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EMPIRICAL ARTICLE

CHILD DEVELOPMENT

Do siblings influence one another? Unpacking processes that occur during sibling conflict

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Abstract

This study examined the extent to which 205 sibling dyads influenced each other during conflict. Data were collected between 2013 to 2015. The sample included 5.9% Black, 15.1% South Asian, 15.1% East Asian, and 63.8% White children. Older siblings were between 7–13 years old (Female = 109) and younger siblings were 5–9 years old (Female = 99). Siblings' conflict resolution was analyzed using dynamic structural equation modeling. Modeling fluctuations in moment-to-moment data (20-s intervals) allowed for a close approximation of causal influence. Older and younger siblings were found to influence one another. Younger sisters were more constructive than younger brothers, especially in sister–sister dyads. Sibling age gap predicted inertia in older siblings. Socialization processes within sibling relationships are discussed.

Siblings are an integral part of most children's social world and have been described as one another's greatest "companions, confidantes, and combatants" (McHale et al., 2012, p. 1). Everyday interactions between siblings provide children with countless opportunities to learn from one another and be influenced by each other's choices and behaviors. On the one hand, the inherent hierarchical nature of the sibling relationship can function like the parent–child relationship, in which the older sibling teaches, dominates, and leads, while the younger sibling learns, submits, and follows. On the other hand, siblings also have more peer-like interactions that are more reciprocal, and egalitarian in nature, engaging in play, and sharing interests and humor that parent–child pairs do not necessarily share (Dunn, 1983, 2007).

Despite these unique attributes, developmental research has neglected the investigation of sibling socialization, both substantively and methodologically. Thus, processes of parental socialization have been examined much more often than those for siblings (Kramer & Conger, 2009). Some of the more advanced methods in developmental science that capitalize on stabilities and fluctuations in behavior as a means of attributing causality (Laursen et al., 2011; Sokolovic, Leckie, et al., 2021; Sokolovic, Plamondon, et al., 2021) have been underutilized in sibling research. To date, the strongest sibling socialization effects outside of experimental design (e.g., Howe et al., 2019; Leijten et al., 2021) have been captured in longitudinal panel studies with both bi-directional and older to younger influences reported, across years (Buist et al., 2019; Jambon et al., 2019; Pike & Oliver, 2017; Snyder et al., 2005). The goal of the current study was to examine influence during real time interaction. Sibling pairs were observed discussing a recent conflict for up to 5 min, and their constructiveness was coded in 20 s periods. Using a recently developed statistical method, dynamic structural equation modeling (DSEM; Hamaker

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et al., 2018), we assessed fluctuations in each sibling's behavior (around their mean) in response to their sibling's prior behavior to examine the extent to which siblings changed one another's behavior.

CONFLICT AS A CONTEXT FOR SIBLING SOCIALIZATION AND INFLUENCE

Interactions are often described as reciprocal exchanges: Person A's behavior influences Person B's internal state (e.g., emotions, cognitions), resulting in Person B's behavioral response, which in turn influences Person A's internal state and subsequent response (Masten & Cicchetti, 2010; Sameroff & Mackenzie, 2003; Sokolovic, Leckie, et al., 2021; Sokolovic, Plamondon, et al., 2021). These reciprocal processes may operate as mechanisms through which people's attitudes, behaviors and physiological processes become synchronized (Bell, 2020; Coutinho et al., 2021). Conflict is an interaction where the nature of this reciprocal process is important. Basic processes of conflict, such as escalation or resolution, depend upon how children react to the behavior of their siblings (Perlman & Ross, 2005; Ross et al., 2006). For example, there is evidence that children may match one another's affect and behavior during conflict, which can either be positive or negative resulting in corresponding outcomes. In this study, we examined the interdependence of sibling's constructiveness during conflict resolution. When engaged in conflict discussions, interpersonal reactions can be seen as moving towards constructive (signaling support of the other's goals through positive affect and behavior) or destructive poles (signaling goal opposition through negative affect and behavior; Deutsch, 1973). While constructive behaviors tend to move the interaction toward a positive or neutral resolution, destructive behaviors tend to escalate or expand the conflict (Deutsch, 1973; Murphy & Eisenberg, 2002; Perlman et al., 2009; Perlman & Ross, 2005). Since constructive and destructive behaviors are so highly negatively correlated ($r = -.83$; McCoy et al., 2013), in the current study, they were treated as two poles of a single dimension that we called ‘constructiveness’ (Murphy & Eisenberg, 2002).

When investigating how siblings influence one another's constructiveness during conflict, it is important to consider that children bring to their interactions their own *individual* effects, which are stable across people and time (i.e., traits and characteristics; Kenny et al., 2006). The social relations model (SRM; Kenny et al., 2006) is an analytic technique used in family research to examine the extent to which an individual's behavior is consistent across interactions with different family members. Studies using the SRM design have found that individual effects account for up to 20%–30% of the variance in children's positive and negative social behavior in family interactions (Ackerman et al., 2011; Browne et al., 2018; Eichelsheim et al., 2009; Rasbash et al., 2011; Sokolovic, Leckie, et al., 2021; Sokolovic, Plamondon, et al., 2021). Furthermore, the contribution of these individual effects to family interactions appears to be developmentally influenced. For example, Sokolovic, Leckie, et al. (2021); Sokolovic, Plamondon, et al. (2021) found that responsivity to family members became more trait-like, from preschool to middle childhood (i.e., the person's mean of negativity consistently expressed across family members). Stable individual effects have been shown to predict the quality of the sibling relationship (Brody, 1998). For example, low agreeableness and high neuroticism in younger siblings has been shown to be associated with negativity in sibling relationships (Binnoon-Erez et al., 2018).

Given that each sibling will bring their own characteristic way of interacting into the conflict, we must separate these stabilities in behavior from the fluctuations in each sibling's behavior that are indicative of the way in which each *reacts* to the other, to accurately investigate the extent to which siblings influence another. The most common methods for investigating contingencies in real-time interactional behavior have been state-space grids and sequential analysis (Lougheed et al., 2016; Patterson, 1986; Perlman & Ross, 2005). Both methods, however, confound the ‘individual’ and the ‘influence’ effects of each person's behavior within an interaction. Transactional sibling studies using short, cross-lagged panel models have come the closest to differentiating individual stabilities from influence effects. These are generally based on few episodes of data, months or years between episodes and questionnaire data, to examine influence (Crocetti et al., 2017; Daniel et al., 2018; Pike & Oliver, 2017). The accuracy of cross-lag influences (the influence component) depends on the accuracy of the stable individual parameters, something that is improved by a higher frequency of episodes (Hamaker et al., 2015). Furthermore, it is difficult to draw conclusions about the mechanism of sibling influence with questionnaire or panel data. Houben et al. (2015, p. 902) have likened transactional models based on global ratings and long-time gaps to “taking still photos of a dance,” because they miss the dynamic, transactional aspect of interactions.

THE DYNAMICS OF SIBLING INTERACTION: SEPARATING INDIVIDUAL AND INFLUENCE COMPONENTS USING DSEM

DSEM is an analytic strategy that can disentangle individual effects from influence effects. An in-depth description of the model is provided by Asparouhov et al. (2018) and Hamaker et al. (2018). Figure 1 illustrates the components of this model. The model identifies two individual-level parameters and one influence

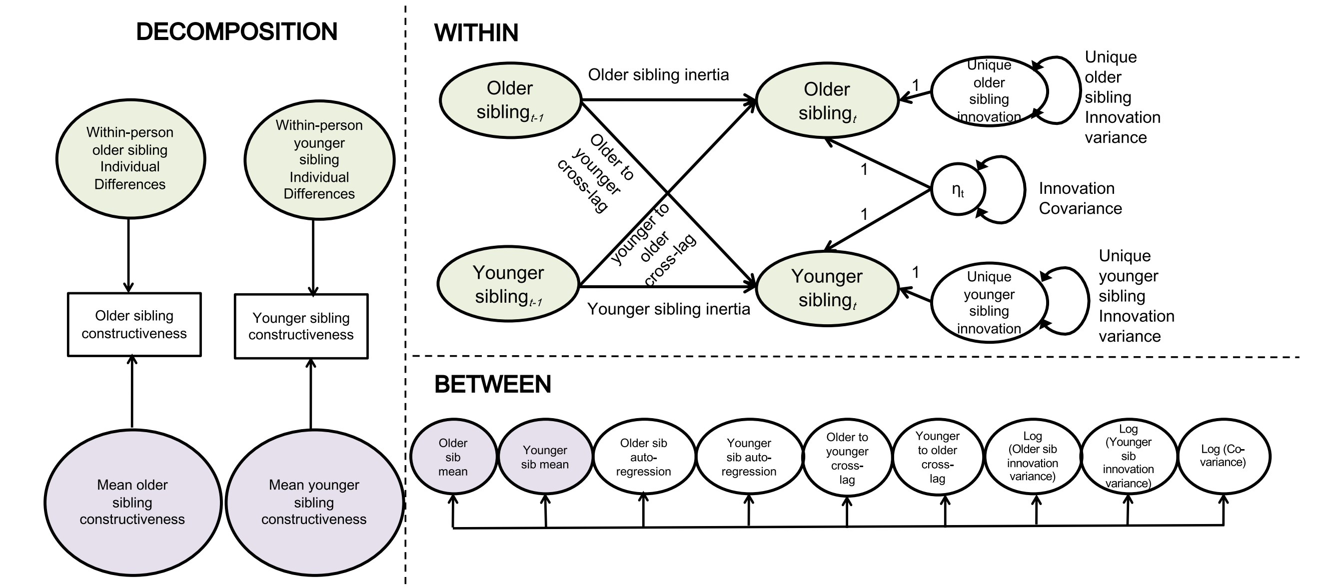

FIGURE 1 Model of the parameters estimated by dynamic structural equation modeling (DSEM). Figure adapted from Hamaker et al. (2018), Sokolovic, Leckie, et al. (2021), and Sokolovic, Plamondon, et al. (2021).

parameter. Individual effects are represented by each siblings' *average conflict constructiveness* across the interaction (i.e., the random intercept), as well as their *inertia*, which represents the autocorrelation of a sibling's constructiveness from one moment to the next (in other words each sibling's tendency to carry over their state from one moment to another).

Inertia is independent of the valence of the measure, as an individual can show a high carryover in their state from one moment to the next (in our case, at both high and low ends of constructiveness). Hollenstein et al. (2013) have argued that during interpersonal interaction, flexibility and variability of emotional reactions is key to a successful interaction, as individuals must upregulate or downregulate emotional responses based on their goals and situational considerations. This flexibility and emotional variability (expression of both negative and positive emotions during conflict) is thought to allow individuals to explore alternative interaction patterns and renegotiation of their relationship (Branje, 2018). In the light of this, lower levels of inertia during interpersonal conflict (both at the positive and negative poles of constructiveness) may indicate an ability to be flexible and responsive to the changing demands of a dynamic situation. In support of this interpretation, measures of flexibility have been found to predict conflict constructiveness during marital interactions (Finkel et al., 2013; Finkel & Campbell, 2001; Greeff & Bruyne, 2000).

The third parameter of interest within the dynamic model is the influence parameter. In DSEM, the *influence* components are operationalized as the cross-lags. These show the extent to which siblings alter their own behavior, *in response* to their sibling's prior behavior. The cross-lags are captured by the random intercept and are thought of as a "potentially causal mechanism" as they exclude unobserved sources of confounding that do not vary over time (Hamaker et al., 2018).

DEMOGRAPHICS OF SIBLING RELATIONSHIPS AND RELATIONSHIP DYNAMICS

Stable individual aspects of conflict behavior (e.g., children's average level of constructiveness and inertia) have been found to vary as a function of gender and age characteristics of individuals and dyads. Girls tend to exhibit higher prosocial skills (i.e., warmth, nurturance, perspective taking) and boys tend to show more aggressive and oppositional behaviors during conflict with siblings (Abramovitch et al., 1980; Brody et al., 1985). Older sisters have been shown to be especially positive interaction partners (Buhrmester & Furman, 1990; Dunn et al., 1999) especially when their younger sibling is a girl (Kier & Lewis, 1998). In contrast, boys have been found to have more conflict with their siblings and are more likely to engage in destructive conflict resolution strategies (i.e., physical aggression) (Brody et al., 1985). Boy–boy pairs demonstrate the highest rate of intersibling conflict and aggression, followed by mixed-sex and girl–girl pairs, suggesting that sibling aggression may be higher when the dyad contains a boy (Aguilar et al., 2001; Buhrmester & Furman, 1990; Buist, 2010; Hoffman et al., 2005; McGuire et al., 2000).

Child age and age gap between siblings has also been found to be associated with sibling interaction. As brain regions responsible for language, attention, executive function, theory of mind, and response inhibition mature with age, the average level of negativity that children show also diminishes (Keltner et al., 2019). Birth order, beyond age, is associated with sibling interaction as earlier-born children have a greater ability to control and direct the interaction (Minnett et al., 1983; Perlman et al., 2000). Thus, it is important to test for independent effects of both birth order and age on constructiveness, as they may have independent effects on conflict constructiveness and inertia.

Birth order and the age gap between siblings have been seen as proxy measures for the power differential that structures sibling relationships (Campione-Barr, 2017; Furman & Buhrmester, 1985; Vandell et al., 1987). In early to middle childhood, the age gap between siblings exerts more of an influence on the relationship and relationship conflict than it does in adolescence (Buhrmester & Furman, 1990; Tucker et al., 2010). Larger age gaps are associated with older siblings behaving like parents as they engage in role modeling, scaffolding, and nurturance (Buhrmester & Furman, 1990; Howe & Recchia, 2005). Problem solving flexibility (related to our construct of inertia) has been shown to increase as children mature (Hopper et al., 2020; Van der Giessen et al., 2013). Thus, on the one hand, we might expect older children to be more constructive and flexible during problem solving (inertia) than younger siblings but also more ready to exert their power if they deem it to be necessary. Consequently, we did not make confirmatory hypotheses about how birth order and age demographics would be associated with mean and inertia constructiveness.

Finally, we consider how birth order may play a role in the extent to which siblings influence one another. Older siblings have been consistently found to influence their younger sibling to greater similarity. This effect has been most consistently reported for aggression and has been noted for children and adolescents (Campione-Barr, 2017; Garcia et al., 2000). Younger siblings may also influence their older siblings although the patterns may be a bit different. Daniel et al. (2018) found that younger sibling's earlier aggression predicted a decrease in older sibling's later aggression. Thus, in this case, younger children influenced their older siblings, but not towards greater similarity. Instead, the older sibling learned from their younger sibling how not to behave. Findings related to birth-order, sibling influences on pro-sociality are mixed. Using observational measurement, Jambon et al. (2019) found that both older and younger siblings influenced one another's empathic concern over time. Pike and Oliver (2017), using questionnaire data, only found a significant influence of older siblings on younger ones.

STUDY HYPOTHESES

The following hypotheses were made regarding sibling's constructiveness during conflict resolution:

1. We hypothesized that there will be a significant positive cross-lag parameter (an influence effect) for each sibling (confirmatory).
2. Exploratory analyses examined whether demographic characteristics of siblings (age, age gap, gender, and gender composition) moderated any of our parameters of interest: constructiveness mean, inertia, and the cross-lags. Based on the literature reviewed above, only the following hypotheses were confirmatory: constructiveness will be higher in (a) females versus males, and (b) sister–sister dyads versus dyads that contain males.

METHODS

Sample

The current study uses a subsample of families from the Kids, Families and Places (KFP) study. This longitudinal study (2006–2012) of multiparous women from Toronto and Hamilton, recruited immediately following birth and followed up until the newborn entered school. The original goal of which was to examine biological and environmental influences on children's socio-emotional development through the investigation of within-family differences (Browne et al., 2018; Meunier et al., 2013). Inclusion criteria for the sample were as follows: (a) English-speaking mother; (b) a newborn weighing at least 1500 g (referred to as "target child"); (c) at least one older child within four years of the newborn ("referred to as next in age older sibling"); and (d) agreement to the collection of observational and biological data in the home. Parents were contacted by a universal public health program within several days after birth; 34% of eligible mothers (N = 501) consented to participate. Reasons for non-enlistment included inability to contact families, ineligibility once contacted and refusals.

The current cross-sectional study includes sibling pairs (N = 205) from the original sample that agreed to be part of the *Development of Family Cooperation* study between 2013 and 2015. Hence, this was an opportunistic sample that agreed to intensive collection of observational data (two parents, an older and younger sibling in all dyadic combinations). Younger siblings were between 5 to 9 years old, and their older siblings were between 7 to 13 years old. Reasons for missing dyads included refusal to do the task, talking in a language other than English and technological difficulties with video recording. The sample was relatively socioeconomically advantaged (average household income between $75,000 to $84,999 Canadian dollars; national average = $76,550–80,940) and ethnically diverse (see Table 1). The University of Toronto Research Ethics Board approved all procedures for this study, including obtaining signed informed consent from parents to participate in the study and assent from children.

Task description

During a home visit, trained interviewers requested that siblings discuss a recent conflict (e.g., sharing of toys) and attempt to resolve the conflict within a five-minute period following the procedures of Recchia et al. (2010). All dyads were asked to stop discussing the conflict after 5 min, irrespective of whether the conflict was resolved. Trained graduate and undergraduate research assistants (blind to the hypotheses of the study) coded for the presence/absence of constructiveness indicators (positive affect/cooperation, other-orientedness/perspective-taking; mental state talk) and destructiveness indicators (negative behavior, aggression, undermining behavior, and disruptive behavior) in each 20-s interval (see Supplemental 'Constructiveness and Destructiveness Indicators' for more details). The indicators were used to generate an overall constructiveness score, based on the balance of constructive and destructive behaviors, as outlined by Murphy and Eisenberg (2002). An individual who displayed only destructiveness with no constructiveness during a 20-s interval received a score of one (highly destructive behaviors), whereas exclusive constructive behaviors were required to receive a score of five (highly constructive). Equal constructive and destructive behaviors in the 20-s interval earned a score of three. Those who showed more constructiveness than destructiveness received a score of four, and those who showed more destructiveness than constructiveness received a score of two. Table 2 presents the percent of snapshots (20-s interval) where siblings demonstrated each level of constructiveness. A 20-s interval was used as previous work examining similar behaviors with this time interval has found expected links to child outcomes (Prime et al., 2014) and parenting constructs (Perlman et al., 2015); a shorter coding interval was not possible due to budgetary constraints. Inter-rater reliability was assessed throughout the coding period in 30% of tapes. The reliabilities for the constructiveness rating were $\kappa = 0.86$ and 0.82 for older and younger siblings, respectively. After the submission of reliability data, experts and coders discussed discrepancies to guard against subsequent coder drift.

Covariates included age of child (years, months converted to decimals and group mean centered), gender (girl = 1, boy = 0), average age of siblings (as above), age gap between siblings (older sibling age minus younger sibling age), gender composition (coded as older sister-younger sister, (OS-YS), older sister-younger brother (OS-YB); older brother-younger sister (OB-YS), older brother-younger brother (OB-YB; reference category)).

TABLE 1 Sample characteristics

Sample characteristics	%	Mean (SD)	Range
Child age (years)			
Older sibling		9.9 (1.1)	
Younger sibling		7.4 (0.8)	
Dyadic age gap (years)		2.5 (0.7)	
Age gap range (years)			1.01–4.0
Child gender (female)			
Older sibling	53.1		
Younger sibling	48.3		
Sex composition of sibling dyad			
Same sex dyad	46.3		
Both siblings are female	22.4		
Both siblings are male	23.9		
Different sex dyad	53.7		
Older sibling female	24.4		
Older sibling male	29.3		
Ethnicity			
European	63.8		
South Asian	15.1		
African Canadian	5.9		
East Asian	15.1		

Data analytic plan

Descriptive analyses of conflict constructiveness were carried out using SPSS, Version 25.0 (IBM Corp., 2017). Sibling discussions ranged from 20 s to 5 min. Most siblings completed their discussions before the allotted 5 min were up. The average length of discussions were 3 min. As result, many dyads did not have data at the end of the observational period (i.e., only 20 dyads were still

TABLE 2 Percent of snapshots (20-s interval) in which each code was present by individual and dyad

	Older sibling → younger sibling	Younger sibling → older sibling
Constructiveness composite index[a]		
(1) Highly Destructive (only negative behaviors)	0%	0%
(2) Somewhat Destructive (more negative than positive)	7.3%	7.0%
(3) Neutral (equal positive and negative)	49.2%	60.5%
(4) Mostly constructive (more positive than negative)	42.4%	32.3%
(5) Highly constructive (only positive and no negative)	1.0%	0.3%

[a]Composite constructiveness index calculated based on balance of positive and negative/withdrawal codes within snapshot.

in discussion at the end of the 5-min period). This was handled as missing data in the model using a Markov Chain Monte Carlo algorithm, incorporating information from adjacent observations, the auto-regression parameter, and residual variances. Previous simulations of DSEM parameters with large amounts of missing data using the Markov chain Monte Carlo algorithm have resulted in good estimates (Asparouhov et al., 2018).

Dynamic Structural Equation Modeling (DSEM) in Mplus version 8 (Muthen & Muthen, 2017) was employed to analyze the dynamics of sibling conflict resolution. As observed in Figure 1, DSEM separates the variance shared across all time-points at the between-level (i.e., time-invariant) from that which varies over time at the within-level (i.e., time-varying). Like standard multilevel models, parameters can either be *fixed* or *random*. Fixed parameters (bottom of Figure 1) capture the average value for each parameter in the population. This allows us to infer normative patterns in the population (i.e., on average, across the population, do siblings influence one another?). The random effects (top of Figure 1) capture individual variation on the same parameters, allowing us to explore the possibility that parameters may hold different values across individuals. For instance, a significant random effect for the cross-lagged parameters indicates that some individuals influence one another more than others. For ease of interpretation, only the fixed effects for the constructiveness mean, inertia, and influence parameters were compared among older and younger siblings. Since DSEM is a Bayesian model, it generates one-tailed *p*-values for parameter estimates. For ease of interpretability, we reported the 95% credibility intervals (CI) and examined the overlap of credibility intervals to determine whether parameters differed significantly from one another.

As mentioned previously, there are several parameters of interest within the DSEM (see Figure 1 and Supplemental 'Dynamic Structural Equation Modeling—The Parameters'), which allow for the examination of the interaction dynamics operating during sibling conflict resolution. The *individual mean* parameter captures an individual's average level of conflict constructiveness across the entire interaction (values ranged from 1 to 5, where 5 indicates an extremely constructive individual). The left side of Figure 1 illustrates the decomposition of individual means. The model removes individual means, and as such, any changes in behavior can be considered fluctuations from an individual's average level of constructiveness. By doing so, this statistical technique allows stable individual differences to be accounted for. Any fluctuations that are carried over within an individual from one interval to the next are represented by an *inertia* parameter (often referred to as auto-regression in panel models). *Inertia* or auto-regressive values range from −1 to +1, where smaller values (i.e., closer to zero) indicate that a person returns to their mean state (i.e., mean constructiveness) quickly when they have moved away from it.

The *influence* parameter indicates the extent to which an individual's current behavior can be predicted by their partner's previous behavior, and vice versa, and is captured by the cross-lagged effects. In Figure 1, the cross-lag effect is labeled and represented by arrows going from the older sibling to the younger sibling and vice-versa. A positive cross-lag is indicative of moving towards greater similarity and behavioral matching with respect to the partner, whereas a negative parameter indicates a divergence in constructiveness.

The *innovation* parameters reflect unexplained variances of each individual and the covariance across individuals (Asparouhov et al., 2018). The innovation parameters are present in the statistical model, because including these more accurately represents the data and model. As they were not pertinent to our research questions, however, they are omitted from the text and tables to reduce complexity but are provided in Tables S1 and S2 in the Supplemental: "Model Results."

The DSEM models are complex and can easily fail to converge. We took steps in preliminary and main analysis to handle non-convergence. First, two sets of models were run, one for individual level covariates and one for dyadic level covariates, as a single model would not converge. Second, sibling demographic covariates and model parameters were dropped if non-significant. The sibling demographic covariates included age and gender (individual level), age gap, dyad average age, and gender composition (dyad level). All individual and dyadic level covariates were regressed on mean constructiveness, inertia, and the cross-lags. Parameters that were non-significant were dropped from the main models and only those parameters that were significant are shown in Table 3 (individual demographics) and Table 4 (dyad demographics). Third, an important component of any Bayesian analysis is the prior distribution of the unknown model parameters. Although it is possible to use the default software settings, we used recommended priors and prior sensitivity analyses to ensure validity (van Erp et al., 2018).

RESULTS

In the preliminary analysis, it was found that age of older and younger siblings was not significantly associated with their constructiveness, inertia, or cross-lag parameters, over and above the effects of birth order (a structural part of the model). Therefore, age was dropped from all subsequent models. Birth order, age gap, gender, and gender composition predicted at least one of our effects of interest (as can be seen in Tables 3 and 4). Information on the final model fit can be found in Supplemental 3 'Model Fit Statistics.'

TABLE 3 Unstandardized point estimates and 95% credibility intervals (CI) for mean, inertia, cross lags with gender regressed on significant parameters

Parameter	Fixed effects means [95% CI]	*b* [95% CI] Female older sibling	Female younger sibling
Mean constructiveness (individual)			
Older sibling	3.343* [3.246, 3.434]	0.101 [−0.004, 0.212]	−0.019 [−0.119, 0.080]
Younger sibling	3.211* [3.149, 3.268]	0.027 [−0.038, 0.090]	0.069* [0.004, 0.134]
Inertia (individual)			
Older sibling	0.185* [0.059, 0.318]	−0.147 [−0.319, 0.014]	−0.019 [−0.167, 0.116]
Younger sibling	0.124* [0.054, 0.194]		
Cross-lag (influence)			
Older sibling to younger sibling	0.072* [0.011, 0.134]		
Younger sibling to older sibling	0.116* [0.023, 0.208]		

*Indicates fixed effects for which the credibility interval does not include zero, $p < .05$, 95% CI does not include zero.

Research question 1 (reciprocal sibling influence) was addressed by examining the strength of the cross-lags. The cross-lags are interpreted as the effect of the older sibling's constructiveness score in one 20-s interval on a change in the younger siblings' constructiveness score in the subsequent 20-s interval and vice versa (while separately estimating the stable individual effects and controlling for individual and dyad level covariates). As hypothesized, both siblings were found to influence one another, changing their behavior to align more with the other siblings' constructiveness. These results can be seen in Table 3 (which controls for the individual level covariate of gender) and Table 4 (which controls for age gap and gender composition). To facilitate reading the tables, Table 3 (column 'Fixed Effect Means') shows that the older to younger cross-lag effect is significant, $b = 0.072$ and 95% CI = [0.011, 0.134], and the younger to older cross lag is also significant, $b = 0.116$ and 95% CI = [0.023, 0.208]. It can also be seen that the CI's overlap, leading to the conclusion that both siblings influence one another's constructiveness, but they show no significant difference in the magnitude of their influence on one another. In other words, greater constructiveness expressed by either younger or older siblings encouraged more constructiveness in the other sibling in the next interval (or the opposite i.e., less constructiveness encourages less constructiveness of the other sibling). By looking at Table 4 (also column 'Fixed Effect Means'), the same conclusion is reached. Younger and older siblings influence one another, when we control for dyadic characteristics (age gap and gender composition).

Our second research questions explored whether demographic characteristics of siblings (age, age gap, birth order, gender, and gender composition) moderated sibling's individual effects (average level of constructiveness and inertia) and well as influence effects (cross-lags). Both older and younger siblings were found to be more constructive than destructive in their approach to conflict resolution (i.e., means greater than 3 on 5-point scale). Mean constructiveness (see Tables 3 and 4, Column: 'Fixed Effect Means' Rows 'Mean Constructiveness' for older and younger siblings) was found to be higher in older than younger children, but this difference was not statistically significant. Furthermore, older sisters were not found to be more constructive than older brothers (Table 3: Column: 'Female Older Sibling') and were not differentially constructive toward their male or female younger sibling. However, younger sisters were found to be more constructive than younger brothers (Table 3: Column: 'Female Younger Sibling'; $b = 0.069$, 95% CI = [0.004, 0.134]). Younger sisters were most constructive in sister–sister dyads (Table 4: $b = 0.092$, 95% CI = [0.005, 0.180]). No sibling demographics were hypothesized to be associated with inertia. However, the age gap between siblings was significantly associated with inertia in the older sibling (Table 4: $b = 0.118$, 95% CI = [0.047, 0.190]). As illustrated in Figure 2, for sibling dyads in which there was a greater age difference, the older sibling takes longer to return to their mean constructiveness, after they have moved away from it. Finally, influence effects (the cross-lags) were not found to differ by gender (Table 3), age gap, average age of the dyad, or gender composition (Table 4).

TABLE 4 Unstandardized point estimates and 95% credibility intervals (CI) for mean, inertia, cross lags with unstandardized dyad level covariates regressed on significant parameters

		b **[95% CI]**				
Parameter	**Fixed effects means [95% CI]**	**Age gap (standardized)**	**Dyad average age (standardized)**	**Sister–sister dyad**	**Older sister–younger brother**	**Older brother–younger sister**
Mean constructiveness (individual)						
Older sibling	3.377* [3.321, 3.432]					
Younger sibling	3.215* [3.144, 3.290]			0.092* [0.005, 0.180]	0.016 [−0.075, 0.092]	0.074 [−0.012, 0.161]
Inertia (individual)						
Older sibling	0.113* [0.028, 0.197]	0.118* [0.047, 0.190]	0.069 [−0.003, 0.140]			
Younger sibling	0.129* [0.056, 0.200]					
Cross-lag (influence)						
Older sibling to younger sibling	0.068* [0.009, 0.128]					
Younger sibling to older sibling	0.120* [0.031, 0.208]					

*Indicates fixed effects for which the credibility interval does not include zero, $p < .05$, 95% CI does not include zero.

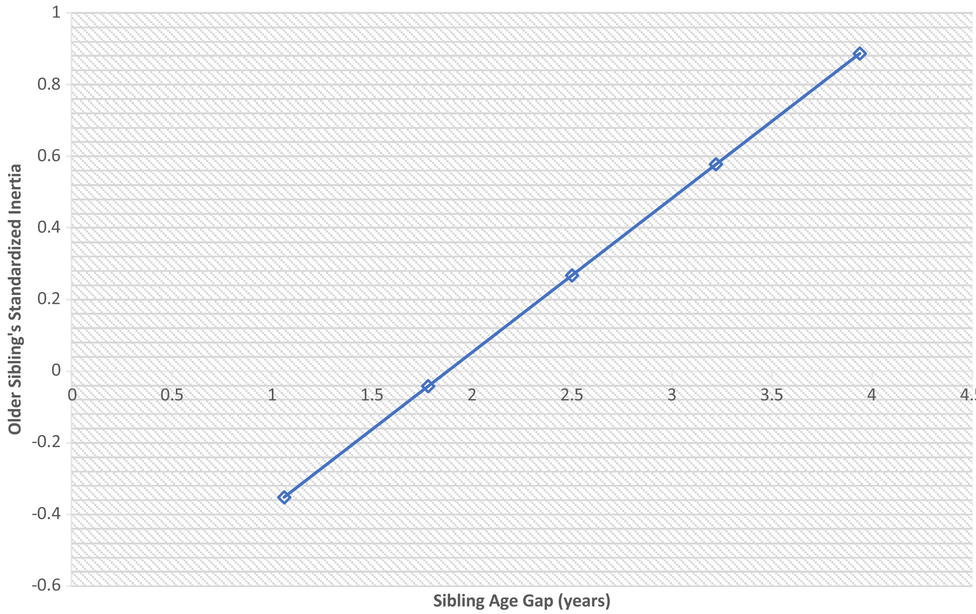

FIGURE 2 Older sibling's inertia as a function of dyad age gap

DISCUSSION

For many, sibling relationships are one of the most enduring and important social relationships throughout the life span. Despite their ubiquity, siblings are under studied in developmental science. The present study advances the study of sibling socialization because it is the first to differentiate stable processes shown by individual siblings from the dynamic that siblings create together. Using moment to moment data and the DSEM framework, we were able to move from "taking still photos of a dance" (Houben et al., 2015, p. 902) to identifying the dynamics of the dance itself.

We found that both younger and older siblings influence each other's constructiveness, and the directionality of this influence is a matching influence. There was no difference in the magnitude of influence between older and younger siblings. We examined the association between mean constructiveness, inertia, and sibling influence and each of their associations with birth order, age, gender, dyad age gap, and the gender composition of the dyad. Younger sisters were more constructive than younger brothers and showed the highest levels of constructiveness when interacting with an older sister. The greater the age gap between younger and older siblings, the higher the inertia of the older sibling.

How do siblings influence one another during conflict resolution?

The traditional view of socialization has been a top-down model with more skilled partners influencing less skilled (Grusec & Hastings, 2014; McHale et al., 2012). We found evidence for an older to younger sibling socialization effect in which the more knowledgeable, more powerful older sibling influenced their younger sibling's constructiveness (Martin & Ross, 1995; Slomkowski et al., 2005; Whiteman et al., 2017). Although hierarchical influence/power differentials are described as a critical mechanism (Campione-Barr, 2017; McHale et al., 2012) given that we, and others, find an equal magnitude of influence from younger to older siblings on certain outcomes (Jambon et al., 2019; Whiteman et al., 2017) mechanisms beyond a hierarchical/power differential must also be considered.

The contagion of emotion and behavior has been widely described as a mechanism explaining a non-hierarchical, younger to older influence that goes beyond the training of risky behaviors (see Hatfield et al., 2014 for review). Younger siblings may influence their older siblings through a contagion process in which the emotion and behaviors of each become attuned to the other. Synchronization is an important underlying mechanism to such contagion and many aspects of human functioning have been shown to synchronize across people, including brain activity, emotions, and physiology (Atzil et al., 2014; Kinreich et al., 2017; Lee et al., 2017; Miller et al., 2019; Sethre-Hofstad et al., 2002). Synchronization is thought to facilitate social interaction, cooperation, and social understanding (Coutinho et al., 2021; Feldman, 2007; Sethre-Hofstad et al., 2002). The contagion/synchronization of health behaviors is thought to be more related to social causation (individuals influence on another) than social selection (individuals choose their social group dependent on their own health characteristics) (Datar & Nicosia, 2018; McPherson et al., 2001). These processes of contagion are evident in interpersonal behaviors as well. Positivity and negativity in family interactions have been found to cluster at the family level (even when the variance attributable to all the individuals and dyads in the family has been separately partialled; Ackerman et al., 2011; Buist et al., 2008; Eichelsheim et al., 2009). This means that there is a process of spillover where family members are observing and imitating each other's interactional behaviors, beyond the learning that occurs in the dyad (Sokolovic, Leckie, et al., 2021; Sokolovic, Plamondon, et al., 2021). These processes of social learning through observation may be stronger the more similar individuals are to one another. Thus, smaller age gaps between siblings and better connectedness between them has been shown to result in better theory of mind development (Peterson, 2000; Prime et al., 2016), while gender similarity has been linked to mental health sibling similarity and aggression (Bandura et al., 1961; Rowe & Gulley, 1992; Slomkowski et al., 2001).

The mutuality (reciprocity) seen in this study has been described as the most fundamental and pervasive pattern in human social interaction (Ross et al., 1988). Reciprocity allows for the ongoing social coordination and mutually co-constructed nature of communication and shared meaning between individuals (Fogel, 1993; Harrist & Waugh, 2002; Leach et al., 2021) and is important for social connectedness in intimate relationships (Clark & Ladd, 2000). Closeness in sibling relationships has been shown to be protective for children dealing with stressful circumstances (Davies et al., 2019; Gass et al., 2007).

Mechanisms of sibling influence and the development of the relationship

The moment-to-moment matching seen in the current study may represent the underlying mechanism for year-to-year effects seen in longitudinal studies of sibling socialization (Jambon et al., 2019; Martin & Ross, 1995; Whiteman et al., 2017). The synchronization/reciprocation of affect between members of a dyad has long been described (Harrist & Waugh, 2002). There are two notable features of the current study that are novel and important for understanding sibling influence. First, this matching mechanism has been identified using a modeling strategy that approximates causality. By using time-varying data (and removing the stable, individual component of each person from the interaction), we get closer to testing whether the behavior of one person triggers an affective matching response in the other. Second, demonstrating a mechanism of social influence in moment-to-moment data (versus across years) is in keeping with the time frame of social learning and family systems theories of influence (Granic & Patterson, 2006; Nichols & Davis, 2017). In dynamic systems theory (DST) timeframes are considered interdependent. Micro-level interactions give rise to the macro (i.e., repeated, frequent interactions develop into stable patterns over enough time), and the macro level limits the variability at the micro-level (i.e., as stable patterns emerge, the behavioral repertoire becomes more constrained and more resistant to change) (Granic, 2005). As episodes of conflict between siblings are frequent with a rapid cascade into the positive or the negative (through the matching response), it is possible that these episodes have an important impact on relationship quality. Gottman (2014) found that partner responses during marital interactions, including behaviors of criticism and belittling, which in our coding scheme, was at the destructive end of the continuum did indeed predict relationship breakdown longitudinally. Gottman's goal in marital therapy is to shift a partner's constructiveness towards their partner to the positive (Gottman & Silver, 2012). Given the matching response that we see in sibling interactions, a slight shift to the positive early in the conflict, shifts the cascade. By helping children to be slightly more generous in an appraisal of their sibling's actions, parents may be able to shift the directionality of the cascade. A recent meta-analysis of the effects of behavioral versus appraisal/problem solving interventions by parents found that both were effective in improving sibling interaction (Leijten et al., 2021).

According to family systems theory, the proposed mechanisms of family members influencing one another are positive and negative feedback loops (Granic & Patterson, 2006; Nichols & Davis, 2017). Positive feedback loops include reciprocation of the same behavior, that is, matching of constructiveness result in escalations of behavior. Negative feedback involves behaviors that curb escalation and maintain the interaction within an acceptable boundary. Examples of both positive and negative feedback loops were evident in our data. Positive feedback loops are seen in the positive cross-lags. Siblings match one another's constructiveness which results in an escalation process towards more positive or negative interactions. A negative feedback loop can be seen in the inertia shown by older siblings (more in males and when the age gap is higher). The older, more dominant sibling's inertia, both at the positive and negative ends of constructiveness, may be a way to push-back to the younger sibling and may function to curb processes of escalation. Of course, in everyday life, particularly when children are in the preschool period, there are multiple examples of negative feedback loops: parental interventions, one sibling exiting the interaction (Campione-Barr, 2017; Leijten et al., 2021; Siddiqui & Ross, 2004) and so on.

How do sibling's individual characteristics impact conflict resolution?

Results suggest that on average, siblings are more constructive than destructive in their approach to conflict resolution when they are under observation. The few instances of negative conflict resolution may in part be due to the developmental period under study. It is likely that sibling relationships become more egalitarian during middle childhood, as younger siblings grow in social, emotional, and cognitive competence. Indeed, higher levels of relational aggression among siblings is consistent with several studies that suggest that during the preschool years the sibling relationship is a relatively ideal situation for children to practice relational aggression (Brody et al., 1985; Dunn et al., 1999). However, as children age, and enter middle childhood and adolescence a different pattern is observed (Reese-Weber, 2000; Updegraff et al., 2005).

In line with our hypothesis, we found younger sisters were more constructive than younger brothers and showed the highest level of constructiveness in sister–sister dyads compared to the older brother-younger brother reference category. These findings are consistent with previous literature which highlight sisters as positive interaction partners (Buhrmester & Furman, 1990; Dunn et al., 1999) especially when the younger sibling is a girl (Kier & Lewis, 1998). Girls begin to exhibit prosocial behaviors at younger ages compared to boys (Baillargeon et al., 2011). Theory of mind (ToM) and emotion understanding have been linked to constructive conflict resolution (Randell & Peterson, 2009). ToM reflects an ability to represent and understand the beliefs and desires of others, which enables children to take on the perspectives of others and accordingly attune their behavior (Wu & Su, 2014). Emotion understanding captures children's capacity to judge or infer an emotional outcome based on multiple determinants. Both ToM and emotion understanding become particularly elaborated during middle childhood when children's adaptive social functioning—that is, the ability to perspective take and interpret and respond to emotional cues in a socially appropriate way—is critical to their successful social interactions and conflict resolution (Denham, 2007). It has been found that in middle childhood girls tend to have higher ToM (Bosacki, 2000) and emotion understanding (Kuhnert et al., 2017), which may explain the gender differences in constructiveness seen in younger siblings in this study.

Younger sisters may benefit from being in a dyadic relationship with an older sister where they can further practice and refine their emotional understanding and emerging conflict resolution skills. Based on the established gender-differentiated nature of children's social relations, whereby female relationships are more interpersonal by nature and have a stronger focus on emotional transactions (Rose & Rudolph, 2006), it seems likely that there may be a greater actual or perceived need for girls to be able to understand how their sibling is feeling and to harness this knowledge to act in a reciprocal prosocial fashion, maintaining their interpersonal emotional bonds. From an evolutionary viewpoint, this behavior may develop earlier for females than males as there is a need for females to interact with and rely on kin and non-kin members, compared with males (Vigil, 2007). Thus, gender distinctions in conflict resolution may reflect a greater proclivity for girls, compared with boys, to capitalize on their understanding of others' emotions and respond in constructive and prosocial ways during social interactions. In contrast to our hypothesis, there were no gender difference in conflict resolution between older sisters and older brothers. However, it is possible that in this study we were unable to capture these differences due to the low incidence of destructive behaviors. Relative to younger siblings, older siblings have maturational capabilities (e.g., language, attention, executive function, theory of mind, and response inhibition; Keltner et al., 2019) whereby brothers and sisters are able to effectively engage in neutral conflict resolution when interactions are not highly conflictual. However, we may see gender differences during unobserved, emotionally charged interactions.

With respect to inertia, we found that both older and younger siblings displayed significant but low levels of inertia, which suggest that older and younger siblings can “bounce back” quickly from minor altercations, which is important for enabling positive sibling interaction. By the time younger siblings are in middle childhood, their growing social competence allows them to push back against their older siblings' power assertions (Campione-Barr, 2017). We also found that when the age gap between siblings was larger, the older sibling displayed significantly higher inertia, suggesting, again, a lower threshold for the perception of challenge. Others have also reported that age gap between siblings result in older to younger control attempts (Buhrmester & Furman, 1990; Campione-Barr & Killoren, 2015; Howe & Recchia, 2005; Perlman et al., 2000) with the suggestion that the older siblings are “standing their ground”. As this is both at the constructiveness and destructiveness ends of the continuum, we might interpret this as more about the older teaching the younger, versus the older sibling being antagonistic toward their younger sibling (Howe & Recchia, 2005).

Strengths, limitations, and future directions

Although siblings are important players in family dynamics, their role has been relatively neglected by family scholars and by those who study social relationships. Incorporating study of siblings into family research provides novel insights into the operation of sibling relationships as socializing systems. The present study allowed for the moment-to-moment investigation of sibling interactions and is the first study to disentangle the stable effects of siblings from the extent to which they influence one another during conflict. By using time-varying data and removing the stable, individual component of each sibling from the perturbations that go on between them, we get closer to testing whether the behavior of one sibling elicits a matching response in the other as well as moderators, which contribute to these dynamics. In addition, by demonstrating a mechanism of social influence in moment-to-moment data, we build support for understanding the ways in which micro processes foster the development of macro processes (e.g., relationship quality over years) that affect long term adjustment (Granic & Patterson, 2006). In doing so, we were able to examine what siblings bring to their interactions with each other, and what they evoke from one another allowing for a rich and nuanced understanding of the causal dynamics in sibling interactions and socialization (Houben et al., 2015).

The current findings should be considered in the light of study limitations. First, the current study used an observation interval of 20-s, and it is possible that many changes took place within, and not between, adjacent intervals. Second, highly destructive behaviors were rarely seen. Previous work has shown that auto-regressive parameters are larger when behavior is very negative (De Haan-Rietdijk et al., 2016), suggesting the possibility that auto-regressive parameters and inertia may have been underestimated in our sample. Third, the low incidence of highly destructive behaviors is likely related to children being observed. Fourth, conflict discussion after the fact may unfold differently than spontaneous conflict. This should be considered in future research. Fifth, while simulation studies have shown a low risk of bias in samples of 200 participants and when coding episodes are as few as 10 (Hamaker et al., 2015; Schultzberg et al., 2017). Nonetheless, the greater the number of time periods at shorter intervals, and the larger the sample size, the better the estimates of stable individual and influence parameters will be. Differentiating stable individual effects from influence processes will improve with automatic data capture that provides low-cost opportunities for recording family interactions, continuously and passively, in naturalistic settings (Nelson & Allen, 2018). A recent study by McNeil and Repetti (2021) presents a feasible, reliable, and valid language-based methodology for scanning large quantities (350 h) of naturalistic recordings to study specific positive emotions that arise across many different situations in family life. Sixth, the complexity of our model meant that we could not test individual and dyad characteristics within the same model. Finally, although families were ethnically diverse, they were not as economically diverse as the general population from which they were drawn. Thus, results should not be generalized to economically disadvantaged families.

This study highlights the sibling subsystem as an important context for social interaction and conflict resolution. Broadening the scope of sibling research to understand the distinct mediating mechanisms by which both younger and older siblings reciprocally exert their influence and how these processes may transform over the course of development represents a crucial avenue for future study (Whiteman et al., 2009, 2017). Another important focus for future work is the impact of diverse cultural and family settings (e.g., non-nuclear families) on sibling interaction. Cross-cultural research suggests that sibling relationships may be less conflictual in cultures that lean towards prescribed and obligatory roles for siblings, versus discretionary roles (Maynard, 2004). Variations in power balance, rivalry, competition, and caregiving responsibility in sibling relationships have been found across cultures (Buist et al., 2017; Maynard, 2019). The rapid growth of ethnic minority and immigrant populations makes this a critical and fruitful area of study.

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CONFLICT OF INTEREST

There are no conflicts of interest to be reported.

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