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The Importance of Both Individual Differences and Dyadic Processes in Children's Emotion Expression

Julie A. Hubbard, Christina C. Moore, Lindsay Zajac

University of Delaware

Elizabeth Marano

College of William and Mary

Megan K. Bookhout

George Mason University

Mary Dozier

University of Delaware

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Address correspondence to Julie A. Hubbard, Department of Psychological and Brain Sciences, University of Delaware, 105 The Green, 108 Wolf Hall, Newark, DE 19716; E-mail: jhubbard@udel.edu. ORCID ID: 0000-0002-7385-5144

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unfamiliar peer. They found significant actor and partner variance[1] for all three observed constructs, although they did not examine whether these variances differed for interactions with friends versus unfamiliar peers. In the final study, Jaggy and colleagues (Jaggy et al., 2019) observed familiar preschoolers' pretend play. They found that actor, partner, and relationship variance each accounted for a significant proportion of the variance in pretend play scores.

Applying the Social Relations Model to Emotion Expression

An SRM study of children's emotion expression could be considered an extension of the round-robin studies of behavior described above, in that emotion expression may be coded as an observable behavior. To the best of our knowledge, though, investigators have never used the SRM to analyze observations of emotion expression in non-familial groups in any developmental period (childhood, adolescence, or adulthood).

A few researchers have studied self-reported emotional experience in adult groups (speed dating, co-workers, military) using an SRM approach (e.g., Berrios et al., 2015; Eisenkraft & Elfenbein, 2010; Lakey et al., 2021). These studies consistently found support for the importance of the partner, and sometimes the unique role of the relationship, in self-reported emotional experience during social interaction. However, because these investigations focus on self-reported emotional experience and not on observed emotion expression, they can only advance our understanding of the role of individual differences versus dyadic influences on the inward experience of emotion, and not on the outward expression of emotion.

In addition, many studies of couples' or patient-caregivers' self-reported emotional experience (e.g., Jacobs et al., 2017), expression (e.g., Marini et al., 2017), and regulation (e.g., Horn & Maercker, 2016) have used the Actor-Partner Interdependence Model (APIM), a close cousin of the SRM for use with dyadic data that separates actor from partner variance. Findings

[1] The significance of relationship variance could not be determined due to the measurement approach.

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from these investigations concur in suggesting that couples influence one another in their self-reported emotional experience, expression, and regulation. However, beyond the influence of the dyadic partner, APIM studies cannot investigate the unique role of relationships in emotional functioning, given that their samples consist of dyads and not round-robin groups.

An SRM approach to emotion expression in children's peer groups would require round-robin data on each child's emotion expression when in the presence of every other child in their group, preferably as each dyad completed similar tasks. Such data would make it possible to determine the extent to which emotion expression is driven by actor effects, partner effects, and relationship effects, with significant actor variance supporting the role of individual differences in children's emotion expression and significant partner and relationship variance supporting the importance of the context of the dyadic interaction partner. Using anger expression as an example, SRM analyses would describe the extent to which anger expression results from children's tendency to express anger toward others in general (actor effect), their tendency to elicit anger from others in general (partner effect), and the unique relationship between each dyad, beyond actor and partner effects (relationship effect).

SRM Correlations and Individual Versus Dyadic Influences on Emotion Expression

This approach could be extended to examine a variety of SRM correlations outlined by Kenny and colleagues (Kenny et al., 2006; see especially Chapter 8), with some correlations providing further support for trait-like influences on children's emotion expression and others supporting dyadic influences. Two types of SRM correlations would provide evidence that some children tend to be broadly expressive across a range of emotions, whereas other children are less so, supporting the trait-like nature of emotional expressiveness. Specifically, multivariate actor-actor correlations assess the association between two different emotions within the same child averaged across partners (e.g., Is Child A's anger expression across partners correlated with

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Child A's sadness expression across partners?), and multivariate intrapersonal correlations measure two different emotions associated within the same child specific to each dyad (e.g., Is Child A's anger expression when with Child B correlated with Child A's sadness expression when with Child B, across all dyads in the sample?). In contrast, two other SRM correlations would provide evidence that children synchronize their emotions with one another, supporting the dyadic nature of emotion expression. Specifically, dyadic reciprocity correlations assess the same emotion associated across dyad members specific to each dyad (e.g., Is Child A's anger expression when with Child B correlated with Child B's anger expression when with Child A, across all dyads in the sample?), and multivariate interpersonal correlations measure two different emotions associated across dyad members specific to each dyad (e.g., Is Child A's anger expression when with Child B correlated with Child B's sadness expression when with Child A, across all dyads in the sample?).

Of note, two of the four SRM studies of children's behavior with peers included dyadic reciprocity correlations, but none of these studies provided information on the other three SRM correlations described above. Specifically, Ross and Lollis (1989) found that dyadic reciprocity correlations were significant for games and contingent interactions during unfamiliar toddlers' play, but not for their conflicts. Similarly, Jaggy et al. (2019) found a significant dyadic reciprocity correlation for the pretend play of familiar preschoolers.

The Current Study

The goal of the current study was to investigate children's observed emotion expression with peers using round-robin data and an SRM approach. Fifty-two playgroups typically consisting of four same-sex unfamiliar nine-year-old children interacted in a round-robin format. Each dyad completed two 5-minute tasks, a challenging frustration task and a cooperative planning task, and we observationally coded each child's emotion expression on a second-by-

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second basis. Our overarching hypothesis was that the SRM approach would provide strong support for both the trait-like nature of children's emotion expression (through significant actor variance, multivariate actor-actor correlations, and multivariate intrapersonal correlations) and the dyadic nature of children's emotion expression (through significant partner and relationship variance, dyadic reciprocity correlations, and multivariate interpersonal correlations).

We chose to focus on unfamiliar peers to provide a particularly stringent test of the hypothesis that dyadic influences play a critical role in emotion expression. We reasoned that, if our hypotheses were supported, the study of unfamiliar peers would suggest that dyadic influences do not require longstanding relationships to emerge, but in fact are present even when interacting with strangers. Of note, as reviewed above, in Ross and Lollis' (1989) longitudinal study of the play behavior of unfamiliar toddlers, one SRM measure of dyadic influence (partner effects) emerged at the beginning of children's acquaintance, although another SRM measure of dyadic influence (relationship effects) emerged more slowly over time. Because our study was not longitudinal, we reasoned that the use of an unfamiliar sample would provide the most rigorous test of the importance of dyadic influences on children's emotion expression.

To the best of our knowledge, the current study is the first SRM investigation of observed emotion expression outside the family context in any developmental period. Beyond the rigor that the SRM approach itself brought to the question of the trait-like versus dyadic nature of children's emotion expression, the current study was marked by additional strengths. These advances included the inclusion of both challenging and cooperative contexts, fine-grained observational coding, and the analysis of SRM correlations.

Method

Participants

Participants included 202 children (55% male) in a mid-Atlantic state. Parents reported

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children's race as 58% African American, 20% European American, 16% Mixed race, 1% Asian American, and 5% Other and children's ethnicity as 23% Latino/a and 77% Not Latino/a. Children were on average 9.49 years old (*SD* = .51).

Children's families reported annual income averaging $42,183 (range = $1800-$225,000; *SD* = $43,889), and 37% of families received some form of welfare benefits. In terms of educational level, 17% of reporting parents did not complete high school, 8% earned a GED, 25% graduated from high school, 18% attended some college, 9% graduated from a four-year college, 5% held a post-graduate degree, and 18% did not report education level.

Most participants were enrolled in a larger longitudinal study on the efficacy of the parenting intervention Attachment and Biobehavioral Catch-Up (ABC; Dozier & Bernard, 2019) on middle childhood outcomes assessed through laboratory visits. The focus of the current paper is the individual-versus-dyadic nature of children's emotion expression during a playgroup procedure at age 9. We designed the playgroup procedure both to assess the long-term effect of the intervention on children's peer relations and to evaluate trait-like versus dyadic influences on children's emotion expression.

One hundred three children were recruited as infants through referrals from Child Protective Services (CPS) due to allegations of maltreatment. These infants were randomized to receive either ABC (*N* = 50) or a control intervention (Developmental Education for Families; DEF; *N* = 53). ABC is a ten-session, home-based parenting intervention designed to increase nurturance to child distress, increase sensitivity to child signals, and decrease frightening and harsh behaviors. DEF was developed as a control intervention for ABC and is delivered in the same format but focuses on teaching parents about child development rather than promoting specific parenting behaviors. A comparison sample of 65 children were recruited to join the longitudinal sample at age 8 through local community centers and schools. This sample was

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other emotion categories.

Training and reliability. A graduate student previously trained in the coding system served as the trainer and gold standard for undergraduate coders. All coders were unaware of study hypotheses. The graduate student trained observers using videos collected during piloting of the task procedures. During training, we first compared undergraduates' coding to the graduate student's coding of these training videos. We considered coders reliable against the graduate student when they achieved an overall Cohen's kappa of at least .75 across emotions and an individual Cohen's kappa of at least .75 for each of the five emotions for five consecutive video segments (a segment was considered to be one member of a dyad completing one five-minute task). We further assessed the reliability of undergraduate coders by then randomly pairing coders with one another and assessing their reliability on additional video segments. We considered coders well-trained when they achieved these same criteria for five additional video segments coded against their undergraduate observer peers. Once coders began to work independently, we made frequent and random reliability checks to assess observer drift, and when we observed drift, we conducted re-training as needed. To assess reliability on the complete observational data set, 20% of interactions were coded by two observers unaware of which video segments served as reliability trials. Final Cohen's kappa was .83 across emotions, .80 for happiness, .99 for sadness, .95 for anger, .96 for anxiety, and .75 for neutral.

Transparency and Openness

All data sets and analyses are available at https://osf.io/y96ph/?view_only=6e25a798b6b1423b99805d461e0a9113, and we follow JARS (Kazak, 2018). Data aggregation and descriptive statistics were conducted using the Statistics Package for the Social Sciences Version 28, and all primary analyses were conducted using the SOREMO program developed by Kenny and available at davidakenny.net/srm/srmp.htm. This

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study's design and its analyses were not pre-registered.

Results

Missing Data

The SRM analyses described below require at least four members per group (Kenny & La Voie, 1984; Little & Card, 2005). For the six playgroups with three members, we imputed data for a fourth "child" and his/her partners using estimation procedures for SRM parameters developed by Bond and Malloy (2018), resulting in a total *N* of 208. In addition, we imputed all data for the planning tasks for the two groups that did not complete those tasks in the Statistical Package for Social Sciences using imputation procedures with fully conditional specification.

Data Aggregation/Transformation and Descriptive Statistics

Data for each child with each partner for each five-minute task were aggregated into ten 30-second intervals. Variables were represented as percentages (percentage of that 30-second interval that the child expressed that emotion). These data were further aggregated into two scores per child per partner per task by averaging the variables across the odd (1^{st}, 3^{rd}, 5^{th}, 7^{th}, 9^{th}) or even (2^{nd}, 4^{th}, 6^{th}, 8^{th}, 10^{th}) intervals of that task. SRM analyses used 10 latent variables (each created with the two odd-and-even interval aggregation scores) representing the expression of five emotions (Happy, Sad, Angry, Anxious, Neutral) during two tasks (Frustration, Planning). All 20 factor loadings (two loadings per five emotions per two task) were statistically significant and ranged from .74 to .87.

Descriptive statistics for these final study variables are displayed in Table 1. For the purposes of this table, we further aggregated these variables across all ten 30-second intervals of each task; however, the two odd-and-even interval aggregation scores were used in the SRM analyses described below. Furthermore, although we display the emotion scores as percentages in Table 1 for interpretability, for primary analyses, these scores were transformed using the

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probit function (z-value that corresponds to that percentage; e.g., 2.5% = -1.96; 50% = 0; 97.5% = 1.96). We took this step to address variable skew on the advice of David Kenny (personal communication, 2018).

Analytic Plan

To address our primary hypothesis, we used the SRM proposed by Kenny (Kenny et al., 2006; see especially Chapter 8). SRM analyses used 10 latent variables (5 emotion variables, each calculated for the Frustration Task and the Planning Task) each with two indicators (the two odd-and-even interval aggregation scores described above). Table 1 also includes an estimate of stable construct variance, a representation of the consistency or reliability of measurement for each latent variable. Ideally, these estimates are above 50% (Bonito & Kenny, 2010; Kenny, personal communication, 2018).

Variance partitioning. We began by using the SRM to partition each of the ten emotion variables into Actor, Partner, and Relationship Variance. As explained in Chapter 8 of Kenny and colleagues (2006), a child's emotion expression score can be defined as follows:

$$X_{bci} = m + a_b + p_c + r_{bc} + e_{bci}$$

where X_{bci} is the emotion expression score on Indicator I for Child B when interacting with Child C, m is the group mean for the expression of that emotion, a_b is Child B's actor effect, p_c is Child C's partner effect, r_{bc} is the relationship effect for Dyad BC, and e_{bci} refers to the error in Indicator I when Child B is the actor and Child C is the partner.

Using the variable of Anger in our four-person round-robin playgroups as an example, Actor Variance measures the degree to which children's anger expression during the playgroup tasks is consistent across their partners (e.g., the extent to which Child A's anger expression is similar across interactions with Children B-D, across all playgroup dyads). In contrast, Partner Variance assesses the degree to which children's anger expression during the playgroup tasks is

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consistent across children interacting with the same partner (e.g., the extent to which Child A's, Child C's, and Child D's anger expression is similar when they are with Child B, across all playgroup dyads). Finally, Relationship Variance indexes the degree to which a child's anger expression is unique to a particular dyad (e.g., the extent to which the anger that Child A expresses when with Child B is unique to their interaction, after accounting for Child A's actor effect and Child B's partner effect, across all playgroup dyads).

Dyadic reciprocity correlations. Next, we used the SRM to calculate Dyadic Reciprocity Correlations for each of the ten emotion variables. Continuing with our anger example, Dyadic Reciprocity Correlations measure the extent to which the amount of anger that Child A expresses when with Child B is related to the amount of anger that Child B expresses when with Child A (across all playgroup dyads).

Multivariate correlations. To examine relations between variables (e.g., Sad and Angry), we used three types of SRM Multivariate Correlations. Actor-Actor Correlations and Intrapersonal Correlations both assess relations between variables within individuals, and thus are akin to bivariate correlations. Using Sad and Angry as an example, the Actor-Actor Correlation indexes the extent to which Child A's anger expression toward Children B-D is related to Child A's sadness expression toward Children B-D (across all playgroup dyads). In contrast, the Intrapersonal Correlation measures the extent to which Child A's sadness expression when with Child B is related to Child A's anger expression when with Child B (across all playgroup dyads). Finally, Interpersonal Correlations assess relations between variables across members of the dyad. Continuing with our Sad and Angry example, Interpersonal Correlations measure the extent to which Child A's sadness expression when with Child B is related to Child B's anger expression when with Child A (across all playgroup dyads).

Social Relations Model Analyses

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Variance partitioning. Actor Variance was significant for all ten variables, with the percentage of variance in emotion expression accounted for by individual differences ranging from 19% to 44%. Partner Variance was significant for five of the ten variables (Sad and Anxious in both tasks; Angry in the Planning Task), with the percentage of variance in emotion expression accounted for by the partner with whom children interacted ranging from 20% to 39% for statistically significant estimates. Relationship Variance was significant for all ten variables, with the percentage of variance in emotion expression accounted for by the specific relationship ranging from 6% to 62% (see Table 2).

Dyadic reciprocity correlations. Dyadic Reciprocity Correlations were significant and positive for eight of the ten constructs, with the exceptions being Anxious in the Frustration Task and Sad in the Planning Task. Significant correlations ranged from .33 for Sad in the Frustration Task to .71 for Neutral in the Frustration Task. Thus, with two exceptions, the more one child expressed an emotion during a task, the more their partner did so as well (see Table 2).

Multivariate correlations. Across both types of multivariate correlations assessing relations between variables within individuals (Actor-Actor Correlations and Intrapersonal Correlations), many significant positive relations emerged among the "emotional" variables Happy, Sad, Angry, and Anxious (9 out of 24, with 1 marginal, and the remainder *ns)*, and many significant negative correlations emerged between these "emotional" variables and Neutral (9 out of 16, with 1 marginal, and the remainder *ns).* Of note, positive correlations emerged not only among Sad, Angry, and Anxious, but also between Happy and variables indexing a negative emotion (see Table 3).

Among the Interpersonal Correlations, which assess relations between variables across individuals, one significant positive correlation emerged between "emotional" variables (out of 12, with the remainder *ns)*, and four significant negative correlations emerged between these

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"emotional" variables and Neutral (4 out of 8, with 1 marginal, and the remainder *ns).* Following the pattern described in the previous paragraph, the positive correlation that emerged between two "emotional" variables was between one positive emotion and one negative emotion (Happy and Angry in the Frustration Task; see Table 4). See Supplemental Appendix C for a description of gender differences in all study variables and SRM estimates included in Tables 1-4.

Discussion

Although children display strong individual differences in emotion expression, they also engage in emotional synchrony or reciprocity with interaction partners. To further understand this paradox, the goal of the current study was to investigate children's emotion expression with peers using a Social Relations Model (SRM) approach. Playgroups typically consisting of four same-sex unfamiliar nine-year-old children interacted in a round-robin format, with each dyad completing both a frustration task and a planning task. We observationally coded each child's emotion expression (happiness, sadness, anger, anxiety, neutral) on a second-by-second-basis during each task. Our overarching hypothesis was that the SRM approach would provide strong support for both the trait-like nature of children's emotion expression (through significant actor variance, multivariate actor-actor correlations, and multivariate intrapersonal correlations) and the dyadic nature of children's emotion expression (through significant partner and relationship variance, dyadic reciprocity correlations, and multivariate interpersonal correlations).

The Trait-Like Nature of Emotion Expression

Strong support for the role of individual differences in children's emotion expression emerged. Actor variance accounted for a significant proportion of each of the five emotion variables (happy, sad, angry, anxious, neutral) in each of the two tasks (frustration, planning). Proportions ranged from 19% to 44%, suggesting that children indeed displayed substantial trait-like differences in their emotional expressiveness. Thus, some children were more likely than

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others to display each of the four emotions, versus remaining neutral in their expression, across the partners with whom they interacted. Furthermore, trait-like differences in emotion expression extended from the context of the interaction partner to the context of the task, with significant effects for actor variance emerging for all variables in both the frustration tasks and the planning tasks. The SRM analytic approach taken here advances our understanding of individual differences in children's outward expression of emotion. Beyond providing empirical support for the existence of trait-like differences between children in emotion expression, the SRM approach provides information on the proportion of variance accounted for by these individual differences.

Significant multivariate actor-actor correlations and multivariate intrapersonal correlations add to the evidence that children display broad trait-like differences in emotional expressiveness. Whereas some children tended to be expressive across emotions, both positive and negative, other children tended to be less so. All significant correlations among the "emotional" variables (happy, sad, angry, anxious) were positive, and all significant correlations between these "emotional" variables and neutral were negative. Moreover, positive correlations emerged not only among the negative emotion variables (sad, angry, anxious), but also between the positive emotion variable (happy) and the negative emotion variables. This pattern suggests that individual children tended to be broadly "emotional" or "unemotional" during the playgroup tasks, with more emotional children displaying both more positive and more negative affect and less unemotional children remaining more neutral in their affect.

The Dyadic Nature of Emotion Expression

At the same time, our findings provided considerable evidence that children's emotion expression is driven by dyadic processes as well. Partner variance accounted for a significant proportion of five of the ten emotion variables, with the proportion for significant effects ranging from 20% to 39%. Moreover, relationship variance was significant for all ten emotion variables,

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with proportions ranging from 6% to 62%. These variance partitioning analyses suggest both that children expressed emotions differently depending upon the partner with whom they interacted and that children differed in the emotion expressions they elicited from their peers. Furthermore, emotion expression varied based on the unique relationship between a particular child and peer, above and beyond the child's tendency to display an emotion across peers and the peer's tendency to elicit an emotion across children with whom he/she interacted. Even more compelling were patterns suggesting that relationship variance exceeded actor variance for four of the ten emotion variables. Clearly, for emotion expression, the notion of context is based in no small part upon the peers with whom children interact.

Findings for dyadic reciprocity correlations further strengthen this argument. Significant dyadic reciprocity correlations emerged for eight of the ten emotion variables, suggesting that the members of each dyad were similar in the degree to which they expressed each emotion in each task (with the exception of anxiety in the frustration task and sadness in the planning task). Thus, for example, the more one child expressed anger during the frustration task, the more the other child was likely to express anger as well. These results suggest that constructs such as emotional synchrony or reciprocity were at work as children completed the tasks (Lindsey et al., 2009a, 2009b; Lunkheimer et al., 2020; Moed et al., 2017; Thomassin & Suveg, 2014).

Finally, the multivariate interpersonal correlations suggest that dyads of children appear to be broadly "emotional" or "unemotional," mirroring the interpretation described above for individual children. A significant positive correlation emerged between two "emotional" variables that differed in valence (e.g., happiness and anger), while at the same time, significant negative correlations emerged between three "emotional" variables (happy, angry, anxious) and neutral affect. This pattern suggests that, the more one child is emotional (across both positive and negative emotional expressions), the more his/her peer partner is emotional as well;

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conversely, the more one child is unemotional, the calmer his/her peer partner is as well. Thus, whereas some peer dyads approached the tasks with considerable emotion, both positive and negative, other dyads handled the tasks with substantial poise or perhaps even detachment.

Implications of the Dyadic Nature of Children's Emotion Expression

Findings supporting the dyadic nature of children's emotion expression with peers build on theory explaining emotional synchrony or reciprocity in social interaction. These theories emphasize shared or similar emotions as a means of promoting social cohesion (Anderson et al., 2003; Preston & de Waal, 2002; Wallbott, 1995), as well as mimicry of emotion expression altering emotional experience (Chartrand & Bargh, 1999; Kappas & Descoteaux, 2003; Preston & de Waal, 2002; Wallbott, 1995). But how do children synchronize their emotions?

In some cases, one child may deliberately attempt to regulate the other's emotion. A few studies have assessed youths' unidirectional and purposeful regulation of a peer's emotion by simply asking children to describe or demonstrate strategies to improve a peer's negative emotional state (Burleson, 1982; Lopez-Perez & Pacella, 2021; Lopez-Perez et al., 2016; McCoy & Masters, 1985). Lougheed and colleagues (2016a) took an observational approach to this question in an investigation of adolescents in a conflict discussion with a close friend. They coded discussions for adolescents' positive and negative emotions and friends' supportive regulation of adolescents' emotions. Through multi-level survival analyses, they found that friends were less likely to escalate adolescents' positive emotions when adolescents had more depressive symptoms than when they had fewer depressive symptoms.

Another possibility is that peers synchronize their psychophysiology, likely without their knowledge. Wade and colleagues (1973) found synchrony in kindergarteners' heart rates during play. Goldstein and colleagues (1989) demonstrated synchrony in preschoolers' heart rates before a play session and cortisol after a play session. Montagner and colleagues (1982) found

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synchrony in the cortisol cycles of preschool classmates. Finally, Cook (2020) demonstrated synchrony in cortisol and salivary alpha amylase in adults and their close friends before and after a conflict discussion.

Limitations and Future Directions

Like all investigations, our study was marked by a number of limitations, each of which suggests directions for future research. First, our playgroups consisted of only 9-year-old children, and so we cannot know how our findings would compare to similar work at earlier or later developmental periods. Future investigators should strive to include samples from different developmental stages in investigations of the role of the individual versus the dyad in emotion expression and to assess change in these influences across development. By focusing on a middle childhood sample, though, our study suggests that both trait-like and dyadic influences on emotion expression are present fairly early in children's development.

Second, our playgroups were composed of unfamiliar children, and so we cannot know how our findings would compare to similar work with familiar peers, such as close friends. However, most previous work on children's emotional reciprocity, synchrony, or co-rumination focuses on familiar dyads of parents/children or close friends. In this way, our study fills an important gap by suggesting that dyadic processes influence emotion expression even when children interact with peers whom they do not know. This finding is important, in that children often experience intense emotion in the presence of unfamiliar peers (e.g., the first day of school). An exciting direction for future research would be to compare dyadic emotion expression process in familiar versus unfamiliar peer groups or to assess changes in dyadic emotion expression processes as children become acquainted with one another.

Third, the SRM approach does not allow for the testing of within-group differences across context (Kenny, personal communication, 2018). Thus, although significant SRM effects

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were fairly evenly divided between the frustration and planning tasks, we could not determine whether the strength of SRM effects differed between these two contexts.

Finally, although our SRM approach was ideally suited to answering our primary question of the balance of individual versus dyadic influences on children's emotion expression, other investigators have approached the question of emotional or physiological synchrony using a wide and complex variety of analytic techniques. These methods include cross-correlation analysis (Abney et al., 2021; Han et al., 2019; McFarland et al., 2020), sequential analysis (Lindsey et al., 2009a, 2009b; Moed et al., 2017; Thomassin & Suveg, 2014), hierarchical linear modeling (Li et al., 2020; Suveg et al., 2019), parallel process growth models (Amole et al., 2016), space-state grids (Lunkheimer et al., 2020), and autoregressive integrated moving average (Han et al., 2019; Suveg et al., 2015). While we do not profess to be experts in any of these approaches, we are eager to learn and apply these techniques to the current data set. We are especially interested in those approaches that will allow us to assess the temporal unfolding of emotional synchrony across the five-minute timespan of the tasks. For now, though, we hope that our current SRM analysis contributes to our understanding of the dual influences of both individual differences and dyadic processes on children's emotional expressiveness.

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References

Abney, D.H., DaSilva, E.B., & Bertenthal, B.I. (2021). Associations between infant-mother physiological synchrony and 4- and 6-month-old infants' emotion regulation. *Developmental Psychobiology, 63,* 1-15. doi: 10.1002/dev.22161

Amole, M.C., Cyranowski, J.M., Wright, A.G.C., & Swartz, H.A. (2016). Depression impacts the physiological responsiveness of mother-daughter dyads during social interaction. *Depression and Anxiety, 34,* 118-126. doi: 10.1002/da.22595

Anderson, C., Keltner, D., & John, O.P. (2003). Emotional convergence between people over time. *Journal of Personality and Social Psychology, 84,* 1054-1068. doi: 10.1037/0022-3514.84.5.1054

Berrios, R., Totterdell, P., & Niven, K. (2015). Why do you make us feel good? Correlates and interpersonal consequences of affective presence in speed-dating. *European Journal of Personality, 29,* 72-82. doi: 10.1002/per.1944

Betts, L.R., & Rotenberg, K.J. (2008). A social relations analysis of children's trust in their peers across the early years of school. *Social Development, 17,* 1039-1055. doi: 10.1111/j.1467-9507.2008.00479.x

Block, J. (1993). Studying personality the long way. In D.C. Funder, R.D. Parke, C. Tomlinson-Keasey, & K. Widaman (Eds.), *Study lives through time: Personality and development* (pp. 9-43). American Psychological Association.

Bond, C.F., & Malloy, T. (2018). Social relations analysis of dyadic data structures: The general case. In T.E. Malloy (Ed.), *Social relations modeling of behavior in dyads and groups* (pp. 357-369). Elsevier.

Bonito, J.A., & Kenny, D.A. (2010). The measurement of reliability of social relations components from round-robin designs. *Personal Relationships, 17,* 235-251. doi:

Accepted Manuscript
Version of record at: https://doi.org/10.1080/10888691.2022.2163247

10.1111/j.1475-6811.2010.01274.x

Burleson, B.R. (1982). The development of comforting communication skills in childhood and adolescence. *Child Development, 53,* 1578-1588. doi: 10.2307/1130086

Card, N.A., & Hodges, E.V. (2010). It takes two to fight in school, too: A social relations model of the psychometric properties and relative variance of dyadic aggression and victimization in middle school. *Social Development, 19,* 447-469. doi: 10.1111/j.1467-9507.2009.00562.x

Card, N.A., Hodges, E.V.E., Little, T.D., & Hawley, P.H. (2005). Gender effects in peer nominations for aggression and social status. *International Journal of Behavioral Development, 29,* 146-155. doi: 10.1080/01650250444000414

Card, N.A., Little, T.D., & Selig, J.P. (2008). Using the bivariate social relations model to study dyadic relationships: Early adolescents' perceptions of friends' aggression and prosocial behavior. In N.A. Card, J.P. Selig, & T.D. Little (Eds.), *Modeling dyadic and interdependent data in the developmental and behavioral sciences* (pp. 245-276). Routledge.

Chartrand, T.L., & Bargh, J.A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology, 76,* 893-910. doi: 10.1037/0022-3514.76.6.893

Coie, J.D., Cillessen, A.H.N., Dodge, K.A., Hubbard, J.A., Schwartz, D., Lemerise, E.A., & Bateman, H. (1999). It takes two to fight: A test of relational factors and a method for assessing aggressive dyads. *Developmental Psychology, 35,* 1179-1188. doi: 10.1037/0012-1649.35.5.1179

Cole, P.M., Wiggins, C.N. Radzioch, A.M., & Pearl, A.M. (2007). DOTS Emotion coding system. *Unpublished manuscript, Department of Psychology, Pennsylvania State*

University.

Cook, E. (2020). Affective and physiological synchrony in friendships during late adolescence. *Journal of Social and Personal Relationships, 37,* 1296-1316. doi: 10.1177/0265407519895106

Dozier, M., & Bernard, K. (2019). *Coaching parents of vulnerable infants: The Attachment and Biobehavioral Catch-Up approach.* Guilford Press.

Duchesne, S., Larose, S., Vitaro, F., & Tremblay, R.E. (2010). Trajectories of anxiety in a population sample of children: Clarifying the role of children's behavioral characteristics and maternal parenting. *Development and Psychopathology, 22,* 361-373. doi: 10.1017/S0954579410000118

Eisenkraft, N., & Elfenbein, H.A. (2010). The way you make me feel: Evidence for individual differences in affective presence. *Psychological Science, 21,* 505-510. doi: 10.1177/0956797610364117

Goldstein, S., Field, T., & Healy, B.T. (1989). Concordance of play behavior and physiology in preschool friends. *Journal of Applied Developmental Psychology, 10,* 337-351. doi: 10.1016/0193-3973(89)90034-8

Han, Z.R., Gao, M.M., Yan, J., Hu, X., Zhou, W., & Li, X. (2019). Correlates of parent-child physiological synchrony and emotional parenting: Differential associations in varying interactive contexts. *Journal of Child and Family Studies, 28,* 1116-1123. doi: 10.1007/s10826-019-01337-4

Hankin, B.L., Stone, L., & Wright, P.A. (2010). Corumination, interpersonal stress generation, and internalizing symptoms: Accumulating effects and transactional influences in a multiwave study of adolescents. *Development and Psychopathology, 22,* 217-235. doi: 10.1017/s0954579409990368

Hernandez, M.M., Eisenberg, E., Valiente, C., Thompson, M.S., Spinrad, T., Grimm, K.J., VanSchyndel, S.K., Berger, R.H., Silva, K.M., Pina, A.A., Southworth, J., & Gal, D.E. (2018). Trajectories of the expression of negative emotion from kindergarten to first grade: Associations with academic outcomes. *Journal of Educational Psychology, 110,* 324-337. doi: 10.1037/edu0000213

Hipwell, A.E., Tung, I., Northrup, J., & Keenan, K. (2019). Transgenerational associations between maternal childhood stress exposure and profiles of infant emotional reactivity. *Development and Psychopathology, 31,* 887-898. doi: 10.1017/S0954579419000324

Horn, A.B., & Maercker, A. (2016). Intra- and interpersonal emotion regulation and adjustment symptoms in couples: The role of co-brooding and co-reappraisal. *BMC Psychology, 4,* 51-61. doi: 10.1186/s40359-016-0159-7

Jacobs, J.M., Shaffer, K.M., Nipp, R.D., Fishbein, J.N., MacDonald, J., El-Jawahri, A., Pirl, W.F., Jackson, V.A., Park, E.R., Temel, J.S., & Greer, J.A. (2017). Distress is interdependent in patients and caregivers with newly diagnosed incurable cancers. *Annals of Behavioral Medicine, 51,* 519-531. doi: 10.1007/s12160-017-9875-3

Jaggy, A.K., Mainhard, T., Sticca, F., & Perren, S. (2019). The emergence of dyadic pretend play quality during peer play: The role of child competence, play partner competence, and dyadic constellation. *Social Development, 29,* 976-994. doi: 10.1111/sode.12445

Kappas, A., & Descoteaux, J. (2003). Of butterflies and roaring thunder: Nonverbal communication in interaction and regulation of emotion. In P. Philippot, E.J., Coats, & R.S. Feldman (Eds.), *Nonverbal behavior in clinical settings* (pp. 45-74). Oxford University Press.

Kazak, A.E. (2018). Editorial: Journal article reporting standards. *American Psychologist, 73,* 1-2. doi: 10.1037/amp0000263

Accepted Manuscript
Version of record at: https://doi.org/10.1080/10888691.2022.2163247

Kenny, D.A. (1994). *Interpersonal perception: A social relations analysis.* Guilford Press.

Kenny, D.A., Kashy, D.A., & Cook, W.L. (2006). *Dyadic data analysis.* Guilford Press.

Kenny, D.A., & La Voie, L. (1984). The social relations model. *Advances in Experimental Social Psychology, 18,* 142-182.

Kenny, D.A., Mohr, C.D., & Levesque, M.J. (2001). A social relations variance partitioning of dyadic behavior. *Psychological Bulletin, 127,* 128-141. doi: 10.1037/0033-2909.127.1.128

Kwon, K., Teer, J.E., Maurice, S.A., & Matejka, C.M. (2020). Self-report of emotional experience and peer nominations of expressivity: Predictability of change in teacher-rated social behavior. *Social Development, 29,* 837-853. doi: 10.1111/sode.12429

Lakey, B., Hubbard, S.A., Woods, W.C., Brummans, J., Obreiter, A., Fles, E., Andrews, J., Molen, R.J.V., Hesse, C., Gildner, B., Llutz, R., & Maley, M. (2021). Supportive people evoke positive affect, but do not reduce negative affect, while supportive groups result from favorable dyadic, not group effects. *Anxiety, Stress, and Coping.* Advance online publication. doi: 10.1080/10615806.2021.1965995

Li, Z., Sturge-Apple, M.L., Liu, S., & Davies, P.T. (2020). Integrating a multilevel approach to examine family conflict and parent-adolescent physiological synchrony. *Journal of Family Psychology, 34,* 773-783. doi: 10.1037/fam0000671

Lindsey, E.W., Caldera, Y.M., & Tankersley, L. (2009a). Marital conflict and the quality of young children's peer play behavior: The mediating and moderating role of parent-child emotional reciprocity and attachment security. *Journal of Family Psychology, 23,* 130-145. doi: 10.1037/a0014972

Lindsey, E.W., Chambers, J.C., Frabutt, J.M., & Mackinnon-Lewis, C. (2009b). Marital conflict and adolescents' peer aggression: The mediating and moderating role of mother-child

Accepted Manuscript
Version of record at: https://doi.org/10.1080/10888691.2022.2163247

emotional reciprocity. *Family Relations, 58,* 593-606. doi: 10.1111/j.1741-3729.2009.00577.x

Little, T.D., & Card, N.A. (2005). On the use of social relations and actor-partner interdependence models in developmental research. *International Journal of Behavioral Development, 29,* 173-179. doi: 10.1080/01650250444000388

Lopez-Perez, B., & Pacella, D. (2021). Interpersonal emotion regulation in children: Age, gender, and cross-cultural differences using a serious game. *Emotion, 21,* 17-27. doi: 10.1037/emo0000690

Lopez-Perez, B., Wilson, E.L., Dellaria, G., & Gummerum, M. (2016). Developmental differences in children's interpersonal emotion regulation. *Motivation and Emotion, 40,* 767-780. doi: 10.1007/s11031-016-9569-3

Lougheed, J.P., Craig, W.M., Pepler, D., Connolly, J., O'Hara, A., Granic, I., & Hollenstein, T. (2016). Maternal and peer regulation of adolescent emotion: Associations with depressive symptoms. *Journal of Abnormal Child Psychology, 44,* 963-974. doi: 10.1007/s10802-015-0084-x

Lunkheimer, E., Hamby, C.M., Lobo, F.M., Cole, P.M., & Olson, S.L. (2020). The role of dynamic, dyadic- parent-child processes in parental socialization of emotion. *Developmental Psychology, 56,* 566-577. doi: 10.1037/dev0000808

Malatesta-Magai, C. (1991). Development of emotion expression during infancy: General course and patterns of individual difference. In J. Garber and K.A. Dodge (Eds.), *The development of emotion regulation and dysregulation* (pp. 49-68). Cambridge University Press.

Malloy, T.E., Barcelos, S., Arruda, E., DeRosa, M., & Fonseca, C. (2005). Individual differences and cross-situation consistency of dyadic social behavior. *Journal of Personality and*

Accepted Manuscript
Version of record at: https://doi.org/10.1080/10888691.2022.2163247

Social Psychology, 89, 643-654. doi: 10.1037/0022-3514.89.4.643

Malloy, T.E., & Cillessen, A.H.N. (2008). Variance component analysis of generalized and dyadic peer perceptions in adolescence. In N.A. Card, J.P. Selig, & T.D. Little (Eds.), *Modeling dyadic and interdependent data in the developmental and behavioral sciences* (pp. 213-244). Routledge.

Marini, C.M., Wadsworth, S.M., Christ, S.L., & Franks, M.M. (2017). Emotion expression, avoidance and psychological health during reintegration: A dyadic analysis of actor and partner associations within a sample of military couples. *Journal of Social and Personal Relationships, 34,* 69-90. doi: 10.1177/0265407515621180

McCoy, C.L., & Masters, J.C. (1985). The development of children's strategies for the social control of emotion. *Child Development, 56,* 1214-1222. doi: 10.2307/1130236

McFarland, D.H., Fortin, A.J., & Polka, L. (2020). Physiological measures of mother-infant interactional synchrony. *Developmental Psychobiology, 62,* 50-61. doi: 10.1002/dev.21913

Mischel, W. (1968). *Personality and assessment.* Wiley.

Moed, A., Gershoff, E.T., Eisenberg, N., Hofer, C., Losoya, S., Spinrad, T.L., & Liew, J. (2017). Parent-child negative emotion reciprocity and children's school success: An emotion-attention process model. *Social Development, 26,* 560-574. doi: 10.1111/sode.12217

Montagner, H., Restoin, A., & Henry, J.C. (1982). Biological defense rhythms, stress and communication in children. *Review of Child Development Research, 6,* 291-319.

Preston, S.D., & de Waal, F.B.M. (2002). Empathy: Its ultimate and proximate bases. *Behavioral and Brain Sciences, 25,* 1-72. doi: 10.1017/S0140525X02000018

Price, N.N., Scelsa, V.L., Zeman, J.L., & Luebbe, A.M. (2022). Profiles of adolescents' sadness, anger, and worry regulation: Characterization and relations with psychopathology.

Accepted Manuscript
Version of record at: https://doi.org/10.1080/10888691.2022.2163247

Emotion. Advanced online publication. doi: 10.1037/emo0001084

Prosen, S., & Vitulic, H.S. (2018). Children's emotion expression in the preschool context. *Early Child Development and Care, 188,* 1675-1683. doi: 10.1080/03004430.2016.1278367

Rose, A.J., Schwartz-Mette, R.A., Glick, G.C., Smith, R.L., & Luebbe, A.M. (2014). An observational study of co-rumination in adolescent friendships. *Developmental Psychology, 50,* 2199-2209. doi: 10.1037/a0037465

Ross, H.S., & Lollis, S.P. (1989). A social relations analysis of toddler peer relationships. *Child Development, 60,* 1082-1091. doi: 10.2307/1130782

Sallquist, J.V., Eisenberg, N., Spinrad, T.L., Reiser, M., Hofer, C., Liew, J., Zhou, Q., & Eggum, N. (2009). Positive and negative emotionality: Trajectories across six years and relations with social competence. *Emotion, 9,* 15-28. doi: 10.1037/a0013970

Scarpati, S., Malloy, T.E., & Fleming, R. (1996). Interpersonal perception of skill efficacy and behavioral control of adolescents with learning disabilities: A social relations approach. *Learning Disability Quarterly, 19,* 15-22. doi: 10.2307/1511049

Simpkins, S.D., & Parke, R.D. (2002). Do friends and nonfriends behave differently? A social relations analysis of children's behavior. *Merrill-Palmer Quarterly, 48,* 263-283. doi: 10.1353/mpq.2002.0014

Stone, L.B., Hankin, B.L., Gibb, B.E., & Abela, J.R.Z. (2011). Co-rumination predicts the onset of depressive disorders during adolescence. *Journal of Abnormal Psychology, 120,* 752-757. doi: 10.1037/a0023384

Suveg, C., Shaffer, A., & Davis, M. (2015). Family stress moderates relations between physiological and behavioral synchrony and child self-regulation in mother-preschooler dyads. *Developmental Psychobiology, 58,* 83-97. doi: 10.1002/dev.21358

Suveg, C., West, K.B., Davis, M., Caughy, M., Smith, E.P., & Oshri, A. (2019). Symptoms and

synchrony: Mother and child internalizing problems moderate respiratory sinus arrhythmia concordance in mother-preadolescent dyads. *Developmental Psychology, 55,* 366-376. doi: 10.1037/dev0000648

Tabachnick, A.R., He, Y., Zajac, L., Carlson, E.A., & Dozier, M. (2022). Secure attachment in infancy predicts context-dependent emotion expression in middle childhood. *Emotion, 22,* 258-269. doi: 10.1037/emo0000985

Thomassin, K., & Suveg, C. (2014). Reciprocal positive affect and well-regulated, adjusted children: A unique contribution of fathers. *Parenting: Science and Practice, 14,* 28-46. doi: 10.1080/15295192.2014.880017

van den Berg, Y.H.M., & Cillessen, A.H.N. (2015). Peer status and classroom seating arrangements: A social relations analysis. *Journal of Experimental Child Psychology, 130,* 19-34. doi: 10.1016/j.jecp.2014.09.007

Wade, M.G., Ellise, M.J., & Bohrer, R.E. (1973). Biorhythms in the activity of children during free play. *Journal of the Experimental Analysis of Behavior, 20,* 155-162. doi: 10.1901/jeab.1973.20-155

Wallbott, H.G. (1995). Congruence, contagion, and motor mimicry: Mutualities in nonverbal exchange. In G.I. Markova & C.F. Graumann (Eds.), *Mutualities in dialogue* (pp. 82-90). Cambridge University Press.

Yew, S.G.K., & O'Kearney, R. (2015). Early language impairments and developmental pathways of emotional problems across childhood. *International Journal of Language and Communication Disorders, 50,* 358-373. doi: 10.1111/1460-6984.12142

Zimmer-Gembeck, M.J., Waters, A.M., & Kindermann, T. (2010). A social relations analysis of liking for and by peers: Associations with gender, depression, peer perception, and worry. *Journal of Adolescence, 33,* 69-81. doi: 10.1016/j.adolescence.2009.05.

Accepted Manuscript
Version of record at: https://doi.org/10.1080/10888691.2022.2163247

Table 1

Descriptive Statistics and Estimates of Stable Variance

	Minimum	Maximum	*M*	*SD*	Skew	% Stable Variance
Frustration Tasks						
Happy	0.00	73.34	8.20	10.74	2.27	.82
Sad	0.00	5.51	0.13	0.52	6.17	.80
Angry	0.00	23.61	1.32	2.61	3.77	.76
Anxious	0.00	26.12	1.02	2.83	5.29	.81
Neutral	26.66	100.00	89.11	12.27	-1.84	.82
Planning Tasks						
	Minimum	Maximum	*M*	*SD*	Skew	% Stable Variance
Happy	0.00	81.97	14.24	13.87	1.59	.83
Sad	0.00	11.24	0.08	0.53	16.37	.84
Angry	0.00	7.43	0.47	1.01	3.54	.81
Anxious	0.00	34.08	0.83	2.63	7.68	.84
Neutral	0.00	100.00	83.85	14.87	-1.59	.83

Note: N = 624 for all variables (208 children x 3 tasks or partners)

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Table 2

Variance Partitioning and Dyadic Reciprocity Correlations

	Actor Variance	Partner Variance	Relationship Variance	Error	Dyadic Reciprocity Correlations
Frustration Tasks					
Happy	.20**	.00	.62***	.18	.66***
Sad	.38**	.31*	.11***	.20	.33*
Angry	.19*	.08	.50***	.23	.67***
Anxious	.27**	.20*	.34***	.19	.31
Neutral	.22**	.00	.60***	.18	.71***
Planning Tasks					
	Actor Variance	Partner Variance	Relationship Variance	Error	Dyadic Reciprocity Correlations
Happy	.44***	.01	.38***	.17	.67***
Sad	.39*	.39*	.06**	.16	.54
Angry	.35**	.34*	.13***	.18	.49*
Anxious	.31**	.27*	.27***	.15	.39*
Neutral	.41***	.02	.40***	.17	.59***

Note: † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

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Table 3

Multivariate Actor-Actor Correlations and Intrapersonal Correlations

	Frustration Tasks				
	1	2	3	4	5
1. Happy	--	.72**	.30	.77**	-.72**
2. Sad	.-.21	--	.80**	.74**	-.70**
3. Angry	.25**	-.03	--	.63*	-.41
4. Anxious	.07	.22	.15	--	-.80*
5. Neutral	-.80***	.08	-.51***	-.29***	--
	Planning Tasks				
	1	2	3	4	5
1. Happy	--	.18†	.19	.17	-.78***
2. Sad	.05	--	.75*	.69*	-.12
3. Angry	-.01	.61	--	.75**	-.16
4. Anxious	.08	.32	.24	--	-.16
5. Neutral	-.80***	-.14	-.19†	-.27**	--

Note: Actor-Actor Correlations are shown above the diagonals, and Intrapersonal Correlations are shown below the diagonals. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

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Table 4

Multivariate Interpersonal Correlations

	1	2	3	4	5
1. Happy	--	-.05	.28***	.09	-.68***
2. Sad	.10	--	-.04	.19	.03
3. Angry	.06	.49	--	.11	-.40***
4. Anxious	.11	.26	.09	--	-.13†
5. Neutral	-.64***	-.10	-.11	-.14*	--

Note: Correlations for the Frustration Tasks are shown above the diagonal, and correlations for the Planning Tasks are shown below the diagonal. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.