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Version of record at: https://doi.org/10.1111/cdev.13917

Emotion Transmission in Peer Dyads in Middle Childhood

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Acknowledgements

This research was supported by National Institute of Mental Health grant R011MH074374 to Mary Dozier. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

We thank the children and families who participated in this research, the research assistants who helped to collect these data, and the child protection agencies in Philadelphia.

We thank Jean-Philippe Laurenceau for his invaluable statistical and analytic consultation.

ClinicalTrials.gov: Intervening Early with Neglected Children; https://clinicaltrials.gov/show/NCT02093052.

The data and code necessary to reproduce the analyses presented here are publicly accessible at https://osf.io/mbf2d/?view_only=9c6ab378cf644c9180096859ae48e56c. Materials necessary to attempt to replicate the findings are available by contacting the first author. Analyses were not pre-registered.

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Version of record at: https://doi.org/10.1111/cdev.13917

Abstract

This study investigated emotion transmission amongst peers during middle childhood. Participants included 202 children (111 males; race: 58% African American, 20% European American, 16% Mixed race, 1% Asian American, and 5% Other; ethnicity: 23% Latino(a) and 77% Not Latino(a); M_{income}=$42,183, SD_{income}=$43,889; M_{age}=9.49; English-speaking; from urban and suburban areas of a mid-Atlantic state in the United States). Groups of four same-sex children interacted in round-robin dyads in 5-minute tasks during 2015-2017. Emotions (happy, sad, angry, anxious, neutral) were coded and represented as percentages of 30-second intervals. Analyses assessed whether children's emotion expression in one interval predicted *change* in partners' emotion expression in the next interval. Findings suggested: a) escalation of positive and negative emotion [children's positive (negative) emotion predicts an increase in partners' positive (negative) emotion], and b) de-escalation of positive and negative emotion (children's neutral emotion predicts a decrease in partners' positive or negative emotion). Importantly, de-escalation involved children's display of neutral emotion and not oppositely-valenced emotion.

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Emotional functioning is critical to children's social development across settings, including the context of peer relationships. We typically conceptualize emotional processes at the individual level with trait-like differences between children. However, children's emotions change as they interact with one another through a process termed emotion transmission (Butler, 2011), suggesting that emotions function at the dyadic level as well. The goal of the current study was to investigate emotion transmission in dyads of 9-year-old peers.

Emotion Transmission

Beginning in infancy, children vary in emotional reactivity, expression, and regulation (e.g., Cole et al., 2004; Malatesta-Magai, 1991; Sullivan et al., 1992). Individual differences continue into childhood and predict social skills and social status, as well as internalizing and externalizing problems (e.g., Arsenio et al., 2000; Cole et al., 2003; Miller & Olson, 2000).

This description focuses on emotional processes within each child. However, emotional processes are also dyadic, in that individuals transfer emotions to one another as they interact. Children first experience emotion transmission in the parent-infant relationship, for example, when a mother calms her upset baby. In this example, emotion transmission is unidirectional and purposeful; however, current conceptualizations are broader. They emphasize bidirectionality between partners, as well as a process that may be either purposeful or incidental (emotions changing simply through interaction; e.g., Butler & Randall, 2013). Theories explaining emotion transmission emphasize shared or similar emotions as a means of promoting social cohesion (Anderson et al., 2003; Preston & de Waal, 2002; Wallbott, 1995).

As noted by Butler (2011) in her treatise on interpersonal emotion systems, researchers have used a variety of overlapping terms to describe the transfer of emotion from one person to another (synchrony, reciprocity, crossover, contagion, coregulation). In the current paper, we

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follow Butler's advice and adopt the term *transmission* to convey the focus of our study, the time-lagged transfer of the same or different emotions between interaction partners (i.e., children's earlier emotion predicts their partner's later emotion, whether the two emotions are the same or different). In contrast, when reviewing related literature, we use the term *synchrony* to convey concurrent linkage of the same emotion between interaction partners (i.e., children's and their partner's expression of the same emotion is linked at the same point in time). Thus, while emotion transmission and emotional synchrony are closely linked constructs, they are differentiated by their focus on concurrent versus lagged relations between dyad members' emotions, as well as whether the emotions linked across dyad partners are necessarily the same.

Although the example of a mother calming an upset baby emphasizes the de-escalation of negative emotion, current theory is more comprehensive (Silk, 2019). Following and expanding upon Butler's (2011) nomenclature, we define four types of emotion transmission in peer dyads, the escalation and de-escalation of both positive and negative emotion. The escalation of positive emotion occurs when children's earlier positive emotion transfers to partners and increases their later positive emotion (i.e., when the percentage of time that children express a positive emotion in one time segment positively predicts the percentage of time that partners express a positive emotion in a later time segment). An analogous definition applies to the escalation of negative emotion: children's earlier negative emotion transfers to partners and increases their later negative emotion. Similarly, the de-escalation of positive emotion occurs when children's earlier negative or neutral emotion transfers to partners and decreases their later positive emotion, and the de-escalation of negative emotion occurs when children's earlier positive or neutral emotion transfers to partners and decreases their later negative emotion.

Our expansion of Butler's taxonomy emphasizes that the transfer of neutral emotion, as well as oppositely-valenced emotion, may de-escalate positive or negative emotion. We define

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neutral emotion expression as occurring when children do not display either positive or negative emotion through their facial expressions, tone of voice, or body language. Moreover, we theorize that children's neutral emotion will have a calming or dampening effect on their partner's emotion by lowering the affective climate of the interaction, whether positive or negative.

Research on emotion transmission or synchrony in parent-child dyads is growing and spans the developmental periods of infancy (e.g., Feldman, 2007; Guo et al., 2015), childhood (e.g., Lindsey et al., 2009; Lunkheimer et al., 2020), and adolescence (e.g., Lougheed, 2020; Mancini et al., 2016). These findings are bolstered by additional work suggesting physiological transmission or synchrony between parents and children during infancy, childhood, and adolescence (for reviews, see Davis et al., 2017, and Palumbo et al., 2017). Additional research document the transmission or synchrony of emotion (e.g., Hilpert et al., 2020; Randall & Butler, 2013) and psychophysiology (see Palumbo et al., 2017, for a review) in marital-romantic couples. Thus, empirical evidence convincingly argues that children and their parents engage in emotion transmission or synchrony throughout infancy, childhood, and adolescence and that these processes continue in adult marital-romantic relationships. However, we have much less empirical evidence for emotion transmission in children's peer interactions, an interpersonal context representing a crucial "middle ground" in the progression from parent-child relationships to marital-romantic relationships. Importantly, though, theorists argue that the understanding of emotion transmission that we described above should apply to all stages of development and all types of relationships (Ramsey & Gentzler, 2015; Randall & Schoebi, 2018).

Emotion Transmission with Peers in Childhood and Adolescence

Indirect evidence of emotion transmission in peers in childhood and adolescence comes from three sources. First, researchers have investigated youths' empathic distress and co-rumination, two contexts in which emotion transmission may occur. Youth display empathic

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distress when they experience negative emotions after witnessing their peers in upsetting situations (e.g., Barhight et al., 2013; Masten et al., 2010). When adolescents co-ruminate with peers, studies suggest that co-rumination acts as a contagion mechanism (Schwartz-Mette et al., 2012, 2018), in that it predicts in-the-moment empathic distress, as well as both concurrent and longitudinal interpersonal stress generation and internalizing symptoms (e.g., Hankin et al., 2010; Rose et al., 2014, 2017; Stone et al., 2011).

Second, investigators have assessed youths' interpersonal emotion regulation. In several studies, researchers simply asked children to describe or demonstrate strategies to improve a peer's negative emotional state (e.g., Burleson, 1982; Gummerum & Lopez-Perez, 2020; Lopez-Perez & Pacella, 2021; McCoy & Masters, 1985). In a related study, Tamminen and colleagues (2016) found that, when teen athletes reported using strategies to improve their teammates' emotions, both the individual and the team reported greater enjoyment of and commitment to the team. Other researchers have approached the question of interpersonal emotion regulation through observations of adolescents' conversations with friends. Lougheed and colleagues (2016) coded discussions for adolescents' positive and negative emotions and friends' supportive regulation of adolescents' emotions; friends were less likely to escalate adolescents' positive emotions when adolescents had more depressive symptoms. In a second observational study, when adolescents were supportive rather than dismissive of their friends' use of emotion terms, friends were more likely to make additional emotional disclosures (Legerski et al., 2014). Finally, Schwartz-Mette and colleagues (2021) found both concurrent and longitudinal links between self-reported intrapersonal emotion regulation difficulties and self-reported maladaptive interpersonal emotion regulation (excessive reassurance seeking, conversational self-focus, negative feedback seeking). Of note, this last study emphasizes adolescents' own strategies to seek regulatory help from peers, rather than peers' attempts to regulate one another's emotions.

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Third, a series of older studies investigated synchrony in peers' psychophysiology. Wade and colleagues (1973) found synchrony in kindergarteners' heart rates during play. Similarly, Goldstein and colleagues (1989) demonstrated synchrony in preschoolers' heart rates before a play session and cortisol after a play session. Finally, Montagner and colleagues (1982) found evidence of synchrony in the cortisol cycles of preschool classmates.

Each of the studies reviewed in the three paragraphs above either did not take a time-based approach, assessed concurrent emotional or physiological synchrony, or used repeated measures spaced over lengthy intervals (e.g., daily). To our knowledge, only one study has directly assessed time-lagged emotion transmission between peers during social interaction during any developmental period, including adulthood. In this study, Normand and colleagues (2022) observed dyads of 6- through 11-year-old children in which one member was diagnosed with attention-deficit-hyperactivity disorder (ADHD) and the other member was a reciprocated friend. Dyads engaged in a cooperative negotiation task and a competitive task, and observers coded children's positive affect (laughter, warmth, smiling), but not negative affect. Sequential analyses suggested positive affect reciprocity across dyad members in both tasks.

The Current Study

The goal of the current study was to expand on the work of Normand and colleagues (2022) with a second investigation of emotion transmission in peers during middle childhood. Fifty-two groups typically consisting of four same-sex unfamiliar nine-year-old children interacted in dyads in a round-robin format. Each dyad completed two 5-minute tasks including a search task (children unsuccessfully searched for an object that did not exist) and a planning task (children successfully planned the perfect event). We coded children's emotion expression during each task second-by-second into one of five categories (happy, sad, angry, anxious, neutral), and we calculated the percentage of time that children expressed each emotion during

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10 30-second intervals per task. We then used multilevel modeling to assess whether children's emotion expression in one 30-second interval predicted *change* in their dyad partner's emotion expression in the next interval, across both the same and different emotions.

Our overarching hypothesis was that peer dyads would demonstrate emotion transmission characterized by both the escalation and de-escalation of both positive and negative emotion. We predicted that: a) the more positive emotion (happiness) children expressed in one interval, the greater the increase in their partner's positive emotion expression in the next interval (escalation of positive emotion), b) the more negative emotion (sadness, anger, anxiety) children expressed in one interval, the greater the increase in their partner's negative emotion expression in the next interval (escalation of negative emotion), c) the more negative or neutral emotion children expressed in one interval, the greater the decrease in their partner's positive emotion expression in the next interval (de-escalation of positive emotion), and d) the more positive or neutral emotion children expressed in one interval, the greater the decrease in their partner's negative emotion expression in the next interval (de-escalation of negative emotion).

Moreover, we made several secondary hypotheses. First, we expected more effects to emerge for the escalation and de-escalation of negative than positive emotions, based on Butler's (2011) theory that the boundaries between individuals' emotion may be more "permeable" for negative emotions than positive emotions, perhaps because negative affect is more salient or easier to recognize. Second, we predicted that more effects would emerge for the escalation and de-escalation of anger than sadness or anxiety, because negative externalizing emotions are easier for children to recognize in others than negative internalizing emotions (Cavioni et al., 2020; Nowicki & Duke, 1994). Finally, for the de-escalation of positive and negative emotion, we expected that more effects would emerge when children transmitted an oppositely-valenced emotion to their partners than a neutral emotion, because of the greater intensity of the emotion

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transmitted.

Finally, we predicted that stronger evidence of emotion transmission would emerge for the search tasks than the planning tasks, particularly for anger. Although both tasks were designed to elicit a range of emotions, the search tasks seemed especially likely to elicit anger, given that children did not succeed at them. We based this prediction on the same reasoning described above regarding the greater permeability of negative than positive emotions and the easier recognition of negative externalizing emotions than negative internalizing emotions. We considered our hypotheses and analyses to be more exploratory than confirmatory, given that the current study was only the second investigation of time-lagged emotion transmission between peers at any point in development.

We made four important decisions in the design of the study. First, although our research questions focused on dyads, children came to the lab in groups of four, and each child interacted with every other group member in a round-robin format. Peer researchers typically do not consider the impact of the particular peers with whom children interact in their observational work. For example, when we naturalistically observe children's anger on the playground, we ignore the fact that some peers elicit more anger than others, and thus, children's anger scores are confounded with the peers with whom they interact. We mitigated this confound through a round-robin design and multilevel analyses that accounted for the nature of this design.

Second, we chose to focus on unfamiliar rather than familiar peers. Theorists speculate that emotional or physiological transmission should be stronger between those in a close relationship than strangers (Field, 2012; Helm et al., 2014). If so, then evaluating emotion transmission with unfamiliar peers may provide an especially strong test of our hypothesis, because the phenomenon may be less likely to occur when children do not know one another. Moreover, in middle childhood, children frequently interact with unfamiliar peers in emotionally

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charged situations such as the first day of school or sports competitions.

Third, we assessed children's observed emotion expression rather than self-reported emotional experience, and fourth, we focused our study on nine-year old children. Our reasons for these two decisions were interrelated. As Butler (2011) noted, children do not have direct knowledge of peers' internal emotional experience during interaction, but they are able to observe peers' expressive behavior. Thus, observed emotion expression may best capture the means through which children transfer emotion as they interact. The focus on nine-year old children was supported by psychometric studies of the Diagnostic Analysis of Nonverbal Accuracy Scale (e.g., Nowicki & Duke, 1994) and the Test of Emotion Comprehension (Cavioni et al., 2020) suggesting that emotion recognition abilities level off around 3rd-4th grade, or around nine years old. For this reason, we considered age nine to be an optimal point at which to investigate peers' emotion transmission through observations of their emotion expression.

The current study is similar to Normand and colleagues' (2022) work in its focus on emotion transmission in peer dyads in middle childhood during comparable tasks. Our study builds on their work through the use of a non-clinical sample, unfamiliar peers rather than reciprocated friends, and a round-robin format in which children interacted with multiple partners. Moreover, we assessed emotion transmission across both positive emotion and a range of negative emotions, whereas Normand and colleagues (2022) evaluated only positive affect. Finally, we believe that our use of multilevel modeling over 10 30-second intervals of each 5-minute task provided a more continuous and fine-grained assessment of emotion transmission over the course of the tasks than Normand and colleagues' (2022) use of sequential analysis.

Method

Participants

Participants included 202 children (55% male; biological sex via parent report) from

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urban and suburban areas of a mid-Atlantic state in the United States. Parents reported 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); the diversity of the sample allowed findings to generalize quite broadly. All children spoke English. Children were on average 9.49 years old (*SD* = .51; range = 7.42-11.18).

Families reported annual income averaging $42,183 (range = $1800-$225,000; *SD* = $43,889), and 37% of families received welfare benefits. In terms of educational level, 17% of parents did not complete high school, 8% earned a GED, 25% graduated from high school, 18% attended some college, 9% graduated from 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 a parenting intervention on middle childhood outcomes. We designed procedures both to assess the effect of the intervention on children's peer relationships and to address the goals of this study. One hundred three children were recruited as infants through referrals from Child Protective Services (CPS) due to allegations of maltreatment. They were randomized to receive either Attachment and Biobehavioral Catch-Up (ABC; *N* = 50; Dozier & Bernard, 2019) or a control intervention (Developmental Education for Families; DEF; *N* = 53). ABC is a 10-session, home-based parenting intervention designed to increase nurturance to child distress, increase sensitivity to child signals, and decrease frightening and harsh behaviors. DEF is delivered in the same format but focuses on teaching parents about child development. Children were followed forward to middle childhood, when a comparison sample of 65 children was recruited through community centers and schools and matched to the intervention sample on race and sex. The final 34 children (known in our lab as back-up children) were similarly recruited to provide an additional child per group when only three children could be scheduled at the same

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time, rather than the desired four.

CPS-referred intervention children did not differ from comparison or back-up children on any study variables. In addition, children whose parents completed ABC did not differ from those whose parents completed DEF on study variables. For these reasons, for the purposes of this paper, we analyzed the sample as a whole.

Procedures and Measures

We obtained both written parental consent and child assent for all procedures. Procedures were approved by the Institutional Review Board of the University of Delaware.

Procedures. Children came to the lab in groups of unfamiliar peers in the summers of 2015-2017. The typical group included four children, although a few groups only included three. Groups were same-sex, because the majority of peer interactions during this developmental period occur within sex (Rose & Smith, 2018). At the beginning of each dyadic interaction described below, children confirmed verbally that they did not know one another.

All interactions occurred in dyads. Dyad members did not interact before or in-between their recorded interactions. Each child interacted with three partners in a round-robin design. In the first set of interactions, Child A and Child B interacted in one room, while Child C and Child D interacted in a separate room. Children then switched partners, so that Child A and Child C could interact at the same time as Child B and Child D. Finally, children switched partners once again to give Child A and Child D an opportunity to interact, as well as Child B and Child C.

Each dyad completed two 5-minute tasks likely to elicit a range of emotions. The first task was a search task, in which children searched for a missing object. Dyads AB and CD searched for a key to unlock a box on a ring of hundreds of keys that did not include the correct key. Dyads AC and BD searched for a squirrel in a book of hundreds of animal photos, but no squirrel. Dyads AD and BC searched for a ball with a smiley face in a bin of hundreds of balls,

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none of which had a smiley face.

The second task was a planning task. Dyads AB and CD planned the perfect party, dyads AC and BD planned the perfect school, and dyads AD and BC planned the perfect field trip. Tasks were not counterbalanced but used the set order described above. Due to changes early in data collection, the first two groups completed only the search tasks and not the planning tasks.

Before the tasks began, an experimenter told children they would earn tickets based on their performance, and she showed them prizes they could choose if they accumulated 30 tickets. At the beginning of each search task, an experimenter stated that children would earn 10 tickets each if they could find the missing object; of course, no dyad earned any tickets. At the beginning of each planning task, an experimenter stated that she would award tickets based on the quality of children's ideas. In truth, the number of tickets each dyad received for each planning task was pre-determined so that each child accumulated 30 tickets and earned a prize.

In total, 52 groups participated, with 46 groups including four members. Due to scheduling difficulties, we ran six groups of three children (for a total *N* of 202). In these cases, each child interacted with two partners, while the third child waited with an experimenter. Ticket totals for the planning tasks were adjusted so that children still earned prizes.

Observational coding. We videorecorded interactions without children's awareness for coding using Noldus The Observer XT version 11. Observers coded one child at a time, and different observers coded each dyad member. Coding focused on four primary emotions (Happy, Sad, Angry, Anxious), as well as a fifth Neutral category. Observers identified each child's primary emotion from these five choices for each second of each 5-minute task using the D.O.T.S. Emotion Coding System (Cole et al., 2007). Coders chose the emotion expression most representative of the child at that second based on facial expression (e.g., "smile may or may not be accompanied by crinkling around eyes"), tone of voice (e.g., "pitch becomes higher or

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louder"), and body language (e.g., "child may dance, jump, raise arms, clap hands, cheer, dance, or high-five"; all examples above serve as indicators of happiness). Coders were instructed to select the primary emotion when a child displayed blended emotions.

A graduate student previously trained in the coding system served as the trainer and gold standard for undergraduate coders, who were unaware of study hypotheses. During training, we compared observers' coding to the trainer's coding of pilot videos. We considered coders reliable against the trainer 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 (one dyad member completing one task). We further assessed coders' reliability on additional video segments by randomly pairing them with one another. We considered coders well-trained when they achieved these same criteria for five additional video segments coded against their 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 re-trained. To assess reliability on the complete 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.

Results

Data Aggregation and Descriptive Statistics

Data for each child for each 5-minute task were aggregated into 10 30-second intervals. This interval length was chosen to balance the need for shorter intervals to capture emotion transmission versus longer intervals to provide sufficient variability in emotion expression. Variables (Happy, Sad, Angry, Anxious, Neutral) were represented as the percentage of the interval that the child expressed that emotion. Descriptive statistics and task differences are displayed in Table 1. Sex, race, and ethnicity differences are displayed in Online Supplemental

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Material A.

As Table 1 suggests, many children maintained a neutral expression throughout a single interval of a single task with a single partner. However, only two children maintained a neutral expression throughout the search tasks with all three partners, and no child maintained a neutral expression throughout the planning tasks with all three partners.

Power Analysis

We conducted a power analysis using procedures and software for multilevel models (Charlton et al., 2020). We based this analysis on the model described below. Findings suggested that we had sufficient power to detect a medium effect size (d = .50) at an alpha of .05.

Multi-Level Modeling of Emotion Transmission in Peer Dyads

Primary analyses were conducted using *M*plus version 8.7 (Muthén & Muthén, 1998-2017) and used multi-level modeling, the preferred approach to evaluate emotion transmission with a limited number of repeated observations (Butler, 2011). Five models assessed relations between peers' expression of the same emotion. Each analysis included autoregressions within dyad member from one interval to the next and cross-lagged relations between dyad members from one interval to the next, allowing us to examine whether children's emotion expression in one interval predicted *change* in partners' emotion expression in the next interval. To account for the indistinguishable nature of children and their partners, we constrained autoregressions to be equal across dyad members and cross-lagged relations to be equal across child-to-partner and partner-to-child. To account for the interdependence of round-robin data (each child appears as the child and the partner in three of the six dyads per group), we further built up the model to: a) include all six dyads per group on one row with data in wide format (see Online Supplemental Material B for an illustration), b) constrain intercepts to be equal and variances to be equal for all 12 lagged variables (child's emotion and partner's emotion for all six dyads), c) set

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autoregressions and cross-lagged relations to be equal across all 6 dyads, and d) set covariances among all 12 lagged variables to 0. To account for the nested nature of the data, we used multi-level modeling with 10 intervals at level 1 and 52 groups at level 2. To compare the strength of cross-lagged relations across tasks using model constraints, we included data for both tasks in each model but set all covariances between variables across tasks to 0. We used Bayesian estimation to make the analyses less computationally demanding and to handle the large number of parameters involved (Muthén, 2010), as well as to address variable non-normality (Martin & Williams, 2017). Table 2 includes the results for the five same-emotion models.

Primary analyses also included 10 models of dyad partners' expression of different emotions (all pairs of the five emotions). These analyses mirror those described above with the following additions: a) we constrained autoregressions to be equal within but not across emotion, b) for the 24 lagged variables, we constrained intercepts to be equal within but not across emotion and variances to be equal within but not across emotion, c) we constrained cross-lagged relations to be equal within but not across direction (Emotion 1 → Emotion 2 versus Emotion 2 → Emotion 1), and d) we included a model constraint to compare the strength of the two directions of the cross-lagged relations. Table 3 includes the results for the 10 different-emotion models. Given that we examined 50 lagged relations across children in Tables 2 and 3 combined, we used a Bonferroni correction of $\alpha = .001$ to test significance of these relations.

Within Tables 2 and 3, we were primarily interested in significant cross-lagged relations, organized in Table 4. These relations are not independent, because the five emotion variables represent percentages summing to 1. For this reason, as depicted in Table 4, cross-lagged relations are best interpreted together when they have different signs and the same emotion for the first interval, but different emotions for the second interval. This pattern occurs when children express an emotion in one interval and partners increase the expression of one emotion

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while simultaneously decreasing the expression of a different emotion in the next interval.

As described in more detail in Table 4, in both tasks, evidence emerged for the escalation of both positive and negative emotion. In the search tasks, evidence emerged for the de-escalation of negative but not positive emotion. In contrast, in the planning tasks, evidence emerged for the de-escalation of positive but not negative emotion. Moreover, in the search tasks, an unexpected pattern emerged; the more children expressed happiness in one interval, the more their partners expressed anger.

Three task differences emerged for cross-lagged relations once family-wise error rate was controlled using a Bonferroni correction of $\alpha = .002$ across the 25 differences tested: a) the $\text{Angry}_i \rightarrow \text{Angry}_{i+1}$ link was positive for the search tasks but *ns* for the planning tasks, b) the $\text{Happy}_i \rightarrow \text{Angry}_{i+1}$ link was positive for the search tasks but *ns* for the planning tasks, and c) the $\text{Neutral}_i \rightarrow \text{Angry}_{i+1}$ link was negative for the search tasks but *ns* for the planning tasks. Finally, in the different-emotion models, the strength of the two directions of the cross-lagged relations did not differ for any model, once family-wise error rate was controlled using a Bonferroni correction of $\alpha = .0025$ across the 20 differences tested.

Supplemental Analyses

We also ran additional analyses included in online supplemental materials. In Online Supplemental Material C, we repeated analyses controlling for task order rather than interdependence of the round-robin design. In Online Supplemental Material D, we repeated analyses using only the last two minutes of each task, rather than the full five minutes. In Online Supplemental Material E, we repeated analyses separately for male versus female groups, and in Online Supplemental Material F, we repeated analyses separately for groups including 0-1, 2, or 3-4 CPS-referred children. In Online Supplemental Material G, we repeated analyses excluding the six groups with three rather than four participants, and in Online Supplemental Material H,

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we repeated analyses excluding the two groups that did not complete the planning tasks.

Discussion

The goal of the current study was to investigate emotion transmission amongst peers in middle childhood. Fifty-two groups typically consisting of four same-sex unfamiliar nine-year-old children interacted in dyads in a round-robin format. Each dyad completed two 5-minute tasks, consisting of a search task and a planning task. We coded each child's emotion expression during each task second by second into one of five categories (happy, sad, angry, anxious, neutral), and we calculated the percentage of time that each child expressed each emotion during each 30-second interval per task. We then used multilevel modeling to assess whether children's emotion expression in one 30-second interval predicted *change* in dyad partners' emotion expression in the next interval, across both the same and different emotions.

Primary Findings

Our primary hypothesis that peers would demonstrate emotion transmission characterized by both the escalation and de-escalation of both positive and negative emotion was supported. Evidence emerged for the escalation of both positive and negative emotion in both tasks, along with evidence of the de-escalation of negative emotion in the search tasks and de-escalation of positive emotion in the planning tasks. Using similar methods and analyses, researchers have conducted many studies of emotion transmission in parent-child dyads (e.g., Guo et al., 2015; Lindsey et al., 2009; Lougheed, 2020) and romantic-marital couples (e.g., Hilpert et al., 2020; Randall & Butler, 2013). However, to our knowledge, this study is the only the second to apply this approach to the study of emotion transmission in peers of any age. Thus, our work and the work of Normand and colleagues (2022) begins to fill a gap by providing evidence that emotion transmission spans development from the parent-infant relationship to children's peer interactions in middle childhood and eventually to adult marital or romantic relationships.

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Furthermore, both our study and Normand and colleagues' work advances extant literature under the broader umbrella of interpersonal emotion regulation by expanding observational work in this area from adolescence down the developmental ladder to middle childhood and by examining contextual differences in children's interpersonal emotion regulation.

Evidence for emotion transmission often involved the same emotion across dyad members. In both tasks, the more children expressed happiness in one interval, the more their partners expressed happiness in the next interval, suggesting the escalation of positive emotion, and countering our secondary hypothesis regarding more effects for the transmission of negative than positive emotions. Similar within-emotion evidence of the escalation of negative emotion emerged for anger and anxiety in the search tasks. However, we did not observe the transmission of sadness in either task. This null finding may be due to the greater ease with which children recognize anger compared to sadness in others, as we postulated; however, it may also be due to the especially low percentage of time that children expressed sadness during the tasks (see Table 1). The search and planning tasks may have been more happiness-inducing (when children believed that they were doing well) or anger- and anxiety-inducing (when children believed that they were doing poorly) than sadness-inducing. Future researchers of children's emotion transmission may want to use tasks explicitly designed to elicit sadness to provide adequate opportunity to investigate its transmission.

Peers also escalated negative emotion across emotions. In the planning tasks, when children expressed more sadness in one interval, their partners expressed more anxiety in the next interval. This between-emotion finding, as well as the findings for neutral emotion discussed below, suggest that emotion transmission does not just involve mimicry, or the simple imitation of a partner's behavior (Chartrand & Bargh, 1999; Wallbott, 1995). Instead, we can predict children's later emotion expression from their partner's earlier emotion expression,

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across both the same and different emotions. Emotional synchrony is likely also distinct from mimicry, even though both constructs involve the same behavior or emotion across partners; given evidence of simultaneous physiological and emotional synchrony (for reviews, see Davis et al., 2017, and Palumbo et al., 2017), synchrony likely encompasses more than simple behavioral or expressive imitation.

Children's expression of neutral emotion was important to their partner's de-escalation of both positive and negative affect. In the planning tasks, children's neutral expression was followed by decreases in partners' expression of happiness, and in the search tasks, children's neutral emotion was followed by decreases in partners' expression of anger. In contrast, and contrary to our secondary hypothesis, no evidence emerged for a pattern of emotion de-escalation in which children's expression of an earlier positive or negative emotion was followed by decreases in their partner's expression of an oppositely-valenced emotion. Thus, children's neutral emotion expression appears to be central to the de-escalation of their partner's emotion, in that it has a calming or dampening effect on both positive and negative emotion.

Importantly, as Table 1 reveals, children expressed neutral emotion during the majority of both tasks. Researchers who take a more macro-oriented approach to emotion coding may be surprised by this finding and question whether our tasks were appropriately emotion-eliciting. However, emotional expressions are typically quite fleeting (e.g., Sweeney et al., 2013), and our second-by-second coding process was designed to capture these momentary expressions. Indeed, it is noteworthy that strong evidence of children's emotion transmission with peers emerged in the context of such brief expressions of positive and negative emotion.

Interestingly, we found support for the de-escalation of negative emotion (anger) in the search tasks, but the de-escalation of positive emotion (happiness) in the planning task. This differential finding likely reflects the fact that children spent more time expressing anger in the

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search tasks and happiness in the planning tasks than vice versa, providing more opportunity for de-escalation to occur. Nonetheless, this pattern highlights the importance of context when investigating emotion transmission in peer dyads.

Although theorists emphasize the social cohesion that emerges from shared or similar emotion (Anderson et al., 2003; Preston & de Waal, 2002; Wallbott, 1995), peers' escalation of negative emotion may sometimes be maladaptive, if it results in children experiencing greater distress or emotional behavior than they can regulate. Scholars of adolescents' co-rumination concur and suggest that, although co-rumination may lead to increased intimacy between teens, it can also result in greater interpersonal stress generation and internalizing symptoms (e.g., Hankin et al., 2010; Rose et al., 2014, 2017; Stone et al., 2011). Addressing the conditions under which emotion transmission between peers is adaptive versus maladaptive represents an important direction for future research.

Finally, our study suggests that emotion transmission occurs even in dyads of unfamiliar peers, a finding which implies that familiar peers would also transmit emotion. The question that remains is whether the strength of emotion transmission differs between familiar and unfamiliar peers. Although theorists have speculated that the process is more powerful between close friends than strangers (Field, 2012; Helm et al., 2014), empirical evidence of that speculation is lacking. An exciting direction for future research would be to compare emotion transmission in familiar versus unfamiliar peers or to assess changes in emotion transmission as children become acquainted with one another.

Unexpected Finding

One finding emerged for the search tasks that surprised us: the more children expressed happiness in one interval, the more their partner expressed anger in the next interval. This pattern does not fit any of the four types of emotion transmission proposed by Butler (2011), but instead

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suggests an upward spiral from positive to negative affect. This spiral may be specific to contexts in which children experience rapid emotional highs and lows. Anecdotally, children often became quite excited during the search tasks when they momentarily believed that they had found the missing object, only to realize seconds later that they in fact had not. However, children's social interactions often involve intense mixtures of positive and negative emotion (e.g., rough-and-tumble play). For that reason, future researchers should consider exploring emotion transmission in peers in these highly-charged situations.

Task Differences

We hypothesized that stronger evidence of emotion transmission would emerge for the search tasks than the planning tasks, particularly for anger. Task differences emerged for three of 25 cross-lagged relations, with all three effects supporting this prediction (escalation of anger, de-escalation of anger, the unexpected finding that children's happiness expression predicted later increases in their partner's anger expression). Of course, these task differences should be interpreted cautiously, since task differences did not emerge for the remaining 22 cross-lagged relations, suggesting that peers' emotion transmission may largely be more similar than different across contexts. Of note, and consistent with our null findings, Normand and colleagues (2022) also failed to find task differences in peers' transmission of positive emotion in similar tasks.

Limitations and Future Directions

Like all investigations, our study was marked by limitations, beyond those described above, each suggesting directions for future research. First, we cannot know how our findings using a 9-year-old sample would compare to similar work at earlier or later developmental periods. Future investigators should include youth of different ages in their studies of emotion transmission in peers and assess change across development. Moreover, it would be fascinating to assess emotion transmission longitudinally across relationship contexts including participants'

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interactions with parents, peers, romantic partners, and finally their own children.

Second, our findings may have been impacted by sociocultural factors, especially the fact that 58% of children's parents reported their race as African American and another 16% of children's parents reported their race as Mixed. Empirical investigations suggest that emotion expression in African Americans is more accurately recognized by other African Americans than by other racial groups (see Elfenbein & Ambady, 2002 for a meta-analysis), who often mis-interpret non-angry emotion expression as anger (e.g., Halberstadt et al., 2018; Thomas et al., 2009). These results suggest that our findings regarding emotion transmission among peers may be specific to the particular sociocultural context of our sample. Future researchers should attend carefully to these sociocultural factors in their own work.

Third, although we assessed emotion through observed emotion expression, the construct is comprised of subcomponents including affective experience and psychophysiology in addition to expressive behavior. Our understanding of emotion transmission would be enhanced by studies measuring emotion across multiple channels and evaluating emotion transmission between as well as within these channels.

Fourth, whereas we assessed three types of negative emotion expression (sadness, anger, anxiety), we only assessed one type of positive emotion expression (happiness). This limitation prevented us from investigating whether children differ in their transmission of various positive emotions and whether emotion transmission occurs between as well as within positive emotions. Theory and empirical work across psychological sub-disciplines have emphasized the study of negative emotions more than positive emotions, and observational methodologists are more advanced in their ability to code children's negative emotions than their positive emotions (Stifter et al., 2020). At the same time, there has been a much-needed call for an emphasis on the study of positive emotion (Stifter et al., 2020), and we encourage future researchers of children's

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emotion transmission to assess positive emotion expression at a more differentiated level.

Fifth, we assessed emotion transmission from one 30-second interval to the next, and our findings are specific to this time scale. Of course, children likely transmitted emotions within as well as between intervals. Our analytic approach did not capture these more fine-grained transmissions, and we encourage future researchers to use even more micro-oriented techniques.

Sixth, we were unable to assess sex differences in emotion transmission, given limitations of *M*plus that prohibit multi-group modeling with lagged variables (Linda Muthén, personal communication, March 21, 2022). A 2013 meta-analysis of sex differences in children's emotion expression revealed that girls were more likely to express positive emotions such as happiness and internalizing negative emotions such as sadness and anxiety, but that boys were more likely to express externalizing negative emotions such as anger (Chaplin & Aldao, 2013). This pattern of sex differences in emotion expression suggests that boys and girls may differ in emotion transmission with their peers as well. Future researchers should address questions of emotion transmission in peers using analytic techniques that permit the evaluation of sex differences. Furthermore, we were limited by the use of a binary categorization of children's sex as either male or female; future researchers should strive to be more inclusive in the categories from which participants may choose.

Finally, beyond sex differences, our study also did not address other individual- or dyad-level characteristics that may facilitate or hinder emotion transmission in peers. Examples include individual-level child popularity or dyadic-level friendship status. These potential moderators represent an important direction for future investigators to consider.

Despite these limitations, we hope that the current study demonstrates the promise and importance of the study of emotion transmission among peers. We look forward to the exciting advances in this work that are sure to come in future years.

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Table 1
Descriptive Statistics

	Search Tasks						Planning Tasks						Task Difference
	Min	Max	*M*	*SD*	Skew	Kurt	Min	Max	*M*	*SD*	Skew	Kurt	*F*
Happy	0.00	100.00	8.20	15.43	2.98	10.59	0.00	100.00	14.24	19.67	1.91	3.67	97.12***
Sad	0.00	35.03	0.13	1.30	13.83	237.79	0.00	81.88	0.08	1.35	40.48	2209.34	2.81
Angry	0.00	76.62	1.32	4.77	6.48	59.58	0.00	58.30	0.47	2.45	10.20	146.48	55.40***
Anxious	0.00	100.00	1.02	5.19	9.21	112.81	0.00	100.00	0.83	4.99	10.71	145.82	1.77
Neutral	0.00	100.00	89.11	17.56	-2.46	6.94	0.00	100.00	83.85	21.11	-1.81	3.22	59.50***

Note: N = 6060 (202 children x 3 partners x 10 intervals); Min = minimum; Max = maximum; Kurt = kurtosis; *** $p < .001$

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Table 2

Multi-Level Models of Cross-Lagged Relations Across Dyad Members Within Same Emotion

	Search Tasks		Planning Tasks		Task Differences	
	Estimate	Posterior SD	Estimate	Posterior SD	Estimate	Posterior SD
Auto-Regressions Within Child						
$Happy_i \rightarrow Happy_{i+1}$	0.55***	0.01	0.53***	0.01		
$Sad_i \rightarrow Sad_{i+1}$	0.19***	0.01	0.15***	0.01		
$Angry_i \rightarrow Angry_{i+1}$	0.32***	0.01	0.13***	0.01		
$Anxious_i \rightarrow Anxious_{i+1}$	0.45***	0.01	0.40***	0.01		
$Neutral_i \rightarrow Neutral_{i+1}$	0.56***	0.01	0.54***	0.01		
Lagged Relations Across Children						
$Happy_i \rightarrow Happy_{i+1}$	**0.04*** **	0.01	**0.06*** **	0.01	-0.03	0.02
$Sad_i \rightarrow Sad_{i+1}$	0.01	0.01	-0.01	0.01	0.02	0.02
$Angry_i \rightarrow Angry_{i+1}$	**0.08*** **	0.01	0.02	0.01	**0.06*** **	0.02
$Anxious_i \rightarrow Anxious_{i+1}$	**0.06*** **	0.01	0.03*	0.01	0.03*	0.02
$Neutral_i \rightarrow Neutral_{i+1}$	**0.06*** **	0.01	**0.07*** **	0.01	-0.01	0.02
Intercepts						
Happy	2.94***	0.21	2.59***	0.26		
Sad	0.11***	0.02	0.07***	0.02		
Angry	0.81***	00.07	0.41***	0.03		
Anxious	0.55***	.07	0.50***	0.06		
Neutral	34.61***	1.25	32.94***	1.03		
Residual Variances						
Happy	152.83***	2.59	265.28***	5.33		
Sad	1.64***	0.03	1.79***	0.04		
Angry	20.39***	0.35	5.90***	0.12		
Anxious	22.17***	0.38	20.88***	0.41		
Neutral	201.17***	3.61	299.48***	5.81		

Note: This table represents five different models with one model per emotion. Estimates are unstandardized. Lagged relations across children are bolded if they are less than the Bonferroni-corrected α of .001. Task differences are bolded if they are less than the Bonferroni-corrected α of .002. *i = interval.* * $p < .05$; ** $p < .01$; *** $p < .001$.

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Table 3

Multi-Level Models of Cross-Lagged Relations Across Dyad Members Across Different Emotions

	Model for Happy and Sad									
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Happy_i \rightarrow Happy_{i+1}$	0.56***	0.01			0.55***	0.01				
$Sad_i \rightarrow Sad_{i+1}$	0.19***	0.01			0.15***	0.01				
Lagged Relations Across Children			-0.26*	0.15			-0.06	0.15		
$Happy_i \rightarrow Sad_{i+1}$	0.00	0.00			0.00	0.00			0.00	0.00
$Sad_i \rightarrow Happy_{i+1}$	-0.26*	0.15			-0.06	0.15			-0.20	0.20
Intercepts										
Happy	3.20***	0.17			6.12***	0.26				
Sad	0.12***	0.02			0.09***	0.02				
Residual Variances										
Happy	152.65***	3.05			266.97***	4.70				
Sad	1.64***	0.03			1.79***	0.03				
	Model for Happy and Angry									
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Happy_i \rightarrow Happy_{i+1}$	0.56***	0.01			0.55***	0.01				
$Angry_i \rightarrow Angry_{i+1}$	0.32***	0.01			0.13***	0.01				
Lagged Relations Across Children			0.05	0.04			0.11	0.09		
$Happy_i \rightarrow Angry_{i+1}$	**0.01***	0.00			0.00	0.00			**0.01***	0.00
$Angry_i \rightarrow Happy_{i+1}$	0.06*	0.04			0.11	0.09			-0.05	0.10
Intercepts										
Happy	3.11***	0.18			6.08***	0.26				
Angry	0.79***	0.07			0.41***	0.04				
Residual Variances										
Happy	152.79***	3.06			267.01***	4.68				
Angry	20.52***	0.35			5.90***	0.11				

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Model for Happy and Anxious										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Happy_i \rightarrow Happy_{i+1}$	0.56***	0.01			0.55***	0.01				
$Anxious_i \rightarrow Anxious_{i+1}$	0.45***	0.01			0.40***	0.01				
Lagged Relations Across Children			0.01	0.04			0.01	0.04		
$Happy_i \rightarrow Anxious_{i+1}$	0.00	0.00			0.00	0.00			0.00	0.00
$Anxious_i \rightarrow Happy_{i+1}$	0.01	0.04			0.00	0.04			0.01	0.05
Intercepts										
Happy	3.17***	0.18			6.12***	0.26				
Anxious	0.58***	0.07			0.54***	0.07				
Residual Variances										
Happy	152.78***	3.05			267.04***	4.68				
Anxious	22.30***	0.39			20.85***	0.40				
Model for Happy and Neutral										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Happy_i \rightarrow Happy_{i+1}$	0.55***	0.01			0.54***	0.01				
$Neutral_i \rightarrow Neutral_{i+1}$	0.57***	0.01			0.55***	0.01				
Lagged Relations Across Children			0.01	0.02			0.00	0.02		
$Happy_i \rightarrow Neutral_{i+1}$	**-0.03*****	0.01			**-0.04*****	0.01			0.01	0.02
$Neutral_i \rightarrow Happy_{i+1}$	-0.02**	0.01			**-0.04*****	0.01			0.02	0.01
Intercepts										
Happy	5.02***	0.84			9.75***	0.99				
Neutral	38.84***	0.97			38.31***	1.04				
Residual Variances										
Happy	153.57***	3.00			267.36***	4.96				
Neutral	202.76***	3.46			301.63***	5.74				

Accepted Manuscript
Version of record at: https://doi.org/10.1111/cdev.13917

Model for Sad and Angry										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Sad_i \rightarrow Sad_{i+1}$	0.19***	0.02			0.15***	0.01				
$Angry_i \rightarrow Angry_{i+1}$	0.32***	0.01			0.13***	0.01				
Lagged Relations Across Children			-0.03	0.05			-0.04	0.03		
$Sad_i \rightarrow Angry_{i+1}$	0.02	0.05			0.04	0.02			-0.02	0.05
$Angry_i \rightarrow Sad_{i+1}$	0.00	0.00			0.00	0.01			0.00	0.01
Intercepts										
Sad	0.12***	0.02			0.07***	0.02				
Angry	0.89***	0.06			0.41***	0.03				
Residual Variances										
Sad	1.64***	0.03			1.79***	0.03				
Angry	20.56***	0.35			5.89***	0.11				
Model for Sad and Anxious										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Sad_i \rightarrow Sad_{i+1}$	0.19***	0.02			0.15***	0.01				
$Anxious_i \rightarrow Anxious_{i+1}$	0.45***	0.01			0.40***	0.01				
Lagged Relations Across Children			-0.02	0.05			-0.10**	0.05		
$Sad_i \rightarrow Anxious_{i+1}$	0.02	0.05			**0.11****	0.05			-0.08	0.06
$Anxious_i \rightarrow Sad_{i+1}$	0.01	0.00			0.01*	0.00			0.00	0.01
Intercepts										
Sad	0.11***	0.02			0.07***	0.02				
Anxious	0.59***	0.06			0.51***	0.06				
Residual Variances										
Sad	1.64***	0.03			1.79***	0.03				
Anxious	22.30***	0.39			20.84***	0.40				

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Model for Sad and Neutral										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Sad_i \rightarrow Sad_{i+1}$	0.19***	0.02			0.15***	0.01				
$Neutral_i \rightarrow Neutral_{i+1}$	0.58***	0.01			0.57***	0.01				
Lagged Relations Across Children			-0.26*	0.15			0.02	0.18		
$Sad_i \rightarrow Neutral_{i+1}$	0.26*	0.15			-0.02	0.18			0.28	0.23
$Neutral_i \rightarrow Sad_{i+1}$	0.00	0.00			0.00	0.00			0.00	0.00
Intercepts										
Sad	0.06	0.07			0.01	0.07				
Neutral	37.71***	0.90			36.41***	0.92				
Residual Variances										
Sad	1.64***	0.03			1.79***	0.03				
Neutral	201.53***	3.46			300.63***	5.71				
Model for Angry and Anxious										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Angry_i \rightarrow Angry_{i+1}$	0.32***	0.01			0.13***	0.01				
$Anxious_i \rightarrow Anxious_{i+1}$	0.45***	0.01			0.40***	0.01				
Lagged Relations Across Children			-0.01	0.02			-0.02	0.03		
$Angry_i \rightarrow Anxious_{i+1}$	0.02*	0.01			0.02	0.03			0.01	0.03
$Anxious_i \rightarrow Angry_{i+1}$	0.02	0.01			0.00	0.01			0.02	0.01
Intercepts										
Angry	0.90***	0.06			0.41***	0.03				
Anxious	0.56***	0.06			0.51***	0.06				
Residual Variances										
Angry	20.56***	0.40			5.91***	0.10				
Anxious	22.29***	0.39			20.86***	0.40				

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Model for Angry and Neutral										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Angry_i$ → $Angry_{i+1}$	0.32***	0.01			0.13***	0.02				
$Neutral_i$ → $Neutral_{i+1}$	0.58***	0.01			0.57***	0.01				
Lagged Relations Across Children			0.10**	0.04			0.18*	0.11		
$Angry_i$ → $Neutral_{i+1}$	**-0.12*** **	0.04			-0.18*	0.11			0.07	0.11
$Neutral_i$ → $Angry_{i+1}$	**-0.02*** **	0.00			0.00	0.00			**-0.02*** **	0.00
Intercepts										
Angry	2.39***	0.28			0.44***	0.13				
Neutral	38.16***	0.90			36.57***	0.92				
Residual Variances										
Angry	20.51***	0.39			5.91***	0.10				
Neutral	201.54***	3.46			300.45***	5.71				
Model for Anxious and Neutral										
	Search Tasks		Lagged Relations Diff. for Search Tasks		Planning Tasks		Lagged Relations Diff. for Planning Tasks		Task Difference	
	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD	Estimate	SD
Auto-Regressions Within Child										
$Anxious_i$ → $Anxious_{i+1}$	0.45***	0.01			0.40***	0.01				
$Neutral_i$ → $Neutral_{i+1}$	0.58***	0.01			0.57***	0.01				
Lagged Relations Across Children			0.06	0.04			0.00	0.05		
$Anxious_i$ → $Neutral_{i+1}$	-0.06*	0.04			0.00	0.05			-0.06	0.06
$Neutral_i$ → $Anxious_{i+1}$	-0.01*	0.00			0.00	0.00			-0.01	0.00
Intercepts										
Anxious	1.18***	0.29			0.55***	0.23				
Neutral	37.86***	0.90			36.44***	0.92				
Residual Variances										
Anxious	22.28***	0.42			20.94***	0.37				
Neutral	201.62***	3.46			300.65***	5.71				

Note: Estimates are unstandardized. Lagged relations across children are bolded if they are less than the Bonferroni-corrected α of .001. Lagged relations differences are bolded if they are less than the Bonferroni-corrected α of .0025. Task differences are bolded if they are less than the Bonferroni-corrected α of .002. SD = posterior standard deviation; Diff. = Difference; *i* = *interval.*
* $p < .05$; ** $p < .01$; *** $p < .001$.

Accepted Manuscript
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Table 4

Interpretation of Cross-Lagged Relations in Multi-level Models of Emotion Transmission in Peer Dyads

	Search Tasks		
	Cross-Lagged Relations	Direction	Interpretation
Escalation of Positive Emotion	$Happy_i \rightarrow Happy_{i+1}$	+	The more happiness a child expresses in one interval, the more happiness and the less neutral emotion their partner expresses in the next interval
	$Happy_i \rightarrow Neutral_{i+1}$	-	
Escalation of Negative Emotion	$Angry_i \rightarrow Angry_{i+1}$	+	The more anger a child expresses in one interval, the more anger and the less neutral emotion their partner expresses in the next interval
	$Angry_i \rightarrow Neutral_{i+1}$	-	
	$Anxious_i \rightarrow Anxious_{i+1}$	+	The more anxiety a child expresses in one interval, the more anxiety their partner expresses in the next interval
De-Escalation of Negative Emotion	$Neutral_i \rightarrow Angry_{i+1}$	-	The more neutral emotion a child expresses in one interval, the less anger and the more neutral emotion their partner expresses in the next interval
	$Neutral_i \rightarrow Neutral_{i+1}$	+	
Unexpected Findings	$Happy_i \rightarrow Angry_{i+1}$	+	The more happiness a child expresses in one interval, the more anger and the less neutral emotion their partner expresses in the next interval
	$Happy_i \rightarrow Neutral_{i+1}$	-	

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Planning Tasks			
	Cross-Lagged Relations	Direction	Interpretation
Escalation of Positive Emotion	$Happy_i \rightarrow Happy_{i+1}$	+	The more happiness a child expresses in one interval, the more happiness and the less neutral emotion their partner expresses in the next interval
	$Happy_i \rightarrow Neutral_{i+1}$	-	
Escalation of Negative Emotion	$Sad_i \rightarrow Anxious_{i+1}$	+	The more sadness a child expresses in one interval, the more anxiety their partner expresses in the next interval
De-Escalation of Positive Emotion	$Neutral_i \rightarrow Happy_{i+1}$	-	The more neutral emotion a child expresses in one interval, the less happiness and the more neutral emotion their partner expresses in the next interval
	$Neutral_i \rightarrow Neutral_{i+1}$	+	

Note: This table only includes lagged relations across children below the Bonferroni-corrected α of .001.