the individual-level. The present study followed this model from Hanscombe in examining the etiology of various environmental contexts using individual child-level data. There were four environmental contexts drawn from the microsystem of the bioecological model examined here: the home environment, the classroom environment, the school environment, and the neighborhood environment.

The Home Environment

An assessment of the home environment was conducted by analyzing twin responses on the chaos. The results from this study did not suggest any sex differences for this measure, therefor male and female twins appear to respond similarly to questions about the home environment. Univariate Cholesky results indicated shared environmental (c^2=0.52) and non-shared environmental (e^2=0.41) influences on the home environment, which did not support the hypothesis that there would be genetic influences on the home environment. This finding is different from previous findings by Hanscombe and colleagues (2010), who noted genetic influences on home chaos. Research has provided evidence that heritability for the same developmental phenotype can vary from population to population, qualifying that heritability is specific to the population for which it is calculated (Cavalli-Sforza & Bodmer, 1971; Bouchard & Segal, 1985; Plomin, DeFries, & McClearn, 1990; Bronfenbrenner & Ceci, 1994). Given that this environment has been treated as a phenotype in the present study, it is possible that the two samples (Hanscombe's and the present) simply vary in heritable contributions to chaos in the home. It is possible that for this sample this environment can be treated as a purely environmental measure absent of individual influences that are due to genetic factors. These findings don't support the bidirectional relationship between the environment and the individual that is outlined in the bioecological model. Due to a null finding of genetic influences on home chaos, the results suggest that the individual is not genetically influencing this environment and that there is no interplay between the home environment and the heritability of the individual. Significant nonshared environmental influences suggest that there still may be some influences from the individual on the environment; however they are environmental in nature.

The Classroom Environment

An assessment of the classroom environment was conducted using the Class Time measure administered to twins. Results from the intraclass correlations revealed large magnitude differences between male MZ (r^2=0.43) and DZ (r^2=0.02) twin pairs, suggesting the potential for dominance genetic effects. The measure was subsequently analyzed by fitting an ADE model to the data. Results indicated no significant sex differences between male and female twins on the classroom environment. The variance in the classroom measure was accounted for by dominance genetic (d^2=0.42) and non-shared environmental (e^2=0.58) influences. The results here suggest that there are genetic factors influencing the classroom environment. The lack of shared environmental influences on the classroom environment indicated by the results is potentially due to twins placed in separate classrooms. This null finding for shared environmental influences could also be attributed to students switching classrooms throughout the school day for older participants. The findings for this scale supported the hypothesis of this study that there would be genetic influences on the classroom environment.

The School Environment

The school environment was assessed using four subscales: the school attachment subscale, the teacher bonding subscale, the school activity participation subscale, and the negative attitudes toward school subscale. The results for this environment were mixed. First, analyses for the school attachment subscale did not suggest any sex differences and there were no major differences in intraclass correlation magnitudes between MZ and DZ twins, so the scale was analyzed using and ACE model. Results from the univariate Cholesky decomposition suggested additive genetic (h^2= 0.33) and non-shared environmental (e^2= 0.53) influences on school attachment. This subscale deals with feelings of safety, belonging, and fair treatment in the school. The results suggest that there are characteristics specific to the children that are potentially genetic in nature which shape their experience or perception of safety, belonging, and fair treatment in school. Furthermore, significant additive genetic effects suggest that this subscale is not simply measuring the environmental context of school attachment, but genetically mediated individual differences in the twins. The findings for this scale support theories highlighting the importance of the individual in shaping and measuring the environment (Plomin & Bergeman, 1991; Bronfenbrenner & Ceci, 1994).

The next subscale was the teacher bonding subscale which measured the twins' perceptions of the relationships held with teachers within the school environment. Intraclass correlations suggested dominance effects; therefore this subscale was analyzed using an ADE model. The model fitting analyses indicated sex differences in the perception of teacher-child relationships. Univariate analyses indicated significant additive genetic influences for female participants, but not male, on teacher bonding. Phenotypic studies indicate differences in teacher bonding between male and female students (Saft & Pianta, 2001; Brophy, 1985; Morgan &

Dunn, 1988; Howes et al., 2000), however no theoretical framework is known that would suggest that these sex differences would occur etiologically.

The next subscale measuring the school environment was the school activity participation subscale, which tapped into the motivation to spend extra time in the school environment and to participate in events above and beyond what was required of the students. Results from analyses of this subscale indicated sex differences in school activity participation with results for female twins indicating significant additive genetic ($h^2= 0.52$) influences and significant non-shared environmental ($e^2=0.48$) influences. These results suggest that there are genetic characteristics driving the participation of female twins in school activities. This subscale does not appear to be simply environmental in nature, but it is tapping into genetic characteristics of female twins that potentially motivate them to participate in these extracurricular activities. As for the male participants, results indicated significant shared environmental ($c^2= 0.31$) influences and significant non-shared environmental ($e^2= 0.69$) influences on school activity participation. The results indicated environmental influences as the driving force on the involvement of twin boys in extracurricular activities. It is possible that there are inherent characteristics for girls, that this scale measures that motivates them to participate in school activities, while the motivation for boys to participate in school activities are derived from the environment or outside sources. Phenotypic studies suggest differences in intrinsic and extrinsic motivations behind extracurricular activity participation for boys and girls; however results vary (Biddle & Brooke, 1992; Daley & O'Gara, 1998).

The final subscale used to measure the school environment was the negative attitudes toward school subscale. Analyses of this subscale suggested additive genetic effects as well as sex differences. Results from the univariate analyses indicated significant, but differential additive genetic (male, $h^2 = 0.55$; female, $h^2 = 0.41$) influences and non-shared environmental (male, $e^2 = 0.45$; female, $e^2 = 0.59$) influences for male and female twin participants. This scale tapped feelings of not belonging, feeling unsafe, and feeling inadequate in the school environment. The results suggested that there were characteristics specific to the twins potentially genetically mediated that were picked up by this measure, instead of the measure assessing only the school environment. Phenotypic findings suggest that males often feel more victimized in the school environment than females (Goldstein et al., 2008), which may explain the larger genetic influences in males compared to females. Males potentially possess some genetically mediated characteristics that make them more sensitive to feeling unsafe, or like they don't belong or measure up in the school environment.

Each of the school environment subscales indicated genetic influences on the school environment. These findings supported the hypothesis of the study that there would be genetic influences on each environmental context. Further, the findings of these genetic influences supported the bioecological model, elucidating the influence of the individual in shaping their environment. These genetic influences on the school environment reveal that the measures of the school environment are not only measuring the environment itself, but individual genetic characteristics of the individuals in the environment.

The Neighborhood Environment

The final environment analyzed in this study was the neighborhood environment, as measured by the neighborhood environment scale. This scale assessed feelings of safety, disorder, and disadvantage in the neighborhood. Results from analyses of this scale indicated sex differences in the measure of the environment. Results for male participants indicated significant additive genetic ($h^2 = 0.51$) and non-shared environmental ($e^2 = 0.36$) influences on the neighborhood environment. Female participant results however, indicated significant shared environmental (c^2= 0.56) and non-shared environmental (e^2= 0.42) influences on the neighborhood environment. The results suggest that for male participants there are significant genetically driven characteristics influencing their perception of and/or experience of their neighborhoods. Various demographic characteristics have been studied in relation to feelings of safety in the neighborhood, including sex. Studies reveal that women exhibit higher levels of fearing crime when compared to men (Perkins & Taylor, 1996; Skogan & Maxfield, 1981; Toseland, 1982). However, much like findings for school safety, men experience victimization at greater rates than women (Donnelly, 1989). Fear in females is potentially encouraged by environmental factors and actual measures of safety in the neighborhood, which the neighborhood environment scale picked up on, explaining the significant environmental influences. Whereas, due to victimization, males tend to be more defensive and the neighborhood environment scale potentially measured some genetically mediated defensive characteristics in the male participants. The neighborhood measure did not only measure the environmental aspects of the neighborhood, it also measured characteristics specific to the individual. As for female participants, the results suggest that the measure of the neighborhood is assessing only environmental factors. The findings for the male participants supported the hypothesis of this study that there would be genetic influences on the different environments.

Some of the findings in this study act to support theories from Plomin and Bergeman (1991) as well as Bronfenbrenner and Ceci (1994). There were genetic influences indicated for proximal environments to the individual; the classroom, the school, and the neighborhood. It was suggested that measures of the environment not only accounted for environmental characteristics, but they also unintentionally measured characteristics of the individuals shaping those environments (Plomin & Bergeman,1991); finding additive genetic influences and dominant genetic influences on the different environments in the present study support this. Plomin and colleagues (Plomin et al., 1994) assert that a measure of the environment has the capacity to show genetic effects to the extent that the measure is assessing genetically influenced characteristics of the individual. Therefore, the findings of pervasive genetic influences on various environmental contexts in the current study reveal that the environmental measures assessed are not only measuring elements of the environment, but genetically influenced characteristics of the individual as well. As Bronfenbrenner and Ceci (1994) note, children interact with and elicit responses from their environments from conception. The twins in this study ranged in age from 9 to 15, meaning they were of age, or approaching an age where they had the capacity to shape the environments around them.

Furthermore, Bronfenbrenner and Ceci (1994) note that as interactions and involvements concerning a certain phenotype increase in environments, the expectation is that the influence of heritability on that phenotype will also increase. In this study the environments found to be influenced by genetic factors potentially fostered more interactions between the individual and other people, objects, and ideas thereby driving the influence of heritability to increase. The results in this study suggested that the experience of different environments in the microsystem is influenced by elements in the environment and in some cases, genetic factors in the individuals.

For the most part, the findings supported the bioecological model, in that both genetic and environmental factors are found to moderate environmental experiences—this directly supports the bidirectional relationship outlined in the model. These findings support the idea that researchers lose nothing by measuring environments at the individual level, but stand to gain valuable information. However, by ignoring the individual and measuring environments using family/class/school/neighborhood-level data researchers are at risk for producing inaccurate results. For etiological studies specifically, using family-level data leaves researchers at risk for generating inflated accounts for shared-environmental influences on phenotypes, and potentially ignoring genetic and non-shared environmental influences. For phenotypic studies, researchers should keep in mind that the environments assessed are not always simply environmental, and they may be under genetic influences. Therefore, results of environmental influences on different outcomes may need to be qualified as also having some potential genetic influences as well.

The focus of this study was the microsystem of the bioecological model. Previous studies examining the impact of environmental contexts on phenotypes however, have often explored SES, an environmental context of the exosystem. In this study SES was not manipulated as it is an element of a more distal layer of the bioecological model and not a direct environment in the microsystem. Because child-level data were examined here, there was no desire to manipulate SES as the children have no direct control of the SES of the family. Moreover, the layers of the bioecological model are nested within one another; therefore pulling out an environmental context in a more distal layer to the microsystem would change the model. It is believed however, that this factor is important in the shaping of each environmental context in the microsystem and it has not been overlooked.

Limitations

A limitation of this study included the reliability of the measures used to assess environmental experiences. A number of the reliability estimates for the environmental measures were lower than desired. It should be noted that in the Hanscombe et al. (2010), study reliability for home chaos was comparably low (age 9 Cronbach's alpha=0.58, age 12 Cronbach's alpha=0.57). Furthermore, using a sample from the same population, researchers found similar reliability for parent responses on the chaos measure (Cronbach's alpha=0.60; Taylor & Hart, 2014). These low reliability coefficients suggest that the items on this scale are potentially measuring different aspects of a larger construct, and while the items do not show high internal reliability as described by Cronbach's alpha, they work together to describe chaos in the home. Furthermore, the intraclass correlations for chaos are all consistent, suggesting consistent responses from the participants. A logical next step from this study would be to assess the multivariate relationship between these environmental contexts at the child-level and achievement outcomes. Future directions should include an examination of the environments in the microsystem at the child-level and how they may moderate the etiology of achievement.

Implications

A major implication of this study is that it is important for researchers to assess how the environment is measured. It is important for researchers to approach the exploration of the environment from the individual level, as in some cases, the environment may be impacted by the individual. Ignoring the individual and assessing environmental influences at the family level may act to ignore the impact that the individual has on the given environment. The general idea here is that it is important to at least test the environment at the individual level in order to potentially pick up on genetic contributions to that context. Overall, this study contributes to the growing literature tasked with better understanding how individuals influence and shape the environments surrounding them.

APPENDIX A

TABLES

Table 1

Descriptive Statistics for Raw Environmental Measure Scores for the Full Sample.

	M	*SD*	*n*	Cronbach α
CHAOS	2.453	0.661	774	0.564
Classroom	3.586	0.552	798	0.613
School				
School Attachment	3.362	0.558	777	0.709
Teacher Bonding	3.363	0.626	780	0.518
School Activity Participation	1.892	0.574	764	0.745
Negative Attitudes Toward School	3.009	0.978	795	0.679
Neighborhood	1.407	0.387	785	0.795

Table 2

Descriptive Statistics for Raw Environmental Measure Scores by Gender.

Measure	Females			Males							
	M	*SD*	*n*	*M*	*SD*	*n*	*t*	*t*-test p-value	Levene's *f*	*df*	Levene's p-value
CHAOS	2.471	0.655	420	2.432	0.668	354	0.810	0.421	1.040	353	0.697
Classroom	3.661	0.495	435	3.496	0.602	363	4.170	<0.001	1.480	362	<0.001
School											
School Attachment	3.386	0.529	425	3.333	0.590	352	1.300	0.193	1.250	351	0.031
Teacher Bonding	3.414	0.581	428	3.300	0.672	352	2.510	0.012	1.340	351	0.004
School Activity Participation	1.926	0.587	419	1.850	0.557	345	1.810	0.071	1.110	418	0.309
Negative Attitudes Toward School	3.121	0.942	435	2.875	1.004	360	3.550	<0.001	1.140	359	0.208
Neighborhood	1.430	0.399	427	1.380	0.370	358	1.800	0.073	1.160	426	0.137

Note. T-test results compare male and female means on environmental measures.

Table 3

Pearson Correlations for Environmental Measures.

	CHAOS	Supportive Classroom	School Attachment	Teacher Bonding	School Activity Participation	Negative Attitudes Toward School	Neighborhood Environment
CHAOS	1 N=774						
Classroom Environment	-0.202*** N=764	1 N=798					
School Attachment	-0.225*** N=745	0.443*** N=770	1 N=777				
Teacher Bonding	-0.212*** N=747	0.338*** N=770	0.547*** N=759	1 N=780			
School Activity Participation	0.248*** N=732	-0.258*** N=756	-0.415*** N=745	-0.250*** N=744	1 N=764		
Negative Attitudes Toward School	-0.069 N=761	0.187*** N=785	0.345*** N=770	0.233*** N=773	-0.155*** N=757	1 N=795	
Neighborhood Environment	0.306*** N=751	-0.118** N=774	-0.201*** N=755	-0.181*** N=758	0.209*** N=742	-0.037 N=772	1 N=785

Note. ** $p<0.01$, ***$p<0.001$.

Table 4

Twin Intra-Class Correlations by Gender and Zygosity for Each Environmental Measure.

	Female				Male				Opposite-sex	
	MZ		DZ		MZ		DZ			
	n	*r*	*n*	*r*	*n*	*r*	*n*	*r*	*n*	*r*
CHAOS	152	0.644***	154	0.491***	138	0.469***	106	0.449***	182	0.574***
Classroom Environment	164	0.169*	168	0.141	146	0.429***	112	0.023	190	0.115
School Attachment	158	0.540***	162	0.316***	140	0.499***	106	0.253**	176	0.196*
Teacher Bonding	162	0.539***	156	0.353***	138	0.450***	110	0.132	182	0.243**
School Activity Participation	156	0.569***	156	0.305***	126	0.280**	108	0.444***	172	0.093
Negative Attitudes Toward School	164	0.271***	164	0.490***	144	0.555***	116	0.145	188	0.127
Neighborhood Environment	154	0.618***	168	0.434***	140	0.647***	114	0.455***	184	0.603***

Note. * p <0.05, **p<0.01, ***p<0.001.

Table 5

Sex Limitation ACE and ADE Model Fitting Across Environmental Contexts

Variable	Model	-2LL	*df*	AIC	Δx^2	Δ *df*	p-value
	Unconstrained ACE	3044.678	1134	776.678			
CHAOS	**Constrained ACE**	**3050.753**	**1137**	**776.753**	**6.075**	**3**	**0.108**
Classroom Environment	Unconstrained ADE	3321.627	1171	979.627			
	Constrained ADE	**3325.531**	**1174**	**977.531**	**3.904**	**3**	**0.272**
School Attachment	Unconstrained ACE	3131.268	1135	861.268			
	Constrained ACE	**3135.242**	**1138**	**859.242**	**3.975**	**3**	**0.2624**
Teacher Bonding	Unconstrained ACE	3264.458	1145	974.458			
	Constrained ACE	3282.782	1148	986.782	18.324	3	<0.001
	Equate A and C; Free E	3275.444	1147	981.444	10.986	2	0.004
	Equate A and E; Free C	3282.411	1147	988.411	17.953	2	<0.001
	Equate C and E; Free A	3279.788	1147	985.788	15.330	2	<0.001
	Equate A; Free C and E	3267.012	1146	975.012	2.554	1	0.110
	Equate C; Free A and E	**3264.495**	**1146**	**972.495**	**0.037**	**1**	**0.847**
	Equate E; Free A and C	3279.339	1146	987.339	14.881	1	<0.001
School Activity Participation	**Unconstrained ACE**	**3139.092**	**1120**	**899.092**			
	Constrained ACE	3147.456	1123	901.456	8.364	3	0.039
	Equate A and C; Free E	3146.142	1122	902.142	7.050	2	0.029
	Equate A and E; Free C	3147.448	1122	903.448	8.356	2	0.015
	Equate C and E; Free A	3146.892	1122	902.892	7.800	2	0.020
	Equate A; Free C and E	3145.753	1121	903.753	6.661	1	0.010
	Equate C; Free A and E	3143.213	1121	901.213	4.121	1	0.042
	Equate E; Free A and C	3143.200	1121	901.200	4.108	1	0.043
Negative Attitudes Toward School	Unconstrained ADE	3114.735	1162	790.735			
	Constrained ADE	3130.181	1165	800.181	15.447	3	0.001
	Equate A and D; Free E	3130.038	1164	802.038	15.304	2	<0.001
	Equate A and E; Free D	3126.062	1164	798.062	11.328	2	0.003
	Equate D and E; Free A	**3115.962**	**1164**	**787.962**	**1.228**	**2**	**0.541**
	Equate A; Free D and E	3123.038	1163	797.038	8.303	1	0.004
	Equate D; Free A and E	3115.962	1163	789.962	1.228	1	0.268
Neighborhood environment	**Unconstrained ACE**	**3048.461**	**1147**	**754.461**			
	Constrained ACE	3059.900	1150	759.900	11.439	3	0.010
	Equate A and C; Free E	3057.780	1149	759.780	9.319	2	0.009
	Equate A and E; Free C	3055.386	1149	757.386	6.925	2	0.031
	Equate C and E; Free A	3059.425	1149	761.425	10.964	2	0.004
	Equate A; Free C and E	3054.486	1148	758.486	6.025	1	0.014
	Equate C; Free A and E	3057.744	1148	761.744	9.283	1	0.002
	Equate E; Free A and C	3053.510	1148	757.510	5.049	1	0.025

Note. Bold type indicates the best model fit.

Table 6

ACE and ADE Univariate Variance Components with 95% Confidence Intervals

Environment	Measure	Gender	Additive Genetics (A)	Shared Environment (C)	Dominance Genetics (D)	Non-Shared Environment (E)
Home	CHAOS	Male	0.072 (0.000-0.309)	**0.519 (0.314-0.633)**	-	**0.410 (0.328-0.499)**
		Female	0.072 (0.000-0.309)	**0.519 (0.314-0.633)**	-	**0.410 (0.328-0.499)**
Classroom	Classroom Environment	Male	0.000 (0.000-0.260)	-	**0.424 (0.112-0.550)**	**0.576 (0.450-0.738)**
		Female	0.000 (0.000-0.260)	-	**0.424 (0.112-0.550)**	**0.576 (0.450-0.738)**
School	School attachment	Male	**0.328 (0.004-0.566)**	0.140 (0.000-0.389)	**-**	**0.532 (0.431-0.655)**
		Female	**0.328 (0.004-0.566)**	0.140 (0.000-0.389)	**-**	**0.532 (0.431-0.655)**
	Teacher Bonding	Male	0.255 (0.000-0.466)	-	0.037 (0.000-0.409)	**0.708 (0.530-0.918)**
		Female	**0.653 (0.266-0.769)**	-	0.037 (0.000-0.424)	**0.310 (0.228-0.425)**
	School Activity Participation	Male	0.000 (0.000-0.298)	**0.307 (0.018-0.454)**	**-**	**0.692 (0.545-0.859)**
		Female	**0.522 (0.275-0.639)**	0.000 (0.000-0.173)	**-**	**0.478 (0.361-0.623)**
	Negative Attitudes toward school	Male	**0.547 (0.403-0.645)**	**-**	0.000 (0.000-0.110)	**0.452 (0.355-0.566)**
		Female	**0.408 (0.265-0.507)**	**-**	0.000 (0.000-0.137)	**0.592 (0.493-0.705)**
Neighborhood	Neighborhood Environment Scale	Male	**0.510 (0.170-0.738)**	0.128 (0.000-0.418)	**-**	**0.362 (0.258-0.505)**
		Female	0.022 (0.000-0.231)	**0.560 (0.373-0.649)**	**-**	**0.418 (0.334-0.506)**

Note. Significance is indicated by bold type text.

APPENDIX B

HUMAN SUBJECTS APPROVAL

IRB Approval Letter

Florida State University

Office of the Vice President For Research
Human Subjects Committee
Tallahassee, Florida 32306-2742
(850) 644-8673 · FAX (850) 644-4392

APPROVAL MEMORANDUM

Date: 03/05/2015

To: Rasheda Haughbrook [redacted]

Address: [redacted]

Dept.: PSYCHOLOGY DEPARTMENT

From: Thomas L. Jacobson, Chair

Re: Use of Human Subjects in Research
Florida Twin Project on Reading, Behavior, and Environment

The application that you submitted to this office in regard to the use of human subjects in the research proposal referenced above has been reviewed by the Human Subjects Committee at its meeting on 03/04/2015 Your project was approved by the Committee.

The Human Subjects Committee has not evaluated your proposal for scientific merit, except to weigh the risk to the human participants and the aspects of the proposal related to potential risk and benefit. This approval does not replace any departmental or other approvals which may be required.

If you submitted a proposed consent form with your application, the approved stamped consent form is attached to this approval notice. Only the stamped version of the consent form may be used in recruiting research subjects.

If the project has not been completed by 03/02/2016 you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the Committee.

You are advised that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report, in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the chairman of your department and/or your major professor is reminded that he/she is responsible for being informed concerning research projects involving human subjects in the department, and should review protocols as often as needed to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

This institution has an Assurance on file with the Office for Human Research Protection. The Assurance Number is IRB00000446.

Cc: Sara Hart [redacted] Advisor
HSC No. 2015.14839

APPENDIX C

ENVIRONMENTAL QUESTIONNAIRES

Home Environment

About my Home

Please answer these questions about your home. Think about how things have been in the last 3 months and circle the number that best describes your feelings.

	Definitely UNTRUE	*Somewhat UNTRUE*	*Not really true or untrue*	*Somewhat TRUE*	*Definitely TRUE*
1. I have a regular bedtime routine (e.g., same bedtime each night, brushing teeth, reading a story).	**1**	**2**	**3**	**4**	**5**
2. You can't hear yourself think in our home	**1**	**2**	**3**	**4**	**5**
3. It's a real zoo in our home	**1**	**2**	**3**	**4**	**5**
4. We are usually able to stay on top of things	**1**	**2**	**3**	**4**	**5**
5. There is usually a television turned on somewhere in our home	**1**	**2**	**3**	**4**	**5**
6. The atmosphere in our house is calm	**1**	**2**	**3**	**4**	**5**

Class Environment

Class Time

This set of questions is about how things work at your school. How true is it that your teacher does the following:

	Not at All	*A little True*	*Somewhat True*	*Quite True*	*Very True*
1. Have students talk about their class work	1	2	3	4	5
2. Let students decide where to sit at the beginning of the school year	1	2	3	4	5
3. Allow students to choose their partners for group work	1	2	3	4	5
4. Ask for students' ideas	1	2	3	4	5
5. Let students help make school rules	1	2	3	4	5
6. Pay too much attention to grades and not enough attention to helping students learn	1	2	3	4	5
7. Only care about the smart kids in the class	1	2	3	4	5
8. Have given up on some of their students	1	2	3	4	5
9. Encourage students to compete against each other for grades	1	2	3	4	5
10. Give students credit for trying hard	1	2	3	4	5

School Environment

What My School is Like

These questions are about what your school is like. Circle the number that explains how true each statement is about your school.

	Not at All True	*Not Very True*	*Sort of True*	*Very True*
1. I work hard in school so I will be able to go to college.	1	2	3	4
2. I am happy to be at my school.	1	2	3	4
3. My teacher(s) treat me fairly.	1	2	3	4
4. I care what my teacher(s) think of me.	1	2	3	4
5. I wish I could drop out of school.	1	2	3	4
6. There are too many kids at my school.	1	2	3	4
7. I often take part in or attend school functions (like athletic events, plays or dances).	1	2	3	4
8. The teachers at my school treat students fairly.	1	2	3	4
9. I have too many different classes.	1	2	3	4
10. I feel close to others at my school.	1	2	3	4
11. There are too many kids that I don't know.	1	2	3	4
12. The work is too hard.	1	2	3	4
13. I feel safe at my school.	1	2	3	4
14. I feel lost at my school.	1	2	3	4
15. Teachers ask me to do things that I don't know how to do.	1	2	3	4
16. I feel very close to at least one of my teachers.	1	2	3	4
17. I feel proud of my school.	1	2	3	4
18. I take part in extracurricular activities (sports, clubs, interest groups) at my school.	1	2	3	4
19. I feel like I am a part of my school.	1	2	3	4

Neighborhood Environment

Neighborhood Environment Scale

Please answer these questions about your neighborhood. Circle the number that best describes your feelings.

	Not at all true	A little true	Sort of true	Very true
1.) There are plenty of safe places to walk or spend time outdoors in my neighborhood.	**1**	**2**	**3**	**4**
2.) Every few weeks, some kid in my neighborhood gets beat-up or mugged.	**1**	**2**	**3**	**4**
3.) Every few weeks, some adult gets beat-up or mugged in my neighborhood.	**1**	**2**	**3**	**4**
4.) I have seen people using or selling drugs in my neighborhood.	**1**	**2**	**3**	**4**
5.) In the morning or later in the day, I often see drunk people on the street in my neighborhood.	**1**	**2**	**3**	**4**
6.) Most adults in my neighborhood respect the law.	**1**	**2**	**3**	**4**
7.) I feel safe when I walk around my neighborhood by myself during the day.	**1**	**2**	**3**	**4**
8.) People who live in my neighborhood often damage or steal each other's property.	**1**	**2**	**3**	**4**
9.) I feel safe when I walk around my neighborhood by myself at night.	**1**	**2**	**3**	**4**
10.) In my neighborhood, the people with the most money are the drug dealers.	**1**	**2**	**3**	**4**

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BIOGRAPHICAL SKETCH

Rasheda Haughbrook earned her Bachelors of Arts in Psychology at Florida A & M University in 2010. She went on to earn a Master's of Science in Cellular and Molecular Biology at Florida A & M University in 2013. She is currently enrolled in the Developmental Psychology graduate program at Florida State University. Rasheda is pursuing a Doctoral degree under the supervision of Dr. Sara Hart.