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An Examination of the Sibling training Hypothesis for Disruptive Behavior in Early Childhood

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Abstract

Sibling training for disruptive behavior (one sibling teaching another disruptive behavior), is examined during early childhood. We used a conservative, recently developed, statistical model to identify sibling training. Sibling training was operationalized as the cross-lagged association between earlier child behavior and later sibling behavior, and differentiated from other reasons that contribute to sibling similarity. A 3-wave longitudinal study tracked 916 children (age *M* = 3.46, *SD* = 2.23) in 397 families using multi-informant data. Evidence for sibling training was found. Earlier younger siblings' disruptive behavior predicted later lower levels of older siblings' disruptive behavior. Thus, the sibling training found in early childhood was producing greater dissimilarity, rather than similarity, on disruptive behavior.

Keywords: Sibling training hypothesis, early childhood, disruptive behavior, multilevel model, clustering, longitudinal design.

An Examination of the Sibling training Hypothesis for Disruptive Behavior in Early Childhood

Disruptive behavior begins in the infancy period, increases in early childhood and then decreases as children learn to regulate anger and aggression (Tremblay, 2015). Some individuals show high levels of disruptive behavior throughout the life course (Odgers et al., 2008), making it important to identify the potentially modifiable processes that contribute to the development of disruptive behavior. One of the socialization processes that has been examined within the family is sibling training (Patterson, 1986). As siblings also share genes and many environmental influences, it is important to control for these influences when testing the sibling training hypothesis. In the present study we differentiate between *sibling training,* and *clustering*. Sibling training is defined as one sibling's earlier behavior predicting change in another sibling's later behavior. This change may take the form of differentiation, as siblings become more different, or similarity, as siblings become more similar. Clustering is defined as commonalities in disruptive behavior. This includes commonalities in relation to multiple siblings behavior (siblings show similarities to one another) and stability in disruptive behavior (commonalities within each sibling across time points). We use a novel multilevel statistical method (Steele, Rasbash, & Jenkins, 2013) to differentiate these processes in a longitudinal study of 397 families with up to four children per family and using multi-informant data. To date, the sibling training hypothesis has largely been investigated amongst adolescent siblings (e.g. Slomkowski, Rende, Conger, Simons, & Conger, 2001). This study is the first to examine sibling training in a large sample of young children, while controlling for clustering. The youngest children were 18 months of age at the first wave of data collection.

The Development of Disruptive Behavior in Young children

The development of disruptive behavior is strongly influenced by maturational factors (Alink et al., 2006; Tremblay, 2015). By 4-6 months of age, infants show characteristic anger expressions, most commonly in response to blocked goals. Expressions of anger, accompanied by aggressive and disruptive behavior, increase in frequency over the second year of life as children's understanding of means-ends relationships increases and growing motor and cognitive competencies lead to autonomy seeking (Alink et al., 2006;Côté, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006;). However, parents expect toddlers to show increased regulation, and often respond to their autonomous behavior with limit setting. This conflict may result in an increase in defiant and disruptive behavior (Sroufe, 1997).

Meaningful stability in high levels of disruptive behavior over the preschool period has been found for a small group of children from the second year of life (Baillargeon et al., 2012). For some children this high level of disruptive behavior continues into adolescence and adulthood (Odgers et al., 2008). As many have argued that the preschool period is a period of high malleability to environmental influence (Fraley, Roisman, & Haltigan, 2012), it is important to identify potentially modifiable environmental processes that operate in this period.

The present study examines the role of the social environment, and specifically the behavior of siblings, in predicting the development of disruptive behavior in early childhood. Correlations between siblings in disruptive behavior have been well documented (Defoe et al., 2013; Natsuaki, Ge, Reiss, & Neiderhiser, 2009; Slomkowski et al, 2001). Although some of this correlation is attributable to genetic influence (see below), processes of socialization are thought to be critical (Patterson, 1986). It has been posited, within social learning theory, that through imitation and reinforcement, individuals learn behaviors from their social partners (Bandura, 1973; Patterson, 1986). Siblings spend a considerable amount of time together with many opportunities for social learning mechanisms to operate (Kramer & Conger, 2009). Sibling influences in early childhood have been demonstrated for skills such as language, social cognition, and social behavior (Howe & Recchia, 2014; Dunn, Slomkowski, Bcardsall & Rende, 1994) and we examine their influence on disruptive behaviour in the current study.

The Social Learning Approach to Disruptive Behavior Development

The sibling training hypothesis postulates that children learn disruptive behavior from their siblings (Patterson, 1986). The sibling relationship may be vital in teaching disruptive behavior (Dunn et al., 1994). Sibling training may take the form of increased differentiation or increased similarity between siblings.

A process of sibling differentiation can be identified when one sibling’s disruptive behavior results in the other sibling becoming *less* disruptive (Whiteman, Jensen, & Maggs, 2014; Whiteman, McHale, & Crouter, 2007). Sibling differentiation may occur as one sibling uses the other sibling’s experiences as a source of feedback on ineffective behavior, akin to observational learning. Thus, in a process of observational learning, siblings see which sibling behavior results in negative consequences and refrain from behaving in the same way (Dunn, Brown, Slomkowski, Tesla, & Youngblade, 1991; Williams, Conger, & Blozis, 2007). Sibling differentiation may also occur when siblings of disruptive children take on caring or regulating roles, to enable smooth functioning of the family system (Lamorey, 1999).

Differentiation effects have been documented in a number of studies. Shanahan and colleagues showed that although first-born children show an increase in parent-child conflict during the transition to adolescence, second-born children did not show such an increase. The authors explained this in terms of second-born siblings learning from the experience of their older siblings. Thus the behavior of first and second born siblings on parent-child conflict shows greater differentiation over the transition to adolescence because younger siblings learn effective communication skills from observing the ineffective communication skills of their older sibling with parents (Shanahan, McHale, Osgood, & Crouter, 2007). A differentiation pattern was also found in a small, observational study of siblings during early childhood. When younger siblings were more aggressive at Time 1, older siblings showed a decrease in aggression two years later (Martin & Ross, 1995).

A differentiation pattern in disruptive behavior, dependent upon sibling sex, has also been shown in adolescent siblings studied annually for four years; younger siblings increased in aggression if they had older brothers. However, as older brothers' aggression increased, the rate of increase in younger siblings' aggression slowed; older siblings with younger sisters decreased in aggression each year. However, as the younger sisters' aggression increased, the rate of decrease in older siblings' aggression was faster (Williams et al., 2007).

Sibling training may also take the form of increased similarity between siblings over time. Such increased similarity can be explained by processes of positive and negative imitation. Siblings may learn from each other's behavior through observation and direct imitation (Kramer & Conger, 2009). They may also engage in negative and coercive interactions (Snyder, Bank, & Burraston, 2005; Patterson, 1986), hence responding to each other's provocations with escalated negativity. This increase in negativity reinforces the use of coercive behavior and, as a result, both siblings become increasingly likely to use more extreme disruptive behavior, within and outside the family system (Patterson, 1986).

An important question, however, concerns the extent to which siblings may influence each other's behavior over an extended period of time, potentially resulting in enduring changes in behavior. This question can be investigated in long-term longitudinal studies, in which the association between the behavior of siblings over time is examined, controlling for the stability in the behavior of each sibling (cross-lagged panel model; Cook & Kenny, 2005). Several studies have estimated this long-term association between siblings in disruptive behavior among adolescents (Defoe et al., 2013; Natsuaki et al., 2009; Slomkowski et al., 2001). For example, Defoe and colleagues studied adolescent siblings annually over four years. The disruptive behavior of one sibling was associated with a subsequent increase in disruptive behavior of another sibling. Similarly, Slomkowski and colleagues, studying adolescent siblings over four waves of data, found that the delinquency of older siblings was associated with a subsequent increase in the delinquency of a younger sibling, but not vice versa (Slomkowski et al., 2001). One study has examined the role of siblings in the development of disruptive behavior in middle childhood. The younger siblings of at-risk early adolescents, were followed over ten years. The results indicated that exposure during middle childhood and early adolescence to disruptive behavior of an older sibling was associated with increased risk for disruptive behavior (Compton, Snyder, Schrepferman, Bank, & Shortt, 2003).

Sibling dyad characteristics may in part explain variations in the magnitude of sibling influence toward greater similarity. While some adolescent studies have found that same sex sibling dyads show more sibling training in disruptive behavior than mixed sex pairs (Slomkowski et al., 2001), others have not (Compton et al., 2003; Defoe et al., 2013; Natsuaki et al., 2009). Both age difference and birth order (Bègue & Roché, 2005) have also been identified as moderators of sibling training.

The Current Study

The aim of the current study is to investigate the role of sibling training for disruptive behavior during early childhood. By examining a sample of young children, we can determine whether sibling training occurs before adolescence. We hypothesized that both older and younger siblings would influence one another's disruptive behavior. We have not explicitly hypothesized the directionality of the sibling training influence (i.e. increased similarity or increased differentiation), given evidence for both directions of effect in adolescent studies, and the lack of previous long term longitudinal studies in early childhood. In addition, the study investigates the role of dyad sex composition (Slomkowski et al., 2001) and sibling age difference, in moderating the effect of sibling disruptive behavior on children's subsequent behavior.

The effect of sibling training on the development of disruptive behavior is examined using a cross-lagged panel model. The cross-lagged panel model has been the gold standard in the investigation of a causal pattern in the context of longitudinal analyses (Cook & Kenny, 2005). However, this model is increasingly criticized for neglecting to account for time-invariant effects: the stable (consistent) nature of the constructs across all time points. We refer to this as clustering and there are two sources of this in the model that we present: individual clustering and sibling clustering. With respect to individual clustering the traditional cross-lag model only takes account of an individual's stability (or consistency) in behavior across two adjacent time points (Hamaker, Kuiper, & Grasman, 2015) but there may be a consistency to the individual's behavior that operates beyond that which is captured by adjacent time-point stability. Thus by examining three or more waves of data we can extract a time-invariant consistency in an individual's behavior, that can be differentiated from adjacent time point consistency. Similarly, by studying siblings over time, we can differentiate between the behavior that is common to all siblings across time (time-invariant), and that which is different across siblings and across time (time varying). Accounting for this time-invariant clustering provides cross-lag estimates free of confounding influences and is thus central to accurately attributing causal processes (Hamaker et al., 2015; Steele et al., 2013).

The basis on which causality is argued within panel models is the *cross-lag* (Cook & Kenny, 2005). This refers to a *time-varying* influence of one construct on another: a construct at one time point is associated with an observed change in another construct at the subsequent time point. In common with other studies of sibling training our operationalization of sibling training is the cross-lag: the contribution of one sibling's earlier disruptive behavior to another sibling's later disruptive behavior.

We separate clustering from the cross-lags, by utilizing a multilevel analysis in which time-invariant effects are separately parameterized from time-varying effects. For instance, we can distinguish between the family average score on disruptive behavior (the average across all siblings, across all time points) and time-varying effects, which refer to each child's deviation from the family mean at each time point. This separation of time-invariant from time varying allows us to 'clean' the cross-lags in the time-varying part of the model, and thus identify sibling training effects that are not biased by clustering.

Clustering effects relate to four types of processes. Each of these processes may be a source of confounding influences, obscuring the identification of sibling training. The first process refers to the individual clustering described above: The consistency of the individual's behavior across three or more measurements that goes beyond that which is captured by adjacent time point stability. The second reason for clustering relates to the fact that full siblings share on average 50% of their genes, and these shared genes may cause similarity in disruptive behavior between siblings (Lacourse et al., 2014). Third, siblings share much of their environment, including parents, neighborhood, socioeconomic status and schools, and this shared environment may contribute to sibling similarity in disruptive behavior. Fourth, siblings can be similar to one another because of sibling training that took place *before* the study period began. Thus, one sibling may have influenced another in the past and as a consequence, the siblings behave similarly on disruptive behavior. Thus, in this model we distinguish the potential for past sibling training from the occurrence of active sibling training, with the former being estimated in the clustering, time-invariant component of the model and the latter in the sibling training, time-varying component, operationalized specifically as the cross-lag.

The current study takes a conservative approach to the study of sibling training by operationalizing sibling training as significant cross-lags in the time-varying component of the model, while controlling for clustering. Figure 1 shows the cross-lag pathways of interest in the bottom half of the diagram (bolded dashed lines) which represents the time-varying component of the model and the sources of potential confounding, related to clustering in the top half of the diagram.

The study hypotheses were examined in a large community sample of siblings with up to four children per family. The families were assessed when the youngest child was 18-, 36-, and 54-months of age, using combined reports of disruptive behavior from mothers and fathers. Family level disruptive behavior was accurately estimated by using all siblings in a family (up to four), instead of focusing on a specific dyad. We controlled for variables that were previously found related to the development of disruptive behavior, including age, gender (Baillargeon et al., 2007; Snyder et al., 2005), family size (Farrington, 2005), birth order, (Bègue & Roché, 2005), socioeconomic status and maternal education (Farrington, 2005; Williams et al., 2007) as well as dyad composition (age difference and gender of dyad; Slomkowski et al., 2001).

Method

Participants

The current study was embedded within a broader longitudinal study, the goals of which were to examine genetic and environmental influences on children's socio-emotional development through the investigation of within-family differences. Multiparous women giving birth to infants in the cities of Toronto and Hamilton between 2006 and 2008, who had been contacted by a public health nurse as part of a universal screening for new mothers (Healthy Babies, Healthy Children: HBHC) were considered for participation. We used the HBHC program as an enlistment frame as it is the only 'centralized' way in Ontario to contact families with newborns (Ontario Ministry of Health and Long-Term Care, 2003). Inclusion criteria were as follows: (1) English-speaking mother; (2) a newborn weighing at least 1,500g; (3) one or more children less than 4 years old in the home; and (4) agreement to the collection of observational and biological data. Thirty-four percent of mothers whose information was passed by HBHC to our study were enlisted. Reasons for non-enlistment included inability to contact families (35%), ineligibility once contacted (14%), overt refusals (40%) and inability to successfully schedule visit (10%). A comparison of this sample with the general population showed that our sample was similar to the general population on family size and mothers' personal income, but our sample showed higher levels of education, more intact marriages and Canadian born parents (versus immigrants) than in the general population (Meunier, Boyle, O'Connor, & Jenkins, 2013).

Five-hundred and one families were enlisted into the original sample when the newborn was 2 months of age. Families were followed-up 3 times during the 4.5 year follow-up and family participation was as follows: newborn was 18 months (*N* = 397 Oct 2007-Sep 2009), 36 months (*N* = 385, Apr 2009-May 2011), and 54 months (*N* = 323, May 2011-Oct 2012). As child disruptive behavior could only be assessed once the newborn had reached 18 months the current study *starts at the second wave of data collection, when the newborn is 18 months*. We examined differences between the original sample and the Time 2 sample that is the basis for the current study. Dropout was related to lower socioeconomic status (SES), $t(498) = 5.07$, $p < 0.001$, and lower maternal education, $t(498) = 2.99$, $p < 0.005$ as in most longitudinal studies (Fitzgerald et al., 1998; Wolke et al., 2009). In the current study we refer to the time points as Times 1-3 (T1-T3) for ease of reference. All children in the family to a maximum of four were included in the study.

Of the children, 51.5% were boys; 72.8% of the families were two-child families, 19.9% were three-child families, and 7.3% were families with four or more children. As a result, 42.4% of the children were the youngest siblings (age *M* = 1.6, *SD* = 1. 55), 15.4% were middle siblings (age *M* = 4.52, *SD* = 1. 57), and 42.2% were the oldest siblings (age *M* = 4.99 *SD* = 2.13). The mean age of all children at T1 was 3.46 (*SD* = 2.23; *Median* = 3.25; *75th Percentile* = 4.5; *Range* = 1.33-15.25). The majority of children were in early childhood at the first time point (90% under six years of age).

The mean age of mothers was 34.54 years (*SD* = 4.57; range = 21-49); and their education was 15.52 years (*SD* = 2.59; *Range* = 8-22). In terms of marital status, at T1, 93.6% reported that they were married or cohabitating, 3.6% were divorced or widowed, and 2.8% were single. Of the two parent families, 66.1% fathers took part in the study. Their mean age was 37.82 years (*SD* = 5.23; *Range* = 21-54) and they had an average of 15.64 years of education (*SD* = 2.64; *Range* = 7-22). Household income was coded on a 16-point scale ranging from very low income (5,000-9,999) (1) to $105, 000 or more (16), in 5,000 (bottom end of scale) and 10,000 increments and afterwards standardized. Mean family income at T1 fell in the range Canadian

Dollars 75,000–84,999. The self-identified origin of participating mothers was European (60.7%), South Asian (13.9%), Black (6.3%), East Asian (12.6%), and other (6.5%).

Procedure

At each time point, mothers participated in a home interview and completed paper and pencil measures about their neighborhood, family life, and parenting behavior. Questionnaires were left in the home for fathers to complete. Both parents reported the disruptive behavior of each participating child, including the target child, and all older siblings, up to four siblings in a family.

Measures

Covariates. Child age (in years), child gender (0 = male; 1 = female), family size (dummy coded number of children with 2 children as the reference group), birth order (dummy coded with oldest as the reference group), and maternal education (in years) were entered as covariates. Socioeconomic status (SES) was computed as a composite of family assets (i.e. house size, ownership status, cars etc.) and family income. Scores were standardized and averaged, with higher scores indicating higher SES (α = .68).

Disruptive behavior. Child disruptive behavior was assessed for each child at each time point using the disruptive behavior scale from the Ontario Child Health Study (Boyle et al., 1993) also used in the National Longitudinal Survey of Children and Youth (NLSCY, 1995). This scale included six items: “is disobedient, defiant”, “is destructive, breaks or ruins things on purpose” and “is physically aggressive”, "gets into many fights", "kicks, bites or hits other children", "has a hot temper". Mothers and fathers rated the frequency of these behaviors for each child on a three point scale: 1 ‘never’, ‘2’ sometimes, and 3 ‘often’. Internal consistency of the scale was good at all times points (α between .71 and .78 for mothers and fathers, respectively). Reports were averaged to create a disruptive behavior composite score, because maternal and paternal ratings were positively correlated within each time point, *r*s = .36-.45.

Missing Values Treatment and Analytic Plan

We first examined the means, standard deviations, and bivariate relations between the study variables (Table 1). As dropout in the Kids, Families and Places sample has been shown to relate to income and maternal education (Wade, Hoffman, Jenkins, 2015) these variables were included in the imputation model. We imputed missing data in Mplus 7, using a multilevel-data multiple imputations (Muthen & Muthen, 2010). Multiple imputations has been shown to be one of the most effective methods for handling missing data in longitudinal studies (Allison, 2002). The study variables (aggregated across mother and father report), and auxiliary variables were used to create 25 imputed data sets, in which missing values due to attrition were replaced with predicted values based on the existing information. Thus, missing fathers were not imputed, and mother reported information was used whenever fathers were missing. Analysis was conducted separately for each full data set. Following Rubin's rules (Rubin, 1987) the parameter estimates were averaged over the 25 fitted models, and standard errors were computed using the average of the standard errors over the set of analyses and the between imputation variation of parameter estimates.

We tested the hypotheses using a multilevel, cross-lagged panel model described in Steele, Rasbash, & Jenkins (2013). This model estimates the role of earlier sibling disruptive behavior on later disruptive behavior of a child. The multilevel structure, dividing the model into time varying and time-invariant components (i.e. clustering) allowed us to rule out alternative explanations. As the model is statistically complex, we only describe it briefly here but provide extensive details in Supplemental Materials.

The model was estimated via maximum likelihood using the aML software (Lillard & Panis 2003). The estimated model (Figure 1) was a three time point, cross-lagged panel model. In line with a standard cross-lagged panel model (Cook & Kenny, 2005), the model included the concurrent relations between siblings' disruptive behavior at time T; the within individual relations between the disruptive behavior of each sibling at time T and at time T+1; and the cross-lagged relations between the disruptive behavior of a sibling at time T and the disruptive behavior of the other siblings at time T+1 (i.e. the time-varying, sibling training effect).

We estimated whether the role of younger siblings' disruptive behavior on the disruptive behavior of an older sibling differs from the role of older siblings' disruptive behavior on the disruptive behavior of a younger sibling. For each child, we used the average disruptive behavior of all his or her younger siblings, and the average disruptive behavior of all his or her older siblings at time T, to predict the child's disruptive behavior at time T+1. The model accounted for varying family sizes, using all available siblings in a family (to a maximum of four children per family) to compute these averages.

Effects of interest, including cross-lags and covariates, are tested by the fixed effects, listed in the top part of Table 2. These can be interpreted as standard regression coefficients, in which coefficients that are approximately twice their standard error are significant at $p < .05$. The model allowed us to examine the effect of covariates on children's time 1 disruptive behavior as well as their change in disruptive behavior ($t = 2, 3$). The sibling training effects of interest are labelled 'Lag younger sib's disruptive behavior' and 'Lag older sib's disruptive behavior'.

The model estimated was especially conservative by using a multilevel model to control for clustering as outlined in the introduction (Hamaker, Kuiper, & Grasman, 2015; Steele et al., 2013). The clustering is tested by the family level random effect, including the variance common to all siblings in a family across all time points (Table 2, Family level, SD of random variance).

To summarize, the model differentiates between two sources of sibling similarity. The first is our operationalization of the sibling training hypothesis. This is the cross-lag of the earlier behavior of a child that contributes to the later behavior of their sibling (while controlling for all other confounds). Said in another way, the behavior of a child at time T is associated with a change in the behavior of this child's sibling between time T and time T+1. We suggest that it is this cross-lag which best tests the sibling training hypothesis. The second source of sibling similarity relates to clustering and is the variance common to all siblings at all time points. By statistically taking account of clustering, we improve the accuracy with which we can identify sibling training.

Results

Preliminary Analyses

The model was first estimated with interactions between the effect of the older and younger siblings at the earlier time point and the gender composition of the dyad. Thus, we tested whether the cross-lag effect varied by gender composition (older brother and younger sister, older brother and younger brother, etc.). No significant effects were found. In addition, all two-way interactions with birth order, and three way interactions with birth order and family size were tested sequentially, and were not significant. Last, we computed interactions with the age difference between the siblings (centered around the average age difference in the sample). These interactions were not significant. To reduce the complexity of the models, all non-significant interactions were dropped from the final models.

Sibling training: Behavioral Influence within the Context of Clustering

Table 2 presents the fixed effect estimates (top panel) and the random effects (bottom panel) for the multilevel model. With respect to the main hypotheses of the study, the effect of older sibling's earlier disruptive behavior on younger sibling's later disruptive behavior was found to be non-significant (Table 2, lag older sib's disruptive behavior). The effect of younger sibling's earlier disruptive behavior on older sibling's later disruptive behavior was, however, found to be significant (Table 2, Model 2, lag younger sib's disruptive behavior). The coefficient was negative (*b* = -.151), indicating that the higher the earlier disruptive behavior of the younger sibling, the lower the later disruptive behavior of their older sibling. This conforms to the *sibling differentiation effect* described in the introduction. Finally, it should be noted that across adjacent time points, children do show stability in disruptive behavior (see Table 2, Earlier child behavior (i.e. child lag)) as expected from existing literature.

The clustering effect was significant (see Table 2, Family variance, *SD* of random variance). This means that sibling similarity (due to genetics, shared environmental influences or sibling training that took place before the study began), as well as individual stability are present, and thus are important to control for if we are to achieve an accurate estimate of the sibling training effect, operationalized by the cross-lags.

Covariates

Girls were found to display less disruptive behavior at T1 than boys, with the influence of gender continuing to operate at subsequent time points (i.e. girls displayed a smaller increase in disruptive behavior across time than boys). Furthermore, sibling birth order was related to disruptive behavior at Time 1, with young and middle siblings displaying more disruptive behavior than older siblings (Table 2, Youngest child in the family, Middle child in the family). Maternal education was found to be positively related to disruptive behavior at T1, with no prediction for subsequent time points. Family size (Table 2, 3-child family (versus 2-child); 4-child family (versus 2-child)), socioeconomic status and age were not related to disruptive behavior.

Discussion

The current study is the first to investigate the role of siblings in training children for disruptive behavior during early childhood in a large, multi-informant, longitudinal study. We hypothesized that even in early childhood, siblings may train each other in disruptive behavior (Compton et al., 2003; Patterson, 1986), causing either sibling similarity or differentiation. By using a conservative cross-lagged panel model (Steele et al., 2013), we examined these effects while minimizing competing explanations.

Our study focuses on sibling influences during early childhood. It had been argued that children in the preschool period are especially malleable to environmental influence (Fraley, Roisman, & Haltigan, 2012), and the environment may 'inoculate' them against chronic disruptive behavior problems (Odgers et al., 2012). Siblings may be an important environmental factor supporting positive developmental outcomes.

Previous studies have identified genetic (Lacourse et al., 2014), as well as maturational factors (Alink et al., 2006), that are responsible for the development of disruptive behavior during early childhood. We hypothesized that social learning may also be implicated in this developmental process (Alink et al., 2006). Specifically, we examined the role of siblings in training young children in disruptive behavior.

Sibling training: Increased Similarity versus Differentiation

The current study found a sibling training effect that was different from the influence seen in several studies of adolescents in two ways. First, rather than “training towards similarity”, we found siblings “training towards differentiation”. Second, rather than older siblings influencing younger siblings, we found younger siblings influencing their older siblings. Thus, using a young age group, and a stringently controlled statistical model, higher disruptive behavior in younger siblings at an earlier time point predicted less disruptive behavior in their older siblings at a later time point (and conversely, less disruptive behavior in younger siblings at an earlier time point, predicted more disruptive behavior in their older siblings at a later time point).

A few interpretations are suggested for differentiation effects in early childhood. Differentiation may take the form of observational learning, as older siblings observe the negative consequences of disruptive behavior of younger siblings, and choose to avoid these consequences by regulating their own disruptive behavior (Dunn et al., 1991). Another possibility is that older siblings of more disruptive children may take on a caring responsibility and assist in managing the behavior of their younger siblings, and as a result, display less disruptive behavior themselves. Consistent with this hypothesis, Lamorey (1999) suggested that older siblings of disabled children may, under some circumstances, increase in nurturance and self-esteem. Such behavior by an older sibling may be encouraged as a positive adaptation to a disruptive younger sibling.

A different interpretation of this pattern looks at the same differentiation effect from another perspective. Younger siblings that are not disruptive may promote disruptive behavior in their older siblings and there are several possibilities. Sibling differentiation may relate to sibling power dynamics and bully-victim relationships. Bullying relationships are characterized by a power difference between the bully and the victim (Martin & Ross, 1995). Older siblings invariably hold a position of power toward a younger sibling. This power gradient may promote a relationship in which weak, powerless, younger siblings facilitate the increased disruptive behavior of an older sibling (Martin & Ross, 1995). This process may also operate through parental behaviours that covary with the sibling influence. As younger siblings behave in a regulated manner, parents may reward them, inciting jealousy among older siblings. Parents respond to jealousy by an older sibling in negative and controlling behaviors (Miller & Volling, & McElwain, 2001). Further researchers have described a “sibling barricade” effect in which negative parenting towards one child may predict an opposite effect on the child's sibling. As the parents discipline a disruptive child, this child's sibling, by comparison, receives positive differential treatment. It has been suggested that this can lead to the formation of niches amongst children: one child develops a reputation for good behaviour and another for disruptive behaviour. Future research is needed to know whether different types of parental responses might mediate sibling differentiation effects and whether interventions with parents could discourage ‘differentiation’ dynamics.

Adolescent studies have typically found a training effect of increased similarity, and older to younger sibling training (e.g. Compton et al., 2003; Slomkowski et al., 2001). Nevertheless, a few studies have found results consistent with differentiation. Among adolescents, disruptive behavior in a sibling predicted less of an increase in disruptive behavior in another sibling (Williams, et al., 2007). A similar process of differentiation was found during early childhood, with Martin and Ross (1995) reporting that younger siblings’ disruptive behavior at T1 was negatively related to older siblings’ disruptive behavior two years later.

One possible factor that may account for the differentiation effect in the current study is the developmental period under study. Tremblay (2015) has argued that disruptive behaviour is normative in early childhood and the developmental task is to learn the regulation of anger and aggression. In adolescence, on the other hand, the developmental task is to resist learning disruptive behaviors (e.g. deviancy training, Dishion, Spracklern, Andrews, & Patterson, 1996). Thus, as children progress toward school age, many children acquire regulation skills that help them avoid the use of disruptive strategies to achieve their goals. The acquisition of these regulation skills may be supported by social learning (Alink et al., 2006; Tremblay, 2015). Here we see older children develop increases in regulation as a function of their younger siblings' disruptive behavior. Perhaps older siblings, ranging from the preschool to the school age periods in our study, are more developmentally ready to acquire these regulation skills, than their younger siblings.

The Advantages of a Conservative Model for Sibling training Estimation

The current study was advantageous in its examination of the sibling training hypothesis due to its use of a conservative method for the estimation of effects. It extends the cross-lagged panel model, that had been considered the gold standard in the investigation of a causal processes in the context of longitudinal analyses (Cook & Kenny, 2005). However, the current model adds to it a control for clustering, resulting from time-invariant factors that operate within the individual and are common to all siblings in a family. Unaccounted clustering may lead to erroneous conclusions, in which stable factors within the individual and common to all siblings, are interpreted as time-varying training effects, in which the behavior of one sibling influences the subsequent behavior of another (Lahey & D'Onofrio, 2010; Steele et al., 2013a).

Although only experimental designs have the potential to rule-out *all* alternate explanations for putative causal effects, the sibling design allowed us to investigate whether this effect could be explained by clustering (Lahey & D'Onofrio, 2010). The parameter for clustering was significant in the current study, highlighting the importance of accounting for this clustering when attempting to isolate a sibling training effect, by means of a cross-lag. The design of the current study did not enable the differentiation between possible sources of clustering, such as genetic influence, shared environmental influence, or sibling training prior to the beginning of the study.

Genetic factors have consistently been found to account for a substantial proportion of individual differences in conduct problems: 60.7% of the variance at 20 months of age, and 50% of the variance at 50 months of age (Lacourse et al., 2014). Shared environmental factors have also been associated with the development of disruptive behavior, although effects are generally smaller than the heritability component of the model. For instance, Lacourse and colleagues (2014) found that the shared environment component of the model accounted for 9% of the variance at 20 months of age, and 22% of the variance at 50 months of age in disruptive behavior. Family wide influences may also include socioeconomic status, parenting behaviors shared by all siblings and common neighborhood and school exposures (Odgers et al., 2012; Winslaw & Shaw, 2007).

Indeed, the statistical technique on which the current study was based was presented in a study that examined the sibling training hypothesis among children in middle childhood, albeit for the purposes of illustrating the statistical technique (Steele et al., 2013). For the demonstration of the model, they compared the traditional cross-lag panel model, with a model that included the parameter for clustering (across siblings within a family, and across time points within individual sibling) prior to testing the significance of the cross-lags, as was done here. They found evidence for a sibling training effect (the cross-lag) that was no longer significant once accounting for clustering. This illustrates the importance of differentiating between clustering and the sibling training effect.

Beyond sibling predictors of children's disruptive behavior

In agreement with previous studies, child gender was associated with disruptive behavior (Snyder et al., 2005). We also found that the youngest and middle children showed higher levels of disruptive behavior at Time 1. Other studies have also suggested that later born siblings are more likely to engage in disruptive behavior (Rohde et al., 2003; Sulloway, 1995), in line with previous studies suggesting high conscientiousness in first born children (Sulloway, 1995). Maternal education was unexpectedly positively related to disruptive behaviors, although the effect size was small. Although socioeconomic status is generally found to be negatively associated with disruptive behaviour in adolescence this has not been consistently demonstrated in early childhood (Romano, Tremblay, Boulerice, & Swisher, 2005). Finally, in this sample there was no effect of gender composition on sibling training. Previous studies that have sampled older age children (Compton et al., 2003; Defoe et al., 2013; Natsuaki et al., 2009; Slomkowski et al., 2001) have also shown inconsistent effects of sibling training as a function of gender composition. This suggests the presence of moderators, with the likelihood that child age is one such moderator.

Limitations and Conclusions

First, this study examined the role of siblings in the development of disruptive behavior. Although many social learning studies have focused on the role of the environment in the development of negative outcomes (Bandura, 1973), siblings may also have a role in positive development. Future studies may apply this model to sibling training in prosociality. Second, as the sample for this study was lower-risk than the general population, findings are generalizable to those families in the community that are lower-risk. Third, although this study only examined the role of sibling influences, many studies have identified an important role for parenting in the development of disruptive behavior in young children (e.g. Feinberg et a., 2000). The simultaneous examination of sibling and parental influences was beyond the scope of the current study because of the complexity of the statistical model that is required. Future studies should model parental and sibling influences simultaneously, using newly developed statistical models that incorporate time varying and time-invariant components.

Fourth, the current study examined the sibling training hypothesis for the first time using a cross-lagged panel model in early childhood, controlling for the effects of clustering. It demonstrated that the improved estimation techniques resulted in sibling differentiation effects. It will be of use to apply this new estimation technique to a sample of adolescents, in order to directly compare the results with past studies, and determine whether the developmental period, or the statistical model, may account for the novel findings. Lastly, the statistical test of the hypotheses represents a state of the art examination of the sibling training hypothesis. This study, however, is based on a correlational design and conclusions about causality cannot be drawn. Randomized intervention studies that target sibling disruptive behavior as a means of reducing target child aggressive behavior will be valuable.

Despite these limitations, this study is the first to rigorously examine the sibling training hypothesis during early childhood. It substantially advances the study of sibling socialization processes, through a causal model that differentiates between clustering and sibling training influences. We demonstrate that even during early childhood, the behavior of siblings does predict a change in their other siblings' behavior. Specifically, we found that the disruptive behavior of a younger sibling is negatively associated with the disruptive behavior of an older sibling during early childhood. We also found that clustering, factors unmeasured in the current study that are common to all siblings across all time points, are important to consider.

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Table 1. Means, standard deviations, and correlations among the study variables.

	Predictors	*N*	*Mean*	*(SE)*	2	3	4	5	6	7	8	9	10
1.	Disruptive behavior T1	885	1.36	.32	.57**	.52**	-.05	-.13**	-.10**	-.04	.07*	.07*	.08*
2.	Disruptive behavior T2	746	1.38	.33		.59**	-.17**	-.11	-.08*	-.01	.06	.25**	.00
3.	Disruptive behavior T3	620	1.42	.35			-.15**	-.13**	-.02	-.01	.01	.18**	-.02
4.	Age at T1	916	3.46	2.22				.03	-.07*	.04	.40**	-.73**	.19**
5.	Gender								-.02	-.01	-.01	-.02	-.05
6.	Years of education mother	878	15.44	2.68						.48**	-.13**	.02	-.07*
7.	Socioeconomic status	881	-.01	.82							-.09**	.01	-.06
8.	Family size											-.19**	.54**
9.	Youngest child in the family												N/A
10.	Middle child in the family												

Note. Frequencies of nominal variables (gender, family size, youngest, middle, and oldest child) are reported in the participants section. $^{*}p < .05$. $^{**}p < .01$.

Table 2. Fixed effect coefficients and random effects for sibling lags, earlier child behavior and covariates in the prediction of child disruptive behavior

	Estimate	(SE)
Fixed effects		
Predictors		
***t* = 1**		
Constant	1.420**	.05
3-child family (versus 2-child)	-.003	.03
4-child family (versus 2-child)	.039	.05.
Age in years at *t* = 1	.004	.001
Girl (versus boy)	-.089**	.02
Maternal education	.001*	.001
Socioeconomic status	-.012	.02
Youngest child in the family (versus oldest)	.074*	.03
Middle child in the family (versus oldest)	.083*	.04
***t* = 2, 3**		
Constant	1.389**	.12
3-child family (versus 2-child)	.031	.03
4-child family (versus 2-child)	.064	.05
Age in years at *t*	-.004	.004
Girl (versus boy)	-.053**	.02
Maternal education	.001	.001
Socioeconomic status	-.001	.01

Youngest child in the family (versus oldest)	.012	.08
Middle child in the family (versus oldest)	.129	.08
Earlier child behavior (i.e. child lag)	.193**	.04
Lag younger sib's disruptive behavior	-.151**	.05
Lag older sib's disruptive behavior	-.100	.06
Random effects		
Occasion level		
SD of **random variance** at $t = 1$	.261**	.01
SD of **random variance** at $t = 2$	.263**	.01
SD of **random variance** at $t = 3$	.311**	.01
Concurrent sibling correlation at $t = 1$	.069	.07
Concurrent sibling correlation at $t = 2$	.104	.07
Concurrent sibling correlation at $t = 3$	.162**	.06
Family level		
SD of **random variance**	.155**	.02

Note. $^{*}p < .05$. $^{**}p < .01$.

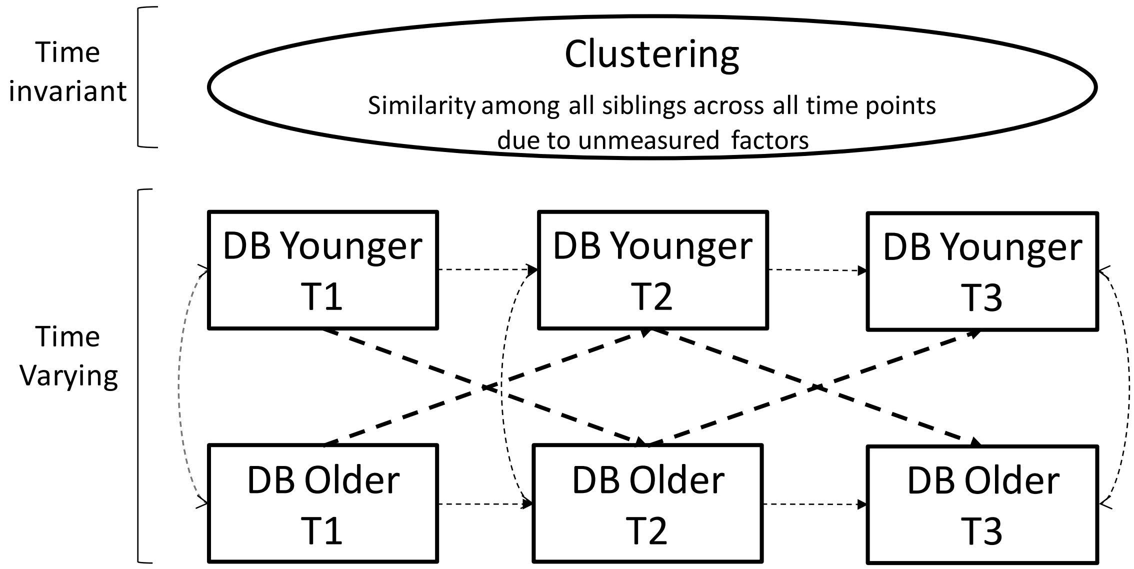

Figure 1. Theoretical multilevel cross-lagged panel model for sibling training effects in a two child family. Bolded dashed arrows indicate sibling training effects, as represented by cross lagged paths. Non-bolded dashed arrows indicate consistency in child behavior between two adjacent time points, or within-time sibling associations. DB = Disruptive behavior. Younger = younger sibling. Older = older sibling. T1 = Time 1. T2 = Time 2. T3 = Time 3.

Supplemental Material

This statistical model is based on Steele, Rasbash, and Jenkins, (2013a) with minor modifications to fit the current research question. The same notation is followed here as outlined in Steele et al., 2013a; 2013b. The model estimated is a multilevel model of sibling reciprocal influences in disruptive behaviors. We allow for the possibility that the disruptive behaviors of siblings are influenced by a common set of time-invariant characteristics, common for all siblings. The multilevel model allows for residual variation in disruptive behavior at the occasion, individual, and family level, and residual correlation between siblings due to unmeasured shared environment, genetic factors and sibling training before the study period. The method accounts for varying family sizes, between two and four siblings in a family (Steele, Rasbash, & Jenkins, 2013a).

We estimated the model via maximum likelihood using the aML software (Lillard & Panis 2003). We denote by y_{tij} the response at occasion t of child i in family j ($i = 1, \ldots, n_j$).

The contribution of the lagged response of child 2 on the response of child 1

$$\beta_1 y_{t-1,2j} \qquad (1)$$

Children are labeled arbitrarily within families. This effect of child 2 on child 1 is allowed to depend linearly on a characteristic of the dyad (12) $z^{(C)}_{t-1(12)j}$ such as their age difference.

$$(\beta_1 + \gamma \ z_{t-1(12)j}) y_{t-1,2j} \qquad (2)$$

For a three child family, we assume equality of effects across siblings, and the contributions of children 2 and 3 to the disruptive behaviors of child 1 can be written $\beta_1 \tilde{y}_{t-1,1j}$, where

$\tilde{y}_{t-1,1j} = \dfrac{(y_{t-1,2j} + y_{t-1,3j} \ldots + y_{t-1,nj})}{n_j - 1}$, or the average lagged disruptive behavior of all siblings. This term can further be extended to depend upon dyad characteristics, as demonstrated before

$$\beta_1 \tilde{y}_{t-1,1j} + \gamma_2 z_{t-1(12)j} y_{t-1,2j} + \gamma_3 z_{t-1(13)j} y_{t-1,3j} \qquad (3)$$

with the constraint $\gamma_2 = \gamma_3$. A similar extension is added for a four child family.

In our sample, there are two, three, and four child families. The contribution of the third and fourth child in a family is "switched on or off" by family size, using an interaction term with an indicator $I(n_j = 3)$ or $I(n_j = 4)$ of whether the family has three or four children.

$$\beta_1 \tilde{y}_{t-1,1j} + \gamma_2 z_{t-1(12)j}\, y_{t-1,2j} + \gamma_3 I(n_j = 3)\, z_{t-1(13)j}\, y_{t-1,3j} + \gamma_4 I(n_j = 4)\, z_{t-1(14)j}\, y_{t-1,4j} \qquad (4)$$

With up to four family members observed on three occasions, we were forced to impose some restrictions on the covariance matrix. We assumed exchangeability between children within a family, conditional on covariates. We thus assumed equal residual correlation for any sibling pair within a family at a given occasion, leading to three correlation parameters. Occasion specific residual variances were also estimated, resulting in three more parameters.

The model is a three level model, with occasion (level 1) nested within children (level 2) nested within family (level 3). Equation (5) thus contains three residual terms, or random effects: a family effect v_j representing unmeasured time-invariant characteristics shared by siblings in family j, a child effect u_{ij} capturing unmeasured time-invariant characteristics specific to child i in family j and an occasion specific residual e_{tij}. The family effects, child effects and occasion-level residuals are assumed to be normally distributed. The overall equation of the model is thus:

$$y_{tij} = \beta_0 + \beta_1 \tilde{y}_{t-1,1j} + \gamma_2 z_{t-1(12)j}\, y_{t-1,2j} + \gamma_3 I(n_j = 3)\, z_{t-1(13)j}\, y_{t-1,3j} + \gamma_4 I(n_j = 4)\, z_{t-1(14)j}\, y_{t-1,4j} + v_j + u_{ij} + e_{tij} \quad (5)$$

The family effects allow for residual correlation at the family level between child responses owing to unobserved time-invariant family-specific factors.

Initial Conditions

As detailed by Steele et al., (2003a), the model of Equation (5) is extended to account for the initial conditions problem (e.g. Bhargava & Sargan, 1983). This problem, extensively studied in economics, refers to the issue that y_1 is endogenous, thus dependent on the same set of unmeasured time-invariant characteristics that influences $y_2, \ldots, y_T$. If ignored, estimates of the lagged and cross lagged effects may be biased.

To account for initial conditions, we specify a model for y_1 which is estimated jointly with the model for $y_2, \ldots, y_T$, in a simultaneous equations model. The general model for the initial outcome for individual *j* is

$$y_{1ij} = \alpha_0 + \lambda_v v_j + \lambda_u u_{ij} + e_{1ij} \quad (6)$$

where α_0 is the intercept, v_j is a random term representing time-invariant family characteristics, u_{ij} is a random term representing time-invariant individual characteristics with loading λ_u, and e_{1j} is a residual specific for the first measurement. We assume that the same process that generated the observed $y_2, \ldots, y_T$ functioned before the first measurement. Equation (6) is jointly estimated with (5) for t>1. We specify indicator variables for whether an observation is measured at t=1 or t>1, and interact them with all explanatory variables, lags and cross lags (Alfò & Aitkin, 2006).

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