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# Codevelopment of Preschoolers' Temperament Traits and Social Play Networks Over an Entire School Year

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Children enter preschool with temperament traits that may shape or be shaped by their social interactions in the peer setting. We collected classroom observational measures of positive emotionality (PE), negative emotionality (NE), effortful control (EC), and peer social play relationships from 2 complete preschool classrooms ($N = 53$ children) over the course of an entire school year. Using longitudinal social network analysis, we found evidence that children's traits shaped the formation of play relationships, and that the traits of children's playmates shaped the subsequent development of children's own traits. Children who exhibited high levels of NE were less likely to form social play relationships over time. In addition, children were more likely to form play relationships with peers who were similar to their own levels of PE. Over the course of the school year, children's level of PE and EC changed such that they became more similar to their playmates in levels of these traits. Finally, we observed moderate to strong rank-order stability of behavioral observations of PE, NE, and EC across the school year. Our results provide evidence for the effects of traits on the formation of play relationships, as well as for the role of these play relationships in shaping trait expression over time.

*Keywords:* effortful control, negative emotionality, positive emotionality, preschool, social networks

*Supplemental materials:* http://dx.doi.org/10.1037/pspp0000135.supp



During early childhood (ages 3–6), children are exposed to increasing expectations for independence, committed compliance with the behavioral demands of socializing agents (e.g., parents, teachers), and social competence commensurate with the more sophisticated peer relationships that emerge during this age (e.g., Hanish et al., 2007; Hawley, 1999; Ladd, 1999). Greater allowance for independence brings more opportunities for reward, mastery, and learning, but also for frustration, threat, and self-doubt. Notably, youth must more flexibly balance their own desires with those of others in their expanding social world. Richer interactions with peers and adults can prompt greater understanding of self and other, but also requires marshalling abilities to communicate effectively, solve problems, and to manage conflict (e.g., Hawley, 1999; Roseth et al., 2011). The many challenges of this period can provoke strong emotional reactions from children, at the same time that peers and adults have greater expectations that youngsters can effectively manage these feelings. Those who navigate these pressures successfully can capitalize on the opportunities they afford for psychological maturation, but those who struggle will be less prepared when they encounter subsequent normative developmental transitions, such as the introduction of formal schooling. These new expectations place individual differences in children's behavioral dispositions in stark relief, and enable the emergence of new behavioral patterns.

In this paper, we examine three major research questions that focus on the longitudinal interplay between children's dispositional characteristics and their social relationships with peers in early childhood: (1) Is there evidence of both rank-order stability and change in children's traits over the course of a school year? (2) Do children's temperament traits predict the formation of social play relationships over time? and (3) Do playmates' temperament traits influence children's own temperament traits over time?

## Childhood Temperament Traits and Developmental Change

Understanding individual differences in psychosocial competencies during early childhood requires not only a recognition of the landscape of developmental pressures that children experience, but also the dispositional characteristics that children bring with them as they navigate these tasks. Children enter this developmental context with temperament profiles that help to shape their acquisition of the social and emotional competencies that are normative for this period. Although there are some meaningful differences in the content and structure of broad dimensions of personality in early childhood compared with later developmental periods (Soto & Tackett, 2015), there is compelling evidence that at least three broad temperamental dimensions are important to understanding dispositions early in life (Shiner & DeYoung, 2013). Positive Emotionality (PE) or Surgency refers to variations in the propen-

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sity toward sociability and positive emotions. Individual differences in Negative Emotionality (NE) are marked by the frequency and intensity of negative affect, including sadness, anger, and fear. Effortful Control (EC) refers to automatic and strategic regulation of attention and behavior in concert with one's goals and environmental demands.

These three higher-order traits can be reliably measured and exhibit a coherent structure in early childhood (Dyson, Olino, Durbin, Goldsmith, & Klein, 2012; Rothbart, Ahadi, Hershey, & Fisher, 2001; Shiner & DeYoung, 2013). By 3 years of age, these traits demonstrate moderate levels of rank-order stability that are similar to that observed for traits in later developmental periods (Durbin, Hayden, Klein, & Olino, 2007; Roberts & Caspi, 2003; Roberts & DelVecchio, 2000). This suggests individual differences in traits in the preschool years provide a reasonably stable structure available for shaping subsequent developmental adaptations. Consistent with this, considerable empirical evidence has borne out the assumption of classic temperament models that early individual differences in these dispositions predict consequential outcomes across the life span (Caspi, 2000; Caspi, Moffitt, Newman, & Silva, 1996; Shiner & Masten, 2012).

An important component of modern personality science is the understanding that traits develop and change (e.g., Roberts, Walton, & Viechtbauer, 2006), often in concert with environmental contexts (Caspi, Roberts, & Shiner, 2005). Delineating the direction, magnitude, and timing of these changes can help inform theory regarding possible mechanisms contributing to these normative trajectories. For example, emerging adulthood is characterized by relatively large normative mean-level changes in traits (Roberts et al., 2006) described as reflecting a *maturity principle* of personality development (Caspi et al., 2005), whereby age-related change is toward more adaptive profiles of lower NE and higher levels of a trait similar to EC, Conscientiousness (e.g., Blonigen, Carlson, Hicks, Krueger, & Iacono, 2008; Donnellan, Conger, & Burzette, 2007; Johnson, Hicks, McGue, & Iacono, 2007; Klimstra, Hale, Raaijmakers, Branje, & Meeus, 2010).

## Role of Environmental Context and Transitions in Developmental Change of Temperament Traits

One mechanism for the trait changes observed in emerging adulthood is investment in social roles that are common to this period, such as beginning work or entering into stable romantic relationships (Lehnart, Neyer, & Eccles, 2010; Roberts, Wood, & Smith, 2005; Specht, Egloff, & Schmukle, 2011). Because these roles offer clear guidance about what trait-relevant behaviors are or are not valued and they create a strong press (in the form of consequences) to behave in new ways, they can facilitate trait change (Caspi & Moffitt, 1993). By contrast, when people encounter new environments that offer relatively little guidance about how to respond, the *corresponsive principle* of development predicts a deepening of preexisting traits, as people rely on familiar patterns of thought and behavior to fill in the uncertainty and navigate the stress of environmental change (Roberts & Caspi, 2003).

The notable magnitude of mean level trait change during emerging adulthood and the ability of environmental factors to account for this change are powerful demonstrations of the richness of person-environment transactions, and support the argument that personality development is most salient (and thus, profitably studied) during periods of environmental change (Caspi & Moffitt, 1993). Indeed, an emerging literature suggests that early to mid-adolescence, which is characterized by its own set of environmental pressures, is characterized by mean-level trait change that is different from that observed in late adolescence/emerging adulthood, namely deviation away from maturation in the form of declines in Conscientiousness and increases in NE (e.g., Allik, Laidra, Realo, & Pullmann, 2004; Denissen, van Aken, Penke, & Wood, 2013; Durbin et al., 2016; Soto, John, Gosling, & Potter, 2011). These findings suggest the importance of exploring patterns of trait change within different developmental periods to understand both the developmental specificity and mechanisms of personality change.

Longitudinal data describing mean-level trait change in early childhood is much sparser, but what data are available, along with a larger literature using cross-sectional comparisons, indicate there are important changes in absolute levels of traits in the preschool and early elementary school years (Shiner, 2014). The best replicated normative developmental pattern in this period is one of increasing capability for emotional and behavioral regulation (i.e., higher EC; Deater-Deckard, Petrill, Thompson, & DeThorne, 2006; Rueda, 2012). Consistent with that, there is evidence that the intensity of negative emotions declines over this interval (e.g., Olino et al., 2011; Sallquist et al., 2009), although some studies have found increase in NE (Lamb, Chuang, Wessels, Broberg, & Hwang, 2002; Prinzie & Dekovic, 2008). Findings for mean level changes in PE traits have been less consistent, with some studies finding increases in positive emotions across preschool to early childhood (Olino et al., 2011) and others showing declines in the sociability aspects of PE (e.g., Lamb et al., 2002; Prinzie & Dekovic, 2008).

We sought to provide detailed longitudinal information on the nature of trait change during the preschool years. Moreover, we took advantage of the fact that this developmental stage is one of considerable environmental change to explore environmental contributors to trait development through longitudinal measurement of traits and a key environmental influence that first emerges in this developmental stage, children's peer relationships.

## Peer Relationships in Early Childhood and the Role of Temperament Traits

Although there has been considerable interest in the role of parent–child relationships and the home environment as contributors to individual differences in traits (Chen & Schmidt, 2015; Kim & Kochanska, 2012; Morris et al., 2002), conceptual and empirical work also highlights the importance of considering other contexts important for early childhood, especially peers in educational settings (see Coplan & Bullock, 2012; Chen & Schmidt, 2015 for reviews). As of 2012, approximately 64% of U.S. children aged 3 to 5 were enrolled in preschool or kindergarten (Snyder & Dillow, 2015). Social interactions in this setting are rich and varied, as the new peer context enables the establishment of stable friendships (e.g., Ladd, 1990), as well as conflict created by competition for resources (e.g., Hawley, 1999; Roseth, Pellegrini, Bohn, Van Ryzin, & Vance, 2007). Social interactions with peers, especially social play, also may presage later success in social and academic domains (e.g., DeLay, Hanish, Martin, & Fabes, 2016;

Hanish et al., 2007; Howes & Matheson, 1992). Because preschool settings provide new peer experiences, they have the potential to illuminate how children's traits shape social interactions and how social interactions shape children's traits during the period in which these relationships are first emerging.

Conceptual frameworks and empirical studies have primarily addressed how children's temperament traits shape social interactions over time (see Coplan & Bullock, 2012 for review). For example, some conceptual frameworks posit that children's temperament traits directly shape children's social interactions (e.g., Eisenberg, Vaughn, & Hofer, 2009; Sanson, Hemphill, & Smart, 2004). Following these frameworks, children's PE, NE, and EC are expected to affect their general ability to form social play relationships. Children with high levels of PE or EC may be more desirable play partners because sociability, enthusiasm, spontaneity, self-regulation, and behavioral flexibility may contribute to play interactions that are more enjoyable and enable more lasting social play relationships (Eisenberg, Fabes, Nyman, Bernzweig, & Pinuelas, 1994; Kochanska, Murray, & Harlan, 2000). While empirical studies support the positive effect of PE on the formation of social relationships (Coplan & Bullock, 2012), the sparse findings for EC are somewhat less clear with one study indicating unexpectedly that impulsivity was associated with more friendship nominations (Gleason, Gower, Hohmann, & Gleason, 2005). Children with high levels of NE may be less desirable play partners owing to their greater emotional reactivity, decreasing their ability to form social play relationships over time (Fernandez-Vilar & Carranza, 2013; Sanson et al., 2004). Indeed, several studies have linked NE to peer rejection in early childhood (Coplan & Bullock, 2012).

Temperament traits may also shape children's selection of play partners. Selection effects of traits upon relationships may be evident, as individuals, including children, are homophilic and prefer to interact with peers who are behaviorally similar to themselves (McPherson, Smith-Lovin, & Cook, 2001; Neal, Neal, & Cappella, 2014). Thus, children may preferentially enter into play partnerships with those exhibiting levels of PE, NE, or EC similar to their own levels. Gleason et al. (2005) did not find that children were more likely to select temperamentally similar others as friends. However, these results were drawn from cross-sectional data that did not account for possible social or behavioral dynamics over time.

Despite a primary focus in the literature on how temperament traits shape social interactions, additional conceptual work suggests that social interactions can shape temperament traits over time (Chen & Schmidt, 2015). Specifically, social interactions with peers can provide a context for exposure to and acquisition of new behavioral patterns, thus influencing children's temperament traits. Specifically, children's own PE, NE, and EC levels may become more similar to those of their social play partners over time. To date, there are few empirical studies of peer influences on temperament traits in early childhood, but studies in adolescence suggest that peer groups can longitudinally shape negative emotions like social anxiety (e.g., Van Zalk, Van Zalk, & Kerr, 2011).

In this study, we collected longitudinal, observational measures of children's traits (PE, NE, EC) and their social play relationships with peers in two complete preschool classrooms over the course of an entire school year. The use of observational measures avoided some of the biases that may be evident in parent reports of child traits (e.g., De Los Reyes & Kazdin, 2005; Durbin & Wilson, 2012), including a tendency for parents to overestimate stability of child dispositions (Kagan, 1998). Using a longitudinal social network approach, we examined whether individual differences in traits shape the formation of social play relationships with peers and tested whether peer playmates' traits influence children's trait development over the course of the school year.

Based on the conceptual and empirical literature, we predicted that children with higher levels of PE or EC would be more likely to be chosen by peers as play partners over time while children with higher levels of NE would be less likely to be chosen by peers as play partners over time (*Hypothesis 1*). Additionally, we hypothesized that children would preferentially enter into play partnerships with those exhibiting levels of PE, NE, or EC similar to their own levels (*Hypothesis 2*). Finally, we anticipated children's own PE, NE, and EC levels would become more similar to those of their social play partners over time (*Hypothesis 3*). Because preschool boys and girls exhibit mean-level differences in aspects of the traits of interest (e.g., Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006) and sex plays a role in the choice of social play partners (e.g., Martin, Fabes, Hanish, Leonard, & Dinella, 2011), we also explored the role of sex in the evolution of traits and social play networks over time.

## Method

The Michigan State University Institutional Review Board approved all procedures for this research study entitled "Peer Relationships Among Preschoolers"(Protocol 11–1198).

### Setting and Participants

Longitudinal temperament trait and social network data were collected in one classroom of 3-year-olds and a separate classroom of 4-year-olds in a university preschool located in the Midwestern United States. The preschool enrolls children in the community surrounding the university and serves as a training and research setting for university students and faculty. The preschool has a play-based curriculum that includes both structured whole and small group activities with a lead teacher as well as unstructured free play periods. Each classroom includes three types of students: (1) students who attended class for a half-day in the morning (AM students), (2) students who attended class for a half-day in the afternoon (PM students), and (3) students who attended class all day (Full Day students).

The sample includes 25 children enrolled in the classroom of 3 year-olds and 28 children enrolled in the classroom of 4-year-olds ($N = 53$). This sample represents all but one child enrolled in these classrooms during the study period (Participation Rate = 98.14%). This child was excluded from analyses due to very low attendance that precluded sufficient social play and temperament observations. Table 1 includes demographic characteristics and attendance status of participants.

### Procedure

Two separate teams of trained observers coded children's temperament traits and social networks between October 2012 and May, 2013. To avoid possible biases based on temporal patterns,

Table 1
*Participant Demographics*

| Characteristic | 3-yr.-olds (*N* = 25) | 4-yr.-olds (*N* = 28) | Total (*N* = 53) |
|---|---|---|---|
| Age (in months), *M* (*SD*) | 41.40 (4.38) | 52.93 (3.55) | 47.49 (7.01) |
| Sex | | | |
| Male | 13 (52%) | 16 (57.14%) | 29 (54.72%) |
| Female | 12 (48%) | 12 (42.86%) | 24 (45.28%) |
| Race/Ethnicity | | | |
| Asian | 3 (12%) | 1 (3.57%) | 4 (7.54%) |
| Black/African American | 2 (8%) | 1 (3.57%) | 3 (5.66%) |
| White | 13 (52%) | 16 (57.14%) | 29 (54.72%) |
| Biracial/Bi-ethnic | 1 (4%) | 4 (14.29%) | 5 (9.43%) |
| Other | 3 (12%) | 0 (0%) | 3 (5.66%) |
| Unknown | 3 (12%) | 6 (21.43%) | 9 (16.98%) |
| Day status | | | |
| AM | 7 (28%) | 10 (35.71%) | 17 (32.07%) |
| PM | 8 (32%) | 8 (28.57%) | 16 (30.19%) |
| Full day | 10 (40%) | 10 (35.71%) | 20 (37.74%) |

observations were conducted in both the morning and afternoon, and were scheduled on several different days of the week. Observations were scheduled to coincide with classroom-scheduled periods of unstructured free play to ensure the ability to assess children's free choice of playmates and to avoid observing during formal instructional periods that might constrain the expression of certain aspects of temperament traits (e.g., activity level) and during children's scheduled nap time. Across the year in which observations were conducted, we observed the two classrooms on Mondays through Thursdays for an average of 4.62 hours each day. Observations were conducted during both indoor and outdoor free play periods. In line with the U.S. Federal Common Rule, the authors' university institutional review board and the participating preschool approved a waiver of active parental consent and student assent for the observational study procedures. This waiver is granted when researchers can demonstrate that study risks are minimal, the study would not be possible without a waiver, and the rights of participants are not adversely affected (Klovdahl, 2005; Neal, 2008).

**Temperament observations.** Seventeen separate research assistants collected temperament trait information. Coding was based on a global system previously validated for rating individual differences in traits observed in a laboratory setting (Durbin et al., 2007; Durbin, Klein, Hayden, Buckley, & Moerk, 2005). Following a randomly ordered list, researcher assistants observed each child for a 1 min period and then rated the target child on their level of engagement, activity level, anticipatory positive affect, initiative, sociability, compliance, attentional control, and impulsivity. A 4-point Likert scale was used to assess these traits, with 0 = *very low*, 1 = *low to moderate*, 2 = *moderate to high*, and 3 = *very high*. Engagement was judged based on the child's level of persistence, engrossment, and immersion in their activity. Activity was assessed via the child's level, speed, and vigor of movement. Anticipatory positive affect was determined by the child's positive affect in clear anticipation of an event that had not yet occurred. Initiative was based on the child's assertiveness in their interactions. Sociability was assessed by the child's investment in interaction with and affiliation with peers and adults. Compliance was judged from the child's willingness to follow the instructions of teachers (not peers). Attentional control included both maintaining attention on a task as well as appropriately shifting attention based on environmental demands. Finally, impulsivity was determined by the child's level of impatience, failure to modulate their behavior, and lack of reflection, as opposed to planfulness and caution.

Affective traits, including positive affect, sadness, anger, and fear were rated on a 5-point Likert scale based on the presence of facial, vocal, and bodily emotional expressions, with 0 = *not displayed*, 1 = *1–2 fleeting instances*, 2 = *1–2 moderate instances*, 3 = *several moderate instances*, 4 = *2–4 high intensity instances, or sustained moderate intensity*, and 5 = *more than 5 high intensity instances, or sustained high intensity.* Since instances of negative affect were anticipated to occur less frequently, coders were scheduled to engage in scan coding of the entire classroom for 15% of each observational period; during scans, the coder observed all children in the classroom for a period of 2 min to capture any negative affect. If a child displaying negative affect was located, that child was observed for the next minute and then coded on negative affect, as well as all of the other traits. Following 2 min of scan coding, coders returned to coding via the randomly ordered list of participants. Reliabilities of trait ratings were computed on a subset of 907 observations for which two coders rated the same child. Intraclass correlation coefficients for the composites (described below) were as follows: PE (.65), NE (.78), and EC (.80). These values are similar to reliabilities obtained using this system for coding laboratory temperament tasks (Durbin et al., 2005, 2007; Durbin, 2010), although somewhat lower for PE than we have found in the laboratory context.

A total of 11,309 observations were collected during the study. Wave 1 (October 1 – October 31, 2012) included 1,976 total observations, with a mean of 40.32 observations per child (*SD* = 16.96). Wave 2 (November 1 – December 31, 2012) included 2,098 total observations, with a mean of 42.82 observations per child (*SD* = 17.57). Wave 3 (January 1 – February 28, 2013) included 3,611 total observations, with a mean of 69.38 observations per child (*SD* = 32.20). Lastly, Wave 4 (March 1 – May 1, 2013) included 3,628 total observations with a mean of 72.54 observations per child (*SD* = 26.28).

**Social network observations.** Fourteen trained observers collected social network data using scan observation procedures previously used in several existing studies to measure preschool children's social interactions (e.g., Hanish, Martin, Fabes, Leonard, & Herzog, 2005; Martin & Fabes, 2001; Schaefer, Light, Fabes, Hanish, & Martin, 2010). During each observation, trained observers were provided with a randomly ordered list of children. They observed each child for a 10 second period, coding their predominant behavior. Possible behavior codes included solitary play, unoccupied behavior, teacher-oriented behavior, onlooking behavior, parallel play, rough and tumble play, and social play. When social behaviors were coded (i.e., onlooking behavior, parallel play, rough and tumble play, or social play), observers also noted identity of each peer partner involved in the social interaction. In this study, network data were constructed using observations of social play and social play partners.

During the study, we collected a total of 15,387 scan observations. Waves were divided by the same dates as those used for the temperament observations above, with at least 2,500 total scan observations collected in each of four waves. Wave 1 included 2,918 total observations and 643 social play observations. The mean total observations per child in Wave 1 was 59.55 ($SD$ = 22.16). Wave 2 included 3,722 total observations and 978 social play observations. The mean total observations per child in Wave 2 was 75.96 ($SD$ = 32.11). Wave 3 included 4,789 total observations and 1034 social play observations; the mean total observations per child was 92.10 ($SD$ = 41.14). Finally, Wave 4 included 3,958 total observations and 870 social play observations; the mean total observations per child in Wave 4 was 79.16 ($SD$ = 35.14). At least two observers coded the same child at the same time for 14.1% of scan observations, allowing the calculation of interrater reliabilities. Percent agreement between raters was 71.9% for behavior codes. For cases where social play behavior was coded by both observers, percent agreement between raters was 92.1% for the number of peer partners and 82.6% for the identity of social play partners.



## Measures

**Sex.** The participating preschool provided data on children's demographics, including sex. In the current study, we use the variable, *female*, which was coded 1 for female and 0 for male. This variable was centered around the mean in the Simulation Investigation for Empirical Analysis (SIENA) model described below.

**Temperament traits.** Trait ratings were averaged across all available observations. A principal-components analysis with an oblimin rotation of the ratings revealed a three-factor solution, including higher-order scales of PE (activity, sociability, impulsivity, positive affect, anticipatory positive affect), NE (sadness, anger, fear), and EC (engagement, initiative, compliance, attentional control; see Section 1 of supplementary materials for factor loadings). Respectively, these three factors accounted for 37%, 26%, and 12% of the variance (jointly, 75% of the variance in trait ratings). To compute composite scores for each trait, we identified the highest loading subtraits for each of the 3 factors. We generally assigned subtraits with cross loadings to the higher-order factor on which they loaded most strongly. However, compliance had nearly identical cross-loadings on EC and NE. We assigned compliance to the EC factor due to its clearer conceptual and empirical fit with this higher order factor. Then, for each observation, the relevant traits were first z-scored and then averaged into composite variables. Finally, these were averaged across wave so that each child had an index of PE, NE, and EC for each of the four study waves. Although PE was not related to NE, EC was moderately related to both PE, $r(53) = .35$, $p = .01$, and NE, $r(53) = -.36$, $p = .01$. These results are broadly consistent with structural findings from other approaches, including parent report methods (Rothbart et al., 2001) and laboratory observations (Dyson et al., 2012). Consistent with Big Three models of personality/temperament (e.g., Rothbart et al., 2001; Tellegen & Waller, 2008), individual differences in PE and NE are largely orthogonal to one another, while higher EC is moderately related to a profile of greater adjustment on the emotionality traits, consistent with models that higher EC enables flexible modulation of behavior and adaptation to environmental demands (e.g., Block & Block, 1980).

SIENA models require that behavioral variables are either binary or ordinal and discrete in nature (Ripley, Snijders, Boda, Vörös, & Preciado, 2016). Therefore, for each trait within each of the four waves of data, the sample was divided into ordinal, discrete quintiles ranging from 1 (i.e., child ranks in the bottom 20% of the sample) to 5 (i.e., child ranks in the top 20% of the sample).

**Social networks.** We constructed social networks for each of the four waves using scan observations of social play behaviors. Similar to previous studies using scan observations (e.g., Schaefer et al., 2010), we first created a matrix for each wave that included the frequency of observations in which each theoretically possible dyad of children was observed together in social play. The SIENA model we used requires binary data (Ripley et al., 2016). Because some children were present in the classroom all day (full day students) while others were only present in the classroom for a half-day (a.m. or PM students), observations were unbalanced across children. Furthermore, some children had a higher overall tendency to be observed in social play than in other behaviors. Therefore, to simplify the network data for analysis and to control for imbalances in observations, we binarized each wave's matrix of frequencies of social play using the following method: Within wave, each theoretically possible dyad's (i.e., child $i$ and child $j$'s) predicted frequency of social play was calculated based on the following regression equation:

$$y_{\text{freq. of social play for } i \,\&\, j} = a + b_1 X_{\text{total obs. of } i} + b_2 X_{\text{total obs. of } j} + b_3 X_{\text{social play obs. of } i} + b_1 X_{\text{social play obs. of } j} + e \quad (1)$$

Predicted scores reflect the expected frequency of social play between child $i$ and child $j$ based solely on how often each was observed (i.e., total observations of $i$ and $j$), and their overall tendencies to be observed in social play (i.e., social play observations of $i$ and $j$). These predicted scores were compared with the actual observed frequency of social play between child $i$ and child $j$ in our data. In this comparison, the social play relationship was counted as present between child $i$ and child $j$ if (a) they were actually observed together in social play at least once during the wave and (b) if their actual observed frequency of social play exceeded their predicted score from the regression equation.

## Analysis Plan

Using a stochastic actor-based model estimated with the R package, SIENA (Ripley et al., 2016), we examined whether children's traits longitudinally predicted playmate selection and whether playmates' traits influenced children's traits. Stochastic actor-based models are commonly used in developmental research to disentangle the effects of behaviors on social networks (i.e., selection) and the effects of social networks on behavior (i.e., influence) while controlling for structural network effects (e.g., density, transitivity, popularity) (Snijders, van de Bunt, & Steglich, 2010; Veenstra, Dijkstra, Steglich, & Van Zalk, 2013). To illustrate, Figure 1 includes two network sociograms displaying the social play relationships among 26 children in this study's classroom of 4-year-olds during the first two waves of observation.[1] Each circle represents an individual child and each line represents a social play relationship between two children. Children's circles are coded by their PE quintile with darker shades indicating their categorization in a higher PE quintile. Clusters of similar shades indicate the potential presence of selection or influence processes for PE. If selection is occurring, we should see new relationships appear in Wave 2 between children with similar levels of PE (e.g., the emerging relationship between Child 22 in the top quintile and Child 7 in the second highest quintile). If influence is occurring, we should see children with ties in Wave 1 become more similar in PE in Wave 2 (e.g., Child 25 and Child 22 had a relationship in Wave 1 and became more similar in their PE quintile in Wave 2).

The model in this paper included all four waves of social network and temperament data for both classrooms, and three distinct periods (i.e., Period 1 from Wave 1 to Wave 2, Period 2 from Wave 2 to Wave 3, and Period 3 from Wave 3 to Wave 4). The network relationships in this study were undirected in nature: Dyads either were or were not engaged in social play with one another during a wave. Although stochastic actor-based models are most commonly used for analyzing directed social networks, the SIENA software can accommodate undirected networks. We used the "Unilateral Initiative and Reciprocal Confirmation Model" for undirected networks, which assumes that the creation or dissolution of each relationship in the network is initiated by one child in the dyad. During relationship creation, the noninitiating child in the dyad must agree in order for a relationship to form. During relationship dissolution, agreement from the noninitiating child in the dyad is not needed (Ripley et al., 2016). This model was selected because it most closely emulates preschoolers' patterns of social play, which typically involve one child initiating play and the other agreeing to or resisting this initiation (e.g., Ladd & Hart, 1992; Rizzo & Corsaro, 1995).

In our dataset, there were several relationships between participants that were not theoretically possible. First, children in the classroom of 3-year-olds could not form relationships with children in the classroom of 4-year-olds. Second, AM children could not form relationships with PM children (although each could form relationships with Full Day children). Finally, because of enrollment changes at the school, 4 children joined the network during the third wave of data collection and 3 children left prior to the last wave of data collection (see Table 2). These children were not able to form relationships during waves where they were not present. We used structural zeros to denote and account for all of these types of theoretically impossible relationships between dyads in the data (Ripley et al., 2016).

The stochastic actor-based model estimated in this study simultaneously models the network dynamics of social play relationships and the behavior dynamics of the three traits of PE, NE, and

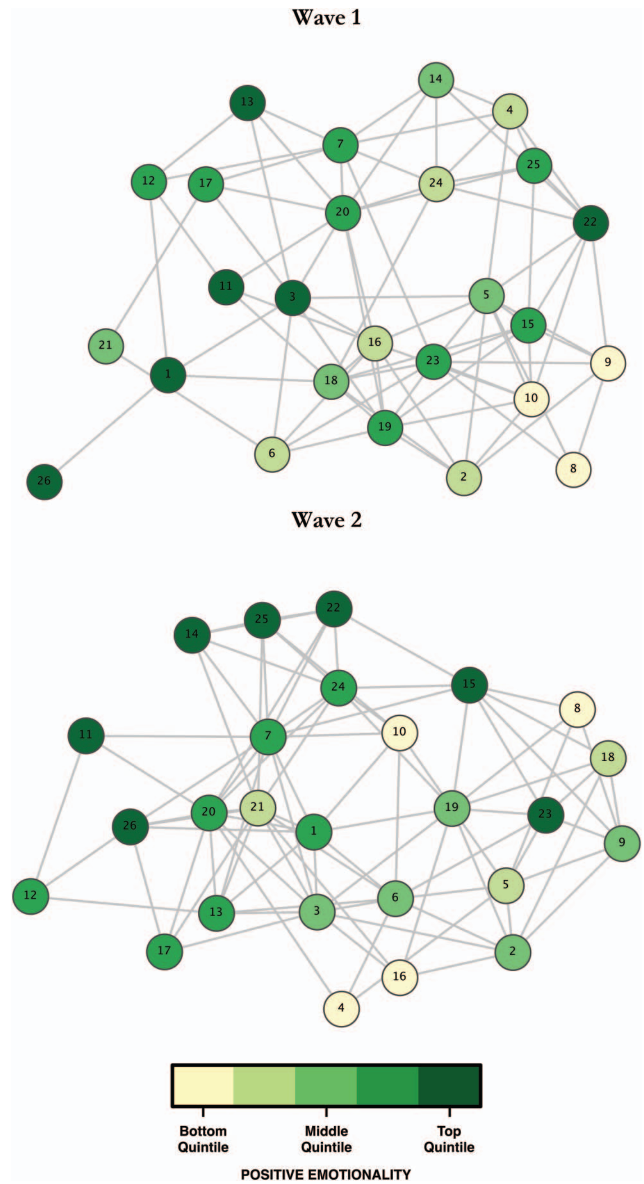


*Figure 1.* Network sociograms of the 4-year-old classroom at Waves 1 and 2.

EC. To model network dynamics, we specify rate effects, structural network effects, sex effects, and temperament trait effects. Rate effects estimate the rate of change in social play relationships for each of the three periods in the study. Structural network effects control for tendencies in relationship formation (see Veenstra et al., 2013). Specifically, the density effect models children's overall tendency to form social play relationships. The transitive triad effect is for the tendency for "playmates of playmates to become playmates" over time. That is, if child A engages in social play with child B and with child C, child B and child C are likely to form a social play relationship over time. The popularity effect

[1] Two children joined the classroom of 4-year-olds in Wave 3, and are therefore not included in the sociograms.

Table 2
*Descriptive Statistics for Social Networks*

| | Wave 1 | Wave 2 | Wave 3 | Wave 4 |
|---|---|---|---|---|
| Density | .336 | .342 | .304 | .340 |
| Average degree | 6.00 | 6.11 | 6.00 | 6.23 |
| Number of ties | 159 | 162 | 159 | 165 |

| | Period 1 (Wave 1–Wave 2) | Period 2 (Wave 2–Wave 3) | Period 3 (Wave 3–Wave 4) |
|---|---|---|---|
| Absent tie (0 → 0) | 1,153 | 1,129 | 1,135 |
| Creation of tie (0 → 1) | 66 | 87 | 84 |
| Dissolving of tie (1 → 0) | 63 | 90 | 78 |
| Stable tie (1 → 1) | 96 | 72 | 81 |
| # of joiners | 0 | 0 | 4 |
| # of leavers | 0 | 1 | 2 |
| Jaccard Index | .43 | .29 | .33 |

models the tendency of children with many playmates to obtain more playmates over time. Sex effects include the effect of being female and the effect of being the same sex as a peer on the formation of social play relationships. Finally, trait effects include the effects of PE, NE, and EC as well as similarity between peers in these traits on the formation of social play relationships.

To model behavior dynamics, we specify rate effects, shape effects, sex effects, and network influence effects. Here, rate effects model the rate of change of each trait—PE, NE, and EC—for each of the three periods in the study. Linear and quadratic shape effects are recommended to model average tendencies and feedback effects over time for each temperament trait (Ripley et al., 2016; Snijders et al., 2010; Veenstra et al., 2013). The linear shape effect models whether there is an overall tendency for a trait to increase or decrease over time in the sample. According to Veenstra et al. (2013),

> The quadratic shape effect models the feedback effect of the behavior on itself. A negative value indicates that behavior of respondents tends to regress to the mean (self-correcting mechanism). A positive value indicates that behavior of respondents tends to regress to the extremes of the scale (polarization or self-reinforcing mechanism). (p. 405)

Sex effects control for the effect of being female on change in the traits. Finally, network influence effects (i.e., average alter effects) measure the extent to which children who have playmates with certain levels of a particular trait tend to exhibit similar levels of that trait over time (Veenstra et al., 2013). A summary of all of the parameters included in the stochastic actor-based model estimated in this study is presented in Table 3.

All *t* ratios for convergence for individual parameters were less than 0.1 in the final stochastic actor-based model, indicating excellent convergence (Ripley et al., 2016). In addition, there were significant rate effects for all periods (Periods 1, 2, and 3), suggesting that opportunities to form social play relationships varied over time. This finding is consistent with prior observational studies of the formation of preschool children's social play relationships (e.g., Schaefer et al., 2010). In addition, rate effects for change in traits across the three periods of the study were significant with the exception of the rate effect for NE in Period 1. To determine goodness of fit, we first checked for potential time heterogeneity in the model parameters using the sienaTimeTest function in R (Ripley et al., 2016). The overall test for time heterogeneity was not significant, $\chi^2(46) = 57.98$, $p = .11$, indicating that it is reasonable to model parameters as homogenous across periods. In addition to checking for potential time heterogeneity, we conducted goodness of fit tests on several network characteristics not incorporated in our model (i.e., degree distribution, geodesic distance distribution, and triad census distribution; see Huitsing, Snijders, Van Duijn, & Veenstra, 2014). Our final model indicated good fit on all of these network characteristics (see Section 2 of supplementary materials).

# Results

## Descriptive Statistics

Tables 2, 4, and 5 provide descriptive statistics about the social networks and temperament traits included in the analyses. As presented in Table 2, the social networks in this study had densities that hovered between .30 and .34. Jaccard indices ranged from .29 to .43, and assess the degree of stability of network data between each wave. These values suggest that between waves, 29% to 43% of ties are stable, close to or above the recommended stability of 30% for SIENA analyses (Snijders et al., 2010; Veenstra et al., 2013). Table 4 provides descriptive information about each trait over time, including Moran's I coefficients for each wave and the percent of children who increased, decreased, or remained stable on the trait between each wave. Moran's I coefficients were significant and ranged from .17 to .76 for PE and .25 to .41 for EC, suggesting the presence of a moderate to strong association between these traits and children's social play relationships within each wave. In contrast, Moran's I coefficients were not significant for NE in any waves. There was some stability in traits between waves (see Table 4). Depending on the trait and time period, between 32.65% and 66% of children remained in the same temperament quintile. Bivariate correlations between traits at each wave as well as sex effects are presented in Table 5. There were moderate to large correlations between PE assessed in each wave ($r$ ranged from .34 to .87, $p < .05$), and moderate correlations for NE across waves ($r$ ranged from .34 to .52, $p < .05$), suggesting moderate to strong temporal stability of classroom obser-

Table 3
*Description of Stochastic Actor-Based Model Parameters*

| Parameter | Description |
|---|---|
| Network dynamics | |
| Rate effects (Periods 1–3) | The rate of change in social play relationships for study periods 1, 2, and 3 |
| Structural network effects | |
| Density | The overall tendency to form social play relationships |
| Transitive triads | The tendency for "playmates of playmates to become playmates" over time |
| Popularity (alter sq. rt.) | The tendency of children with many playmates to obtain more playmates over time |
| Sex effects (female and same sex) | |
| Female | The effect of being female on the formation of social play relationships |
| Same sex | The effect of being the same sex as a peer on the formation of social play relationships |
| Trait effects | |
| PE, NE, EC | The effects of positive emotionality (PE), negative emotionality (NE), and effortful control (EC) on the formation of social play relationships |
| PE, NE, and EC similarity | The effects of similarity between peers in traits on the formation of social play relationships |
| Behavior dynamics | |
| Rate effects (Periods 1–3) | |
| PE, NE, EC | The rate of change of positive emotionality (PE), negative emotionality (NE), or effortful control (EC) for study periods 1, 2, and 3 |
| Shape effects | |
| Linear shape—PE, NE, EC | The overall tendency for positive emotionality (PE), negative emotionality (NE), or effortful control (EC) to increase or decrease over time in the sample |
| Quadratic shape—PE, NE, EC | The presence of a feedback effect of positive emotionality (PE), negative emotionality (NE), or effortful control (EC) on itself over time in the sample |
| Sex effects | |
| Female—PE, NE, EC | Effects of being female on change in positive emotionality (PE), negative emotionality (NE), or effortful control (EC) |
| Network influence effects | |
| Average alter—PE, NE, EC | The extent to which children who have playmates with higher average levels of a particular trait—positive emotionality (PE), negative emotionality (NE), or effortful control (EC)—also exhibit a tendency to have higher levels of that trait over time |



vations of these traits. For EC, there were moderate to large corrections between consecutive waves ($r$ ranged from .34 to .82, $p < .05$), but somewhat less stability between nonconsecutive waves ($r$ ranged from $-.04$, *ns* to .32, $p < .05$.). Taken together with the results obtained for structural analyses of the traits, these results provide support for the validity of classroom observation techniques for assessing stable individual differences in these traits among young children.

Finally, within wave, there were some sex differences in temperament traits that were evident only in the early part of the school year. Boys were higher than girls in PE in Wave 1 (boys' $M = 3.48$, girls' $M = 2.32$), $t(47) = 3.11$, $p < .01$; and Wave 2 (boys' $M = 3.33$, girls' $M = 2.50$), $t(47) = 2.13$, $p < .05$. Girls were higher than boys in NE in Wave 1 (boys' $M = 2.33$, girls' $M = 3.41$), $t(47) = -2.55$, $p < .05$; and Wave 2 (boys' $M = 2.22$, girls' $M = 3.45$), $t(47) = -2.91$, $p < .01$. Finally, boys were higher than girls in EC in Wave 1 only (boys' $M = 3.41$, girls' $M$ in Wave 1 = 2.41; $t = 2.60$, $p < .05$). Our findings for PE and NE were consistent with evidence from parent report measures of these traits (Else-Quest et al., 2006). However, we did not replicate findings from laboratory assessments of traits showing higher levels of EC among girls (Olino et al., 2011).

## Network Dynamics

**Structural network effects.** Results of the stochastic-actor based model are presented in Table 6. There was no significant density effect on the formation of social play relationships. However, there was a significant positive transitive triad effect and a significant negative effect of popularity on the formation of social play relationships. Specifically, children were 1.29 times (i.e., exp [0.25]) more likely to form a social play relationship with a partner when it yielded a transitive triad than with a partner when it did not, meaning that children were more likely to develop a play relationship with another child if that child was already in a play relationship with one of their other playmates. Additionally, children were significantly less likely to form relationships with peers who already had many playmates ($b = -.35$, $p < .05$).[2]

**Sex effects.** There was no main effect of sex on the formation of social play relationships. However, children were 1.55 times (i.e., exp [0.44]) more likely to form relationships with a play partner who was the same rather than the opposite sex. This finding replicates many earlier findings that suggest that

[2] There was evidence of collinearity between the density and popularity (alter sq. rt.) parameters in the model ($r = -.97$). If the popularity (alter square root) parameter is removed from the model, the density effect is negative and significant as expected given that the densities in each network wave were below 0.5 (Veenstra et al., 2013). However, we have chosen to retain both parameters given recommendations from Ripley et al. (2016) who note that suggests "correlations between parameter estimates close to −1.0 or +1.0 should not be used too soon in themselves as reasons to exclude effects from a model" because "collinearity is not a problem in and of itself" (Ripley et al., 2016, p. 69). Given the level of collinearity between these two structural network control variables, it is important to proceed with caution in interpreting their effects.

Table 4
*Descriptive Statistics for Temperament Traits*

| Trait | Wave 1 | | Wave 2 | | Wave 3 | | Wave 4 | |
|---|---|---|---|---|---|---|---|---|
| | *M* (*SD*) | Moran's I | *M* (*SD*) | Moran's I | *M* (*SD*) | Moran's I | *M* (*SD*) | Moran's I |
| PE | 2.96 (1.41) | .17$^{**}$ | 2.96 (1.41) | .24$^{**}$ | 2.96 (1.43) | .66$^{**}$ | 3.00 (1.43) | .76$^{**}$ |
| NE | 2.82 (1.55) | .09 | 2.76 (1.58) | −.03 | 2.92 (1.47) | −.04 | 2.90 (1.50) | .05 |
| EC | 2.96 (1.41) | .25$^{**}$ | 2.96 (1.41) | .30$^{**}$ | 2.96 (1.43) | .26$^{**}$ | 3.00 (1.43) | .41$^{**}$ |

| | Period 1 (Wave 1–Wave 2) | Period 2 (Wave 2–Wave 3) | Period 3 (Wave 3–Wave 4) |
|---|---|---|---|
| | $N = 49$ | $N = 48$ | $N = 50$ |
| PE change | | | |
| Percent children increased | 36.73% | 35.42% | 16.00% |
| Percent children decreased | 30.61% | 27.08% | 18.00% |
| Percent children stable | 32.65% | 37.50% | 66.00% |
| NE change | | | |
| Percent children increased | 32.65% | 37.50% | 28.00% |
| Percent children decreased | 26.53% | 22.92% | 34.00% |
| Percent children stable | 40.82% | 39.58% | 38.00% |
| EC change | | | |
| Percent children increased | 34.69% | 29.17% | 24.00% |
| Percent children decreased | 30.61% | 31.25% | 28.00% |
| Percent children stable | 34.69% | 39.58% | 48.00% |

*Note.* PE = positive emotionality; NE = negative emotionality; EC = effortful control.
$^{**}$ $p < .01$.

preschool children prefer same sex playmates (e.g., Maccoby, 1990).

**Do children's temperament traits predict the formation of social play relationships?** Results are partially consistent with Hypothesis 1. Children's own levels of PE and EC did not have effects on the formation of social play relationships over time. However, children with higher levels of NE were less likely to be selected by their peers as social play partners. Specifically, children's level of NE had a significant negative effect on the formation of social play relationships such that for every one-unit increase in NE, children were 0.87 (i.e., exp [−0.14]) times as likely to be chosen as a social play partner, controlling for the effects of child sex, rate effects, and structural network effects.

Findings are also partially consistent with Hypothesis 2. There were no trait similarity effects for EC or NE on the formation of social play relationships. However, there was a significant positive trait similarity effect of PE on the formation of social play relationships. Namely, for every one unit of increased similarity in PE between children, children were 1.84 times (i.e., exp [0.61]) more likely to form a social play relationship with that partner.

To summarize, there was evidence that children high in NE were less likely to develop social play relationships over the

Table 5
*Bivariate Correlations Between Temperament Traits and Sex Covariate*

| Variable | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. PE—W1 | — | | | | | | | | | | | | |
| 2. PE—W2 | **.61**$^{**}$ | — | | | | | | | | | | | |
| 3. PE—W3 | **.40**$^{**}$ | **.56**$^{**}$ | — | | | | | | | | | | |
| 4. PE—W4 | **.34**$^{*}$ | **.50**$^{**}$ | **.87**$^{**}$ | — | | | | | | | | | |
| 5. NE—W1 | −.30$^{*}$ | .08 | −.12 | −.12 | — | | | | | | | | |
| 6. NE—W2 | −.19 | −.01 | −.03 | .00 | **.35**$^{*}$ | — | | | | | | | |
| 7. NE—W3 | −.09 | .14 | .06 | .05 | **.46**$^{**}$ | **.36**$^{*}$ | — | | | | | | |
| 8. NE—W4 | −.17 | .08 | .25 | .27 | **.34**$^{*}$ | **.52**$^{**}$ | **.51**$^{**}$ | — | | | | | |
| 9. EC—W1 | .48$^{**}$ | .31$^{*}$ | .51$^{**}$ | .39$^{**}$ | −.39$^{**}$ | −.46$^{**}$ | −.17 | .04 | — | | | | |
| 10. EC—W2 | .37$^{**}$ | .43$^{**}$ | .34$^{*}$ | .38$^{**}$ | −.10 | −.24 | .04 | −.11 | **.34**$^{*}$ | — | | | |
| 11. EC—W3 | .08 | .36$^{*}$ | .20 | .18 | .04 | −.25 | .03 | −.29$^{*}$ | **.12** | **.41**$^{**}$ | — | | |
| 12. EC—W4 | −.02 | .21 | .09 | .14 | −.01 | −.24 | .05 | −.39$^{**}$ | **−.04** | **.32**$^{*}$ | **.82**$^{**}$ | — | |
| 13. Female | −.41$^{**}$ | −.29$^{*}$ | −.22 | −.17 | .35$^{*}$ | .39$^{**}$ | .02 | .22 | −.35$^{*}$ | −.15 | −.08 | −.17 | — |

*Note.* PE = positive emotionality; NE = negative emotionality; EC = effortful control. Bold values reflect correlations between the same temperament traits over time.
$^{*}$ $p < .05$. $^{**}$ $p < .01$.

Table 6
*Stochastic Actor-Based Model Examining Effects of Temperament Traits*

| Trait | Unstandardized coefficient | *SE* | *t* ratio |
|---|---|---|---|
| Network dynamics | | | |
| Structural network effects | | | |
| Density | .12 | .43 | .29 |
| Transitive triads | .25 | .04 | 6.53** |
| Popularity (alter sq. rt.) | −.35 | .18 | −1.98* |
| Sex effects | | | |
| Female | .02 | .10 | .17 |
| Same sex | .44 | .07 | 5.96** |
| Trait effects | | | |
| PE | .06 | .04 | 1.48 |
| PE similarity | .61 | .30 | 2.03* |
| NE | −.14 | .06 | −2.47* |
| NE similarity | −.04 | .38 | −.10 |
| EC | .06 | .05 | 1.20 |
| EC similarity | −.29 | .31 | −.91 |
| Behavior dynamics | | | |
| Shape effects | | | |
| Linear shape—PE | −.01 | .09 | −.06 |
| Quadratic shape—PE | −.10 | .09 | −1.05 |
| Linear shape—NE | −.09 | .06 | −1.62 |
| Quadratic shape—NE | .15 | .04 | 3.87** |
| Linear shape—EC | −.06 | .07 | −.81 |
| Quadratic shape—EC | −.01 | .07 | −.20 |
| Sex effects | | | |
| Female—PE | .15 | .19 | .78 |
| Female—NE | .15 | .11 | 1.30 |
| Female—EC | −.09 | .13 | −.65 |
| Network influence effects | | | |
| Average alter—PE | .66 | .22 | 2.99** |
| Average alter—NE | −.09 | .19 | −.48 |
| Average alter—EC | .44 | .13 | 3.28** |

*Note.* PE = positive emotionality; NE = negative emotionality; EC = effortful control. Rate effects for both network dynamics and behavior dynamics were included in the model, but are not reported here for readability. All were significant except the Period 1 parameter for the rate of change in negative emotion.
* $p < .05$. ** $p < .01$.



course of an entire school year; an analogous effect was not evident for PE or EC. Children were equally likely to form relationships with peers who were similar to or differed from them on their levels of EC and NE, but were more likely to develop a relationship with a child similar to them on their level of PE, indicating assortative pairing among preschoolers for this trait.

## Trait Behavior Dynamics

**Shape effects.** The only significant shape effect was the quadratic shape effect for NE ($b = .15$, $p < .01$). The positive value indicates that children's NE tended to move toward more extreme values over time (see Veenstra et al., 2013). Consistent with the corresponsive principle of personality development (Roberts & Caspi, 2003), children initially high in NE deepened their level relative to their peers over the course of the school year. Additionally, children initially low in NE exhibited even less of this trait relative to their peers over the course of the school year. This finding suggests that children exhibited levels of negative emotionally reactivity that became more calcified, rather that moderated by, their experiences in the classroom.

**Sex effects.** There were no sex effects on change in PE, NE, or EC over time, indicating that boys and girls changed in similar ways on observations of these traits over the school year.

**Do playmates' traits influence children's traits?** There was a positive significant average alter (i.e., influence) effect of PE. Comparing two children, A and B, who are equal on all variables except the playmates of child A are on average one unit higher on PE than the playmates of child B, the odds of increasing in PE rather than no change is 1.93 times (i.e., exp [0.66]) higher for the child A than for child B. There was also a positive significant average alter (i.e., influence) effect of EC such that the odds of increasing in EC rather than no change is 1.55 times (i.e., exp [0.44]) higher for child A whose playmates are on average one unit higher on EC than the playmates of child B. There was no significant average alter effect of NE. Children's playmates' NE did not influence their own NE over time, potentially because high NE children were less likely to develop stable play relationships. Thus, our results were partially consistent with Hypothesis 3 that children's change in traits over the school year was associated with the temperamental characteristics of those children with whom they spent the most time in social interaction.

## Discussion

This data-intensive longitudinal study provides novel evidence consistent with codevelopment of social play relationships and temperament traits in early childhood, as assessed in the ecologically valid setting of preschool classrooms. First, we found evidence for both rank-order stability and change in children's traits over the course of a school year, as assessed via rich observational assessments of children's trait-relevant behavior. Consistent with evidence from other measurement approaches (i.e., parent report and structured laboratory assessments; Durbin et al., 2007; Kochanska, & Knaack, 2003; Roberts & DelVecchio, 2000), we found modest to large rank-order stability of traits using a classroom observational approach. For PE, stability was quite high between more closely spaced waves, but moderate from the first to last wave of observation. Stability was moderate and fairly similar across varying intervals for NE. For EC, stability was moderate to high between successive waves, but weak from the first to the last wave, suggesting considerable reorganization of the rank-ordering of children on this trait across the school year. We are aware of no other examinations of the stability of trait measures assessed via behavioral observation in the classroom over a significant time interval. Our results lend support to the validity of this approach for tapping stable individual differences in traits during this developmental period. Thus, these data add to the literature focusing on trait change in young adulthood and adolescence to demonstrate that the dynamic nature of personality development is evident as early as 3 to 5 years of age.

Further, consistent with prior conceptual frameworks, we found that preschool children's social play relationships are both shaped by and shape the ongoing development of their own temperament traits over time. First, there is evidence that children's temperament traits shape the formation of peer relationships over time (Coplan & Bullock, 2012). Second, children's traits also appear to shape the trait levels of their playmates, providing evidence for the role of the peer environment in personality development during the period in which stable friendships are first starting to emerge (Chen & Schmidt, 2015). Specifically, the nature of the interplay between temperament traits and social play relationships that was revealed using our observational, longitudinal design depended in part on the trait. Thus, our findings were partially consistent with each of our three of our study hypotheses.

## Positive Emotionality

Children's level of PE did not increase or decrease their likelihood of developing social play relationships over time. However, children's level of PE did shape their selection of play partners. Over time, children were more likely to develop social play relationships with peers who were similar to them in their level of PE, indicating assortative pairing for this trait. It is somewhat surprising that children's level of PE did not affect the likelihood that they would develop social play relationships over time, given prior research that has linked positive emotions and sociability to friendship formation (Coplan & Bullock, 2012). Results also conflict with past research that did not find evidence that children tended to select temperamentally similar peers as friends (Gleason et al., 2005). However, past research was cross-sectional (e.g., Gleason et al., 2005; Mobley & Pullis, 1991) or dyadic (e.g., Park, Lay, & Ramsay, 1993), and did not control for network dynamics. The current study findings account for natural tendencies in children's networks (e.g., transitive triads, sex similarity), and reflect longitudinal change across the entire school year.

Preschoolers' own levels of PE tended to become more similar to the levels of PE of their social play partners over time. Play relationships are an important context for understanding the development of PE, as this trait involves not only sociability, but also positive emotions, which are more likely to be elicited by the free play contexts in which these preschoolers interacted. The influence effect that we observed for PE is consistent with past research on adults, which suggest that people become more similar in their expression of positive emotions like happiness to those with whom they associate (Fowler & Christakis, 2008).

## Negative Emotionality

In contrast to PE, selection or influence effects were not observed in the coevolution of NE and social play relationships in preschool children. Children did not prefer play partners that exhibit similar levels of NE to their own levels, and play partners' levels of NE did not influence children's own NE over time. Rather, of all three traits we examined, only NE predicted children's overall likelihood of forming social play relationships over time. Children who exhibited higher levels of NE had a lower tendency to form social play relationships over time. Because children who are high in NE display more frequent and intense negative affect (i.e., sadness, anger, fear), they may be more hesitant to interact with peers, be perceived by peers as less desirable play partners, or may engage in behaviors that hinder the development of stable play relationships. Indeed, the findings from this study are consistent with prior research linking high levels of NE to lower peer status in preschool (e.g., Eisenberg et al., 1993; Fabes & Eisenberg, 1992; Szewczyk-Sokolowski, Bost, & Wainwright, 2005).

We also found a general trend for preschoolers' NE to change over time in a manner consistent with the *corresponsive principle* (Roberts & Caspi, 2003). We found a significant quadratic shape effect for NE such that children high in NE were more likely to increase their NE over time while children low in NE were likely to decrease their NE over time. Children high in NE might experience the classroom setting as more stressful and therefore be less aware of or able to capitalize on the environmental supports available to facilitate adaptive social interactions. Their lower likelihood of developing stable play relationships may have also contributed to the accentuation of their high NE levels. High NE children with fewer close peer relationships had fewer opportunities for the rewarding experiences that come with friendship, including those peer interactions (modeling, support provision, distraction) that may promote the management of negative emotions.

## Effortful Control

Children's level of EC did not increase or decrease their likelihood of developing social play relationships over time. Additionally, there was no evidence of a selection effect for EC on children's choice of play partners. Children did not prefer play partners that exhibit similar levels of EC to their own levels. Although EC is linked to positive social skills and prosocial behaviors (Coplan & Bullock, 2012), these positive social adaptations do not appear to translate into more friendships over time. Additionally, children do not seem to exhibit homophily in their selection of play partners.

There was evidence of an influence effect of social play partners on children's EC. Over time, preschoolers' own levels of EC tended to become more similar to the levels of EC of their social play partners. Social play partners may model behaviors associated with high or low EC. For example, high EC play partners may engage in planful, compliant, and flexible behavior that encourage their peers to acquire these skills. Low EC play partners may also model impulsive, inattentive, or noncompliant behaviors that that encourage their peers to act similarly. The influence effect for EC in young children is consistent with recent evidence that among adult couples, one partner's conscientiousness is associated with better work outcomes for their spouse, over and above the spouse's own level of conscientiousness, and that this effect is partially mediated by the degree of emulation of the partner's activities and lifestyle (Solomon & Jackson, 2014). Thus, in the same way that adults model the behaviors of their spouses, children may model the behaviors of their play partners. This modeling can potentially lead to adaptive outcomes when play partners' levels of EC are high, but maladaptive outcomes when play partners' levels of EC are low.

## Study Limitations and Future Directions

Although the longitudinal design and observational assessments of this study are clear strengths, it was resource-intensive and precluded a large sample. Future research is needed to determine whether these findings generalize, and to determine whether there is important demographic variation based on ethnic composition or contextual variation based on classroom, preschool, or geographic location that we could not detect our sample. Additionally, teachers play an important role in structuring classroom peer relationships (Farmer, McAuliffe Lines, & Hamm, 2011), and may also influence trait development (e.g., Rimm-Kaufman et al., 2002). For example, some teachers may be better than others at helping children manage their NE effectively over the course of the school year. Future research that includes more classrooms could examine the contribution of teacher practices to the coevolution of preschoolers' traits and social play relationships. Finally, although our results indicated that children are influenced by their playmates' levels of PE and EC over time, our model did not distinguish the direction of influence. Future dynamic network models could examine the playmate influence on trait increases by using a creation function to define effects or playmate influence on trait decreases by using an endowment function to define effects (see, e.g., Haas & Schaefer, 2014).

Our findings also have practical implications for understanding adaptive trait development and the formation of social play relationships in preschool. Our study results suggest that in preschool, peers are important socializing agents for PE and EC, but not NE. These results suggest that efforts to encourage adaptive trait development must consider and account for the role of peer relationships in this process. Additionally, findings in this study point to potential struggles that NE children may face in forming social play relationships. Thus, high NE children may require extra supports from teachers and other classroom adults to build and maintain social play relationships.

In sum, study findings suggest that individual differences in broad traits that are evident when children entering preschool (i.e., NE and PE) influence how they form social play relationships over time. However, results also indicated that preschoolers' traits are not static, but rather coevolve alongside the development of play relationships. Specifically, children became more similar to their playmates over time in their exhibition of some traits (i.e., PE and EC). Future research with larger, more diverse samples and research that accounts for teacher practices will help further clarify these complex and transactional associations between temperament traits and social play relationships in preschool.

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