Published in final edited form as:

Learn Individ Differ. 2014 October 1; 35: 70–77. doi:10.1016/j.lindif.2014.07.020.

A Chaotic Home Environment Accounts for the Association between Respect for Rules Disposition and Reading Comprehension: A Twin Study

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Abstract

This study examined the association between socioemotional dispositions from the developmental propensity model and reading comprehension and whether those associations could be accounted for by level of chaos in the home. Data from 342 monozygotic and 333 same-sex dizygotic twin pairs age 7-13 years were used. A parent rated the twins on sympathy, respect for rules, negative emotionality, and daring and level of chaos in the twins' home. Reading comprehension was measured using a state-wide school assessment. Only respect for rules significantly and uniquely predicted reading comprehension. Biometric models indicated that respect for rules was positively associated with reading comprehension via the shared environment and home chaos accounted for a significant amount of that shared environmental variance even after controlling for family income. Children with higher respect for rules have better reading comprehension scores in school and this relationship owes partly to the level of chaos in the family home.

Keywords

reading comprehension; shared environment; home chaos; socioemotional disposition

1. Introduction

It is self-evident that children enter the classroom with inherent differences in temperament, behavioral dispositions, and other factors that can affect learning. It is also understood that children have home environments that differ in resources, structure, and other factors that can affect learning. Increasingly, U.S. education reforms are focusing on standardized tests of foundational skills like reading to measure student achievement and assess the

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effectiveness of teachers and schools. However, achievement is not the result of only classroom experiences but also child- and family-level factors that teachers and schools may be less able to influence. The present study builds on two prior bodies of work: one showing that school achievement is significantly associated with children's personality traits (Bramlett, Scott, & Rowell, 2000; Martin, Nagle, & Paget, 1983; Matlin & Mendelsohn, 1965) and the other showing that school achievement is impacted by the level of chaos (noise; disorderliness; tension) in the home environment (Brody & Flor, 1997; Evans, 2006; Hanscombe, Haworth, Davis, Jaffe, & Plomin, 2011). The present study begins to bridge these prior findings by examining the relationship between socioemotional dispositions and reading comprehension and assessing whether those relationships are attributable to level of chaos in the home environment.

Twin studies compare data from identical twins (who share 100% of their segregating genes) and fraternal twins (who share, on average, 50% of their segregating genes) to estimate how much of the variability in a phenotype is associated with genetic factors versus environmental factors. Various studies show that genetic differences between children account for much of the differences in their reading comprehension scores in early elementary school (Keenan, Betjemann, Wadsworth, DeFries, & Olson, 2006; Logan et al., 2013; Olson et al., 2011). While there is ample evidence showing genetic influence on the variability in reading comprehension scores, it is not clear whether that genetic variability is accounted for by some of the same genes that are associated with variability in other child-level factors.

The dispositional stress model suggests that behavioral outcomes in school are the result of the combination of dispositions and environmental risk (Martin, 1994). Chaotic environments characterized by distractions, noise, and unpredictability in the home represent an environmental risk as they can hinder a child's internalization of social norms for behavior and parental values regarding education. Children in chaotic homes are less able to understand and respond to social cues (Dumas et al., 2005) and have more behavioral and emotional problems (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005), and these effects are not accounted for by socioeconomic status (SES) or general intelligence (Dumas et al., 2005; Evans et al., 2005). A chaotic home environment also negatively impacts cognitive development even after controlling for SES (Hart, Petrill, Deater Deckard, & Thompson, 2007; Petrill, Pike, Price, & Plomin, 2004). Finally, studies have shown lower achievement among children in chaotic homes (Brody & Flor, 1997; Evans, 2006; Hanscombe et al., 2011; Johnson, Martin, Brooks-Gunn, & Petrill, 2008). These findings suggest that a chaotic home environment negatively affects school performance directly and indirectly.

According to the dispositional stress model (Martin, 1994), the environment interacts with a child's disposition (presumed to be underlied by genetic factors) to affect school outcomes. Under this model, dispositions gain stability over the course of development through gene-environment correlation wherein the genetic underpinnings of the disposition are also associated with the environment (Martin, 1994). Gene-environment interplay can be examined through twin studies when the environment is measured at the level of the child and may be a source of differences between twins. When the environment is measured at the family level, it can be examined as a possible source of shared environmental effects. Although twin studies are uniquely suited to assess theories such as the dispositional stress model, no twin research has focused on the associations among dispositions, achievement, and specific aspects of the environment.

Only one study was found that examined the genetic and environmental contributions to the association of dispositional traits and achievement, but no specific measure of environment was examined. Petrill and Thompson (1993) found a positive correlation (r = .21) between a temperament factor (emotionality, activity, sociability, etc.) and an achievement factor (reading, math, language, etc.) after controlling for general cognitive ability in a relatively small sample of twins. The association between achievement and temperament was mediated by shared environmental factors, suggesting that factors common to twins in a pair (e.g., aspects of the home and/or school environment) contribute to the covariation of dispositional traits and achievement. This work is important because it begins to address the question of how child-level and family-level factors relate to reading – through genes or through environment.

As noted already, shared environmental factors appear to mediate the relationship between achievement and temperament (Petrill & Thompson, 1993). Chaos in the home has been identified as a specific component of the shared environment that mediates cognitive ability in young children (Petrill et al., 2004) as well as cognitive development across later childhood (Hart et al., 2007). Chaos in the home has also been identified as an environmental mediator of disruptive behavior problems in late childhood, accounting for a significant proportion of the shared environmental effects (Jaffe, Hanscombe, Haworth, Davis, & Plomin, 2012). This finding is noteworthy, in part, because behavior problems are often associated with achievement problems and it is possible that chaos in the home is a shared environmental factor that affects both. This idea is supported by data showing that shared environmental factors account for a large proportion of the association between achievement and home chaos (Hanscombe et al., 2011). Based on the various associations and mediations that have been shown in the literature, chaos in the home is a good candidate as an environmental mediator of the relationship between dispositional traits and reading achievement. This may be especially true when considering dispositions that are also associated with behavior problems.

Lahey and Waldman (2003; 2005) proposed the developmental propensity model wherein negative emotionality, prosociality, and daring are socioemotional dispositional traits that interact with the environment in producing conduct problems in children. Twin research has shown that each of the three primary dispositions from this model share genetic and/or environmental factors with conduct disorder (Waldman et al., 2011) and the broader externalizing factor comprised of conduct disorder, oppositional defiant disorder, and attention-deficit/hyperactivity disorder (Taylor, Allan, Mikolajewski, & Hart, 2013). Recently, the Prosociality factor has been shown to be comprised of two related dimensions, respect for rules and sympathy (Mikolajewski, Chavarria, Moltisanti, Hart, & Taylor, in press), as outlined by Lahey and Waldman (2003; 2005). Importantly, only respect for rules showed shared environmental influence at the factor level (Mikolajewski et al.), highlighting the utility in examining the component dimensions of Prosociality separately.

Although the developmental propensity model (Lahey & Waldman, 2003; 2005) identified socioemotional dispositions thought to be related to the development of conduct problems, it may also be that these dispositions relate to correlates of behavior problems such as reading achievement. The purpose of the present study was to further understanding of the way that environment and dispositions relate to reading comprehension in order to clarify how family- and child-level factors combine to influence a key learned skill. The dispositional stress model (Martin, 1994) provided a framework for why it is important to examine dispositions in relation to the environment when studying school achievement. The literature suggests that a chaotic home environment negatively impacts learning (Brody & Flor, 1997; Evans, 2006; Hanscombe et al., 2011) and is likely part of the "stress" in the dispositional stress model. In sum, the "dispositional" aspect of the model should have empirical and theoretical links to chaos and reading achievement. The developmental propensity model (Lahey & Waldman, 2003; 2005) provides a set of candidate dispositions that allow the present study to extend prior work on dispositions related to reading achievement while also expanding the scope of outcomes that may be explained by the model. Finally, prior studies examining chaos in the home as it relates to general cognitive abilities (Hart et al., 2007; Johnson et al., 2008; Petrill et al., 2004) included an important control for SES. The only study showing the shared environmental underpinnings of the relationship between home chaos and school achievement (Hanscombe et al., 2011) did not include this control. In combining these various elements, the present study tested the hypothesis that reading comprehension would be significantly and uniquely related to four dispositions (respect for rules, sympathy, negative emotionality, and daring) through genetic and shared environmental factors and that chaos in the home would account for shared environmental influence on those bivariate relationships above and beyond the effects of SES.

2. Material and Methods

2.1 Sample and Procedure

Participants were 342 monozygotic (MZ; 164 male) and 333 same-sex dizygotic (DZ; 167 male) twin pairs age 7-13 years (M = 10.08; SD = 1.71) in first through eighth grade who were participants in a longitudinal study of reading and reading-related constructs. As part of that ongoing study, achievement data generated by schools were obtained on twins directly from the state each year. Twin pairs were initially identified through state school records based on a match on last name, birth date, and school and then parents were contacted to complete a brief zygosity questionnaire and provide permission to use their achievement data (Taylor, Hart, Mikolajewski, & Schatschneider, 2013).

In summer 2010, parents of 686 same-sex twin pairs completed a questionnaire on the twins' home environment, behavior, and other traits related to reading achievement and received a $30 gift card for participating. Around two-thirds of the participating families had twins age 9 and older who received a $10 gift card for completing measures about traits, behaviors, and peers. (Note that children did not rate the level of chaos in their environment nor did they report on SES and, therefore, could not provide an additional source of information on those study variables.) Informed consent and assent were obtained in accordance with APA ethical principles on the conduct of research with human subjects. The overall response rate was 49% with non-responding families showing a small but significant (*d* = .12; *p* = .03) tendency to live in zip codes with lower median household income (*M* = $41,321; *SD* = $13,473) than responding families (*M* = $42,869; *SD* = $12,851), but there was no significant difference in housing density or median home values according to 2000 Census data. Self-reported income (used in the present study) was variable with just over 20% of families indicating a household income under $30,000. Parents reported that 71% of the twins were White, 12% African American, 9% mixed race, 2% Asian, 5% Other, and 1% did not report race. The sample was 24% Hispanic and 71% non-Hispanic (5% did not report ethnicity). Eleven of the 686 families were excluded from the present study due to missing data.

2.2 Measures

FCAT—The Florida Comprehensive Achievement Test (FCAT) reading test is a group-administered criterion referenced test of reading comprehension. Students are asked to read passages and answer multiple choice, short answer or long answer format items based on the content of the passage. The questions on the FCAT become more conceptually difficult and the text becomes more complex as grade level increases to account for the increases in reading skills. The FCAT is administered to all students in the state of Florida during 10 day testing window in the spring, with the present data from the 2010-2011 school year testing period (year immediately following data collection on the home environment and rule-abiding disposition). The present analyses utilize the FCAT reading scale score, an IRT based score, for all twins with available data from the same grade level within twin pair. Twins' were in grade 3 to 7 when they were tested. Reliability for the FCAT reading test has been shown to be high at .90 (Florida Department of Education, 2001). The FCAT measure is scaled to provide a range of 400 points and, therefore, capture a wide range of skill level. To assess this in the present sample, three grade bands were formed (third; fourth and fifth; sixth and seventh) and the range of FCAT scores in those groups was 351, 336, and 400 points, respectively.

Dispositions—The Child and Adolescent Dispositions Scale (CADS; Lahey et al., 2008) contains 57 items with four response choices scored 1-4 (Not at all to Very much/very often) and scales are created by averaging its items. Data from the CADS-parent version was used and, according to confirmatory factor analysis (Mikolajewski et al., in press), it produces a Prosociality factor with two indicators: sympathy (mean of 8 items; taps empathy and tendency to help others) and respect for rules (mean of 4 items; taps concerns about right and wrong and rule-abiding). Negative emotionality had nine items reflecting stress reactivity and mood liability. The daring scale taps risk-taking and excitement seeking through five items. Alpha reliability for respect for rules, sympathy, negative emotionality, and daring was .64, .82, .78, and .77, respectively. (Although twins age 9 and older rated dispositions using the child version of the CADS, only the parent ratings were used in order to maximize the size of the sample as parent ratings were available from all families and child ratings were available from about two-thirds of the families in the sample.)

CHAOS—The short form of the Confusion, Hubbub and Order Scale (CHAOS; Matheny et al., 1995) was used to measure level of chaos within the twins' home. The original CHAOS measure shows significant positive correlations with number of siblings in the home, experimenter noise ratings, and decibel level in the home after controlling for parent occupation as an indicator of SES (Matheny et al.). The short form of the CHAOS scale shows significant associations with conduct and hyperactivity problems in children (Jaffe et al., 2012). In this study, a primary caregiver in the home filled out the short form of the questionnaire, which is composed of six questions that tap the level of noise (e.g., "can't hear yourself think in our home"), orderliness (e.g., "it's a real zoo in our home"), and tension (e.g., "the atmosphere in our house is calm" which is reverse scored) reported on a five-point likert scale (1 = "definitely untrue" to 5 = "definitely true"). The CHAOS scale score was derived by averaging across all items and then it was reverse scored to facilitate model-fitting. The reverse scored scale is referred to as rCHAOS (alpha reliability was .60). High rCHAOS scores indicated less noise and greater order within a home and low scores indicated more noise and less order within a home.

SES—Socioeconomic status was defined as household income. Parents rated their household income on a scale ranging from 1 "less than $10,000" to 6 "$90,000 or more." The mean was 3.92 (*SD* = 1.64) and this corresponded to "$50,000 – 69,000" on the scale.

2.3 Data Analytic Plan

The distribution of each variable was normal and none required transformation. A regression procedure (McGue & Bouchard, 1984) was used to age- and gender-correct the data, and this procedure also served to z-score the data. The corrected data were used in all analyses. To address the first part of the hypothesis, that reading comprehension would be significantly and uniquely related to four dispositions (respect for rules, sympathy, negative emotionality, and daring), Pearson correlations among all study variables were calculated using one twin from each pair to ensure independence of observations. This was followed by linear regression models testing the unique association of the dispositions to reading comprehension (FCAT) as well as mediation of those associations by SES and rCHAOS.

Twin analyses were conducted as a first step in addressing the second part of the hypothesis, that genetic and shared environmental factors contribute to the association of socioemotional dispositions and reading comprehension. Twin data are used to estimate the extent to which a behavior or trait is associated with additive genetic (A) factors that contribute to phenotypic similarity among individuals who share genetic material, shared environmental (C) factors that contribute to phenotypic similarity among individuals who share an environment, and non-shared environmental (E) factors that contribute to differences between individuals and also include measurement error. Intraclass correlations were computed by zygosity to reveal the extent to which genetic and environmental influences were associated with each variable. Genetic influences are inferred when the MZ intraclass correlation is approximately twice the magnitude of the DZ intraclass correlation. Shared environmental influences are inferred when the MZ and DZ correlations are similar in magnitude. Non-shared environmental influences are inferred when the MZ correlation is less than 1.0. Cross-twin, cross-trait correlations (e.g., respect for rules score of twin 1 correlated with FCAT score of his/her co-twin) were then calculated by zygosity to assess the extent to which the correlation between variables was associated with genetic and environmental influences. These provided similar inferences as the intraclass correlations.

Following the twin analysis, biometric models were fit to obtain estimates of A, C, and E. Univariate biometric models (see Figure 1) were fit to the age and gender-corrected z-scores using Mx software (Neale, Boker, Xie, & Maes, 2003) and Full Information Maximum Likelihood (FIML) estimation for FCAT and dispositions that were significantly and uniquely related to FCAT as per the regression analyses. Parameter significance of the biometric models was indicated by 95% confidence intervals that did not include zero. The univariate models were used to assess whether SES and rCHAOS accounted for shared environmental variance by first fitting univariate models without those measured environmental variables (see Figure 1a) and then re-fitting the model with one of the measured environmental variables included (see Figure 1b). It should be noted that the measured environmental variables of SES and rCHAOS can *only* mediate the shared environment because they were measured at the family level and are shared across a twin pair.

Finally, two different bivariate biometric models were fit to the data for each disposition that was uniquely related to FCAT as indicated by linear regression analyses. The first model was a bivariate Cholesky decomposition model between a disposition and FCAT (see Figure 2). This model parameterizes the common additive genetic, shared environmental, and non-shared environmental covariance between the disposition scale and FCAT (represented by A1, C1, E1, respectively, in Figure 2) as well as the specific genetic, shared environmental, and non-shared environmental variance on FCAT independent from the disposition scale (represented by A2, C2, E2, respectively, in Figure 2).

Following the approach taken by others (Hart et al., 2007; Petrill et al., 2004), the second bivariate Cholesky was an extension of the first that included mediating effects of the measured family environments of SES and rCHAOS (see Figure 3). This model allowed for not only the genetic and (general) environmental influences between the disposition scale and FCAT to be estimated as described above in the first Cholesky model, but it also estimated the specific environmental effects due to SES and rCHAOS on the relation between the disposition and FCAT. More specifically, these two measured family environmental influences were loaded onto two factors, namely, “SES + rCHOAS,” which represented the common variance between SES and rCHAOS, and “rCHAOS,” which represented the remaining effect of rCHAOS after controlling for the commonality between the SES and rCHAOS measures. These known environmental factors were then allowed to account for the variance and covariance on and between the disposition scale and FCAT.

3. Results

Significant correlations were found among rCHAOS, respect for rules, negative emotionality, sympathy, and FCAT (see Table 1). The results are notable for the consistent magnitude of the correlations between FCAT and respect for rules (r = .27) and income (r = .35). Income is a well-described correlate of school performance and respect for rules had a similar association to FCAT as indicated by a non-significant correlation contrast test between the correlation coefficients (z = -1.52, p = .06; Meng, Rosenthal & Rubin, 1992). Daring did not correlate significantly with FCAT and it was excluded from further analysis. A linear regression was then performed to test the hypothesis that the remaining dispositions had a significant unique association with FCAT and that SES and rCHAOS mediated those associations (see Table 2). Only respect for rules was a significant predictor and its influence was reduced but remained significant when SES and rCHAOS entered the model in a subsequent step. Two alternatives were also examined. First, the aforementioned model was reversed such that dispositions were entered at step two to serve as mediators of rCHAOS and SES. Results were very similar to those from the model presented in Table 2: Only respect for rules was significant among the dispositions and the effect of rCHAOS was reduced but remained significant (results available from authors upon request). Second, a model that included the interaction between respect for rules and rCHAOS was examined and it was non-significant (B = .006; $SE\ B$ = .046; β = .007; p = .88), indicating no moderation effect. Based on the results of these phenotypic analyses, only respect for rules was examined further.

Twin intraclass correlations among respect for rules, rCHAOS, SES, and FCAT are provided in Table 3. These correlations indicated shared environmental influence on the covariation of respect for rules and FCAT as the magnitude of the cross-twin, cross-trait MZ and DZ correlations were similar. Genetic influence on respect for rules and FCAT was indicated by a substantially greater MZ than DZ intraclass correlation for each variable. This was confirmed by the initial univariate analyses that did not contain measured environmental variables: results showed that approximately half of the variance in each variable was associated with individual differences in genetic factors (see top of Table 4). Shared environmental variance accounted for roughly one-quarter of the variance in both respect for rules and reading comprehension. Two subsequent univariate models were fit to examine whether SES and rCHAOS each served to account for (mediate) shared environmental variance in each variable. Results showed that SES and rCHAOS were significant for both the disposition and reading measure (see center and lower parts of Table 4). Variance measured by rCHAOS accounted for 7% of the variance in respect for rules and 5% of the variance FCAT. This represents 23% of the general shared environmental variance for respect for rules (.07 /[.23 + .07] = .23) and 20% of the general shared environmental variance for FCAT (.05/[.20 + .05]). Similar calculations for income showed that it accounted for much less of the shared environmental variance in respect for rules (7%) but more than twice the amount of shared environmental variance in reading comprehension (44%). Indeed, income accounted for all of the shared environmental variance in FCAT as indicated by the non-significant estimate of C when income was in the model.

Although the regression analyses indicated that respect for rules may slightly mediate the relationship between the environment (SES and rCHAOS) and FCAT, this alternative could not be examined in a biometric model because SES and rCHAOS were measured as family-level variables and were invariant within twin pairs. Thus, a pair of biometric models was fit to the data to test the main study question regarding the independent effect of chaos in the home as a shared environmental mediator of the association between a dispositional trait (respect for rules) and reading comprehension.

The first Cholesky decomposition did not include measured environmental variables and was used to establish estimates of genetic and environmental variance associated with the covariation of FCAT and respect for rules (see Figure 2). The fit statistics for the first model were: -2LL = 7430.53; df = 2956; AIC = 1518.53. Consistent with the twin correlations, the model suggested strong genetic influence on respect for rules and reading comprehension. Shared environmental effects were significant for respect for rules, and the covariation between respect for rules and reading comprehension was accounted for only by significant shared environmental effects (.40).

The second bivariate Cholesky model tested the extent to which the measured shared environmental variables (SES and rCHAOS) accounted for shared environmental variance associated with the covariation between respect for rules and reading comprehension (see Figure 3). The model was used to provide an estimate of the effect of chaos in the home independent of SES akin to what was accomplished in the initial regression analyses that tested for mediation. The upper part of Figure 3 reflects the estimates of A, C, and E on the association of respect for rules and reading comprehension. The lower part of Figure 3 illustrates the inclusion of the measured environmental variables as a bivariate latent factor model that allowed variance in C to be accounted for by the combined environment (SES + rCHAOS) and residual rCHAOS that represented the independent effect of home chaos on the association of respect for rules and reading comprehension above and beyond the contributions of SES. Thus, the covariation between respect for rules and reading comprehension is partitioned into variance accounted for by A, C, and E (upper part of Figure 3) and also SES and home chaos (lower part of Figure 3). The path from the combined environmental factor (SES + rCHAOS) to the SES observed variable represents the unique variance in SES associated with the covariation of respect for rules and reading comprehension. The path from the combined environmental factor (SES + rCHAOS) to the rCHAOS observed variable represents the SES-related variance in rCHAOS that is associated with the covariation between respect for rules and reading comprehension. The final path from the rCHAOS factor to the rCHAOS observed variable represents what is left of the shared environment associated with the covariation between respect for rules and reading comprehension after accounting for unique SES and SES-related chaos: chaos in the home that is not attributable to level of economic resources.

The fit statistics for the second model were: -2LL = 11793.30; df = 4275; AIC = 3243.30. As expected, family income and chaos in the home accounted for (mediated) the shared environmental effect on the covariation between respect for rules and reading comprehension as indicated by two things. First, a comparison of the path from C1 to reading comprehension in the first Cholesky model without measured environment showed a significant estimate of .40, which was reduced to a non-significant .22 in the second, expanded Cholesky model in which the measured environmental variables were included. Second, the environmental mediation part of the model (lower part of Figure 3) had all significant paths, indicating that the reduction to non-significance in the path from C1 to reading comprehension from the first Cholesky model to the second Cholesky model was accounted for by the measured environmental variables included in the second model. In addition, chaos in the home accounted for unique variance beyond SES as indicated by the significance of the path from the rCHAOS latent factor to the rCHAOS measure (.11).

4. Discussion

While education reforms in the U.S. have increasingly focused on standardized tests of essential learning outcomes in gauging student, teaching, and school success, the fact remains that children enter the classroom with individual differences that impact learning and, therefore, represent important factors when considering the causes of academic achievement levels. The aim of the present study was to examine how specific child- and family-level factors combine to contribute to variability in reading comprehension. It was hypothesized that four dispositions (respect for rules, sympathy, negative emotionality, and daring) would relate uniquely to reading comprehension. Furthermore, the observed covariation between reading comprehension and dispositions was expected to be explained, in part, by level of chaos in the home.

Partial support was found for the first part of the hypothesis such that respect for rules was significantly and uniquely related to reading comprehension; however, the other dispositions were not. These results provide an important extension of Lahey and Waldman's (2003; 2005) dispositional propensity model by showing an association between one of the model's dispositions and a novel outcome variable. As part of the Prosociality factor, sympathy and respect for rules combine to significantly predict conduct problems (Lahey & Waldman, 2003; 2005; Waldman et al., 2011) and the externalizing dimension in children (Taylor, Allan et al., 2013). Moreover, the association between Prosociality and childhood behavior disorders owes largely to common genetic factors (Taylor, Allan et al., 2013; Waldman et al., 2011). The present study showed that respect for rules alone represents a child-level factor that significantly and positively predicts reading comprehension achievement level. Thus, low respect for rules may increase risk for conduct problems but, it also appears to be associated with risk for poorer reading comprehension performance in school.

The second part of the hypothesis was that socioemotional dispositions would be associated with reading comprehension through a combination of genetic and shared environmental factors. However, the association between respect for rules and reading comprehension was forged only through shared environmental factors. As such, the present data are consistent with the idea that the relationship between respect for rules and reading comprehension performance is indirect. That is, a home environment in which children can develop a lack of respect for rules is also one in which homework and school progress is not monitored, which could lead to poor performance on reading comprehension measures. The present results suggest possible novel targets of intervention for reading problems, namely, parent education and training that promotes homework and academic progress monitoring as well as behavior modification strategies that could improve the child's level of respect for rules by tying rule-breaking to meaningful consequences (e.g., loss of highly desired privileges).

The final part of the hypothesis was that a chaotic home environment would account for at least some of the shared environmental influences associated with the covariation between socioemotional dispositions and reading comprehension. Martin's (1994) dispositional stress model provided a framework for examining child- and family-level factors in relation to reading achievement. This model suggests that a child's disposition interacts with the school environment to affect achievement. Phenotypic analyses in the present study showed a non-significant interaction between home environment and dispositions. Instead, results supported the hypothesis that level of chaos in the home accounts for shared environmental variance that contributes to the positive relationship between respect for rules and reading comprehension. These data are consistent with the idea that children with greater respect for authority and rules show better understanding of what they read in school and this owes in part to the level of noise, distractions, and unpredictability at home. Presumably, as noted above, this is because children living in homes with clearer rules, lower noise levels, and more explicit expectations from parents develop a respect for rules and this in turn encourages behavior that contributes to school success such as completing homework and reducing behavior problems that can detract from learning. It is conceivable that socioeconomic conditions have important effects on the level of noise, rules, and order in the home and that SES accounts for the covariation observed between the respect for rules disposition and reading comprehension in this study. However, the significant effect of chaos in the home was found after controlling for the effects that chaos shared with SES.

The results from this study also contribute to the sizable literature showing that variability in reading comprehension is associated with variability in genetic factors. The heritability of reading comprehension was .53 in this study, which is comparable to the estimates from other similarly aged twin samples (Logan et al., 2013). Beyond genetic factors, when the reading comprehension measure in this study was examined without the measured home environmental variables in the model, there was a significant shared environmental effect. However, there was not a significant residual shared environmental effect on reading comprehension in the bivariate model, indicating that the effects of shared environment on reading comprehension in the later school years are common to those that are influencing individual differences factors like respect for rules.

The present results should be considered in light of some limitations. First, parent ratings of socioemotional dispositions, SES, and home chaos were used and shared method variance could contribute to the associations among those variables. Future studies should incorporate multiple raters of constructs where possible. Second, data were available at one time point and, therefore, the results provide only a snapshot of the environmental influence on dispositions and reading comprehension and this may be different at different ages. Future work should aim to examine changes in the relationship between dispositions and reading outcomes over time. Relatedly, the age range of this sample (7-13 years) represents a relatively wide swath of development with regard to a number of processes, including reading comprehension. Thus, even within the single time point examined in this study there may be important developmental differences that would require larger samples to fully explore. The FCAT measure used here was designed to capture the wide variability in reading comprehension evidenced across school grades and this bolsters confidence in the findings. Third, the fact that the paths from C1 and C2 to reading comprehension were not negligible in magnitude and yet were non-significant suggests that the power of the sample may not have been sufficient to detect shared environmental effects not accounted for by the measured environmental variables. Thus, the present data should not be interpreted to mean that respect for rules, chaos in the home, and SES completely account for shared environmental effects associated with individual differences in reading comprehension. Finally, because both the SES and rCHAOS variables represented family-level measures, the only possible source of variance the two could account for (mediate) was the shared environment. Although SES and chaos in the home are both seemingly obvious "environmental" measures, work in other samples has suggested that there may also be genetic sources of variance on environmental variables when measured at the child-level (Hanscombe, Haworth, Davis, Jaffe, & Plomin, 2010), or that passive gene-environmental influences are spuriously inflating shared environmental influences (Turkheimer, D'Onofrio, Maes, Eaves, 2005). While this is a possible limitation, the association between respect for rules and reading comprehension was entirely environmental, so concerns about the genetic influence on the measured environmental variables is attenuated.

5. Conclusions

Reading comprehension is a critical skill that educators focus on, but children vary in their achievement even within classrooms and that variability is associated largely with factors such as genetics that are outside of teachers' control (Byrne et al., 2010). It is not clear that the various individual differences factors related to performance on school achievement tests are considered when formulating policies aimed at improving education. However, as more findings emerge on specific child- and family-level factors that influence school achievement measures such as reading comprehension, additional avenues for intervention may open up. The present study identified chaos in the home as a mediator between the socioemotional disposition of respect for rules and reading comprehension. These findings further highlight the importance of individual differences factors in understanding children's school performance and suggest home chaos as a potential target for interventions aimed at improving achievement in reading comprehension.

Acknowledgments

This research was supported in part by grant NICHD P50 HD052120.

The authors would like to thank Brooke Soden for assistance with data collection. The authors are grateful to the twins and their parents for their participation.

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Highlights

- Respect for rules is a socioemotional disposition related to reading comprehension
- Reading comprehension is related to respect for rules through shared environment
- Chaos in the home accounts for that shared environmental variance

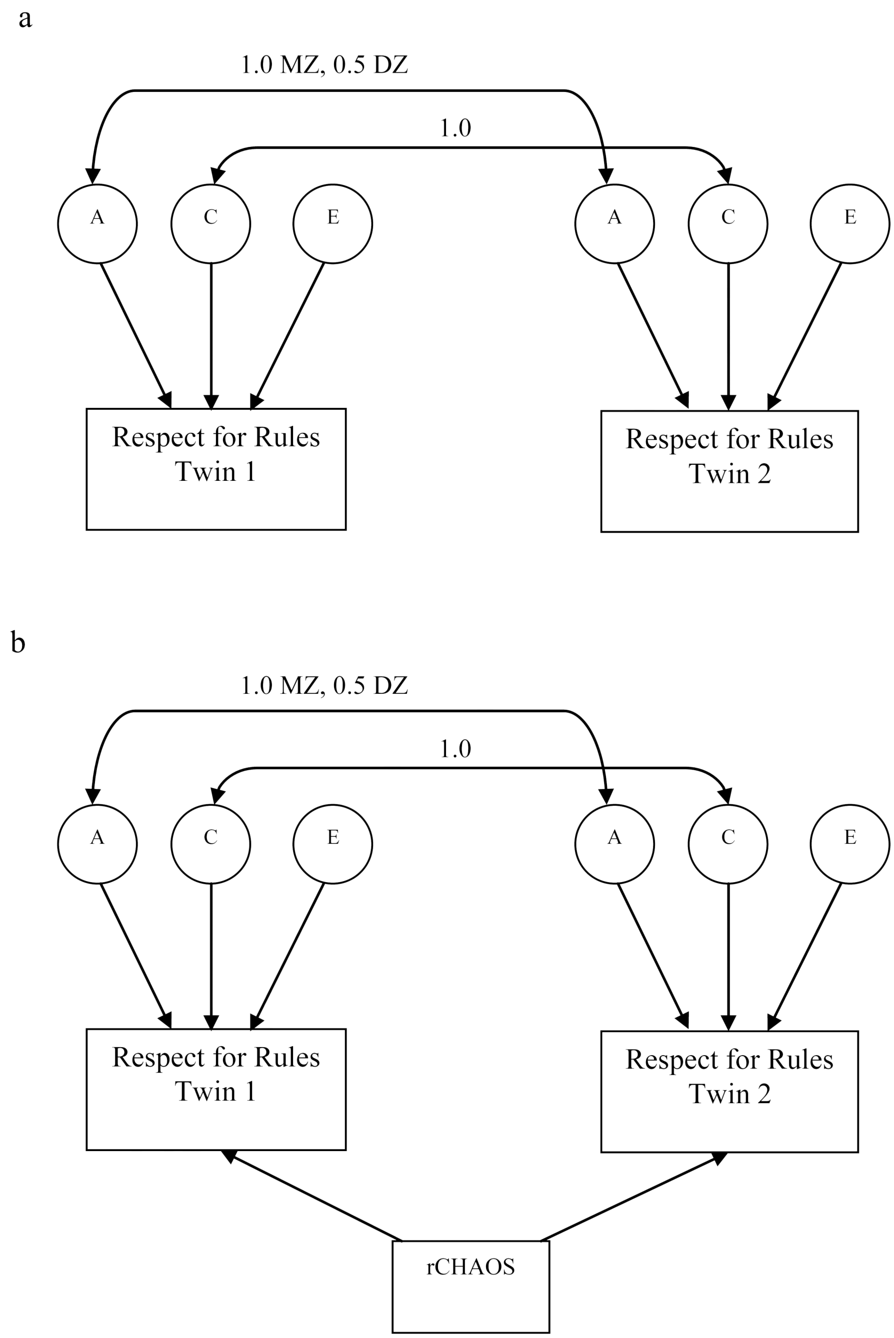

Figure 1.
Univariate model without mediation (a) and with mediation (b). Sample univariate twin model in which variance was decomposed into additive genetic (A), shared environmental (C), and non-shared environmental (E) factors first without a measured environmental variable (Figure 1a) and then with a measured variable included (Figure 1b).

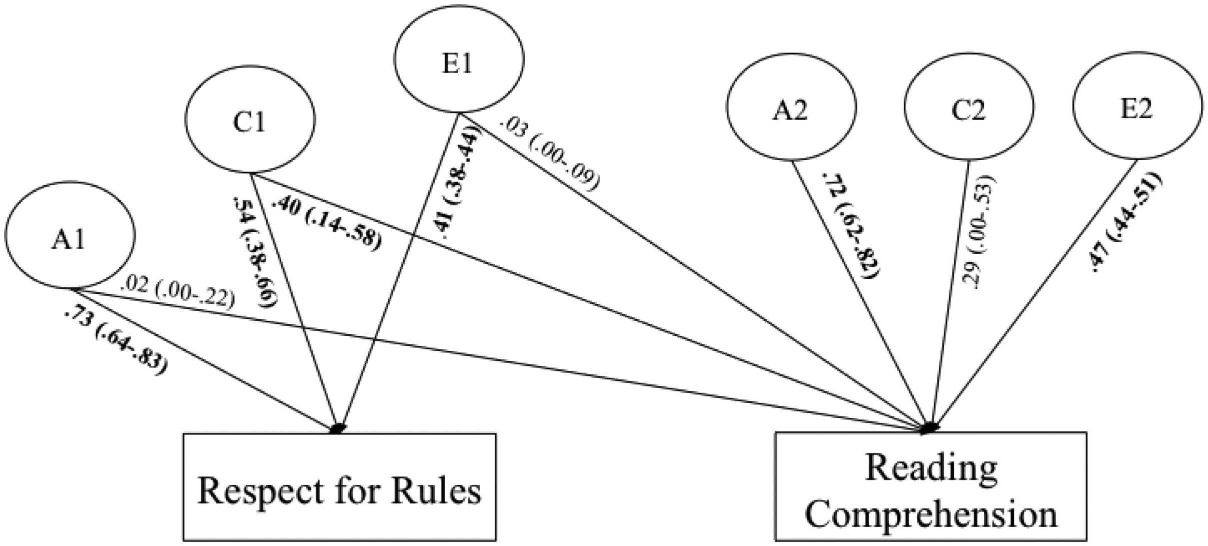

Figure 2.
Bivariate model without mediation. Respect for rules and reading comprehension variance and covariance was decomposed into additive genetic (A), shared environmental (C), and non-shared environmental (E) factors.

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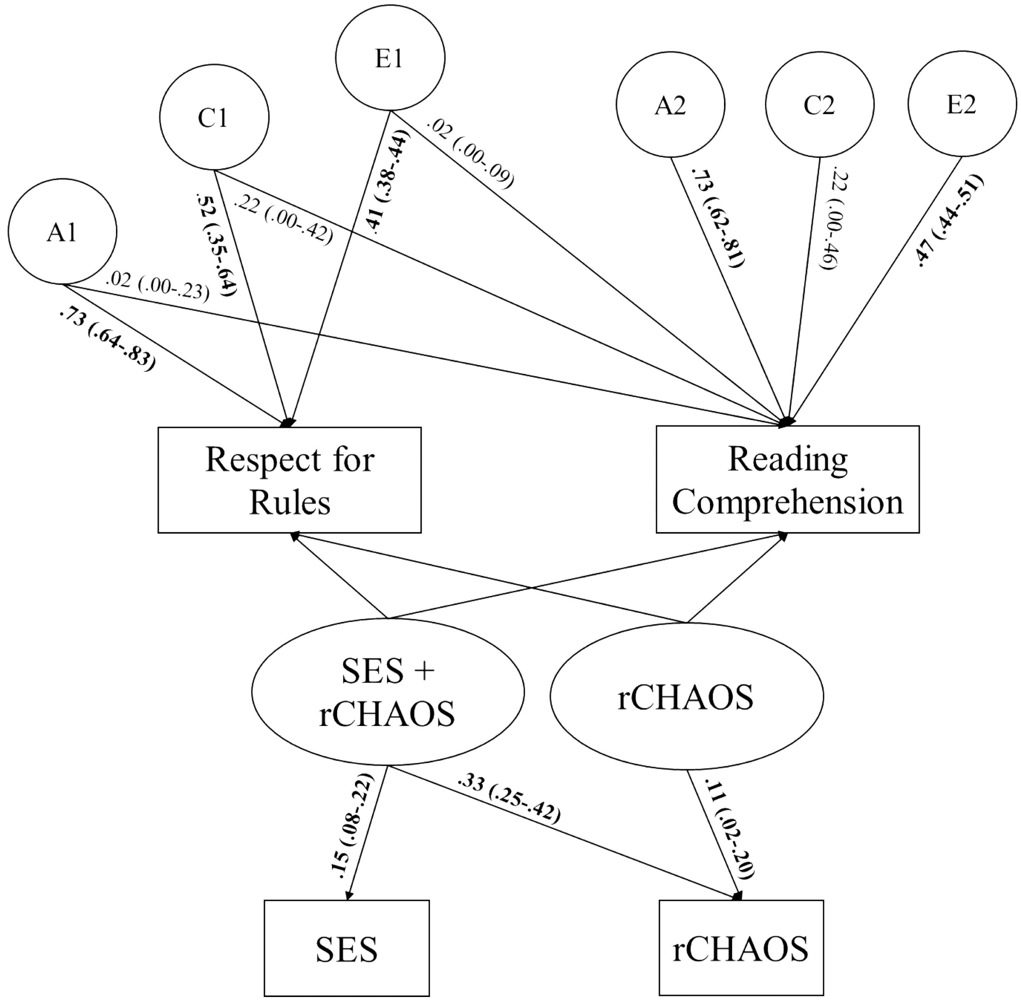

Figure 3.

Bivariate model with shared environmental mediation. Respect for rules and reading comprehension variance and covariance was decomposed into additive genetic (A), shared environmental (C), and non-shared environmental (E) factors. SES = socioeconomic status; rCHAOS = chaos in the home (reverse scored).

Table 1

Pearson Correlations (and Ns) for Environment, Reading Comprehension, and Dispositions

	rCHAOS	Income	FCAT	Respect for Rules	Sympathy	Negative Emotionality	Daring
rCHAOS	1.0						
Income	.04 (641)	1.0					
FCAT	.22** (371)	.35** (345)	1.0				
Respect for Rules	.29** (675)	.00 (642)	.27** (370)	1.0			
Sympathy	.19** (685)	.00 (642)	.14** (371)	.50** (675)	1.0		
Neg. Emotionality	−.32** (683)	−.01 (642)	−.11* (369)	−.20** (673)	−.16** (684)	1.0	
Daring	−.08* (678)	−.04 (637)	.00 (367)	−.05 (670)	.12* (678)	.05 (677)	1.0
Raw Mean (SD)	3.69 (0.60)	3.92 (1.64)	329.71 (59.15)	3.24 (0.53)	3.30 (0.47)	2.07 (0.51)	2.62 (0.66)

Note: Correlations were calculated using the age- and gender-corrected variables. Means (and standard deviations) are given for the raw distributions in order to reflect original scaling.

* $p < .05$

** $p < .01$.

Table 2

Regression Model Predicting Reading Comprehension from Dispositions and Environment

Variable	***B***	***SE B***	β
Step 1			
Respect for Rules	.252	.060	257***
Sympathy	−.001	.060	−.001
Negative Emotionality	−.057	.052	−.058
Step 2			
Respect for Rules	.227	.056	231***
Sympathy	−.008	.056	−.008
Negative Emotionality	−020	.050	−.021
rCHAOS	.128	.052	.129*
Income	.344	.048	.344***

Note: R^2 = .07 for Step 1; Δ R^2 = .14 for Step 2 (*p*s < .001).

* $p < .05$

*** $p < .001$.

Table 3

Twin Intraclass Correlations for Home Chaos, Respect for Rules, and Reading Comprehension.

	rCHAOS	FCAT	Respect for Rules	Income
rCHAOS	1.0	.20	.29	.13
FCAT	.28	.77/.48	.24	.44
Respect for Rules	.23	.25	.83/.57	.16
Income	.04	.22	.15	1.0

Note: All correlations were calculated using the age- and gender-corrected variables. Twin intraclass correlations are presented on the diagonal for MZ (monozygotic)/DZ (dizygotic) twins. Cross-twin, cross-trait intraclass correlations are presented below the diagonal for MZ twins and above the diagonal for DZ twins. Only the rCHAOS-income correlation among MZ twins (.04) was not significant at $p < .05$.

Table 4

Univariate Models for Respect for Rules and Reading Comprehension with and without Mediation.

	Respect for Rules	Reading Comprehension
No mediation		
A	.53 (.40-.68)	.53 (.38-.68)
C	.30 (.16-.43)	.24 (.09-.38)
E	.17 (.14-.20)	.23 (.19-.27)
−2LL (df)	3285.19 (1339)	4173.62 (1629)
Income mediation on C		
A	.53 (.40-.68)	.59 (.38-.74)
C	.28 (.13-.40)	.08 (.00-.28)
E	.17 (.14-.19)	.22 (.18-.27)
Income	.02 (.01-.05)	.10 (.04-.18)
−2LL (df)	5762.29 (1987)	6608.58 (2273)
Chaos mediation on C		
A	.54 (.41-.68)	.52 (.38-.68)
C	.23 (.08-.35)	.20 (.05-.34)
E	.16 (.14-.19)	.23 (.19-.27)
Chaos	.07 (.04-.11)	.05 (.02-.09)
−2LL (df)	5162.08 (2017)	6087.87 (2307)

Standardized variance estimates (and 95% CIs) are provided. A = additive genetic; C = shared environment; E = non-shared environment.