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UNDERSTANDING THE ASSOCIATIONS BETWEEN PARENT-CHILD COREGULATION PATTERNS AND CHILD SELF-REGULATION

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ABSTRACT

Biobehavioral coregulation is the process by which parents and their children regulate one another through their goal-oriented behavior, affect, and physiology, thought to support children's burgeoning regulatory capacities. Recent findings suggest that particular coregulation patterns – dyadic affective flexibility and positive behavioral contingency - appear beneficial in early childhood and are associated with having fewer behavioral problems. However, it is not yet clear whether and how parent-child biobehavioral coregulation supports other aspects of self-regulation in the child. The present study used path analyses to examine whether these coregulation patterns predicted behavioral, emotional, and temperament-based components of preschoolers' self-regulation. We also investigated the relative contributions of affective and behavioral coregulation patterns in predicting children's individual regulatory capacities in light of each other. Our findings suggest that flexible parent-child affective exchanges, as long as the interaction content is primarily positive, support various aspects of children's self-regulation in early childhood. On the other hand, flexible affective exchanges and predictable behavioral exchanges present as a risk factor for children's regulatory abilities in the context of more negative interaction content. The present findings also point to the potential importance of investigating cross-domain relations between coregulatory patterns and children's regulatory capacities, given that affective coregulation was associated with children's behavioral self-regulation and behavioral coregulation was associated with children's emotional self-regulation. Discussion centers on the importance of considering process, content, and domain in studies examining parent-child biobehavioral coregulation as a mechanism of child regulatory development.

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Introduction

Throughout early childhood, preschoolers are asked to manage their emotions and behaviors appropriately to respond to the bids of their caregivers and teachers. Self-regulation is a broad term used to describe such self-management in response to situational demands; it encompasses the processes that modulate an individual's constitutional responses to changes occurring within the internal or external environment (Kopp, 1982; Rothbart, Sheese, Rueda, & Posner, 2011). Studies demonstrate that various behavioral, affective, and cognitive skills emerge in children during the preschool period that support the growth of their regulatory capacities (Bronson, 2000; Calkins, 2007). These capacities lie at the heart of improving children's cognitive skills, academic success, and school readiness (Blair & Diamond, 2008; Blair & Raver, 2015; Raver et al., 2011). Additionally, they protect children from adverse psychological outcomes (e.g., Wang, Chassin, Eisenberg, & Spinrad, 2015; Nigg, Silk, Stavro, & Miller, 2005) and promote better socio-emotional functioning across the lifespan (Calkins, Graziano, & Keane, 2007; Diamond & Aspinwall, 2003). Because self-regulation skills seem to underlie individual differences in important competencies for young children and plays a significant role in shaping their long-term outcomes, the study of its development in preschoolers could help us better understand its etiology and identify its primary influences.

The parent-child relationship could provide one explanation for the variability in the developmental trajectories of self-regulation in preschoolers. Apart from spending a few hours in a daycare or preschool environment, young children pass the majority of their time with their caregivers who model and scaffold how they regulate themselves and interact with the world. Preschoolers are susceptible to the influences of their context, and the parent-child relationship exerts strong adaptive or maladaptive influences on the development of their regulatory skills

(Campbell, 1995; Shaw et al., 1998). Researchers suggest that in the course of interacting with one another in relationship, children and their caregivers regulate and shape one another (Sameroff, 2010). *Biobehavioral coregulation* is the moment-to-moment attunement of goal-oriented behaviors, physiology, and affect between a parent and child that allows each member of the dyad to regulate the other during their interaction; such coordination in real time can develop into dyadic coregulation patterns over time (Lunkenheimer et al., 2015). This process of coregulation begins primarily with extensive parental involvement as caregivers respond to their infant's physical, physiological, and emotional needs and provide the external regulation needed for them to survive. Over time, children's motor skills, language abilities, cognitive skills, and emotional and behavioral capacities evolve, and they begin to regulate their caregivers as much as their caregivers are externally regulating them. Therefore, through their interactions with one another, the dyad organizes itself into coregulation patterns that shape the development of both parent and child (Sameroff, 1990).

From infancy through early childhood, parents play an important role in establishing behavioral and affective patterns with their children that help the children regulate themselves and eventually internalize these patterns for themselves (Feldman, 2007). For example, the rhythmic patterns between mothers' touch behaviors and social attention in response to their infants' crying, nursing, or sucking behaviors serve to externally regulate the child's emotional and physiological arousal (Feldman, 2007). Over time, the co-occurrence and predictable sequence of parental responsivity in connection with the infant's behaviors teaches the child how to share in the mothers' vocalizations and body movements until the child learns how to soothe himself or herself (Feldman, 2007). This work indicates that improving our understanding of parent-child coregulation patterns could shed light on the development of children's outcomes.

In particular, the present study aims to investigate the relation between two coregulation patterns shown to be adaptive for children - dyadic affective flexibility and positive behavioral contingency – and their association with children's various self-regulation abilities. This study could provide greater insight into the individual differences observed in preschoolers' regulatory capacities in early childhood.

Role of the Parent-Child Relationship

A large body of literature investigating how environmental factors shape self-regulation focuses upon the role of the parent-child relationship in child development. An important contribution from Freud's psychoanalytic theory is the idea that early experiences have a lasting effect on personality and that childhood shapes the emerging adult (Freud, 1940/1964). More specifically, Freud posited that a caregiver has a large role in shaping a child. He emphasized that development proceeds from conflicts stemming from emotional relationships with parents, and that through the caregiver-child relationship, infants are able to construct representations about significant others (Freud, 1940/1964). Bowlby's (1969) attachment theory builds off these assumptions by suggesting that through the infant-parent relationship, infants create internal working models of themselves, a significant adult, and their interactions. These mental representations involve assumptions about and expectations for how responsive significant others are and also how children can interpret the behaviors of others. If infants experience predictable and responsive caregiving, they become securely attached to their caregivers. Bowlby (1969) argued that insecurity in the attachment relationship causes children to be concerned about the dynamics of the relationship, leading them to monitor the availability, responsiveness, and resources of their caregivers. On the other hand, when children are securely attached to their caregivers, they can instead attend to other aspects of their environments. They use the parent as a secure base in order to explore their environment and develop their own sense of autonomy. Taken together from a broad perspective, these theories posit that the quality of the caregiving experience shapes children's development.

Researchers studying children's regulatory abilities delve more deeply into the parent-child relationship and posit that interactions between parent and child provide an important context for children to learn how to regulate their cognitions, emotions, and behaviors. Socio-cultural theorists argue that the history of the parent-child relationship and the context of parent-child interactions could shed light on children's development. Vygotsky (1978) defined the *zone of proximal development* as the distance between the developmental level a child could reach from problem-solving on their own and their capacities acquired under the guidance of a capable adult such as a caregiver. He used a child-in-activity-in-context perspective to suggest that parent's scaffolding and guiding behaviors in particular tasks improves children's competence in that area (Vygotsky, 1978). For example, parents often teach children a skill through guided practice using prompts, clues, modeling behaviors, leading questions, joint participation, encouragement, and regulating the child's attention (Vygotsky, 1978). Social learning theory (Bandura, 1969; 1977) complements these ideas by suggesting that children are socialized into a society through parental modeling behaviors and children's observational learning and social referencing. For example, parents who are responsive to children's cues could model for them how to regulate emotions and repair mismatched affective states; children could learn how to regulate their emotions through social referencing and practicing these skills through the course of the interaction.

Many studies drawing from these various theoretical perspectives have examined whether positive parenting behaviors and positive interactions between parent and child promote the development of better self-regulation in children. A meta-analysis conducted by Karreman, van Tuijl, van Aken, and Deković (2006) demonstrated no overall relation between maternal responsiveness and children's self-regulation when aggregating findings across 41 studies. However, in the paper, the authors acknowledged that many of these studies only included community samples for which the restricted variation in responsiveness might undermine the relation with self-regulation. Additionally, they suggested that forms of "good-enough" parenting might have been labeled as parental responsiveness in some of these studies, decreasing the reported correlations between parenting and child outcomes.

Other studies suggest that positive parenting is related to better self-regulation in kids. Several studies show a positive relation between maternal warmth or sensitivity and young children's self-regulation (e.g., Eiden, Colder, Edwards, & Leonard, 2009; von Suchodoletz, Trommsdorff, & Heikamp, 2011), particularly if the child has a temperament high in negative affectivity (Thomas, Letourneau, Campbell, Tomfohr-Madsen, & Giesbrecht, 2017). Consistent, responsive caregiving characterizing secure attachments promotes better emotion regulation (Cassidy, 1994), better task orientation (Vondra, Shaw, Swearingen, Cohen, & Owens, 2001), better delay of gratification (Gilliom, Shaw, Beck, Schonberg, & Lukon, 2002), and less stress reactivity (Bernard & Dozier, 2010), whereas inconsistent responding is related to greater dysregulation (Schore, 2001). Secure attachments are associated with more expression of positive emotions (Sroufe, 2005). On the other hand, more insecure children may experience greater demands and opportunities for controlling their emotions (Kochanska, 2001).

Mixed findings also exist in the literature for the relation between parent control and children's regulatory capacities. On one hand, harsh and rigid parenting is related to poor inhibitory control (Moilanen, Shaw, Dishion, Gardner, & Wilson, 2009), altered physiological regulation (Skowron, Cipriano-Essel, Benjamin, Pincus, & Van Ryzin, 2013), less autonomous self-regulated behavior (Maughan & Cicchetti, 2002), and greater levels of externalizing behaviors (Scaramella, Neppl, Ontai, & Conger, 2008). While some studies suggest that greater control is related to positive development of child self-regulation (e.g., Feldman & Klein, 2003; Feldman, Greenbaum, & Yirmiya, 1999), other studies demonstrate a negative relation (Kochanksa & Knaack, 2003; Stansbury & Zimmermann, 1999). The meta-analysis by Karreman and colleagues (2006) attempted to address this by distinguishing between positive and negative control in predicting child self-regulation. Positive control involving guiding and directing the child, using limit-setting, and demonstrating mild to moderate power-assertion was associated with better behavioral compliance. On the other hand, negative control involving coercion, criticism, hostility, and power-assertion was related to lower levels of compliance. They found no relations between parenting and either inhibitory control or emotion regulation.

These findings reflect great variation in characteristics of parenting practices and their influence on different aspects of children's self-regulation. Taken together, some of the literature seems to have coalesced around the importance of supportive and attentive caregiving in promoting children's regulatory abilities, but there are still inconclusive relations yet to be explored (Grolnick & Farkas, 2002; Grolnick & Ryan, 1989). While researchers have emphasized the importance of positive interactions between parent and child, the designs of many of these studies have used overall descriptions of parenting or broad qualitative characterizations of an observed interaction to describe the influence of parenting on child outcomes. Therefore, they do not typically provide us with an explanation for the actual *process* by which dynamic parent-child interactions influence child development. Given that young children interact with their parents daily, exploring the dynamic moment-to-moment patterns making up their interactions could be critical for gaining a more nuanced understanding of *how* the parent-child relationship is actually contributing to the development of preschoolers' self-regulation. Examining how parents and children interact together in real time could inform interpretation of the mixed findings in the literature. In particular, researchers have suggested that the behavioral and affective patterns making up biobehavioral coregulation between parent and child could ultimately shape the development of children's self-regulation capacities. This hypothesis is grounded in dynamic systems theory.

Dynamic Systems Theory and Parent-Child Coregulation

Dynamic systems are made of many heterogeneous components that are continuously interacting with each other and that assemble and self-organize into more complex, coherent patterns (Thelen & Smith, 1998). Each child can be considered a system that is made up of multiple parts like neural architecture and motor faculties. As a child interacts with the environment, her components interact with the elements of her surroundings, and both shape each other and mold the larger system as a whole. For example, a young girl told she cannot eat the marshmallow placed in front of her might use the colored posters on the laboratory wall to distract herself from taking a bite, a strategy she has learned and used previously to avoid an impulse. Just as she might be attending differently to the room to refrain from thinking about the temptation, the richness of the environment may give her an opportunity to enact this strategy. Development therefore proceeds as a series of patterns that emerge and dissolve over time based on this reciprocal transaction with the environment (Thelen & Smith, 1998). These patterns appear spontaneously without explicit instruction, as a function of naturally occurring and repeated behaviors that serve a function for the system (Lunkenheimer & Dishion, 2009).

Positive feedback stimulates reorganization and the emergence of a new pattern within the system in response to changes in the environment, whereas negative feedback dampens the system's response and promotes stability (Granic, Dishion, & Hollenstein, 2003). A young child trying to garner attention in a preschool classroom might realize that interrupting story time to tell a joke makes the rest of the class laugh. This response from the environment provides positive feedback that could encourage him to continue disrupting the class. However, if the other children become upset or frustrated, this unwanted consequence might dampen the system and prevent him from engaging in such behaviors. Within and across time, recurrent stable patterns emerge, predictable "attractor" states to which the system is drawn away from other potential states (Granic, Dishion, & Hollenstein, 2003). If the child's classmates repeatedly laugh every time he interrupts his teacher, this desired positive attention could reinforce his behavior and increase the likelihood that he predictably disrupts story time. Attractors remain resistant to small changes in the environment; over time, less energy in the system is needed to activate them and a large amount of energy is required to disrupt them (Granic, 2000). In the case of the child, if a pattern has emerged, very few cues would be needed to elicit his dysregulated behavior and stronger external feedback would be necessary to alter his behavior.

A close relationship can also be considered a dynamic system, and the same principles can be used to examine the structure and organization of a dyad's interactions. A parent and child can self-organize into dyadic attractor states as both parent and child find themselves moving to predictable and reinforced behavioral or affective attractors (Granic, Dishion, & Hollenstein, 2003; Lunkenheimer & Dishion, 2009). Additionally, in the course of interaction, parent and child could engage in sequences made up of these dyadic attractor states; these sequences, or behavioral and affective patterns, could also become attractors for the dyad. For example, whenever a parent asks his child to clean up her toys, the child may throw a tantrum and refuse to comply. The parent may then scold the child. Over time, the dyad may follow this predictable series of contingent behaviors during any interaction involving the child stopping play to clean up, and they both may consistently find themselves in a mutual state of negative affect; this behavioral sequence and dyadic affective state become the attractors for this type of interaction. It is important to note that each component of a system has its own degree of stability; therefore, some individual components and dyadic components are more easily modifiable in response to changes in the environment than others (Thelen & Smith, 1998). In the interaction just described, the child's tendency to throw a tantrum and become visibly upset may currently be stable because of her limited emotion regulation capacities. However, the parenting strategy her dad uses to elicit compliance and calm his child down might be more modifiable, even if his own affect remains stable.

The characteristics described of open, dynamic systems provide us with a clarified explanation for the course of child development through the parent-child relationship. Just as open systems draw information from the surrounding environment to improve their own self-organization, children develop through recursive feedback from social interactions with their parents, and their characteristics and skills are reinforced through predictable patterns or attractors (Lunkenheimer & Dishion, 2009). Dynamic systems theory also emphasizes that the characteristics and skills of each member of the dyad continuously interact with the system at-large to mold and shape it as well (Thelen & Smith, 1998). From this perspective, we can expect that children's self-regulatory skills are molded through their predictable dynamic interactions with their parents, and reciprocally, their own characteristics over time continuously shape the attractor states of the dyad.

Theorists have suggested that the dynamic interaction patterns between parent and child may serve a coregulatory function necessary for the development of children's individual regulatory capacities. Over the course of interactions, parents and children regulate each other through their behaviors, physiology, and affect in real-time. Tronick's mutual regulation model (Tronick & Beeghly, 2011) posits that the development of self-regulation in a child is scaffolded through these *repeated* interactions with a caregiver who is responsive and sensitive to the child's needs. The process of repair following mismatched biobehavioral states unconsciously teaches infants that their needs will be met by a responsive caregiver, the framework needed for reciprocal regulatory transactions, or coregulation. For example, a toddler may be happily playing with his parent when he encounters a box containing a toy that he cannot open easily. When he becomes frustrated, his parent might take the time to help him open the box, repairing his negative affect. If his moments of frustration with an obstacle are consistently met with a helpful response from his parent, he may learn that he can reliably ask his parent for help rather than becoming frustrated, building his sense of autonomy in the relationship as well as his own emotion regulation capacities.

Sameroff's (2010) transactional regulation model goes one step further to suggest that *continuous dynamic interactions* with a social context are essential for the development of regulatory skills. Parents and caregivers provide regulation for young children and scaffold their learning and practice of self-regulation; their transactions over time enable children to engage in *increasingly complex* social, emotional, and cognitive experiences with greater regulatory demands (Sameroff, 2010). Dynamic systems theory would suggest that over time, dyadic patterns emerge that allow the child to move from external sources of regulation toward internal processes of self-regulation (Bernier, Carlson, & Whipple, 2010; Sameroff, 2010). From learning how to regulate physiological needs like hunger and biological experiences like arousal in infancy, young children eventually learn how to regulate their own attention, behavior, emotions, and social interactions (Sameroff, 2010). Therefore, interaction patterns provide a framework for transactional regulation that shapes the development of children's own regulatory capacities. In turn, children's individual skills may mold and shape processes of transactional regulation and impact their caregivers. This theoretical account for the development of regulatory capacities in children provides us with a mechanism by which children are shaped through their interactions with their caregivers. However, very few studies have been conducted examining whether observed behavioral and affective coregulatory patterns between parents and their children actually do impact regulatory outcomes in early childhood.

Behavioral Coregulation and Patterns of Contingency

Behavioral coregulation is the moment-to-moment attunement of goal-oriented behaviors between a parent and child that serve to regulate one another during an interaction; over time, the dyad can fall into predictable sequences of these behaviors, or coregulation patterns (Lunkenheimer & Dishion, 2009; Lunkenheimer, Kemp, Lucas-Thompson, Cole, & Albrecht, 2017). Patterns of contingency are a form of behavioral coregulation and involve a predictable and consistent pairing of parent and child behaviors during the course of an interaction. Dynamic systems theory suggests that the greater the repetition in the coupling of behaviors between parent and child, the higher the likelihood that this pattern induces stability in the skill the child is attempting to develop (Thelen & Smith, 1998). In other words, consistent responding within the dyad is likely to influence dyadic regulatory processes and foster the development of children's self-regulation capacities.

Researchers examining behavioral coregulation have used terms like *mutual responsivity*, *mutual reciprocity*, and *mutual cooperation* to reflect a parent-child relationship in which each member of the dyad is attending to and responding to the needs of the other, or regulating one another, in a generally positive way. Behavioral contingencies involving mutual responsiveness between parents and children have been shown to help children develop their social skills and emotion regulation and to encourage the exploration of their surrounding environment, all of which are key processes in the development of cognitive abilities and executive functioning (Harrist & Waugh, 2002). The importance of behavioral contingencies involving mutual responsiveness between parent and child for better self-regulation in children has been verified in much of the literature (Criss, Shaw, & Ingoldsby, 2003; Deater-Deckard & Petrill, 2004; Kochanska, Aksan, Prisco, & Adams, 2008; Kochanska & Kim, 2014; Laible & Thompson, 2000; Mize & Pettit, 1997). Feldman (2015) even found that greater reciprocity between parent and child during observed interactions was related to higher child emotion regulation abilities and vice versa over the course of the first ten years of a child's life. This relation mediated the difference in the child's own physiological regulation across those ten years. Taken together, this body of work suggests that when parents and children respond appropriately to one another's cues in positive exchanges, their behavioral coregulation is related to better cognitive, emotional, and behavioral regulation in children.

Parents' contingent responding to children's behavior leads to predictability in the parent-child relationship and gives children a greater sense of control and mastery over their interpersonal interactions (Ladd & Kochenderfer Ladd, 1998). This creates the framework that allows children to actively engage in and shape these behavioral coregulatory patterns, and increases the probability of these patterns molding the development of their own individual capacities. For example, children are often asked to do something they may not want to by a caregiver, like switching from play time to cleaning up the toys. Over the course of many interactions, a child may learn he has a role in eliciting either positive parenting behaviors or negative behaviors depending on the choices he makes with regard to his parent's bid. He may learn that his parent will reward compliance with verbal praise and compliments or respond to noncompliance and behavioral dysregulation with punishment. Therefore, his own intent and behaviors shape the course of the dyadic interaction and the opportunities the interaction presents reinforces his learning and development. Repeated choices to comply may be rewarded and reinforced, forging stronger abilities in the child to regulate emotions and behavior. On the other hand, recurring non-compliance may lead to increasingly negative disciplinary action on behalf of the parent which is associated with internalizing and externalizing behaviors in the child.

In a number of the studies examining mutual responsiveness, parent-child interactions have been coded for elements of positive synchrony or mutuality (e.g., manifestations of shared affect, coordination of behaviors, cooperation, responsivity) and these have been measured using scales or composites indicating the degree to which these behaviors are present (Criss, Shaw, & Ingoldsby, 2003; Kochanksa, Aksan, Prisco, & Adams, 2008). This body of work informs the literature by presenting evidence that parents' and children's behavior do organize around observable patterns, and it highlights that mutually-responsive positive behavior is related to child outcomes. However, though this work emphasizes that positive mutually responsive exchanges promote children's regulatory outcomes, it does not tell us about *how* or *why* parent-child interactions are affecting children's development. Nevertheless, studies that utilize moment-to-moment pairings of behaviors provide us with more fine-grained detail about *how* members of the dyad are responding to each other and moving together in real time. In other words, they offer us more information about the developmental process by which interactions shape children.

Very few studies have actually assessed how parent-child behavioral contingency patterns coded in real-time are associated with children's regulatory outcomes (e.g., Putnam, Spritz, & Stifter, 2002; Tarabulsy, Tessier, & Kappas, 1996). A strong contingency between maternal directives or teaching statements and child compliance is related to fewer internalizing and externalizing behaviors in the child (Lunkenheimer, Kemp, & Albrecht, 2013). Meanwhile, the contingency between coercive and controlling parental behaviors with non-compliance is associated with greater distress in the child (Scaramella, Neppl, Ontai, & Conger, 2008) and more behavioral dysregulation (Dumas, LaFreniere, & Serketich, 1995; Dumas, Lemay, & Dauwalder, 2001). For these studies, the real-time modeling of parents and children responding to each other shows us how the predictable pairing of specific behaviors may be related to particular outcomes in the child. This level of specificity affords us the opportunity to understand how particular behavioral contingencies over time induce stability in children's skills and provide a clearer developmental *process* for child development than overall descriptions of parent-child interactions.

In the literature, autonomy-supportive parenting behaviors are related to stronger concurrent task persistence in children (Landry, Smith, Swank, & Miller-Loncar, 2000) and are associated with better child self-regulation skills (e.g., Supplee, Shaw, Hailstones, & Hartman, 2004). However, only one study could be found investigating the contingency between autonomy-supportive behaviors and child autonomy from a moment-to-moment perspective (Lunkenheimer, Ram, Skowron, & Yin, 2017). The findings from Lunkenheimer, Ram, Skowron, and Yin (2017) indicated that when mothers responded to their children's autonomous behavior with autonomy-supportive parenting, this behavioral pairing was related to less internalizing and externalizing behaviors in the child over time. While the overall amount of positive behaviors was not uniquely related to this reduction in emotional and behavioral dysregulation, the positive behavioral contingency pattern was (Lunkenheimer, Ram, Skowron, & Yin, 2017). This dyadic behavioral pattern was a stronger predictor of child outcomes than individual parent or child characteristics. The pairing between autonomy-supportive parenting behaviors and child compliance behaviors is tested in the present study as a predictor of regulatory outcomes in children four months later.

There is some evidence that self-regulation develops in young children in the absence of behavioral contingencies and behavioral coregulation. Raver (1996) reported that parental inconsistency is associated with the emergence of adaptive primitive regulation in infants. Using observational data of mothers and their toddlers, she examined dyadic turn-taking behaviors (described as social contingency) as a predictor of children's emotion regulation and delay of gratification strategies. Increased time spent in states of joint attention was associated with better regulation in children but greater frequency of dyadic turn-taking behaviors focused on reciprocity was not a significant predictor of child outcomes. On the other hand, greater involvement in passive bid sequences (i.e., the child accepts the parent's bid for joint attention but the mother does not follow-up) was associated with increased self-soothing behaviors in the toddler. This evidence suggested that lower levels of behavioral contingency and follow-up from a parent might actually encourage some infants to develop primitive self-regulatory behaviors in the absence of external regulation. However, low-level regulatory capacities organize into more complex regulatory skills over time in the context of interactions between the growth of neural and physical systems (Nigg, 2017) and the environment (Lunkenheimer & Dishion, 2009).

Insufficient parental support and external regulation over time through behavioral coregulation might then be related to a lack of development of these more sophisticated regulatory skills needed for the internalization of self-regulation at later stages of development.

A number of researchers have argued that a lack of clear behavioral contingencies over time inhibits the development of children's self-regulation. Poor contingencies reflective of inconsistent parenting behaviors are related to greater behavioral dysregulation (Campbell, 1990; Lunkenheimer, Lichtwarck-Aschoff, Hollenstein, Kemp, & Granic, 2016; Wahler & Dumas, 1986) as well as higher anxiety in children (Ladd & Kochenderfer Ladd, 1998). In the absence of contingencies, many children lack the appropriate structure and scaffolding afforded by behavioral coregulation to appropriately observe, practice, and internalize regulation skills.

Taken together, there is strong theoretical rationale that behavioral coregulation and patterns of contingency provide an important framework for how parent-child interactions influence the development of child outcomes. While many studies have tried to quantify or describe the behaviors within a parent-child interaction using Likert scales or composites, only a handful of studies have coded them in real time. These studies provide us with a more detailed understanding of how dyadic behavioral contingencies reflect consistency and predictability within the dyad; these patterns are related to children's self-regulation outcomes, though a number of the findings for data coded moment-to-moment were only examined in association with just one or two components of self-regulation. The current study seeks to extend the previous empirical work by investigating how the pairing of autonomy-supportive behaviors and child compliance in the context of positive, responsive exchanges is related to various forms of self-regulation in preschoolers.

Affective Coregulation and Patterns of Flexibility

In addition to patterns of behavioral coregulation, dyads also regulate each other during exchanges through affective coregulation patterns. Affective coregulation is the process by which parent and child coordinate their affective states in close temporal proximity of one another (Lunkenheimer, Olson, Hollenstein, Sameroff, & Winter, 2011). Researchers examining affect dynamics in the dyad have found that patterns of dyadic affective flexibility are associated with children's regulatory outcomes. In order to examine the relation between affective coregulation and child development, one must understand current perspectives on emotion dynamics and the functionalist and dynamic systems perspectives of emotions.

In contemporary emotion regulation theory, two aspects of emotions emerge as being pivotal for understanding their operations – appraisal and action patterns. Emotional appraisal is the "process of appreciating the specific significance of a situation (or perception or representation of a situation) for individual well-being" (Cole, Martin, & Dennis, 2004, pp. 319). As a child develops, an increasing understanding of the self and the self in relation to context influences what becomes emotionally salient in the environment (Cole, Martin, & Dennis, 2004). As a function of appraising or categorizing their experiences, children are prepared to act in order to deal with challenges or to take advantage of positive circumstances according to their action patterns (Cole, Martin, & Dennis, 2004). These characteristics of emotions and their accompanying affect allow them to regulate both internal processes and interpersonal processes.

Functionalist theories of emotion posit that each discrete emotion is organized around an adaptive exchange between the person and the environment (Witherington & Crichton, 2007). For example, fear is elicited to help someone avoid harm or threat. The emotional system includes the following components: the goals of the individual, the situational events that impact those goals, the appraisal of a situation's significance, and the instrumental actions that could be used to alter the transaction between the person and the environment (Witherington & Crichton, 2007). The relations among these components lay the foundation for an individual's emotional system. We can use the case of a mother trying to scaffold her child's learning while helping her complete a problem-solving task for a prize as an example to examine these components. This mother might have a goal of completing the task, but may have been told that she cannot do the task for her child herself. The prize might be a significant motivating factor, but a time-limit set by the experimenter might add stress to the situation. Fueling this stress, her child may be struggling with the task and could be displaying medium negative affect, frustration, inattention, and noncompliance. In this situation, the expression of mild anger in the mother's vocal tone and frustration in her facial expression might serve to release some of her stress and encourage better attentiveness and compliance in her child. On the other hand, the mother's expression of high positive affect may repair the child's negative affect and replace her own frustration with more optimism.

A dynamic systems lens complements this functionalist perspective by emphasizing the importance of task and situational context as elements of the environment that could introduce change and stimulate reorganization or reinforce predictability and stability through recursion. In the example presented earlier, the expression of affect in the parent is shaped by the affect and behavior of her child and the demands of the task. The theory suggests that alterations to the interactions among the emotional system's components could change the system's structural organization and contribute to the spontaneous emergence of new emotional systems in real time (i.e., new patterns of emotions) without explicit instructions (Witherington & Crichton, 2007). If the child started throwing a tantrum and escalated in her negative affective intensity, this could stimulate a sharp change in the parent's affect in response to deescalate her child's affective intensity and behavioral dysregulation. The emergent form may include new biases or strategies for appraisal as well as the addition of more action patterns, changing the association between the person and their environment. The mother may become highly positive or highly negative in order to alter her interaction with her child; both states could present as a sharp change from her former affective state and serve different functions in her environment.

Drawing from the functionalist and dynamic systems perspectives, dyadic affective patterns could also self-organize based on the dynamics of the parent-child relationship. Just as emotional systems actively change to adaptively react and regulate internal processes, dyadic affective patterns also help to regulate interpersonal processes. Through interactions with each other, a child may learn how to read a parent's facial, gestural, postural, and vocal cues, and vice-versa, giving them access to each other's emotional appraisals, expressions, and motivations (Bretherton, Fritz, Zahn-Waxler, & Ridgeway, 1986). Over the course of many interactions, parent and child alter the existing components of each other's emotional systems and allow for the emergence of new components. This describes the process of affective coregulation, or the process by which each member of a dyad regulates the other's affect.

Affective coregulation between parent and child is an important predictor of children's regulatory capacities (e.g., Feldman, Greenbaum, & Yirmiya, 1999). The empirical literature emphasizes the influence of dyadic affective flexibility and rigidity on children's outcomes. Higher levels of dyadic affective flexibility could afford children with the ability to enter more affective states and make use of them as opportunities to practice regulation and repair. Greater dyadic affective flexibility is associated with positive behavioral regulation in children (Feldman, Greenbaum, & Yirmiya, 1999; Lunkenheimer, Hollenstein, Wang, & Shields, 2012).

Meanwhile, lower dyadic affective flexibility, or rigidity, mediates the association between parental conflict and infant's poor vagal regulation (Busuito & Moore, 2017). Additionally, dyadic rigidity is related to behavioral dysregulation in the form of higher levels of externalizing behaviors (Hollenstein, Granic, Stoolmiller, & Snyder, 2004; Lunkenheimer, Albrecht, & Kemp, 2013). Patterns of dyadic rigidity are also associated with the persistence of these externalizing behaviors in children, even after they undergo extensive clinical treatment (Granic, O'Hara, Pepler, & Lewis, 2007). In using this rigid dyadic pattern, parent and child provide each other with limited opportunities for regulating across the transitions between different emotional states and they seem to get stuck in a negative attractor state. Families with greater levels of risk demonstrate higher levels of dyadic rigidity around negative affect (Cole, Teti, & Zahn-Waxler, 2003; Dagne & Snyder, 2011; Dumas et al., 2001; Hollenstein et al., 2004; Lunkenheimer, Albrecht, & Kemp, 2013).

The available literature on affective flexibility emphasizes that this dynamic pattern is an important predictor of children's individual regulatory capacities, but there are still gaps in this literature left to be addressed. Some researchers have argued that there may be an optimal level of flexibility for children's positive outcomes and that too many transitions among affective states could harm child outcomes (Busuito & Moore, 2017). Moreover, the pattern of affective flexibility presents us with a description of the dyad's transitions across affective states, but it does not provide us with an evaluation of the content of the interaction and how that might be shaping children's outcomes. Previous research has demonstrated that patterns of dyadic affective flexibility should be investigated in context. Hollenstein & Lewis (2006) found that more flexible dyads tend to express more negative emotion during conflict. Greater dyadic flexibility is also positively related to infants' displays of negativity during the Still-Face paradigm (Sravish, Tronick, Hollenstein, & Beeghly, 2013). Patterns of dyadic flexibility do encourage the expression of negative affect in contexts that could be appropriate and beneficial for infants. There is some evidence that affective coregulation paired with positive affect is also related to adaptive outcomes in children. Lunkenheimer, Olson, Hollenstein, Sameroff, & Winter (2011) compared patterns of affective flexibility in mother-child and father-child dyads. The researchers found that the interaction between higher dyadic flexibility and higher dyadic positive affect in mother-child and father-child dyads was associated with better behavioral regulation in children. These findings indicated that dyadic affective flexibility paired with positive affect was more beneficial for child outcomes than general flexibility across positively and negatively-valanced dyadic emotional states. Therefore, while the patterns of dyadic affective flexibility offer a unique contribution to the development of children's regulatory capacities, pairing this coregulation pattern together with other indicators of content and context could provide us with a better understanding of the process by which dyadic influences are shaping children's outcomes. An aim of the present study is to examine how dyadic affective flexibility operates in the context of primarily positive and neutral exchanges to shape the development of children's self-regulation.

The Association Between Coregulatory Processes

Parents and children each regulate and are regulated by expressed affect, behavior, and physiology in the other (Calkins, 2011; Fogel, 1993). For this reason, examining one domain in the absence of other dimensions may lead to an incomplete interpretation of how development proceeds (Smith, Hubbard, & Laurenceau, 2011). Affective, behavioral, and physiological coregulation patterns do not occur in a vacuum, and a gap in the literature exists with regard to how these patterns support one another or mitigate the effects of each other to shape children's regulatory outcomes. Literature investigating the relation between dyadic processes across domains has been sparse in number and the findings have been mixed (e.g., Feldman, Magori-Cohen, Galili, Singer, & Louzoun, 2011; Ham & Tronick, 2009). A couple of studies found evidence that physiological synchrony co-occurs with patterns of affective coregulation (Field, 2012; Sbarra & Hazan, 2008), but there are inconsistent findings in the literature relating patterns of behavioral coregulation with physiological synchrony (Palumbo et al., 2017).

With regard to the aims of the present investigation, only one study has examined parallel changes in dyadic behavioral and affective processes across parent-child interaction contexts to understand child development. Lunkenheimer, Kemp, Lucas-Thompson, Cole, & Albrecht (2017) observed mother-child dyads interacting during a baseline condition and a challenging situation and looked at the differences in each individual's affect, behavior, and physiology, as well as their dyadic regulatory processes during the two conditions. The authors found that more stressful and structured contextual demands elicited lower dyadic behavioral variability and greater dyadic affective variability. The researchers concluded that when specific behaviors were required from parents, especially in such a demanding teaching situation, this constrained the set of goal-directed behaviors they could use and the amount of goal-relevant behaviors that children could engage in, thus reducing the dyad's behavioral variability. Additionally, the increased behavioral demands constrained the resources that parents had to attend to children's emotions, stimulating corresponding changes in children's emotion and behavior. This led to more disorganized and chaotic dyadic affect. The researchers found this influence of the situation on dyadic interaction patterns in families regardless of the level of the child's behavioral dysregulation. This study suggests that an examination of behavioral and affective dyadic processes together may give us a more nuanced appreciation for the influence of the environment on parent-child interactions. Therefore, when trying to examine the parent-child relationship as a dynamic system that shapes the development of children, we must consider the relation between coregulation patterns across domains and both the context and content of the interactions.

In the present study, we posited that including positive behavioral contingencies with affective flexibility in the same model would provide us with a better understanding of the relative contributions of these dyadic processes on children's outcomes. Behavioral contingencies involving autonomy-supportive parenting and children's compliance promote better self-regulation in children (Lunkenheimer, Ram, Skowron, & Yin, 2017; Lunkenheimer, Kemp, & Albrecht, 2013). Similarly, dyadic affective flexibility is related to better self-regulation outcomes in children in the context of positive affect (Feldman et al., 1999; Lunkenheimer et al., 2012) and poor outcomes in the context of negative affect (Hollenstein et al., 2004; Lunkenheimer, Albrecht, & Kemp, 2013). Therefore, by including both of these dyadic processes in the same model, and accounting for the degree of positive and neutral interaction content, we provide a novel contribution to the literature by demonstrating how related these processes are and which processes are more salient for supporting the development of various components of children's regulatory skills.

The Multidimensional Nature of Self-Regulation

Any investigation examining the influence of coregulation on the development of children's regulatory capacities must acknowledge not only the complex nature of dyadic processes but also the transactional nature of self-regulation itself. Research suggests that self-regulation is multidimensional, and its components underlie children's cognitive, behavioral, emotional, and social competencies (McClelland & Cameron, 2011; Vohs & Baumeister, 2004).

Studies examining the developmental trajectories of self-regulation indicate that various components emerge in early childhood such as effortful control (Eisenberg, Smith, Sadovsky, & Spinrad, 2004), inhibitory control (Diamond, 2002), emotion regulation skills (Calkins, 1994), and behavioral compliance and task persistence (Kopp, 1989; Stayton, Hogan, & Ainsworth, 1971). Many studies examining moment-to-moment dyadic processes look at how they are related to only one or two aspects of self-regulation. However, in his review of the self-regulation literature, Nigg (2017) argued that a conceptual framework for self-regulation should acknowledge the subdomains of emotion, action, and cognition. For this reason, the present study attempts to take a more complete perspective of the development of self-regulation across different domains by examining the influence of coregulation patterns on children's emotion regulation, behavioral regulation in the form of compliance and persistence, and inhibitory control, which is a component of executive functioning and children's temperamental regulation.

Emotion regulation. Emotion regulation is necessary for monitoring, evaluating, and modifying an individual's emotional reactions, especially their intensity and timing, to accomplish one's goals (Thompson, 1994). Emotional lability is related to emotion regulation and is defined as the reactivity of the individual to emotion-eliciting stimuli and the ability of the individual to recover from negative emotional states (Kim-Spoon, Cicchetti, & Rogosch, 2013). While good emotion regulation skills improve children's outcomes in early childhood, higher levels of emotional lability are associated with child aggression, social withdrawal and internalizing problems, and problems in social relationships (e.g., Calkins, 1994; Eisenberg et al., 1995; Silk, Steinberg, & Morris, 2003). Given the importance of developing adequate emotion regulation skills in early childhood, many researchers have sought to understand the etiology of its development in preschoolers.

Much of the literature has taken a contextualist perspective on the development of emotion regulation. In particular, the parent-child relationship is considered the primary context for socializing young children's abilities to express and regulate their own emotions (Morris, Silk, Steinberg, Myers, & Robinson, 2007). Parents scaffold the development of their children's emotion regulation through the attachment relationship, their parenting style and modeling of behaviors, and the emotional climate they create for children (Morris et al., 2007). Investigation of dyadic patterns in real time could therefore shed light on the context and mechanism by which parents shape these capacities in their children.

Autonomy-supportive parenting is associated with the development of better emotional adjustment in children (Grolnick & Ryan, 1989). The greater the contingency between such parenting behaviors and the child's own regulatory skills over time, the more predictable the home environment, which could engender less child emotional negativity (Bridgett, Burt, Laake, & Oddi, 2013). Additionally, parental responsiveness, especially to emotional and situational cues from the child, could provide the scaffolding needed for reducing children's immediate emotional lability and helping them develop better emotion regulation skills (Calkins, 1994). Parent-child interactions characterized by mutual responsiveness are related to better emotion regulation skills in children (Harrist & Waugh, 2002).

Some theorists also argue that the dynamics of affect flexibility within an individual reflect their abilities for regulating emotions (Hollenstein, 2015). Therefore, an examination of the relation between dyadic affective flexibility and emotion regulation could suggest whether parental influence in the course of interaction shapes these regulatory abilities in children. More specifically, dyadic affective flexibility paired with parental modeling and child observational learning could scaffold children's experience of various affective states, thus reducing their emotional lability and helping them learn how to regulate their own emotions. These findings have already been established in the literature (e.g., Lunkenheimer et al., 2012; Sroufe, 2000), but it is unclear whether this pattern will hold when taking into account other aspects of self-regulation.

Behavioral compliance. Compliance is an early form of self-regulation that emerges in infancy and reflects a person's voluntary control over their behavior in response to another's request or agenda (Kopp, 1982; Stayton, Hogan, & Ainsworth, 1971). In preschoolers, it is an easily observable form of behavioral regulation that demonstrates an awareness of the social and contextual demands of a given situation, such as a parent's bid for behavior change. Additionally, at such a young age, compliance can reflect the early coordination of a child's attentional, behavioral, and emotional systems in response to a challenging situation (Olson & Lunkenheimer, 2009). Some researchers posit that compliance in early childhood is related to greater internalization of more complex self-regulation skills (e.g., Gralinski & Kopp, 1993). Taking this one step further, Kopp (1989) suggested that a meaningful distinction exists among control, self-control, and self-regulation. While control involves compliance and self-monitoring behaviors to meet social demands, self- control refers to the ability to delay or act in response to social expectations in the *absence* of external monitoring and self-regulation involves being able to *flexibly* use various regulatory strategies depending on the demands of the situation. Proof of children's internalized regulatory capacities must therefore be found when children are following rules and regulating their emotions and behaviors in the absence of others. Therefore, behavioral compliance could be an important early form of self-regulation.

Many researchers have studied the relation between parenting and children's compliance behaviors. Children are more likely to engage in compliance behavior whether caregivers use warmth, support, and scaffolding versus power assertion and control behaviors (Crockenberg & Litman, 1990; Power & Chapieski, 1986). Lunkenheimer, Kemp, and Albrecht (2013) examined the relation between mother-initiated contingencies involving child compliance and children's behavioral regulation four months later using the same dataset being utilized in the present study. They found that a strong contingency between maternal directives and child compliance was associated with better mother-reported and teacher-reported behavioral regulation in the child, suggesting that parental control might provide needed direction and scaffolding for the child as he or she learns to focus during a challenging task. Compliance on behalf of the child was indicative of the child's responsiveness to the parent's clear guidance, and the relation between this contingency and the child's self-regulation may have reflected the parents' perception that the child is regulating well because the child was responding appropriately to their demands. On the other hand, a strong contingency between maternal teaching statements and child compliance was related to higher levels of mother-reported behavioral regulation and lower levels of teacher-reported behavioral regulation. The authors suggested that young children who may require more scaffolding might be perceived by teachers as not being well regulated. Children who had lower levels of contingent responding may have been well regulated already and those who had high contingent responding may have been developing their regulatory skills and generalizing them to the classroom environment. These findings highlight that compliance therefore might be an important pre-cursor to future internalization of regulatory skills and could pave the way for stronger levels of persistence and displays of autonomy in the child.

Task persistence and social persistence. There is already an association between the quality of the parent-child relationship and children's social and task persistence in the literature. Children who have more secure attachments in infancy are more likely as toddlers to persist with challenging exploratory tasks and engage in on-task behavior than their more insecurely attached counterparts (Sroufe, 1978). Numerous studies have identified a relation between parental responsiveness and preschoolers' task persistence (Mokrova, O'Brien, Calkins, Leerkes, & Marcovitch, 2012; Pino-Pasternak & Whitebread, 2010). Furthermore, autonomy-supportive parenting is related to positive behavioral adjustment in children (Grolnick & Ryan, 1989), greater persistence at tasks (Frodi, Bridges, & Grolnick, 1985), and higher levels of intrinsic motivation and persistence of behavioral change across samples (Deci & Ryan, 1987). These findings suggest that the behavioral pairing between autonomy-supportive parenting and children's compliance should reinforce children's regulatory abilities and promote better task persistence.

Meanwhile, higher parent-child positive affective quality is related to children's improved work habits and more positive teacher-child relations in kindergarten (Pianta, Nimetz, & Bennett, 1997). Processes of affective coregulation involving flexibly transitioning across emotional states during primarily positive exchanges could foster positive emotional climates that encourage the development of children's emotion competence and later, their behavioral regulation capacities. Denham and colleagues (2003) found that preschoolers' emotional competence (encompassing emotional expressiveness, emotion regulation, and emotion knowledge) was associated with their social competence with peers and adults in both preschool and later in kindergarten. Therefore, if affective coregulation provides the scaffolding that promotes children's emotion competence, then the children might be able to focus their resources on their social and task persistence.

Inhibitory control. Effortful control and executive function are two components of self-regulation (temperamental and cognitive, respectively) that are associated with better social competence in early childhood (Razza & Blair, 2009; Zhou, Main, & Wang, 2010) and positive academic outcomes (Blair & Razza, 2007; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009). Underlying both effortful control and executive function is inhibitory control, defined as the ability to inhibit dominant responses (Rothbart & Bates, 2006). Inhibitory control emerges late in the second year and develops through preschool through complex interactions between genetics and the environment (Diamond, 2002; Gagne & Goldsmith, 2011; Gagne & Saudino, 2016). Parenting is an important environmental influence that shapes the development of early regulatory abilities in children (Grolnick & Ryan, 1989). In particular, research suggests that sensitive, responsive, and supportive parenting can shape the development of children's effortful control (Kochanska, Murray, & Harlan, 2000) and executive function abilities (Bernier, Carlson, & Whipple, 2010). The behavioral contingency between autonomy-supportive parenting behaviors and children's compliance could reflect the child's responsiveness to positive parenting and their ability to inhibit impulses in order to respond to the parent's agenda. Furthermore, this contingency could also reflect the parent's sensitivity to the needs of the child, which could shape the parent's choices to offer autonomy-support to the child and foster externally-regulated inhibition of impulses until inhibitory control is internalized by the child. With regard to the affective domain, van Dijk and colleagues (2017) found that dyadic affective flexibility was associated with lower levels of preschooler's inhibitory control nine months later. However, when examining maternal negative affect as a context for mother-child interactions, lower levels of dyadic affectively flexibility coupled with high maternal negative affect was related to lower inhibitory control (van Dijk et al., 2017). This research suggests that dyadic affective flexibility is related to children's inhibitory control, though the association may be shaped by the affective context of the interaction. We hypothesized that affective flexibility in the context of primarily positive and neutral exchanges might improve children's inhibitory control.

The Present Study

Taken together, the theoretical foundations and empirical literature reviewed serve to provide a model for how the child's interaction with the environment (his or her parent) may be related to the development of regulatory skills in children. The present study addressed the relation between parent-child coregulation patterns and child regulatory outcomes in the preschool period. Utilizing a dynamic systems perspective, this study used continuous measures of dyadic interactions to capture indicators of two different parent-child coregulatory patterns – positive behavioral contingency and dyadic affective flexibility – both within the context of positive exchanges. An investigation of the association between each form of coregulation and various components of children's own self-regulation four months later provided us with a more nuanced understanding of how these dyadic processes shape child outcomes. In particular, we examined whether and how these dyadic patterns affect children's emotion regulation, task persistence, social persistence, and inhibitory control over time. Additionally, this study assessed the relation between these coregulation patterns as well as their relative contributions on children's development in light of each other. Only one previous study had examined how both dyadic behavior and dyadic affect patterns were associated with children's self-regulation (Lunkenheimer, Kemp, Lucas-Thompson, Cole, & Albrecht, 2017). However, the influence of these coregulation patterns were investigated in parallel rather than within the same model. Our research questions and hypotheses were as follows:

1. *Is the behavioral contingency between autonomy-supporting parenting and children's autonomous behaviors related to various components of children's self-regulation?*

We predicted that a stronger behavioral contingency between autonomy-supportive parenting and child autonomy would be associated with better self-regulation in children, with the strongest association being with task persistence.

2. *Is dyadic affective flexibility related to various components of children's self-regulation?* Drawing from previous research findings, we posited that greater dyadic affective flexibility would be related to greater emotion regulation, lower inhibitory control, and greater task persistence.

3. *Are dyadic behavioral contingency and dyadic affective flexibility associated with various components of children's self-regulation, in light of each other? Is there evidence that dyadic behavior patterns and dyadic affect patterns are related to one another?* These questions were exploratory due to the paucity of research examining the interrelations of dyadic interactions patterns across domains. Since there was evidence that both dyadic behavioral contingency and affective flexibility patterns are separately associated with higher competence in particular components of self-regulation, we posited that they would still be strongly related to components of self-regulation when included in the same model. However, we predicted that the strongest associations would be within-domain, such that dyadic behavioral contingency would most strongly be related to task persistence and dyadic affective flexibility would have the strongest association with emotion regulation. Finally, given the importance of parental sensitivity to emotional and situational cues for both dyadic patterns, we posited that dyadic behavioral contingency would be positively correlated with patterns of dyadic affective flexibility.

Method

Participants

Participants were 100 children (54 percent female) and their mothers (*N* = 100) recruited for a longitudinal study focused on parent-child coregulation. The children were 41 months old (*SD* = 3) at time 1 (T1) and 45 months old (*SD* = 3) at time 2 (T2) on average. Parents reported that 86% of the children were Caucasian, 8% biracial, 3% Asian, and 3% “other.” Ten percent were identified as Hispanic/Latino. Of the parents participating in the study, 79% were married, 7% were cohabitating, 7% were single-parents, 5% were separated or divorced, and 1% were remarried. The median annual family income was $65,000, and on average, parents in the sample were college graduates. We recruited participants through email listservs of agencies serving families with young children and through flyers posted in preschools, day care centers, and other businesses. We excluded families from the study if the parents could not read or speak in English, if the child exhibited a developmental disorder, or if either the parents or child had a heart condition that could add noise to the physiological data collection.

Procedure

At T1, mother-child dyads completed a two-hour laboratory visit. While mothers filled out several questionnaires about their child’s behaviors, children performed cognitive and behavioral tasks with an experimenter. Mother-child dyads also participated in a videotaped unstructured free play task, a semi-structured clean-up task, and a problem-solving task described in greater detail in the next section. We compensated families with $50 for their time. At T2, mothers reported on a variety of child characteristics and regulatory behaviors by filling out questionnaires online. We compensated those who participated at this wave of data collection with a $20 gift card to a local store.

Measures

Videotaped parent-child interaction tasks. During the laboratory visit at T1, maternal-child dyads completed four videotaped interaction tasks together: a resting condition, a free play task, a clean-up task, and the Parent-Child Challenge Task (PCCT). In the resting condition, mothers and children sat together and watched a three-minute clip of dolphins swimming. We included this condition to capture the mother and child's overall baseline physiology during a non-stressful period requiring minimal interaction; we made no observations of parent or child behavior or affect. During the seven-minute unstructured free play task, we gave each dyad the opportunity to play with a variety of toys together. Next, mothers were instructed to guide their children through stopping play and cleaning-up the toys instead during the semi-structured four-minute clean-up task. Parents could verbally scaffold how the child shifted from one desirable task to a less-desirable task, but they could not physically help them put the toys away. Finally, the dyad completed the ten-minute Parent-Child Challenge Task (PCCT), shown previously to be useful in examining parent and child behaviors during goal-oriented tasks (Lunkenheimer, Kemp, & Albrecht, 2013; Lunkenheimer, Kemp, Lucas-Thompson, Cole, & Albrecht, 2017).

During the PCCT, mothers were instructed to help their children physically recreate three wooden three-dimensional puzzles using designs from a guidebook (Lunkenheimer, Kemp, Lucas-Thompson, Cole, & Albrecht, 2017). We utilized these designs in the study because their demands were just above the cognitive abilities of preschoolers and required that parents instruct them in how to complete the task. We did not initially set any time limit for a particular design or the whole task, but children were told they would get a prize if they completed all three puzzles. After the dyad had interacted for four minutes (the PCCT baseline condition), the experimenter interrupted and mentioned they only had two minutes left to complete all three puzzles (the PCCT stressor condition). Regardless of completion of the task, mother-child dyads all received a prize - either a coloring book or some playdough. For the final three minutes, we encouraged the dyad to play with the prize together (the PCCT repair condition).

In the present study, we used data from all tasks and all conditions of the PCCT to consider parent and child behavior and affect across circumstances that were both unstructured and structured as well as situations that were non-stressful and stressful. Undergraduate and graduate students trained by the creator of the coding system coded the videotaped interactions for affect and behavior. We computed reliability for 20 percent of the behavioral and affect data using the Noldus Observer 8.0 XT software, taking into account a standard three-second window for convergence. We also calculated drift reliability to ensure that coders were consistent with each other.

Affect coding. Using the Dyadic Interaction Coding system (Lunkenheimer, 2009), we coded parent and child affect using Noldus Observer 8.0 XT on a second-by-second basis during the videotaped interaction tasks. We coded affect based on observable vocal tone, eye contact, facial expressions, and accompanying body movements. There were four possible codes for affect: medium-high positive, low positive, neutral, and negative. *Medium-high positive affect* was characterized by regular positive fluctuations in vocal tone (e.g., higher pitch or lilts), broad smiles, laughing or singing, direct eye contact, and body movements indicating warmth, affection, surprise, or happiness. For positive affect to be considered medium or high-intensity, the coder had to observe multiple of these indicators at once. *Low positive affect* involved slightly positive lilts or a warm vocal tone, small and close-mouthed smiles, and warm eye contact; however, these indicators were not observed at the same time. *Neutral affect* referred to a matter-of-fact vocal tone with very few fluctuations, a lack of eye contact with the other person, and an absence of frowns or smiles, and warmth or negativity in eye contact and facial expressions. Finally, *negative affect* referred to any facial expressions, vocal tone, or body movements related to feelings of irritation, distress, anger, disgust, sadness, discomfort, or anxiety. Examples of indicators of negative affect included rolling eyes, frowns, heavy sighing or sounds of exasperation, teasing or mocking, narrowed eyes, or nervous, repetitive movements.

Behavioral coding. We coded parent and child behaviors during the videotaped interaction tasks on a second-by-second interval using Noldus Observer 8.0 XT software. The Dyadic Interaction Coding system (Lunkenheimer, 2009) has been used previously to look at the behavioral contingencies in parent and child behavior (e.g., Lunkenheimer, Kemp, & Albrecht, 2013). There were nine codes for parent behavior: directives, teaching, proactive structure, positive reinforcement, emotional support, engagement, disengagement, intrusion, and negative discipline. In accordance with previous work, we considered all these behaviors as adaptive or supportive of the child except for parental disengagement, intrusion, and negative discipline (Kemp, Lunkenheimer, Albrecht, & Chen, 2016). Child behavior had seven codes: compliance, persistence, noncompliance, disengagement, behavioral dysregulation, social conversation, and solitary/parallel play. We considered all these as adaptive except for child noncompliance, disengagement, and behavioral dysregulation (Kemp et al., 2016). These parent and child codes were mutually exclusive. For the present study, we used the maternal codes for teaching and proactive structure and the child code for compliance in the analyses.

Maternal autonomy-supportive behaviors included both maternal teaching statements as well as mothers' attempts to proactively structure the interaction tasks with their children. We defined teaching statements as any parent explanation, feedback, or helpful instruction for how something should be done or how a toy works. Additionally, we considered parental questions that encouraged the child to be involved in the task or to learn for himself or herself as forms of teaching. Examples of teaching statements included 'Where do you think the orange block goes?' or 'Yes, the red block does go in the middle.' Proactive structuring also involved maternal behaviors that prompted or guided positive behavior in the child. If mothers used singing, imaginative prompts, games, or joint activities that playfully encouraged children to remain engaged or comply with a particular task, we coded these behaviors as proactive structuring. For example, the parent could sing a 'clean up song' to encourage the child to put toys away. In addition, we coded suggesting constructive approaches, providing reflections of the child's behavior, and scaffolding their progress through a task as proactive parenting.

Child compliance behavior reflected instances when a child responded appropriately to a parent's bid for behavior change or engaged in on-task behavior in accordance with the parent's autonomy-supportive parenting. Examples included when a child played along with a game set up by a parent, followed the parent's teaching instructions, picked up and placed a block in a specific location, or sang a clean-up song the parent suggested. The child remained in compliance as long as he or she responded appropriately to ongoing parental bids or requests. If a parent stopped providing further instruction, scaffolding, or direct commands, then we coded the child's on-task behavior as a form of autonomous behavior rather than compliance after such behavior persisted more than three seconds.

Children's self-regulation. We assessed children's self-regulation abilities at T1 and T2. Since effortful control has been used in the literature as a measure of children's temperament-based regulation, we decided to use it in this study to help control for children's regulatory abilities at T1. Four months later, mothers reported on their children's task persistence, social persistence, emotion regulation, and inhibitory control (Shields & Cicchetti, 1997). We describe these measures assessing child self-regulation below:

Effortful control. We used a task battery previously established in the literature as a measure of effortful control to account for children's temperament-based self-regulation at T1 (Kochanska, Murray, Jacques, Koenig, & Vandergeest, 1996). Children completed the tower task and the gift delay task, and we standardized and averaged together their scores for an overall effortful control score (Cronbach's $\alpha = .81$).

In the tower task, we asked children to help the experimenter build a tower using 20 wooden blocks. The experimenter told the child they would be taking turns and helped the child practice. After this, the experimenter placed the first block (the largest piece) and told the child it was his or her turn. The experimenter gave the child no further reminders regarding turn-taking and waited for an explicit signal from the child to add a block. We used the proportion of blocks placed by the experimenter as a proxy for the child's effortful control abilities. Greater difficulty alternating turns with the experimenter to build the tower suggested lower effortful control. We used the mean score across two trials as the child's score for this task.

In the gift delay task, we offered the child a present but told him or her that the experimenter needed to wrap it first. While the experimenter wrapped the gift over the course of 60 seconds, we told the child not to peek. We gave the child a score for peeking at the experimenter ranging from 0 (*turned around to peek*) to 2 (*no attempt was made to peek*). We standardized and averaged together this peeking score, the latency to peek over the shoulder, and the total number of times the child peeked for a peeking score. Next, the experimenter placed the wrapped gift on the table in front of the child and left the room "to get a bow." The experimenter asked the child to wait in his or her chair and to refrain from touching the bag until he or she returned two minutes later. We coded the child's latency to touch the gift or the strategies they used to examine it (e.g., touches, lifts, fully opening the gift) during this time. Once again, we standardized and averaged the scores to create a composite for this task.

Task and social persistence. We used the Dimensions of Mastery Questionnaire (DMQ-17; Morgan, Busch-Rossnagel, Barrett, & Wang, 2009) to examine children's persistence during challenging problem-solving tasks and their social persistence. Previous research has demonstrated that this measure is significantly correlated with independent ratings of reported and observed persistence in preschoolers, particularly with regard to task persistence, and it has been shown to distinguish low- and high-risk children based on mastery-related behaviors (Morgan et al., 2009). Mothers responded to the items using a scale from 1 (*not at all typical*) to 5 (*very typical*), with higher scores reflecting greater persistence in the child. The nine-item object-oriented persistence subscale (DMQ-TP) included example items such as "Tries to complete tasks, even if it takes a long time to finish" and "Repeats a new skill until he or she can do it well." We also utilized the 6-item social persistence with adults subscale (DMQ-SP) which included items such as "Tries hard to get adults to understand" and "Enjoys talking with adults, and tries to keep them interested." For both subscales, item responses were averaged together for a mean score of ranging from 1 to 5. Cronbach's alpha for these subscales were acceptable (DMQ-TP: $\alpha = .92$; DMQ-SP: $\alpha = .85$).

Children's emotion regulation. We utilized the 24-item Emotion Regulation Checklist (ERC; Shields & Cicchetti, 1997) to assess children's abilities to manage their emotions. This measure is highly correlated with observations of children's emotions during a free play task, as well as counselors' ratings of their positive and negative mood using the Minnesota Behavior Ratings (Shields & Cicchetti, 1997). It also includes content that is similar to measures of psychopathology and is often highly correlated with measures of children's behavior problems (e.g., Lunkenheimer, Kemp, & Albrecht, 2013). In prior research, it has been used with preschoolers and early elementary school children and is consistently associated with their school and social competency outcomes (Shields et al., 2001). The scale's 9-item adaptive emotion regulation subscale included items about the appropriateness of the child's emotional displays. An example item was "Can modulate excitement in emotionally arousing situations." The overall reliability for this scale was a little low (α = .66). The 15-item lability/negativity subscale captured the child's dysregulated negative affect, lack of flexibility, and mood lability (e.g., "Exhibits wide mood swings"). Mothers responded to the items using a 4-point scale from 1 (*never*) to 4 (*always*); responses for each item were summed together such that scores ranged from 9 to 36 for the adaptive emotion regulation subscale and 15 – 60 for the lability/negativity subscale. The overall reliability for this scale was good (α = .77). Because of the lower internal consistency of the adaptive emotion regulation subscale, we only used the subscale for emotional lability/negativity in our analyses.

Children's inhibitory control. Mothers responded to the 13-item inhibitory control subscale of the Child Behavior Questionnaire (CBQ; Rothbart, Ahadi, & Hershey, 1994) using a scale from 1 (*extremely untrue*) to 7 (*extremely true*). Maternal ratings of children's inhibitory control are moderately associated with behavioral assessments of their inhibitory control across early childhood (Kochanska, Murray, & Coy, 1997). Example items from this subscale included "Can easily stop an activity when s/he is told no" and "Has difficulty waiting in line for something." We averaged together ratings for each item to yield a mean score for the child's inhibitory control. The overall reliability for this scale was good (α = .79).

Children's cognitive abilities. The Wechsler Preschool and Primary Scale of Intelligence (WPPSI; Wechsler, 2002) assesses children's cognitive and language skills. For the purposes of this study, we used children's scores on the Block Design subtest as a proxy for their cognitive abilities. We presented children with identical blocks that had surfaces which were red, white, or half red and half white. This subtest examined spatial ability and reasoning as children assembled these multicolored blocks to match pictures given to them by the experimenter. The demands of the task increased with each trial, and children were required to use an increasing number of blocks to replicate the patterns they saw. We evaluated performance on the WPPSI according to national norms.

Analytic Plan

Missing Data

Of our sample of 100 families, 92 had complete dyadic data, 88 had complete self-regulation questionnaire data, and 80 had complete behavioral, affective, and questionnaire data for our analyses. Data was missing completely at random according to Little's (1988) test, $\chi^2(97) = 91.97$, $p = .63$. Therefore, to handle missing data in this study, the researchers used a full information maximum likelihood (FIML) approach in each of the analyses. This approach estimates each parameter using all available data for that parameter.

Extracting Dyadic Variables

We used dynamic systems analysis and state lag sequential analysis to extract our dyadic variables – affective flexibility, duration of positive and neutral affect, behavioral contingencies, and duration of positive behavior.

Dyadic affective flexibility. We used State Space Grids (Lewis et al., 1999) to plot the time series of codes we have for parent and child affect. By creating a grid in which each cell represented a particular combination of a parent and child affective state (from high negative to high positive), we could plot the trajectory of their dyadic affect over the course of their interaction using Gridware software version 1.15 (Lamey, Hollenstein, Lewis, & Granic, 2004). We mapped the combination of parent and child affect codes during each second on a 4 x 4 state space grid. *Dyadic affective flexibility* was the rate of transitions made from cell to cell during the interaction. We computed this variable by dividing the total number of transitions across all tasks by the length of the interaction in minutes. More flexible dyads demonstrated a greater rate of transitions across affective states.

Dyadic positive and neutral affect. Using the same 4 x 4 state space grid comprising of parent and child affect codes, we plotted the trajectory of each dyad's affect over the course of their interaction. We created a positive-neutral affect region by selecting the cells in which both parent and child displayed positive affect or neutral affect and the cells in which either member of the dyad displayed positive affect while the other exhibited neutral affect. In other words, all cells in which parent or child displayed any negative affect were excluded, yielding a nine-cell region. We used Gridware to calculate the duration of *dyadic positive and neutral affect*, or the amount of time that each dyad spent in this region in seconds.

Behavioral contingencies. We used state lag sequential analyses to assess the likelihood that the target behavior (i.e., child compliance) directly followed the criterion behavior (i.e., maternal autonomy-supportive behaviors). We computed transitional probabilities for this pairing of behaviors across all tasks in Noldus Observer XT 13.0 for each dyad. We did not specify the interval between the start times of each of the behaviors. These probabilities reflected the strength of our behavioral contingency for each parent-child dyad, with higher probabilities indicating a stronger contingency between maternal autonomy support and child compliance.

Dyadic positive and neutral behavior. We also utilized State Space Grids (Lewis et al., 1999) to plot the time series of parent and child behavior codes. We mapped the trajectory of each dyad's behaviors over the course of their interaction on a 9 x 7 state space grid. We created an adaptive behavior region by selecting the cells in which both mother and child were engaged in neutral behavior, the mother demonstrated positive support for the child, or the child exhibited on-task behavior; this region has been used in previous work and essentially excludes all cells in which either parent or child are engaging in negative or maladaptive behavior (Kemp et al., 2016). We used Gridware to calculate the duration of *dyadic positive and neutral behavior*, or the amount of time that each dyad spent in this region in seconds.

Data Analyses

First, we conducted descriptive analyses to examine the interrelations among our self-regulation variables, among our predictors, and between our predictors and our outcomes. Additionally, we examined the distributions of all our variables. Next, using RStudio version 1.1.383 (RStudio, Inc., 2009 -2017), we examined three models – an affective flexibility model, a behavioral contingency model, and a combined affect-behavior model.

Affective flexibility model. In this model, we examined whether the interaction between dyadic affective flexibility and dyadic positive and neutral affect at T1 predicted children's regulatory abilities at T2, controlling for child sex, child cognitive abilities at T1, and child effortful control at T1 (see Figure 1). In this model, we accounted for the interrelations among the predictors and among the outcomes. Finally, to improve the fit of the model and achieve greater parsimony, all insignificant covariances were constrained to zero.

Behavioral contingency model. In this model, we investigated whether the interaction between behavioral contingency and dyadic positive and neutral behavior at T1 predicted children's regulatory abilities at T2, over and above the effects of child sex, child cognitive abilities at T1, and child effortful control at T1 (see Figure 2). Once again, we originally accounted for all the interrelations among the predictors and among the outcomes. However, to improve the fit of the model and achieve greater parsimony, we eventually constrained all insignificant covariances to zero.

Combined affect-behavior model. In the overall model, we included both the affect and behavior interactions at T1 as predictors of children's self-regulation at T2, still controlling for child sex, child cognitive abilities at T1, and child effortful control at T1 (see Figure 3). By looking at both of these coregulatory patterns in one overall model, we could evaluate the relative contributions of each dyadic process on child outcomes in light of each other.

Results

Preliminary Analyses

First, we conducted some preliminary analyses to examine the variables and their distributions. We centered all variables before including them in any analyses, and we assessed the normality of their distributions using Kolmogorov-Smirnov tests. With regard to the self-regulation variables, assumptions of normality were met for each participant's CBQ scores, $D(90) = 0.08$, $p = .17$, and their DMQ-SP scores, $D(88) = 0.09$, $p = .10$. Their DMQ-TP scores did not pass such a conservative test, $D(88) = 0.13$, $p = .001$. However, this variable had a standardized skewness that had an absolute value less than 1.96; for the present sample size, this reflected a fairly normal distribution (Ghasemi & Zahedaisl, 2012). The ERC scores, $D(87) = 0.13$, $p < .01$, passed neither test, and we used a log transformation to transform this variable before using it in the primary analyses.

We also checked the distributions of the predictors in the models. With regard to our coregulation patterns, the transitions per minute across affective states (affective flexibility), $D(91) = 0.09$, $p = .07$, and the transitional probabilities between maternal autonomy-supportive behaviors and children's compliance (behavioral contingencies), $D(90) = 0.08$, $p = .20$, were normally distributed. However, the durations the dyads spent in positive and neutral affect, $D(91) = 0.13$, $p = .001$, and in positive and neutral behavior, $D(91) = 0.13$, $p = .001$, did not pass the Kolmogorov-Smirnov test. We did not use any log transformations on these variables though because that only exacerbated their skew. We also planned to include two covariates into the models to account for child characteristics that might affect the development of self-regulation. Children's standardized scores from the observed effortful control battery were normally distributed, $D(97) = 0.06$, $p = .20$, but their WPPSI scores were not, $D(97) = 0.19$, $p < .001$. Once again, we did not use a log transformation to transform the latter because that would have only exacerbated its skew. Sociodemographic factors such as parent-reported maternal education, child ethnicity, child age, and financial stress were unrelated to any of the self-regulation variables or the main dyadic variables of interest. However, child sex was weakly related to the transitional probabilities between maternal autonomy-supportive parenting and children's compliance ($r = -.21$, $p = .05$). For this reason, we included child sex as a covariate in the models as well.

Descriptive Statistics

We used IBM SPSS Statistics Version 25 (IBM Corp., 2017) to find descriptive statistics for our data. Table 1 includes the means, standard deviations, and ranges for all the variables, and Table 2 shows the raw bivariate correlations among the dyadic interaction patterns, children's self-regulation variables, and our covariates.

The self-regulation outcomes were moderately related to one another. Children's ERC scores were weakly correlated with their DMQ-TP (r = -.28, p = .01) and DMQ-SP scores (r = -.25, p = .02), and were strongly related to their CBQ scores (r = -.58, p < .001). Additionally, children's DMQ-TP scores were moderately related to their CBQ scores (r = .35, p = .001) and their DMQ-SP scores (r = .45, p < .001), supporting the inclusion of both forms of persistence in this study. However, there was no association between the DMQ-SP and CBQ scores (r = .17, p = .11). Since our indicators were meant to represent various components of self-regulation, the associations among these variables at the same time point is unsurprising and provide evidence of the multi-faceted but interrelated nature of regulatory processes in preschoolers.

Evidence also demonstrated the importance of including children's effortful control and cognitive abilities as covariates in this study. Children's observed effortful control scores at T1 were moderately associated with their CBQ scores (r = .36, p = < .001) and ERC scores (r = -.31, p = .01) at T2, but they were unrelated to children's DMQ-TP (r = .07, p = .52), and DMQ-SP (r = .02, p = .88) scores. The relation between observed effortful control scores at T1 and children's CBQ scores four months later was unsurprising since inhibition underlies effortful control (Rothbart & Bates, 2006). However, it is surprising that there was no relation between children's observed effortful control and their later social persistence scores since temperamental regulation is related to behavioral regulation. Children's WPPSI scores were moderately related to their ERC scores (r = -.36, p < .001) and CBQ scores (r = .44, p < .001).

We also examined the bivariate correlations for the relation between our dyadic predictors and self-regulation variables. Interestingly, neither the transitions per minute across affective states (affective flexibility) nor the transitional probabilities between maternal autonomy-supportive behaviors and children's compliance (behavioral contingencies) were related to any of the self-regulation variables, nor were they related to one another (*r* = .03, *p* = .82). However, the duration each dyad spent in positive and neutral affect was related to children's ERC scores (*r* = -.23, *p* = .05); furthermore, there was an association between the duration each dyad spent in positive and neutral behavior and children's CBQ scores (*r* = .30, *p* = .01). Since the literature has suggested that dyadic interaction patterns should be examined in context (e.g., Lunkenheimer et al., 2011), we decided to move forward with including interactions between each dyad's duration spent in positive and neutral affect and their transitions per minute across affective states (affective flexibility) as well as between each dyad's duration spent in positive and neutral behavior and their transitional probabilities between behavioral states (behavioral contingency) in our models.

Primary Analyses

We conducted the primary analyses for this study in RStudio version 1.1.383 (RStudio Team, 2016) using a more robust version of maximum likelihood as the estimator to account for the skew of any manifest variables. A non-significant chi-square test indicates adequate absolute fit of models, particularly when the sample size is small. In addition to using the chi-square test, we examined goodness-of-fit for each of the path models using the comparative fit index (CFI) and the Tucker-Lewis Index (TLI); a CFI and TLI of .95 and above is indicative of good model fit to the data (Hu & Bentler, 1999). Additionally, we evaluated approximate misfit in the models using the root-mean-square error of approximation (RMSEA) and the standardized root mean square residual (SRMR); acceptable values for these indices fall below .06 and .08, respectively (Browne & Cudeck, 1993; Hu & Bentler, 1999).

Affective Flexibility Model

In the affective flexibility model, we investigated the relations of the interaction between each dyad's transitions per minute across affective states (affective flexibility) and the duration spent in positive and neutral affect with the indicators of children's self-regulation at T2, controlling for child sex, observed effortful control, and children's WPPSI scores at T1. This model fit the data well, $\chi^2(17) = 17.87$, $p = .40$, CFI = 0.99, TLI = 0.97, RMSEA = 0.02 (0.00, 0.10), SRMR = 0.08, explaining variance in children's CBQ scores (32%), ERC scores (27%), DMQ-SP scores (10%), and DMQ-TP scores (6%). The significant paths and standardized regression coefficients are reported in Figure 5. The duration spent in dyadic positive and neutral affect was marginally associated with children's CBQ scores ($\beta = 0.20$, $z = 1.91$, $p = .06$, 95% CI [0.02, 0.38]) and significantly related to their ERC scores ($\beta = -0.29$, $z = -3.17$, $p = .002$, 95% CI [-0.45, -0.13]). Moreover, the interaction between each dyad's transitions per minute across affective states (affective flexibility) and the duration spent in positive and neutral affect was a significant predictor of children's DMQ-SP scores ($\beta = 0.31$, $z = 2.50$, $p = .01$, 95% CI [0.04, 0.58]). Simple slopes testing revealed that for dyads who spent a lower duration in positive and neutral affect (two standard deviations below the mean), there was a significant negative relation between their transitions per minute and their DMQ-SP scores, $\beta = -0.64$, $z = -2.51$, $p = .01$. In other words, lower levels of dyadic positive and neutral affect coupled with more transitions per minute (greater affective flexibility) were associated with lower levels of children's social persistence. On the other hand, for dyads who spent a higher duration in positive and neutral affect (two standard deviations above the mean), there was a significant positive relation between their transitions per minute and their DMQ-SP scores, $\beta = 0.60$, $z =$

1.97, $p = .05$. Higher levels of dyadic positive and neutral affect and more transitions per minute (greater dyadic affective flexibility) were associated with greater social persistence.

Behavioral Contingency Model

We used a path analytic model to examine the relations of the interaction between the transitional probabilities between behavioral states (behavioral contingencies) and the duration spent in positive and neutral behavior on indicators of children's self-regulation at T2, above and beyond the effect of child sex, observed effortful control, and children's WPPSI scores at T1. This model also fit the data well, $\chi^2(15) = 17.47$, $p = .29$, CFI = 0.97, TLI = 0.92, RMSEA = 0.04 (0.00, 0.11), SRMR = 0.08, explaining variance in children's CBQ scores (25%), ERC scores (20%), DMQ-SP scores (6%), and DMQ-TP scores (4%). The significant paths and standardized regression coefficients are reported in Figure 4. The duration spent in positive and neutral behavior was marginally associated with children's CBQ scores ($\beta = 0.18$, $z = 1.79$, $p = .07$, 95% CI [-0.01, 0.40]). Additionally, the interaction between the transitional probabilities between behavioral states (behavioral contingencies) and the duration spent in positive and neutral behavior was a marginally significant predictor of children's DMQ-SP scores ($\beta = -0.17$, $z = -1.70$, $p = .09$, 95% CI [-0.39, 0.02]) and a significant predictor of their ERC scores ($\beta = -0.21$, $z = -2.01$, $p = .04$, 95% CI [-0.41, -0.02]). Simple slopes testing revealed that for families who spent a lower duration in dyadic positive and neutral behavior (two standard deviations below the mean), a higher transitional probability of the pairing of maternal autonomy support and children's compliance (stronger behavioral contingency) was significantly associated with higher ERC scores, $\beta = 0.57$, $z = 2.56$, $p = .01$, and was marginally associated with higher DMQ-SP scores, $\beta = 0.43$, $z = 1.80$, $p = .07$. These findings indicate that a stronger behavioral contingency between maternal autonomy support and children's autonomous behavior was associated with higher levels of children's social persistence as well as higher levels of emotional lability when families exhibited a greater duration in negative behavioral states.

Combined Affect–Behavior Model

The final path analytic model included both the behavioral interaction between the duration spent in dyadic positive and neutral behavior and the transitional probabilities of the pairing of behavioral states as well as the affective interaction between the duration spent in dyadic positive and neutral affect and the transitions per minute across affective states as predictors of the indicators of children's self-regulation. Once again, child sex, observed effortful control, and children's WPPSI scores were used as covariates in the model. The significant paths and their standardized regression coefficients can be found in Figure 6. Our model showed excellent fit, $\chi^2(33) = 33.46$, $p = .45$, CFI = 1.00, TLI = 0.99, RMSEA = 0.01, SRMR = 0.07, explaining variance in children's CBQ scores (29%), ERC scores (25%), DMQ-SP scores (9%), and DMQ-TP scores (6%).

The affective interaction positively predicted children's DMQ-SP scores ($\beta = 0.27$, $z = 1.99$, $p = .05$, 95% CI [0.00, 0.54]). Simple slopes testing revealed that the direction of effects was in the same direction as in the affective flexibility model. For dyads who spent a lower duration in positive and neutral affect (two standard deviations below the mean), there was a significant negative relation between their transitions per minute and children's DMQ-SP scores, $\beta = -0.54$, $z = -2.07$, $p < .04$; for dyads higher in positive and neutral affect (two standard deviations above the mean), there was a marginally significant positive relation between their transitions per minute and children's DMQ-SP scores, $\beta = 0.53$, $z = 1.69$, $p = .09$. This suggests that lower levels of positive and neutral affect coupled with higher transitions per minute (greater affective flexibility) serves as a risk factor for children's social persistence, whereas higher levels of dyadic positive and neutral affect and higher transitions per minute (greater affective flexibility) supports children's social persistence.

Additionally, after the inclusion of the behavioral interaction in our model, the affective interaction was also marginally positively related to children's DMQ-TP scores (β = 0.17, z = 1.71, p = .09, 95% CI [-0.02, 0.35]). Simple slopes testing revealed that for dyads who spent a higher duration in positive and neutral affect (two standard deviations above the mean), there was a marginally significant positive relation between their transitions per minute and children's DMQ-TP scores, β = 0.53, z = 1.69, p = .09. Taken together, these findings suggested a lower duration of positive or neutral affect coupled with higher levels of affective flexibility was maladaptive for children's regulatory outcomes. However, there was also marginal evidence that higher dyadic flexibility of affect, as long as it was primarily positive or neutral affect, was associated with higher child persistence.

Lastly, the behavioral interaction was marginally negatively associated with children's ERC scores (β = -0.20, z = -1.83, p = .07, 95% CI [-0.41, 0.01]). For families who spent a lower duration in dyadic positive and neutral behavior (two standard deviations below the mean), there was a significant positive relation between transitional probabilities between behavioral states (behavioral contingencies) and children's ERC scores, β = 0.51, z = 2.35, p = .02. These findings suggest that a lower duration spent in an adaptive positive behavioral state coupled with a stronger coupling of maternal autonomy support and child compliance is related to higher levels of child emotional lability. The relation between our behavior interaction and children's DMQ-SP scores from the behavioral contingency model was no longer marginally significant.

Discussion

The purpose of the study was to examine parent-child interactions as dynamic systems and investigate how coregulation patterns shape the development of self-regulation in preschoolers. After coding parent and child affect and behavior during dyadic interaction tasks, we utilized path analytic models to see how coregulation patterns were related to children's mother-reported self-regulation four months later. More specifically, we investigated the influence of dyadic affective flexibility and positive behavioral contingencies on children's inhibitory control, task persistence, social persistence, and emotional lability. As expected, when we paired primarily positive and neutral content with dyadic affective flexibility, this coregulation pattern supported the development of adaptive skills in the child. Our findings suggest that flexible parent-child affective exchanges, as long as the interaction content is affectively neutral or positive, could support multiple aspects of children's self-regulation in early childhood. On the other hand, contrary to what we expected, if the interaction content was less affectively positive or neutral, flexible parent-child affect exchanges and contingent and predictable behavioral exchanges tended to be a risk factor for children that was related to lower levels of regulatory abilities. These results provide additional evidence that coregulation patterns can be adaptive or maladaptive depending on the context, task, or sample (e.g., Fischer et al., 2017; Hollenstein & Lewis, 2006; Suveg, Shaffer, & Davis, 2016). Therefore, although many studies have used overall composites of general parenting behavior as predictors of children's self-regulation, the present study demonstrates how specific coregulation patterns afford us with a more nuanced description of how parenting in the moment relates to children's outcomes.

Furthermore, this study reveals the importance of taking a multidimensional perspective of regulatory processes when understanding how child development is impacted by the parent-child relationship. With this design, we were able to examine how coregulation patterns supported individual regulatory capacities in light of other dimensions of self-regulation. Moreover, we could look at the relative contributions of coregulation patterns as well as examine their association with one another. We found that these coregulatory processes were not related to one another, and surprisingly, they exhibited cross-domain relations with components of children's regulatory capacities. Therefore, through this approach, we discovered that it is necessary to examine the influence of coregulatory processes on children's self-regulation across domains. Taken together, this study highlights the importance of considering process, content, and domain when trying to understand how coregulatory patterns shape the development of children's self-regulation.

The Process of Affective Coregulation and Children's Self-Regulation

We hypothesized that the interaction between dyadic positive and neutral affect and affective flexibility would be negatively related to children's emotional lability, in accordance with the findings of a previous study examining these relations in older children (Lunkenheimer et al., 2012). Although research has demonstrated that expressing a range of emotions is adaptive for children and increases the number of opportunities they have to practice regulating their emotions (Gottman, Katz, & Hooven, 1996), some parents may restrict their children's expressivity thus limiting their emotion regulation abilities (Eisenberg, Cumberland, & Spinrad, 1998; Ramsden & Hubbard, 2002). For example, Lunkenheimer, Albrecht, and Kemp (2013) found that higher maternal depressive symptoms were associated with lower affective flexibility, which in turn was associated with greater emotional lability in early childhood. Drawing from the empirical literature, we posited that when dyads are able to flexibly navigate changes in environmental demands, preschoolers are able to practice transitioning into and out of various emotional states without getting stuck in negative affect. We thought this would reduce their emotional lability and improve their emotion regulation over the course of many flexible parent-child interactions. However, our affective flexibility model and combined affect-behavior model did not indicate a significant negative association between our affective interaction and children's emotional lability.

Our results instead did reveal a significant positive relation between the affective interaction and children's social persistence with adults. Previous studies have shown that a pattern of dyadic affective rigidity is harmful for the development of children's behavioral regulation (e.g., Hollenstein et al., 2004) and that negative contexts like a conflict discussion can reduce dyadic affective flexibility (Hollenstein & Lewis, 2006). However, in this study, if the dyad experienced lower levels of positive or neutral exchanges, higher levels of affective flexibility seemed to be maladaptive for children and were associated with lower levels of child social persistence. The codes for affect were mutually exclusive, such that parents and children could each only exhibit one of four affective states in a given second (i.e., negative, neutral, low-to-medium positive, and medium-to-high positive affect); therefore; dyads low in positive and neutral affect exhibited high levels of dyadic negative affect. A pattern of greater dyadic negative affect and more affective flexibility reveals that the dyad was exposed to more transitions into negative emotional states from positive and neutral emotional states. Research has shown that in the midst of negative exchanges, emotion-related stimuli become more salient, and individuals' cognitive and behavioral resources to adapt to environmental demands decrease (Derryberry & Tucker, 1994). Lunkenheimer, Kemp, Lucas-Thompson, Cole, and Albrecht (2017) also previously demonstrated that when the contextual demands placed on dyads increased, this evoked coregulatory changes that induced lower levels of behavioral variability and greater dyadic affective flexibility; in other words, when the demands for specific behaviors were high, particularly from parents, they may have had fewer resources to attune to and regulate affective states. Together, these studies suggest that dyads who engaged in higher levels of negative affect expression and more affective flexibility may have exhibited higher levels of emotional reactivity and may have experienced difficulty with handing the changing contextual demands of the laboratory session. In particular, given that we controlled for children's own temperamental regulation, this pattern could be reflective of parents' poor regulatory abilities as the demands placed on them became more stressful. Therefore, rather than regulating one another, greater affective flexibility in this context could be indicative of a dyad that augments one another's dysregulation in the context of changing environmental demands, contributing to more chaotic or disorganized dyadic affect. Our findings suggest that these chaotic dyadic affect dynamics are related to children's lower persistence with adults.

However, as expected, if the dyad experienced more positive or neutral exchanges (rather than dyadic negative affect) and more transitions into and out of emotional states, this pattern was marginally associated with higher levels of social persistence. This finding supports previous work in slightly older children suggesting that parent–child flexibility across primarily positive and neutral emotional states is adaptive for children's behavioral outcomes (Lunkenheimer et al., 2011). Although dyads often spend the longest portion of their interactions in a neutral state (Dishion, Andrews, & Crosby, 1995), more transitions into states of positive affect could increase children's motivation to interact adaptively with their parents, regardless of the type of task in which they are engaging. Lunkenheimer and Wang (2017) demonstrated that higher levels of dyadic persistence (i.e., greater duration in neutral or adaptive behavioral states from the parent and child) were related to higher levels of social mastery in the child. Taken together, these studies suggest that patterns of affective flexibility and the matching of adaptive behavioral states, or behavioral synchrony, might support interpersonal processes and social aspects of self-regulation.

Additionally, this adaptive pattern of high dyadic positive and neutral affect and high dyadic flexibility could reflect that these dyads are repairing mismatched affective states by transitioning from negative states to more neutral or positive states rather than getting stuck in a negative attractor state. This explanation would support the findings from prior literature examining the relation between parent-child affect dynamics and children's adaptive outcomes. Granic and colleagues (2007) posited that families who are able to quickly transition out of a dyadic negative affect state and repair any aversive exchange may have children who have better regulatory outcomes. Using a sample of children who were in middle childhood, they conducted a dynamic systems analysis of parent-child affect after families underwent therapy to reduce children's behavior problems. Families whose children's behavior problems improved tended to have higher levels of parent-child affective flexibility, a longer duration of dyadic positive affect, and higher levels of repair following a discussion of conflict. Therefore, in the present study, if members of the dyad were helping one another repair mismatched affective states and move toward states of neutral or positive affect, this pattern may be reflected in higher levels of dyadic affective flexibility that would support children's social persistence.

We also found a marginally significant relation between our affective coregulation interaction and children's task persistence in the combined affect-behavior model. Previous studies have established a relation between affective flexibility and children's behavioral regulation (e.g., Lunkenheimer et al., 2011). However, perhaps this finding was marginal because the effect of dyadic flexibility in the context of primarily positive and neutral exchanges impacts the willingness of the child to not only engage with the other member of the dyad but also his or her motivation to persist on the tasks that person offers the child. Other researchers have demonstrated the relation between interpersonal processes, social motivation, and children's task persistence (e.g., Wentzel & Wigfield, 1998). For example, secure attachment relationships are also related to more instances of children taking initiative and persisting in the face of challenge (Riksen-Walraven, Meij, van Roozendaal, & Koks, 1993). Drake, Belsky, and Fearon (2014) discovered that children's social self-regulation mediated the relation between attachment security and their engagement in the classroom, suggesting the possibility that parental responsiveness through the attachment relationship might shape children's task-oriented self-regulation through social processes first. The present study would suggest then that when children are more willing to interact with an adult, they may be more likely to persist in the tasks given to them by adults.

Taken together, our findings revealed that the process of affective coregulation was an important predictor of children's social self-regulation and marginally, their task-oriented regulatory abilities. In the context of more negative exchanges between mother and child, higher levels of flexibility may have reflected an inability of both members of the dyad to adjust to the changing contextual demands of each task; this seems to have decreased both children's social and task persistence. On the other hand, when families had higher levels of positive and neutral affect, higher levels of affective flexibility could have represented that dyad's ability to repair aversive interactions or their tendency to move toward more neutral or positive emotional states while engaging one another during the course of their interaction. This pattern was associated with higher levels of persistence in the child.

The Process of Behavioral Coregulation and Children's Self-Regulation

In this study, we found that stronger contingencies and low durations of dyadic positive and neutral behavior were related to higher levels of emotional lability; this association was significant in the behavioral model and only marginally significant in the combined model. We might have expected that patterns of consistency and predictability would be more beneficial in reducing children's lability and contributing to more appropriate emotional expression. Research has suggested that consistent, responsive caregiving is associated with having a positive emotional family climate in which children can predict what the expectations and consequences are of their behavior (Eisenberg, Cumberland, & Spinrad, 1998). Such a positive emotional climate helps children feel more emotionally secure and encourages appropriate emotional expressivity knowing their needs will be met (Morris, Silk, Steinberg, Myers, & Robinson, 2007). Many studies have established an association between parental responsiveness and consistent caregiving and children's emotion regulation abilities (Cassidy, 1994; Eisenberg, Fabes, Schaller, Carlo, & Miller, 1991). However, in the present study, a pattern of predictability coupled with low levels of dyadic positive and neutral behavior was related to higher levels of emotional lability in children.

As part of the method, the codes for behavior used in the State Space Grids were mutually exclusive for each second. Therefore, families who had low durations of positive or neutral dyadic goal-directed behavior spent more time in behavioral states where one or both members engaged in negative or maladaptive behavior. In the literature, many researchers have suggested that negative parenting (e.g., negative parental control, harsh discipline, rigid parenting) is associated with children's poor regulatory capacities (e.g., Karreman et al., 2006; Moilanen, Shaw, Dishion, Gardner, & Wilson, 2009; Thomas et al., 2017). However, our results support the body of work suggesting that individual negative behaviors might impact child outcomes through dyadic behavioral coregulatory processes by pulling the dyad toward a negative attractor state. In other words, when the dyad remains in a more negative or maladaptive behavioral states, this impacts children's development.

For these dyads, one possible explanation for our results is that the parents may not have been very responsive to their children's needs overall and may have not provided much autonomy support to which children could respond. Previous studies have demonstrated a relationship between maternal disengagement and lower levels of both child self-regulation and dyadic coregulation. Higher levels of maternal disengagement are associated with lower levels of attentional control in toddlers (Rodriguez, Ayduk, Aber, Mischel, Sethi, & Shoda, 2005), higher levels of behavior problems (Boutwell, Beaver, Barnes, & Vaske, 2012), greater anxiety (Beato, Pereira, Barros, & Muris, 2016), greater levels of child behavioral disengagement over time (Rasmussen, Borelli, Decoste, & Suchman, 2016), and more divergent patterns of physiological coregulation among preschooler-mother dyads (Skoranski, Lunkenheimer, & Lucas-Thompson, 2017). Accordingly, one possible explanation for our findings is that parents disengaged more during the dyadic tasks and this was related to higher levels of emotional lability in the child.

Furthermore, dyads who engaged in low levels of positive or neutral dyadic goal-directed behaviors could have experienced moderate to high levels of negative or maladaptive behaviors overall, beyond parental disengagement. As mentioned previously, studies have demonstrated that during negative interactions, emotion-relevant stimuli become more salient (Derryberry & Tucker, 1994). Additionally, dyadic behavior becomes more rigid as the abilities of parent and child to adapt to environmental demands decrease (Lunkenheimer, Kemp, Lucas-Thompson, Cole, & Albrecht, 2017). There is evidence that harsh or rigid parenting and parental control is related to higher levels of emotional dysregulation in children (Rhoades et al., 2011). Therefore, one possible explanation for our findings is that parents in these dyads more rigidly engaged in higher levels of control behaviors or harsh parenting. Researchers have demonstrated that the contingency between coercive and controlling parental behaviors with non-compliance is associated with higher levels of child behavioral dysregulation (Dumas, LaFreniere, & Serketich, 1995; Dumas, Lemay, & Dauwalder, 2001). Our findings suggest that even in the context of tighter contingencies of positive behaviors with child behavioral compliance, these maladaptive interaction patterns overall might have been related to having a higher level of child emotional lability (Dunsmore, Booker, & Ollendick, 2011; Pietromonaco & Barrett, 2009), particularly if the child is over-regulated by the parent.

We had hypothesized that positive behavioral contingency paired with dyadic positive and neutral behavior would be related to children's inhibitory control and behavioral regulation. We found a marginally significant relation between the behavior interaction and children's social persistence with adults in the behavioral contingency model; low levels of positive behavior coupled with a strong behavioral contingency was associated with higher levels of children's willingness to persist in interactions with adults. Unlike in the case of children's emotional lability, children's responsiveness to maternal bids was a protective factor for the development of their social persistence. However, this association might reflect that a child's level of social mastery motivation underlies both their behavioral compliance and their social persistence with adults. It did not appear in the combined model though, possibly because the dynamics of affective coregulation is a stronger predictor of social persistence than behavioral coregulation.

The Importance of Interaction Content for Children's Self-Regulation

The results from this study also emphasize the importance of considering the content of interactions when investigating the effects of dyadic coregulation patterns. Previously, Hollenstein and colleagues (2004) indicated that a pattern of flexibility is more important for child regulatory outcomes than the affective content of the interaction. They examined the relation between parent-child interaction patterns and the trajectories of children's internalizing and externalizing problems across 18 months. Families whose children exhibited consistently higher levels of externalizing problems or whose problems increased over time displayed greater dyadic rigidity than families whose children had consistently low problems or whose problems desisted over time. This relation lasted over time, even after controlling for the duration of dyadic negative affect or positive affect, suggesting that rigidity was a stronger predictor of children's behavioral dysregulation than just duration in dyadic emotional states. However, the findings from the present study and others in the empirical literature indicate that the context and content of interactions are important factors that shape the process of coregulation and must be considered.

This study demonstrated that positive content (or the absence of negative content) can impact children's outcomes. In the affective flexibility model, dyadic positive and neutral affect was significantly negatively related to children's emotional lability and marginally positively associated with their inhibitory control. Dyadic positive and neutral behavior was marginally associated with children's inhibitory control in the behavioral contingency model and significantly associated with children's emotional lability in the combined model. These findings indicated that experiencing fewer negative exchanges was more salient for children's emotional lability and inhibitory control than patterns of flexibility or contingency. Moreover, dyadic affective flexibility only supported children's self-regulation in the context of primarily positive and neutral exchanges, complementing the findings of other studies examining the relation between coregulatory processes and children's self-regulation (e.g., Kochanksa, Aksan, Prisco, & Adams, 2008; Lunkenheimer et al., 2011).

Fredrickson (2013) posits a broaden-build theory for positive emotions that may explain the marginal relations between positive content and children's adaptive development. First, she argues that positive emotions broaden an individual's thoughts, activities, and relationships. For example, in the literature, positive emotions are associated with an expansion of attention (Derryberry & Tucker, 1994), higher levels of cognitive flexibility (Ashby, Isen, & Turken, 1999), greater creativity (Isen, Daubman, & Nowicki, 1987), and a wider range of actions (Renninger, 1992). Second, positive emotions build an individual's physical, cognitive, and social resources for future goals and tasks (Diamond & Aspinwall, 2003; Fredrickson, 2013; Wang, 2017). Therefore, drawing from this theory, positive emotions could allow members of the dyad to mobilize their resources appropriately in the service of situational demands and contextual goals during parent-child interactions, thus bolstering coregulatory processes and promoting the development of individual regulatory capacities.

Unexpectedly, we did not find that the interaction between higher levels of positive and neutral behavior and stronger behavioral contingencies was related to higher levels of self-regulation in children. One possible reason for this could be the sample utilized in this study. We recruited a local community sample to understand how these dyadic and individual regulatory processes are related to one another in normative samples. However, our sample was relatively high-functioning and included families that were largely middle-class, Caucasian, and well-educated. These families engaged predominantly in neutral exchanges and low levels of positive behaviors; we did not observe much heterogeneity at the average to high levels of dyadic positive behaviors. Without such variability, we may not have had enough power to be able to detect how behavioral coregulation processes drive positive development in children.

Although we were primarily interested in the effect of coregulation patterns in the context of more positive exchanges on the development of children's regulatory abilities, we discovered that negative regulatory processes are particularly important for shaping children's outcomes. The most robust findings from this study involved negative exchanges. Although dyadic affective flexibility in the context of more positive and neutral affective interactions served as a form of coregulation that supported children's regulatory abilities, this pattern seemed to be dysregulating for dyads in the context of low dyadic positive and neutral affect (or higher levels of negative affect). Similarly, stronger positive behavioral contingency was more of a protective factor for children's social persistence for dyads low in positive dyadic behavior, but it had no effect on children's regulatory abilities for dyads high in positive dyadic behavior. These findings support previous research suggesting negative interaction contact is particularly salient for children's development and is harmful for both individual and dyadic regulatory processes. For example, a number of studies have demonstrated how mutual negative affect in parent-child interactions is related to less dyadic behavioral flexibility (Forgas, 2002; Paulhus & Martin, 1988) and greater behavioral dysregulation in children (Carson & Parke, 1996; Patterson, 1982; Patterson & Dishion, 1988). Though negative expressions like anger or fear serve a regulating function for the individual that helps him or her marshal resources appropriately, they may limit the abilities of children to develop more complex forms of self-regulation, particularly if they elicit higher levels of parental distress and harsh parenting (e.g., Fabes, Leonard, Kupanoff, & Martin, 2001). Children exposed to parental negative affect exhibit difficulties with regulating their emotions and behavior (Cummings, Iannotti, & Zahn-Waxler, 1985) and display lower levels of social regulation in peer contexts (Isley, O'Neil, Clatfelter, & Parke, 1999).

Taken together, these findings provide evidence that the overall affective content of dyadic interactions plays an important role in shaping how interaction patterns either promote adaptive coregulation or serve as dysregulating processes associated with poor outcomes in the child. Therefore, studies examining the relation between coregulation patterns and children's self-regulation must consider how positive and negative contexts shape these associations.

The Relations Among Dyadic and Individual Regulatory Processes Across Domains

Lastly, the present study's findings also point to the importance of investigating cross-domain relations between coregulatory patterns and children's regulatory capacities, given that affective coregulation was associated with children's behavioral self-regulation whereas behavioral coregulation was associated with children's emotional self-regulation. Affect-behavior chains have already been described in the literature, particularly in the field of developmental psychopathology (e.g., Dumas, LaFreniere, & Serketich, 1995). However, this study highlights the importance of considering parent-child interactions as a dynamic system as well and investigating the interrelations among coregulatory processes and individual child capacities across domains.

Transactional models are useful for evaluating the dynamic relations between children and their environments in a system to understand developmental outcomes; additionally, they shed light on the continuities and discontinuities in the environment over time (Sameroff & Mackenzie, 2003). With regard to this study, self-regulation by itself is multi-dimensional in nature, and children need to develop various regulatory skills in order to meet the emotional, behavioral, cognitive, and physiological demands placed on them by transacting internal and external factors (Bronfenbrenner, 1986; McClelland & Cameron, 2011). Similarly, coregulatory processes also occur across multiple domains and could be influencing both one another as well as children's individual regulatory outcomes (Lunkenheimer & Dishion, 2009). Therefore, the influence of cross-domain coregulatory processes on children's regulatory outcomes occurs in a complex environment of transacting influences that need further elucidation (Sameroff, 2010). We should thus utilize interaction models and transactional analyses to understand the process of development of children's regulatory capacities.

One explanation for this study's transactional effects could be that coregulatory patterns are compensatory processes that provide moment-to-moment external regulation for children's regulatory skills, particularly at this age range. For preschoolers, whose self-regulation capacities are only just burgeoning, coregulatory processes might induce particular skills in the children that are reflective of the patterns to which they are exposed (Thelen & Smith, 1998). For example, we had initially predicted that greater dyadic flexibility might induce higher levels of individual emotional flexibility and lower children's emotional lability by helping children practice moving out of states of negative affect. However, children with higher levels of emotional lability may already be overly reactive to changes occurring in their internal and external environments and may exhibit high levels of individual emotional flexibility already (Dunsmore, Booker, & Ollendick, 2011; Pietromonaco & Barrett, 2009). Therefore, patterns of consistency and predictability might be more beneficial in reducing children's lability and contributing to more appropriate, regulated emotional expression. The literature suggests that consistent, responsive caregiving is associated with having a positive emotional family climate in which children can predict what the expectations and consequences are of their behaviors (Eisenberg, Cumberland, & Spinrad, 1998). Such a positive emotional climate helps children feel more emotionally secure and encourages appropriate emotional expressivity knowing their needs will be met (Morris, Silk, Steinberg, Myers, & Robinson, 2007). Therefore, patterns of positive behavioral contingencies are likely to be associated with children's emotional lability. Similarly, dyadic patterns of flexibility might help children develop regulatory skills that require higher levels of flexibility; in this case, affective flexibility was related to children's behavioral regulation, which requires being flexible in response to changes in internal and external environments.

Furthermore, coregulatory processes might mitigate the need for children to develop their regulatory skills across all domains at once. In the context of more positive or neutral exchanges, affective coregulation may provide the external regulation of emotions needed by children, while behavioral coregulation may afford them with the scaffolding they require to meet their behavioral demands. When parents serve as good external regulators, this may provide children with the security and the resources they need to maximize the opportunities of their situation. Adaptive affective coregulation could free up resources for children to focus on the behavioral and cognitive demands of their environments. Similarly, adaptive behavioral coregulation may free up children's resources to develop their emotion and cognitive regulation skills. On the other hand, in the context of more negative exchanges, parents may not take the lead in coordinating their goal-directed behavior or affect with their children, contributing to more disorganized patterns that may serve to dysregulate children even further. Further empirical evidence is needed to investigate these claims and understand how cross-domain moment-to-moment transactions support the development of preschoolers' individual regulatory capacities over time.

Limitations and Future Directions

The first limitation of this study was the sample. We utilized data collected from a sample that was largely Caucasian, middle-class, well-educated, and relatively high-functioning. Therefore, our findings may not be generalizable to other populations with differing sociodemographic factors or to high-risk families. Future studies should investigate the relations between coregulation patterns and the development of children's regulatory abilities in more diverse samples and in clinical samples. Together, this body of work could be informative for identifying targets for interventions involving parents and their children.

An important limitation of this study is that the self-regulation outcomes were reported by mothers. Therefore, the results from this study should be interpreted with regard to mothers' perceptions of their children's regulatory capacities. Using multiple reporters (e.g., multiple caregivers, siblings, preschool teachers) in the study or behavioral measures of children's self-regulation would provide us with a more unbiased assessment of each child's standings on the various components of self-regulation. Additionally, these measures would provide us with a better understanding of whether the effects of coregulation processes with a parent impact the self-regulation capacities children exhibit in other contexts.

Another limitation of this study was the choice of coregulation patterns for investigation in this study. Coregulation patterns can take various forms and be examined, for example, as dyadic synchrony, dyadic contingency, and dyadic flexibility or variability, to name a few. Because dyadic affective flexibility and positive behavioral contingencies were associated with children's self-regulation in the literature, we examined whether they were related to one another in this study; however, we found no relation between these patterns. It is possible that coregulation processes across domains may not be related to one another unless they include an assessment of the same kind of pattern. For example, Lunkenheimer, Kemp, Lucas-Thompson, Cole, & Albrecht (2017) examined patterns of dyadic behavioral variability and affective variability in parallel to one another in relation to the same context. Though they did not examine the relation between these patterns directly, they were able to use the context as an explanation for how these patterns may be related to each other. Follow-up studies should therefore examine the relation among various coregulation patterns (i.e., synchrony, contingency, and flexibility/variability) involving affect and goal-directed behavior and how they might impact children's development.

Lastly, in this study we used behavioral observations of child compliance as a proxy for preschoolers' self-regulation. However, though there is positive evidence in the literature for the association between dyadic behavioral patterns involving child compliance and children's individual regulatory capacities (e.g., Lunkenheimer, Kemp, & Albrecht, 2013), Kochanska and her colleagues argued that a meaningful difference exists in the literature between situational compliance sustained by a parent's ongoing bids and committed compliance, which tends to be connected with positive affect and child autonomy in the absence of parental control (Kochanska & Aksan, 1995; Kochanska, Coy, & Murray, 2001). They argue that if a child is continually told how to perform a challenging problem-solving task and is complying with the given instruction, as in the case of situational compliance, then she is missing the opportunity to practice regulatory skills and task persistence on her own, particularly as the child gets older and needs to develop more complex regulatory abilities. Committed compliance predicts continued independent rule-following behavior (Crittenden & DiLalla, 1988) and forms of internalization (Kochanska et al., 2001). Therefore, future studies should examine the relations between coregulation patterns and the trajectory of children's abilities from behavioral compliance to more complex, internalized forms of self-regulation across childhood.

Conclusion

Overall, this study emphasizes the importance of considering parent-child interactions as dynamic systems in order to provide a more clarified explanation for how the parent-child relationship impacts adaptive and maladaptive outcomes in the child. In particular, the study's findings suggest that patterns of affective flexibility and predictable behavioral contingencies support or harm various aspects of children's self-regulation skills, depending upon the context and affective content of the interaction. Such findings are important because they provide researchers not only with a more nuanced understanding of the complex environments in which children are developing, but also with important targets for intervention aimed at improving children's regulatory skills. In particular, programs aimed at parent management training and child skills training could benefit from further research focused on identifying and describing coregulation patterns and examining their relation with children's emotional, cognitive, and behavioral self-regulation in both positive and negative contexts.

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Appendix A: Tables

Table 1

Descriptive Statistics for Study Variables

Variable	***M***	***SD***	**Actual Range**	**Possible Range**
Child cognitive abilities (WPPSI)	17.72	4.92	0 - 30	---
Child observed effortful control	-0.01	0.68	-1.97 – 1.32	---
Dyadic positive and neutral affect	1018.73	64.44	858.46 – 1141.50	---
Dyadic affective flexibility (transitions per minute)	2.08	1.03	0.33 – 4.88	---
Dyadic positive and neutral behavior	851.75	111.28	568.77 – 1021.86	---
Behavioral contingency (transition probabilities)	0.27	0.10	0.07 – 0.56	0.00 – 1.00
Child emotional lability/negativity (ERC)	25.21	4.92	15.00 – 38.00	15.00 – 60.00
Child task persistence (DMQ-TP)	3.41	0.73	1.83 – 4.83	1.00 – 5.00
Child social persistence (DMQ-SP)	3.77	0.60	2.29 – 5.00	1.00 – 5.00
Child inhibitory control (CBQ)	3.87	0.74	1.38 – 5.15	1.00 – 7.00

Note. *M* = mean. *SD* = standard deviation. Possible ranges are reported for the self-regulation variables as well as our behavioral contingency variable since these transition probabilities had a defined range.

Table 2

Correlations Among Study Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Child cognitive abilities (WPPSI)	1									
2. Child observed effortful control	.438***	1								
3. Dyadic positive and neutral affect	-.156*	-.047	1							
4. Affective flexibility (transitions per min)	.035	-.087	-.201^{T}	1						
5. Dyadic positive and neutral behavior	.298**	.151	.293**	-.028	1					
6. Behavioral contingency	.050	-.116	-.031	.025	-.035	1				
7. Child emotional lability/negativity (ERC)	-.361**	-.307**	-.204^{T}	-.037	-.209^{T}	.060	1			
8. Child task persistence (DMQ-TP)	.146	.072	.011	.057	.048	.044	-.271*	1		
9. Child social persistence (DMQ-SP)	.031	.017	.133	-.025	.138	.123	-.222*	.446***	1	
10. Child inhibitory control (CBQ)	.442***	.356**	.082	-.074	.304**	.015	-.586***	.348**	.172	1

Note. N = 100. $^{T}p < .01$. $*p < .05$. $**p < .01$. $***p < .001$.

Appendix B: Figures

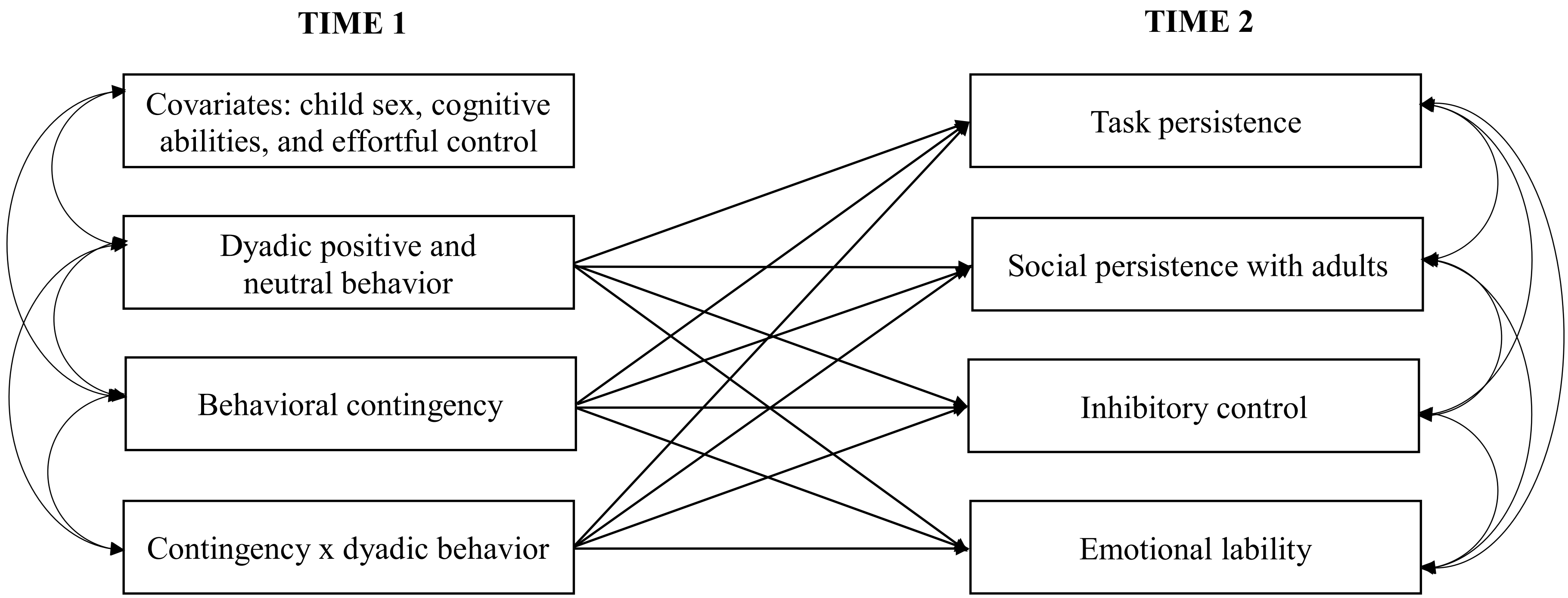

Figure 1. Conceptual behavioral model. This model examines the relation between behavioral coregulation in the context of dyadic positive and neutral behavior and various components of child self-regulation at T2, controlling for child sex, child cognitive abilities at T1, and child effortful control at T1.

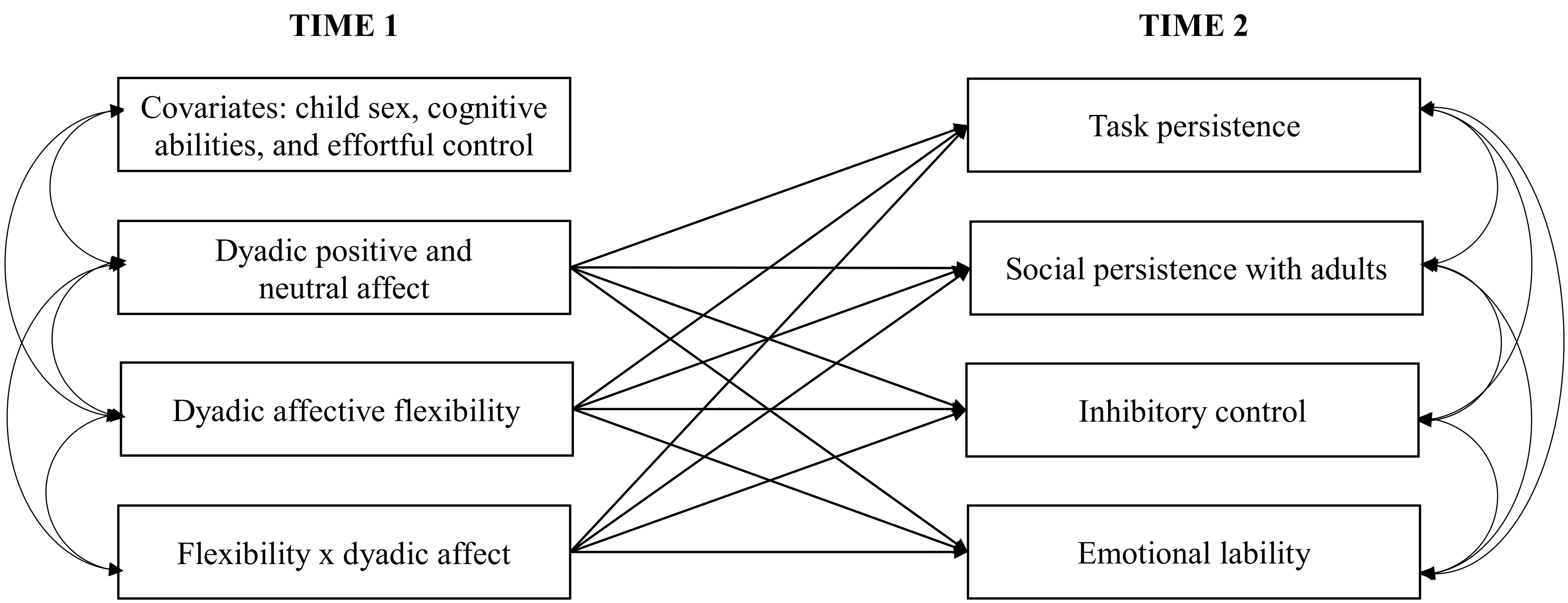

Figure 2. Conceptual affective model. This model examines the relation between affective coregulation in the context of dyadic positive and neutral affect and various components of child self-regulation at T2, controlling for child sex, child cognitive abilities at T1, and child effortful control at T1.

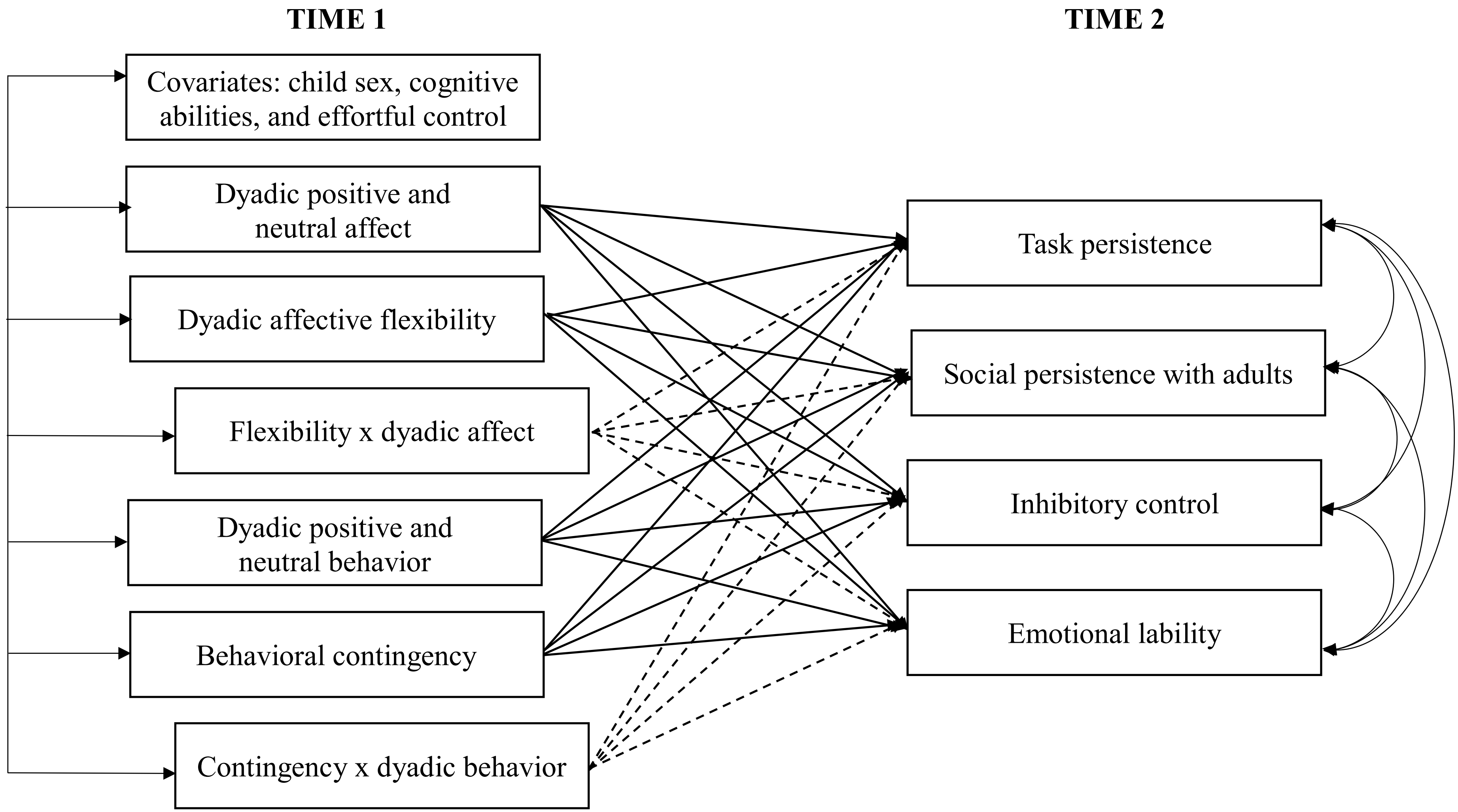

Figure 3. Conceptual combined affect-behavior model. This model examines the relation between coregulation patterns and various components of children's self-regulation at T2, controlling for child sex, child cognitive abilities at T1, and child effortful control at T1. Main effects are represented by solid lines and interaction effects are represented by dashed lines.

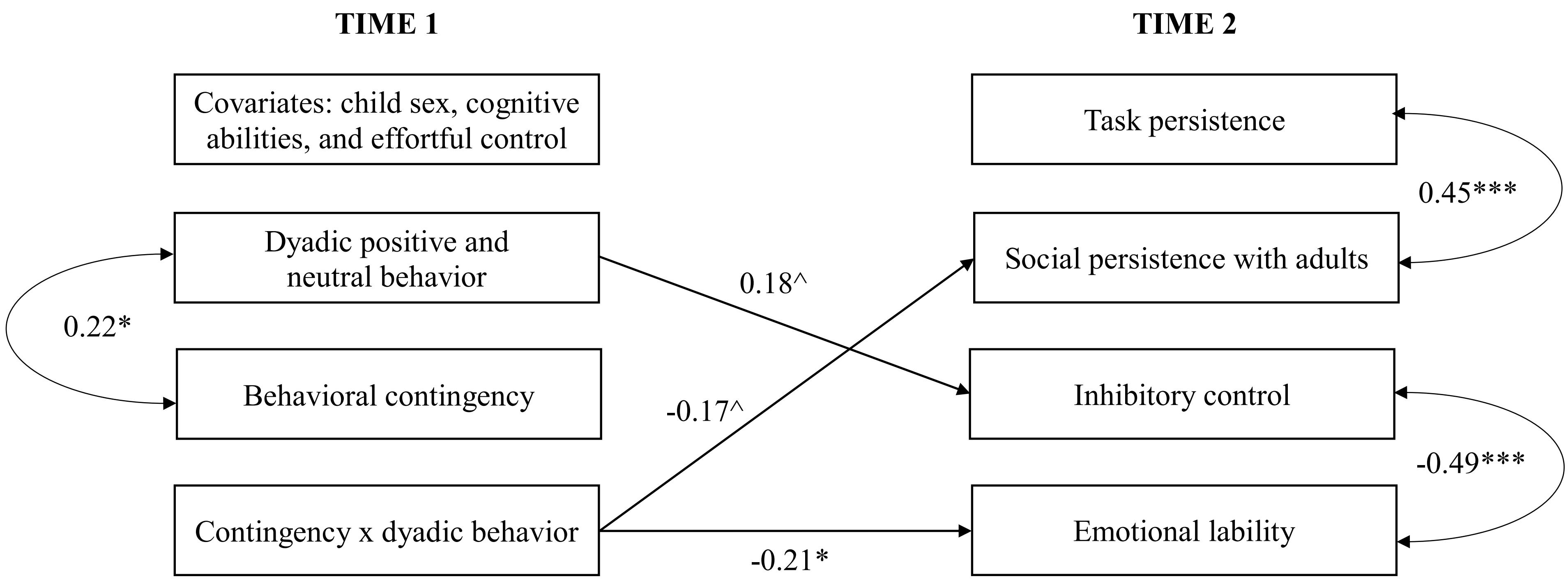

Figure 4. Behavioral coregulation model. This model assesses the relation between behavioral contingencies in the context of primarily positive behavioral exchanges and various components of self-regulation at T2, over and above the effects of child sex, child cognitive abilities at T1, and child effortful control at T1. Only the standardized regression coefficients for significant or marginally significant relations are reported in the model. ^$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$.

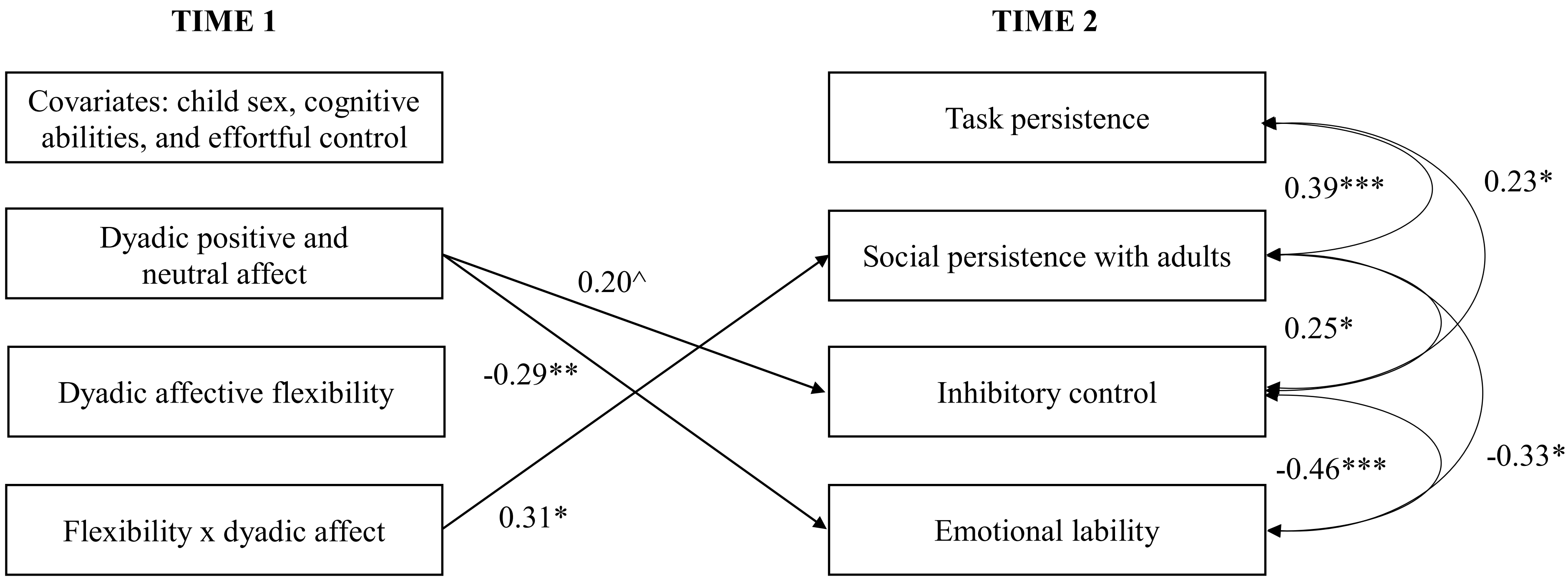

Figure 5. Affective coregulation model. This model assesses the relation between dyadic affective flexibility in the context of primarily positive and neutral affect and various components of self-regulation at T2, controlling for the effects of child sex, child cognitive abilities at T1, and child effortful control at T1. Only the standardized regression coefficients for significant or marginally significant relations are reported in the model. ^p < .10, *p < .05, **p < .01, ***p < .001.

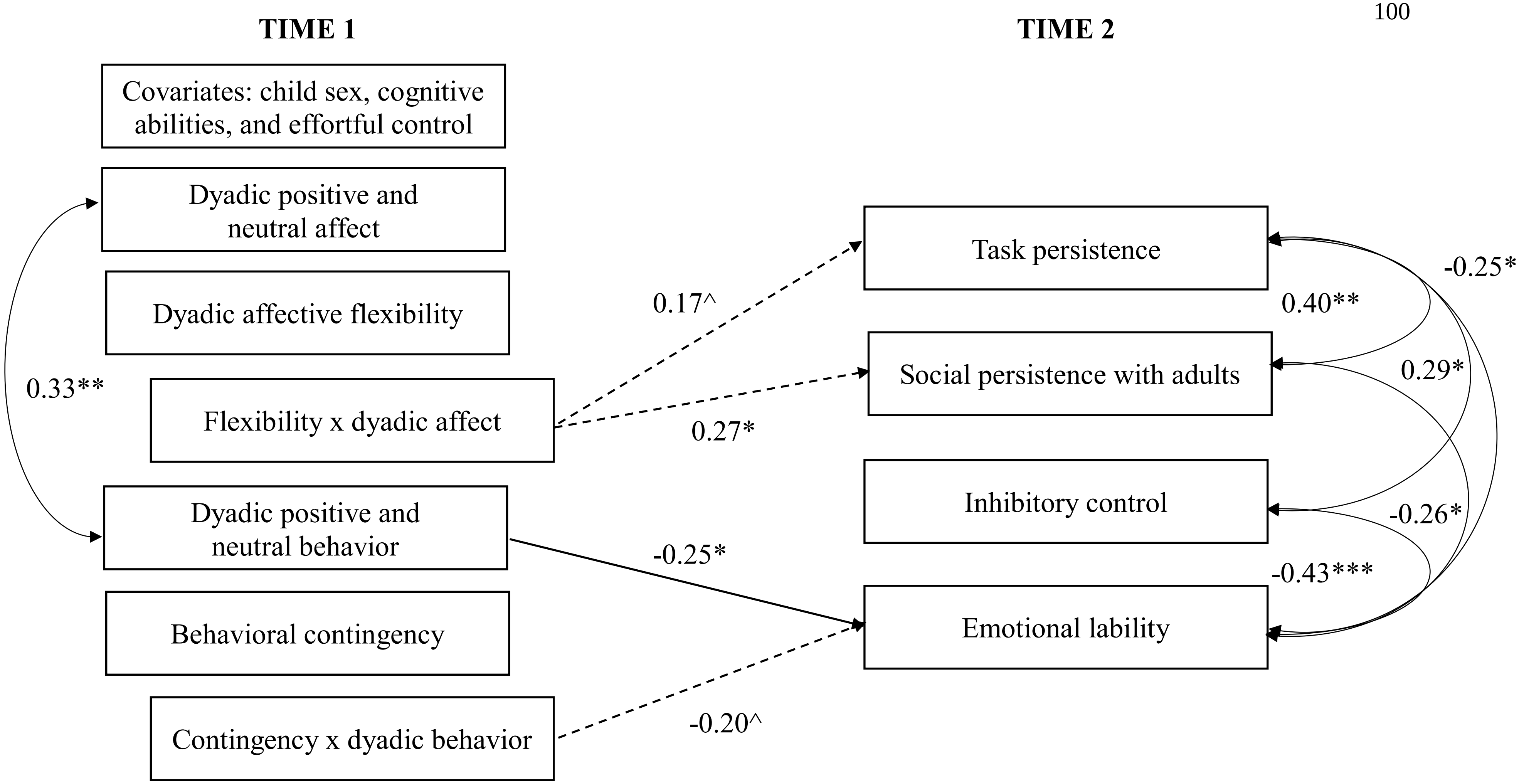

Figure 6. Combined affect-behavior model. This model assesses the relation between dyadic interaction patterns and various components of self-regulation at T2, over and above the effects of child sex, child cognitive abilities, and child effortful control at T1. Main effects are represented by solid lines and interaction effects are represented by dashed lines. Only the standardized regression coefficients for significant or marginally significant relations are reported in the model. ^p < .10, *p < .05, **p < .01, ***p < .001.

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EDUCATION

May 2013 **Duke University**
B. S., Double major in Neuroscience and Psychology

COMPETITIVE FELLOWSHIPS, HONORS, AND AWARDS

2017 - 2021	Training Interdisciplinary Education Scientists (TIES) Fellowship
2017	NSF Graduate Research Fellowship Program - Honorable Mention
2017	Robert & Ruth Faris Child Psychology Graduate Scholar Award ($3500)
2016 - 2017	University Graduate Fellowship

RESEARCH

Publication in Press:

Lunkenheimer, E. S. , Panlilio, C., **Lobo, F. M.**, Olson, S. L., & Hamby, C. M. (2019). Preschoolers' self-regulation in context: Task persistence profiles with mothers and fathers and later attention problems in kindergarten. *Journal of Abnormal Child Psychology.* Advance online publication. doi: 10.1007/s10802-019-00512-x

Conference Presentations (selected):

Lobo, F. M., Hamby, C. M., & Lunkenheimer, E. S. (2019, March). *Understanding the parent-child coregulation patterns shaping child self-regulation.* Paper accepted to the 2019 Biennial Meeting of the Society for Research in Child Development, Baltimore, MD.

Lunkenheimer, E. S., & **Lobo, F. M.** (2017, November). *Parental emotion coaching and dismissing moderate the effects of family chaos on child coping*. Paper presented at the 79th annual conference of the National Council on Family Relations, Orlando, FL.

TEACHING EXPERIENCE

2018 Co-guest lecturer, Introduction to Developmental Psychology

ACADEMIC SERVICE

2018	Ad-hoc co-reviewer for the *Merrill Palmer Quarterly*
2017	Ad-hoc co-reviewer for the *Journal of Applied Developmental Psychology*