Emotion Regulation from Infancy to Toddlerhood: Individual and Group Trajectories of Full-Term and Very-Low-Birthweight Preterm Infants

Nicole Atkinson

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Signed by the final examining committee:

____________________________	Chair	Dr. Andreas Arvanitogiannis
____________________________	Examiner	Dr. Diane Poulin-Dubois
____________________________	Co-Supervisor	Dr. Lisa Serbin
____________________________	Supervisor	Dr. Dale Stack

Approved by ____

Chair of Department or Graduate Program Director

____

Dean of Faculty

Date ____

Abstract

Emotion Regulation from Infancy to Toddlerhood: Individual and Group Trajectories of Full-Term and Very-Low-Birthweight Preterm Infants

Nicole Atkinson

Adaptive emotion regulation begins with infants operating jointly with their parents to regulate their emotions, which fosters the development of independent regulation. Little is known about when or how this transition occurs, or the impact of factors such as parental availability or premature birth status. The current study examined the use of self-, parent-, and environment-reliant emotion regulation behaviours in full-term and healthy very-low-birthweight (VLBW) preterm infant-mother dyads at 5 ½, 12, and 18 months of age. At 5 ½ months, dyads participated in the Still-Face procedure (two normal interactions and one in which mothers are non-responsive and expressionless). At 12 and 18 months, dyads participated in two free-play interactions, a puzzle task, and an interference task. Emotion regulation behaviours were coded using two systematic, observational systems. Results indicated that infants used fewer self- and environment-reliant strategies as they aged, but more mother-reliant strategies. Increased use of self-reliant strategies at earlier ages predicted increased use of mother-reliant strategies at subsequent ages. Toddlers used more independent, attention-seeking, and escape behaviour during periods of maternal unavailability. There were no significant differences between full-term and VLBW/preterm toddlers' emotion regulation behaviours. The current study contributes to the understanding of normative development of emotion regulation and the risk associated with prematurity.

Key words: emotion regulation, mother-infant interaction, VLBW and prematurity, maternal (un)availability, socioemotional development

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Emotion Regulation from Infancy to Toddlerhood: Individual and Group Trajectories of Full-Term and Very-Low-Birthweight Preterm Infants

The development of emotion regulation is a key feature of socioemotional functioning, and is tied to healthy outcomes throughout life. Emotion regulation involves the ability to "manage, modulate, inhibit, and enhance [one's] emotions" (Calkins & Fox, 2002, p. 483). It is central to emotional competence, which also includes emotional expressiveness, emotional understanding, recognition of emotions in self and others, and emotion knowledge (Denham et al., 2003; Denham, Mitchell-Copeland, Strandberg, Auerbach, & Blair, 1997), and to self-regulation, which includes regulatory processes in physiological, attentional, emotional, cognitive, and interpersonal domains of functioning (Calkins & Fox, 2002). The development of effective emotion regulation is a key milestone in early life (Thomas, Letourneau, Campbell, Tomfohr-Madsen, & Giesbrecht, 2017). It is predictive of several aspects of social functioning, including social competence, positive relationships with others, popularity with peers, empathy, sympathy, and academic success (Leerkes, Blankson, & O'Brien, 2009; Penela, Walker, Degnan, Fox, & Henderson, 2015). Adaptive emotion regulation may also protect against internalizing and externalizing problems throughout childhood, and promote healthy adjustment in adulthood (Kim, Stifter, Philbrook, & Teti, 2014; Penela et al., 2015). Failure to develop adaptive regulation strategies in early life is associated with socioemotional (Di Maggio, Zappulla, & Pace, 2016), behavioural (Crespo, Trentacosta, Aikins, &Wargo-Aikins, 2017; Hill, Degnan, Calkins, & Keane, 2006), and academic problems (Graziano, Reavis, Keane, & Calkins, 2007), and ultimately to risk of psychopathology (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Rawana, Flett, McPhie, Nguyen, & Norwood, 2014).

Development of Emotion Regulation

The Transactional Model posits that all aspects of development are a product of the reciprocal exchanges between children, their parents, and the environment (Sameroff, 2009). Developmental changes are driven by the child's constant interactions with and adaptation to their social environment, including their interactions with parents. According to this model, regulation by others provides the social context in which self-regulation occurs, shaping the child's development of self-regulatory abilities. Similarly, the Mutual Regulation Model (Tronick & Beeghly, 2011; Tronick & Gianino, 1986) posits that infants are simultaneously regulating to their own internal emotional state, and to their engagement with the external environment. This involves self-directed regulatory strategies intended to modify internal states, as well as other-directed strategies directed at regulating parent behaviour. Through these processes, dyads develop a coordinated, mutually regulated communicative system in which infants' regulatory capacities are bolstered by their parents, contributing to infants' emerging sense of agency. Thus, the development of emotion regulation is driven both by the infant's adaptation to the social environment, and their modification of this environment to suit their needs.

Indeed, the parent-child relationship is the first, and arguably most important, context in which emotion regulation abilities develop (Thompson, 1994). In early development, infants are reliant on parents' involvement in the dyadic regulation of their distress (Ostlund, Measelle, Laurent, Conradt, & Ablow, 2017; Schore, 2015; Thomas et al., 2017). Infants communicate their emotional states to their parents using facial, vocal, and behavioural cues; parents act to regulate their infants' emotions by interpreting and responding to their needs in a timely and appropriate manner, and by reciprocating and reinforcing infant reactions (Cole, Martin, & Dennis, 2004; Thomas et al., 2017; Weinberg & Tronick, 1994). Parent-infant interactions thus both shape and are shaped by infants' emotional responses (Thompson & Goodman, 2010; Tronick & Beeghly, 2011). When dyadic regulation is effective, it allows for the development of adaptive independent regulation processes in the infant (Conradt & Ablow, 2010; Granat, Gadassi, Gilboa-Schechtman, & Feldman, 2017). Through contingent responses to children's emotional displays, parents reinforce or inhibit these regulation processes in an ongoing process of emotion socialization (Garside & Klimes-Dougan, 2002).

Some primitive forms of emotion regulation appear to be innate. Infants are born with approach-withdrawal responses to pleasant or aversive stimuli, and rudimentary self-soothing behaviours such as sucking (Thompson & Goodman, 2010). Over the course of the first year, infants become more deliberate in their efforts to self-soothe as they develop controlled cognitive processes, they are increasingly reliant on themselves rather than exclusively on others, and they use more cognitive soothing strategies as opposed to relying on contextual support such as seeking help or avoiding emotionally arousing situations (Fox & Calkins, 2003; Thompson & Goodman, 2010). The increased role of cognition in emotion regulation may be explained by developmental changes in the anterior cingulate cortex occurring during the second half of the first year of life, a region associated with both emotion regulation and cognitive processes (Bell & Wolfe, 2004; Bush, Luu, & Posner, 2000). Indeed, the development of more sophisticated, cognitive emotion regulation strategies coincides with, and is likely enabled by, the development of higher order cognitive processes such as sustained attention (Bell & Wolfe, 2004; Calkins & Marcovitch, 2010). During this first year, infants also become more adept at social signalling as they come to recognize that parents' behaviour may assist them in regulating emotion (Calkins & Hill, 2007).

During the second year of life, brain maturation allows for more consistent use of active emotion regulation (Calkins & Hill, 2007). Changes in the attention system enable toddlers to use attentional allocation to independently regulate their emotions (Feldman, 2009), executive control abilities allow for the control of emotional arousal and reactivity (Rueda, Posner, & Rothbart, 2004), and coordinated motor and language skills allow for an increased ability to communicate effectively with others (Calkins & Hill, 2007).

Although the transition from dyadic to independent emotion regulation strategies is considered a normative part of development (Granat et al., 2017; Thompson & Goodman, 2010), there is a dearth of research regarding when and how this transition takes place. Further, this conceptualization is complicated by findings that infants' capacities for dyadic regulation become more sophisticated with age, suggesting that these strategies may continue to play an important role in adaptive regulation (Calkins & Hill, 2007).

Individual Stability and Trajectories of Emotion Regulation

In order to understand the development of emotion regulation, it is important to explore not only the mean-level continuity (or discontinuity) of behaviours, but also the individual-order stability (or instability) of these behaviours (Bornstein, Putnick, & Esposito, 2017). The developmental trajectories of dyadic and independent strategies may differ for individual infants. Indeed, there is significant individual variability in strategy use in both infants and toddlers (Morales, Mundy, Crowson, Neal, & Delgado, 2005). However, little is known about the stability of these individual differences, and the individual trajectories of emotion regulation behaviours over time. Identifying early patterns of regulation may aid in the recognition of early signs of maladaptive regulation, potentially contributing to early intervention.

There is preliminary evidence for early individual-order stability in regulation behaviours, particularly in later infancy. Feldman (2009) found low to moderate correlations between measures of emotion regulation at 3, 6, and 12 months, providing evidence for some developmental stability. However, although emotion regulation behaviours were observationally coded in this study, a composite score was used for analyses, preventing the direct examination of different behaviours. Rothbart, Ziaie, and O'Boyle (1992) examined individual regulation behaviours at 3, 6 ½, 10, and 13 ½ months. They found little stability in early infancy (3-6 ½ months), but moderate stability of some behaviours in later infancy (10-13 ½ months), suggesting that stability in regulation behaviours may be developing over time. Indeed, by middle childhood and adolescence there is significant stability in individual differences in self-regulation (Raffaeli, Crockett, & Shen, 2005).

Findings from our own laboratory demonstrated associations between emotion regulation behaviours at 5 ½ months and 4 years of age, such that infants' self-comforting, attention-seeking, and fretting predicted negativity in preschoolers, characterized by negative attention-seeking, fretting, and over-activity (August et al., 2015). These findings not only provide evidence for stability of behaviours over time, they also speak to the importance of understanding *patterns* of regulation strategies, such that early strategies may provide insight into later regulation abilities, allowing for the long-term prediction of adaptive and maladaptive regulation.

Contextual and Relationship Factors

Understanding these patterns of regulation also requires consideration of the parent-infant interaction. Parents are crucial both to early dyadic regulation, and to the development of independent strategies. In infancy, dyadic regulation is often considered to be adaptive, as these strategies may be more effective than their independent counterparts (Khoury et al., 2016). Under conditions of distress, independent self-soothing strategies may actually elevate distress in

12- and 13-month-olds, whereas parent-reliant strategies lead to increased positive affect (Diener, Mangelsdorf, McHale, & Frosch, 2002). However, when infants are denied access to responses from their parent, it may be more effective and more adaptive for the infant to depend on self- and environment-reliant strategies (Kim et al., 2014). Indeed, throughout the first year of life infants are more likely to rely on independent strategies when personal experiences have taught them that their parent does not respond appropriately to their distress (Manian & Bornstein, 2009; Tronick & Gianino, 1986).

Briefly depriving infants of maternal responsiveness is a common practice in emotion regulation research; this enables researchers to induce distress or frustration in order to observe emotion regulation behaviours as they occur. For this reason, emotion regulation behaviours are often measured during tasks such as the arm-restraint procedure (Stifter & Braungart, 1995), the Still-Face (SF) procedure (Tronick, Als, Adamson, Wise, & Brazelton, 1978), and the Strange Situation Procedure (Ainsworth & Wittig, 1969). However, by exclusively measuring emotion regulation in situations in which artificial constraints have been imposed on the mother-child interaction, there is a risk of obscuring meaningful changes in dyadic regulation behaviours over time. Further, uniquely observing emotion regulation during periods of induced distress neglects the importance of regulation of positive emotions, which is a key piece of emotion regulation that has been linked to cognitive and interpersonal benefits (Diamond & Aspinwall, 2003). Although efforts have been made to observe emotion regulation behaviours in more naturalistic frustration tasks (e.g. Kim et al., 2014), it is important to understand these findings in the context of more positive interaction tasks as well in order to more accurately represent the range of infant experience. Obtaining a full picture of emotion regulation in a mother-child dyad thus requires inclusion of procedures that are naturalistic, and tasks that support positive exchanges as well as tasks that challenge the dyad (Cole et al., 2004).

A previous study from our laboratory (i.e. Jean & Stack, 2012) used the SF procedure (Tronick et al., 1978) to examine infants' emotion regulation behaviour during periods of maternal availability and unavailability at 5 ½ months. This procedure consists of two normal interaction periods separated by a disrupted period in which mothers are emotionally unavailable and nonresponsive to their infants. Findings indicated that infants used more self-regulatory, exploratory, escape, and attention-seeking behaviour during the SF period (in which mothers are emotionally unavailable to their infant), as compared to both normal periods. Infants appear to be compensating for the lack of maternal availability by increasing their self-soothing behaviour, attempting to reengage with their mothers, and attempting to remove themselves from the distress-inducing situation. Infants used less gaze aversion and more bidirectional exchange during the reunion period following the disruption to the interaction, suggesting that infants were engaging more with their mothers following the disrupted interaction period than prior to it. This is in contrast to previous research demonstrating a "carry-over effect" of the SF period, in which infants exhibit increased negativity and difficulty reengaging with their caregiver during the reunion period (e.g. Kogan & Carter, 1996), and suggests that infants may be increasing their engagement with their caregivers in some ways in order to regulate from the distress of the SF period. The current study aims to extend these findings into toddlerhood using developmentally appropriate procedures that include both periods of maternal availability and unavailability.

Prematurity

Obtaining a full picture of emotion regulation also requires consideration of larger contextual factors that may influence parent-infant interactions. According to the Transactional (Sameroff, 2009) and Mutual Regulation (Tronick & Beeghly, 2011; Tronick & Gianino, 1986) models of regulation, disruptions to the parent-child relationship may lead to disruptions in the development of emotion regulation in the infant. This may be the case for premature infants, whose mothers are more likely to exhibit maladaptive patterns of parenting, including decreased sensitivity and increased controlling behaviour (Forcada-Guex, Borghini, Pierrehumbert, Ansertmet, & Muller-Nix, 2011; Muller-Nix et al., 2004). Preterm infants tend to display heightened negative reactivity (Hsu & Jeng, 2008; Langerock et al., 2013) and to be less socially responsive (Bozzette, 2007) than their full-term counterparts. Preterm infants may also experience greater difficulty with self-regulation (Mouradian, Als, & Coster, 2000; Wolf et al., 2002). For example, Montirosso, Borgatti, Trojan, Zanini, and Tronick (2010) found that preterm infants used more distancing from mothers and more social monitoring than full-term infants, suggesting a deficit in independent regulatory strategies and an increased reliance on external sources of support. Preterm infants may be especially reliant on mother-assisted regulation following a period of perturbed interaction, such as during the SF procedure (Jean & Stack, 2012; Montirosso et al., 2010).

These differences between preterm and full-term infants may be especially pronounced in very preterm and very small infants, or those at medical risk (Clark, Woodward, Horwood, & Moor, 2008; Feldman, 2009; Mouradian et al., 2000). Previous findings from our own research laboratory indicate that at 5 ½ months, full-term infants use more self-soothing behaviour than VLBW/preterm infants during the reunion with their mothers that follows a disruption to the interaction (Jean & Stack, 2012). The current study aims to extend these findings into toddlerhood using the same sample. Although past studies have compared preterm and full-term infants' emotion regulation (e.g. Clark et al., 2008; Montirosso et al., 2010), none to our knowledge have done so longitudinally through infancy and into toddlerhood.

Current Study

Our current understanding of early emotion regulation is thus incomplete in many ways. First, the traditional view that infants transition from dyadic to independent emotion regulation strategies has been challenged by evidence of increasing sophistication in dyadic strategies over time, suggesting that these behaviours may continue to play an important role in toddler regulation. Our perception of early development is further muddied by a lack of research into individual trajectories of emotion regulation, potentially obscuring important longitudinal relationships between dyadic and independent strategies, and by the use of distress-inducing tasks that may undervalue the importance of both dyadic strategies and regulation of positive affect. Finally, we lack clarity as to how larger-scale contextual risk factors such as prematurity may be disruptive to parent-child interactions and thus to the early development of emotion regulation.

The current study was designed to address these gaps in the literature in four important ways. The first objective was to examine age-related changes in the use of self-, mother-, and environment-reliant regulation behaviours through infancy and into toddlerhood. An age-related decrease in rudimentary self-reliant soothing techniques, such as mouthing and self-touch, was hypothesized as infants replace these innate behaviours with more sophisticated regulation strategies. Consistent with maturational changes in attention over the first two years of life (Feldman, 2009), an age-related increase in more deliberate environment-reliant behaviours was hypothesized, reflecting the increased ability of infants to use cognitive strategies such as attention redirection as a means of regulating their emotions. Similarly, it was hypothesized that mother-reliant regulation strategies would increase as infants become more purposeful in their use of social signalling (Calkins & Hill, 2007).

The second objective was to identify the individual stability and trajectories of emotion regulation behaviours across early development. Consistent with past literature (e.g. Feldman, 2009; Rothbart et al., 1992), it was hypothesized that there would be small to moderate individual-order stability in self-, mother-, and environment-reliant regulation behaviours, and that this stability would be greater at later time points. Given that dyadic regulation is key to the development of independent regulation (Conradt & Ablow, 2010; Granat et al., 2017), it was also hypothesized that the use of mother-reliant regulation behaviours would predict increased self- and environment-reliant strategies at subsequent time points.

The third objective was to extend previous findings on the effects of interaction context on emotion regulation behaviours across the first 18 months of life. At 5 ½ months, infants used more independent strategies during periods of maternal availability, and more dyadic strategies following a disruption to the interaction (Jean & Stack, 2012). It was hypothesized that these findings would replicate across ages, such that infants would rely more on independent regulation strategies during periods of maternal emotional unavailability, as is adaptive (Kim et al., 2014), and that there would be increased use of dyadic strategies during interaction periods in which the mother was emotionally available to the infant, especially following a disruption to the interaction. Consistent with findings at the 5 ½ month time point, it was also hypothesized that attention-seeking would increase during periods of emotional unavailability as infants struggled with the transition from dyadic to independent strategies.

The final objective was to examine differences in regulation strategies used by full-term and VLBW/preterm toddlers. At 5 ½ months, full-term infants used more self-soothing strategies than VLBW/preterm infants during the reunion period following a period of maternal emotional unavailability (Jean & Stack, 2012). Given the maturational changes in emotion regulation occurring between infancy and toddlerhood, it was hypothesized that full-term toddlers would use more sophisticated strategies requiring cognitive processes such as distraction and allocation of attention, whereas VLBW/preterm toddlers would rely more heavily on rudimentary self-soothing strategies such as mouthing and self-touch. It was expected that this difference would be more pronounced at 12 months than at 18 months, as biological differences are most evident at younger ages (Feldman, 2009; Hall et al., 2015).

By addressing these gaps in the literature, we aimed to provide increased insight into normative early emotion regulation, as well as how this regulation is impacted by developmental changes, contextual factors, and risk to the mother-child dyad. Identifying both group and individual trajectories of emotion regulation behaviours over time is a crucial step towards understanding the development of socio-emotional competence and predicting adaptive and maladaptive outcomes in later life.

Methods

Participants

Participants in the current study were drawn from a longitudinal study and consisted of mothers and their full-term (n = 46) and very low birthweight (VLBW) preterm (n = 56) infants. Mother-infant dyads were recruited from the same hospital to ensure similarity in socio-economic status and ethnic backgrounds, and were matched on infant sex, maternal age (within 5 years), and maternal education. Demographic and medical characteristics of full-term and VLBW preterm infants are presented in Table 1. All dyads were tested in their homes when infants were 5 ½ months (Time 1), 12 months (Time 2), and 18 months (Time 3) of age. Due to attrition, technical difficulties, damage to videos, and procedural issues, not all dyads had data available at all three time points.

Full-term. Following ethics approval from both Concordia University and the hospital, and in collaboration with the chief neonatologist, mother-infant dyads were recruited using birth records from a major community hospital in Montreal, Quebec. Criteria for inclusion included a birthweight of at least 2750 g (6 lbs), a gestation period of 37-41 weeks, and an uncomplicated medical history. Mothers received a letter outlining the research, after which they were contacted by telephone and asked to participate. Forty-eight dyads agreed to participate. At Time 1, eight were excluded due to: infants' gaze obstructed (n = 2), procedural error (n = 1), SF period repeated more than once due to infants' fussiness (n = 2), and mothers touching their infant for less than 10% of the time during the first normal period (n = 3). The latter criterion was included because touch is a major focus of the ongoing longitudinal project. In addition, touch is an important part of infant emotion regulation, and is typically used more than 65% of the time during normal face-to-face interactions (Jean & Stack, 2012; Stack & Jean, 2011). The final sample at Time 1 consisted of 40 (20 females, 20 males) full-term infants with a mean age of 5.40 months (SD = .22). At Time 2, seven dyads who had data at Time 1 did not participate, one dyad was removed due to procedural error, and six dyads whose data had been excluded at Time 1 were included at Time 2. The final sample at Time 2 consisted of 38 (19 females, 19 males) toddlers with a mean age of 12.44 months (SD = .41). At Time 3, three dyads with data at Time 2 did not participate, one dyad was excluded due to technical problems with the video recording, and two dyads who had data at Time 1 but not Time 2 were included. At Time 3, the sample consisted of 36 (18 females, 18 males) toddlers with a mean age of 18.59 months (SD = .57). Thirty dyads (65%) had data at all three time points, eight dyads (17.5%) had data at two of the three time points, and eight dyads (17.5%) had data at only one time point.

Very-low-birthweight/preterm. VLBW/preterm infants were pre-screened for medical status variables by a nurse during their 3-to-4-month follow-up visit. Criteria for inclusion included a birthweight of between 800 and 1500 g (1.76 – 3.30 lbs) and a gestation period between 26-32 weeks. Exclusion criteria included: infants who suffered from any medical illnesses, syndromes, or complications, including Grade IV intraventricular hemorrhage, hydrocephalus, severe neurological impairment, hearing loss, and retinopathy; infants who had been diagnosed with congenital abnormalities; infants who had experienced prolonged and/or repeated hospitalizations since the neonatal period; and mothers at psychological risk due to a history of inadequate prenatal care, drug-abuse, or mental illness. Mothers of infants who met criteria were sent a letter outlining the research, and subsequently contacted by telephone and asked to participate. Sixty-three dyads agreed to participate. At Time 1, 23 were excluded due to: mothers' failure to follow instructions ($n = 10$), procedural error ($n = 7$), SF period repeated more than once due to infants' fussiness ($n = 4$), excessive infant crying ($n = 1$), and mothers touching their infant for less than 10% of the time during the first normal period ($n = 1$). The final sample at Time 1 included 40 (21 females, 19 males) VLBW/preterm infants with a mean age of 5.47 months ($SD = .27$). At Time 2, 14 of the dyads with data at Time 1 did not participate, one dyad was removed due to procedural error, one was removed due to technical problems with the video recording, and 14 dyads who were excluded at Time 1 were included. At Time 2, the sample consisted of 38 (17 females, 21 males) toddlers with a mean age of 12.56 months ($SD = .59$). At Time 3, 10 dyads with data at Time 2 did not participate, and nine dyads without data at Time 2 were included. At Time 3, the sample consisted of 37 (17 females, 20 males) toddlers with a mean age of 18.59 months ($SD = .55$). Eighteen dyads (32%) had data at all three time points, 23 dyads (41%) had data at two time points, and 15 dyads (27%) had data at only one time point. Corrected gestational age (postnatal age minus the number of weeks the infant was premature) was used.

Procedure

Mother-infant dyads participated in home visits when infants were 5 ½, 12, and 18 months of age. Testing took place in a well-lit room, and external distractions were minimized. At the beginning of each home visit, informed consent was obtained from the mother for herself and her child.

At the 5 ½-month visit (Time 1), dyads participated in the Still-Face (SF) procedure (Tronick et al., 1978), consisting of two two-minute normal interaction periods (normal, reunion-normal), in which mothers were instructed to interact with their infant as they normally would, separated by a two-minute perturbed (SF) interaction period, during which mothers maintained a neutral facial expression and gazed at their infants but refrained from interacting with them. During the SF period, mothers were nonresponsive and emotionally unavailable to their infants. Each of these periods was separated by a 20-30 second transition period, during which mothers received instructions for the following period. Testing was interrupted if infants fretted for 20 seconds or more, or if mothers wished to stop the session for any reason (n = 7). Following testing, mothers were asked to complete questionnaires regarding their demographics, and their infants' developmental and medical histories.

At the 12- and 18-month visits (Times 2 and 3), dyads participated in a series of interaction periods while positioned on a mat on the floor with a set of standardized toys. The tasks included: a 90-second free play period, in which mothers were instructed to play with their infants as they normally would; a three-minute puzzle task, in which mothers were asked to engage their infants in developmentally appropriate puzzles provided to them; a three-minute interference task, in which mothers were instructed to complete questionnaires while their child played close to them; and a second three-minute (reunion) free play period. The interference task was designed to mimic everyday situations in which mothers must divide their attention. As such, mothers were not explicitly instructed how to react to their infants' bids for attention. However, the task parallels the SF period at Time 1 in that mothers are emotionally unavailable to their infants but physically present.

Apparatus

Interactions were recorded using a Sony video camera positioned on a tripod to simultaneously capture infants and their mothers. During the SF procedure, a mirror was used to capture the mother's face on the video recording. A stopwatch was used to time the duration of each period. At the 5 ½ month visit, infants were securely fastened in an infant seat without toys or pacifiers. At subsequent visits, dyads were provided with a set of age-appropriate standardized toys, including a doll, a tea set, a toy telephone, building blocks, books, and puzzles. Observational coding of videos was completed using Mangold INTERACT (version 14.3.7), a software system used for behavioural research that allows for the qualitative and quantitative analysis of multimedia data.

Measures

Emotion regulation behaviours. All three time points were coded using age-appropriate systematic, observational coding systems. Video records of mother-infant interactions were coded using software with an adjustable speed control, allowing for slow motion, frame-by-frame, and second-by-second coding.

Emotion regulation at Time 1 was coded as part of a previous study (i.e. Jean & Stack, 2012) using the Infant Self-Regulation Scheme (ISRS; Millman, Jean, & Stack, 2007). This system was adapted from the Infant Regulatory Scoring System (IRSS; Tronick & Weinberg, 1996), and captures the following infant behaviours on a second-by-second basis: self-comfort regulatory, self-comfort exploratory, attention-seeking, escape, gaze aversion, and bidirectional exchange. Twenty to thirty percent of the sample was double-coded by an undergraduate student who was blind to the study's hypotheses and infant birth status; an overall kappa of .90 was obtained. See Jean and Stack (2012) for a full description of the coding system.

In order to reflect the developmental changes in regulation occurring between Time 1 and Times 2 and 3, the Toddler Self-Regulation System (TSRS; Atkinson & Stack, 2017) was developed for the current study. Behavioural categories correspond to those of the ISRS and the Preschool Self-Regulation Scheme (PSRS; August & Stack, 2010) to reflect both continuity and change in emotion regulation across development. The TSRS captures the frequency and duration of emotion regulation behaviours in the following categories: self-comfort regulatory, self-comfort exploratory, attention-seeking, escape, dyadic exchange, over-activity, and independent play. In order to gain a better understanding of the source used for the regulation behaviour, behaviours were also divided into self-, mother-, and environment-reliant behaviours. In addition, the TSRS captures the proportion of time in which the infant is engaging versus not engaging with their mother during the interaction. This allows for the analysis of individual behaviours as a function of whether the toddler was engaged or not engaged with their mother. Table 2 provides brief operational definitions for each behaviour and category of behaviours. Thirty-two percent of video records were double-coded by a trained undergraduate student who was blind to the study's hypotheses and infant birth status; kappa values for individual behaviours ranged from .75 to .89 at Time 2, and .76 to .89 at Time 3. Kappa values for each category are presented in Table 3.

Results

Data Preparation

Emotion regulation behaviours were transformed into percent durations for each dyad by adding together the total time allocated to each behaviour in a given interaction period, dividing by the total time of the interaction period, and multiplying by 100. This provided the percentage of time infants engaged in a given behaviour over the course of each interaction period. Descriptive statistics were used to identify outliers and assess the normality of the distribution. According to the method outlined by Tabachnick and Fidell (2013), univariate outliers were identified as cases with standardized scores in excess of 3.29. These were brought in to the value of the next score plus or minus one. After bringing in outliers, square root transformations were applied to variables that remained significantly positively skewed, including escape behaviour at Times 1 and 2, attention-seeking at Times 2 and 3, and over-activity at Times 2 and 3. After making these adjustments, some variables remained skewed (escape at Time 1, attention-seeking at Times 2 and 3); however, there is no theoretical basis for expecting emotion regulation behaviours to be normally distributed. Further, the analyses undertaken are considered robust to violations of normality (Tabachnick & Fidell, 2013). Given that data was missing at all time points, data was tested to ensure that data was missing completely at random (MCAR). The results of Little's MCAR test was nonsignificant ($\chi^2 = 85.42$, $df = 72$, $p = 0.134$); data can thus be assumed to be missing completely at random. Descriptive statistics are presented in Table 4.

The effects of age, interaction period, and birth status were analyzed using a series of MANOVAs conducted in IBM SPSS (v.22). Significant multivariate effects were followed by analysis of univariate effects and Bonferroni-adjusted pairwise comparisons to isolate the source of the significance. Partial eta-squared (partial η^2) are reported as a measure of effect size. Individual trajectories were analyzed using MPlus (v.8). The path model was estimated using full information maximum likelihood (FIML), which uses all available information to estimate the population parameters.

Developmental Continuity and Change in Sources of Emotion Regulation

The first objective of the study was to assess the effect of age on the source of the emotion regulation behaviours used by infants and toddlers. As discussed, behaviours in both coding systems were grouped according to whether the infant relied on themselves, their mothers, or the environment as the source of regulation. Behaviours were categorized as self-reliant if the infant used self-touch, vocalizations, or movement to regulate, and included self-comfort regulatory behaviours, and at Times 2 and 3, over-activity. Mother-reliant behaviours included behaviours where the infant regulated by engaging with or attempting to engage with their mother, and included bidirectional/dyadic exchange and attention-seeking behaviour. Behaviours were categorized as environment-reliant if the infant used the environment or the toys provided to them at Times 2 and 3 to regulate, and included self-comfort exploratory behaviours, escape, gaze aversion at Time 1, and independent play at Times 2 and 3.

As there were no significant differences between the groups, full-term and VLBW/preterm infants were analyzed together. A one-way repeated measures MANOVA was conducted in IBM SPSS (v.22). In order to control for the differential effect of the perturbed interaction period on behaviour, only the first normal and free play periods were used.

There was a statistically significant effect of age on the combined dependent variables, $F(6, 42) = 34.437$, $p < .001$; Wilks' $\Lambda = .379$; partial $\eta^2 = .621$. Mauchly’s test of sphericity indicated that the assumption of sphericity had been violated for self-reliant ($\chi^2(2) = 10.535$, $p = .005$) behaviours; as such, the Greenhouse-Geisser correction was used for this variable. There were statistically significant differences in the use of self-reliant, $F(1.660, 78.028) = 8.013$, $p =$

.001; partial $\eta^2 = .146$, mother-reliant, $F(2, 94) = 8.747$, $p < .001$; partial $\eta^2 = .157$, and environment-reliant behaviours, $F(2, 94) = 11.041$, $p < .001$; partial $\eta^2 = .190$. Pairwise comparisons revealed that infants used the least self-reliant and the most mother-reliant behaviour at Time 3. Infants used more environment-reliant behaviour at Time 1 than Times 2 and 3. Results are presented in Figure 1.

Individual Stability and Trajectories of Sources of Emotion Regulation

To examine individual stability and trajectories of regulation behaviours over time, a path model was conducted in MPlus (v.8). Zero-order correlations are presented in Table 5. The bivariate relationships indicate a lack of stability in the source of emotion regulation over time, but a significant relationship between self- and mother-reliant behaviours over time. Categories of behaviour were regressed on all categories at the previous time point and allowed to correlate with categories at the same time point. The model was tested using a robust maximum likelihood (MLR) estimator to account for non-normality in the data. Using FIML, the model was estimated using data from all 102 participants with data for at least one time point. Although larger samples are preferable for structural equation models, evidence suggests that these models can perform well even with smaller sample sizes (Iacobucci, 2010; Wolf, Harrington, Clark, & Miller, 2013). The model was sequentially tested while controlling for infant birth status, infant gender, and maternal age to ensure consistency of results.

The path model showed good fit to the data ($\chi^2(9) = 4.665$, $p = .8625$; CFI = 1.000; RMSEA = .000 (.000-.059); SRMR = .029). Standardized paths are presented in Figure 2. Most of the hypothesized regression paths were not significant. Mother-reliant behaviour at Time 2 was associated with mother-reliant ($\beta = .271$, $p = .046$) and self-reliant ($\beta = .261$, $p = .022$) behaviour at Time 1. Mother-reliant behaviour at Time 3 was associated with self-reliant behaviour at Time 2 ($\beta = .246$, $p = .012$).

There were significant correlations between self-reliant and environment-reliant behaviour ($\beta = -.318$, $p < .001$) and mother-reliant and environment-reliant behaviour ($\beta = -.858$, $p < .001$) at Time 1. At Time 2, there were significant correlations between environment-reliant behaviour and self-reliant ($\beta = -.202$, $p = .028$) and mother-reliant ($\beta = -.707$, $p < .001$) behaviour. At Time 3, there was a significant correlation between environment-reliant and mother-reliant behaviour ($\beta = -.848$, $p < .001$).

Effect of Interaction Period on Use of Emotion Regulation Behaviours

The effects of birth status and interaction period on the use of regulatory behaviour were assessed simultaneously using two two-way mixed MANOVAs. In order to obtain a more detailed picture of emotion regulation in toddlerhood, emotion regulation behaviours were examined individually, rather than grouping them according to the source of regulation. The following outcome variables were included at both time points: engagement, self-comfort regulatory, self-comfort exploratory, attention-seeking, escape, dyadic exchange, over-activity, and independent play. Significant effects were followed by analysis of univariate effects to determine which emotion regulation behaviours were implicated, and pairwise comparisons to determine at which interaction periods these differences occurred. The Wilks' Lamda correction to degrees of freedom was used.

At Time 2, there was a statistically significant effect of interaction period on the combined dependent variables, $F(24, 48) = 67.040$, $p < .001$; Wilks' $\Lambda = .029$; partial $\eta^2 = .971$. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for: self-comfort regulatory ($\chi^2(5) = 32.053$, $p < .001$), self-comfort exploratory ($\chi^2(5) = 37.152$, $p < .001$), attention-seeking ($\chi^2(5) = 664.789$, $p < .001$), escape ($\chi^2(5) = 39.520$, $p < .001$), dyadic exchange ($\chi^2(5) = 20.588$, $p = .001$), over-activity ($\chi^2(5) = 20.127$, $p = .001$), and independent play ($\chi^2(5) = 26.574$, $p < .001$); the Greenhouse-Geisser correction was used for analysis of univariate effects with these variables. There were significant univariate main effects of interaction period on engagement, $F(3, 213) = 132.828$, $p < .001$; partial $\eta^2 = .652$, self-comfort exploratory, $F(2.375, 168.646) = 15.252$, $p < .001$; partial $\eta^2 = .177$, attention-seeking, $F(1.008, 71.562) = 59.097$, $p < .001$; partial $\eta^2 = .454$, dyadic exchange, $F(2.491, 176.850) = 206.305$, $p < .001$; partial $\eta^2 = .744$, and independent play, $F(2.399, 170.329) = 87.380$, $p < .001$; partial $\eta^2 = .552$.

Toddlers spent the most time engaged with mothers during the puzzle task, followed by the free play and reunion-free play periods, and the least during the interference task. Toddlers used the most self-comfort exploratory behaviour during the free play and interference periods, and the least during the puzzle task. Toddlers used more attention-seeking behaviour during the interference task than any other period. Toddlers spent the most time in dyadic exchange behaviour during the puzzle task, followed by the free play and reunion-free play periods, and the least during the interference task. Toddlers engaged in the most independent play during the interference task, and the least during the puzzle task. Results are presented in Figure 3.

At Time 3, there was a statistically significant main effect of interaction period on the combined dependent variables, $F(23, 47) = 90.289$, $p < .001$; Wilks' $\Lambda = ..022$; partial $\eta^2 = .978$. Mauchly's test of sphericity indicated that the assumption of sphericity had been violated for: engagement ($\chi^2(5) = 24.634$, $p < .001$), self-comfort regulatory ($\chi^2(5) = 75.877$, $p < .001$), self-comfort exploratory ($\chi^2(5) = 77.856$, $p < .001$), escape ($\chi^2(5) = 70.344$, $p < .001$), dyadic exchange ($\chi^2(5) = 31.725$, $p < .001$), over-activity ($\chi^2(5) = 26.306$, $p < .001$), and independent play ($\chi^2(5) = 68.115$, $p < .001$). There were significant main effects of interaction period on engagement, $F(2.453, 169.225) = 113.632$, $p < .001$; partial $\eta^2 = .622$, self-comfort regulatory, $F(2.212, 152.629) = 4.050$, $p = .016$; partial $\eta^2 = .055$, self-comfort exploratory, $F(1.691, 116.685) = 17.744$, $p < .001$; partial $\eta^2 = .205$, attention-seeking, $F(1.001, 69.054) = 53.130$, $p < .001$; partial $\eta^2 = .435$, escape, $F(2.074, 143.126) = 4.497$, $p = .012$; partial $\eta^2 = .061$, dyadic exchange, $F(2.268, 156.471) = 156.471$, $p < .001$; partial $\eta^2 = .758$, and independent play, $F(2.167, 149.552) = 102.966$, $p < .001$; partial $\eta^2 = .599$.

Toddlers spent significantly more time engaged during the puzzle task than any other period, and least during the interference task. Self-comfort regulatory behaviour was used most during the interference task and least during the puzzle task. Toddlers used the most self-comfort exploratory behaviour during the interference task, followed by reunion-free play, free play, and the puzzle task. Toddlers used more attention-seeking behaviour during the interference task than any other task. Toddlers used the most dyadic exchange behaviour during the puzzle task, and the least during the interference task. Toddlers used the most independent play during the interference task, and the least during the puzzle task. Results are presented in Figure 4.

Effect of Birth Status on Use of Emotion Regulation Behaviours

There was no significant multivariate main effect of birth status at either time point. At Time 3, the multivariate Interaction period x Birth status interaction effect approached significance, $F(23, 47) = 1.650$, $p = .073$; Wilks' $\Lambda = .553$; partial $\eta^2 = .447$. A follow-up univariate ANOVA revealed that there was a significant Interaction period x Birth status interaction effect on Attention-seeking, $F(3, 207) = 3.368$, $p = .020$; partial $\eta^2 = .047$, such that full-term toddlers used more attention-seeking behaviour than VLBW/preterm toddlers during the interference task but not during other periods. Results are presented in Figure 5.

Discussion

The present study was designed to examine the development of emotion regulation behaviours across infancy and into toddlerhood. Our approach allowed for the longitudinal examination of both developmental continuity and individual stability in self-, mother-, and environment-reliant emotion regulation. Using observational coding and multiple interaction periods, we were able to obtain ecologically valid data on the occurrence of regulation of positive and negative emotions in contexts of maternal emotional availability and unavailability. Finally, we examined group differences between full-term and VLBW/preterm toddlers' emotion regulation behaviours. The longitudinal nature of the study allowed for an examination of the normative developmental trajectories of emotion regulation behaviours, as well as the impact of individual, contextual, and risk factors on these trajectories.

Developmental Changes in Sources of Emotion Regulation

Our first objective was to examine age-related changes in the use of emotion regulation behaviours that were self-reliant, mother-reliant, and environment-reliant. As hypothesized, there was a decrease in the use of self-reliant emotion regulation behaviours, such that infants used a lower proportion of rudimentary self-soothing behaviours at 18 months than at 5 ½ and 12 months. This is consistent with prior research that shows that innate, physical self-soothing strategies may be replaced by more deliberate, cognitive strategies as infants mature (Fox & Calkins, 2003; Thompson & Goodman, 2010). The hypothesis that the use of mother-reliant strategies would increase with age was also supported: toddlers used a higher proportion of mother-reliant behaviours at 18 months than at prior ages. Past research has demonstrated age-related improvements in social signalling as infants begin to recognize the potential of their parents to assist in their emotion regulation (Calkins & Hill, 2007). The increased use of mother-reliant strategies during this naturalistic interaction may also reflect changes in the mother-child relationship. Towards the end of the first year of life, social synchrony between parent and child increases, allowing for increased mutual responsivity and shared attention (Feldman, 2007). This may facilitate increased use of dyadic emotion regulation behaviours.

Contrary to expectations, the use of environment-reliant emotion regulation behaviours decreased with age, such that infants used a greater proportion of environment-reliant strategies at 5 ½ months than at 12 and 18 months. This may have been partly a function of the different coding systems used in infancy and toddlerhood. At 5 ½ months, gaze aversion was coded as an environment-reliant strategy, as it is likely indicative of attention redirection. This behaviour was not included in the coding system for toddlers, as toddlers were expected to be more active in their regulation strategies, such as by using specific toys or aspects of the environment to redirect their attention (which would not have been possible at the 5 ½ month time point due to the nature of the experimental procedure). Infants used gaze aversion an average of 38.8% of the time during the first interaction period at 5 ½ months, potentially accounting for the difference between ages.

The decrease in environment-reliant strategies may also reflect an increase in the breadth and flexibility of strategies used as infants age (Thompson & Goodman, 2010). Infants may rely less on any one given independent behaviour as they develop an increasingly varied repertoire of strategies. Infants may also be replacing environment-reliant strategies with mother-reliant strategies as they gain the ability to substitute more effective strategies for those that have proven to be less effective (Khoury et al., 2016; Thompson & Goodman, 2010). Given that mothers were emotionally available to their infants during this period, the use of mother-reliant strategies may have been more adaptive in this context.

Our findings suggest that, contrary to common conceptualizations (e.g. Conradt &

Ablow, 2010; Rothbart, Posner, & Kieras, 2006; Thompson & Goodman, 2010), infants are not *transitioning* from dyadic to independent regulation strategies as these abilities develop. Rather, they may be becoming increasingly adept in the use of both dyadic and independent strategies, or in shifting between them. During periods of maternal emotional availability, infants may become increasingly dependent on mother-reliant strategies as they age, consistent with their increased ability to use social cues (Calkins & Hill, 2007). These strategies are likely more adaptive for the infant, as they are more effective in regulating negative affect (Diener et al., 2002; Khoury et al., 2016) and may promote a healthy parent-child relationship (Tronick & Gianino, 1986).

Although results from our study showed a decrease in both self- and environment-reliant strategies with age, this was only in a context of maternal availability (i.e. normal and free play periods, which encouraged natural interaction between mothers and infants). As infants age, they may be increasingly able to recognize and adapt to their mother's availability or unavailability, perhaps by selecting and implementing emotion regulation strategies accordingly. Future research should examine whether these age-related decreases in independent strategies hold out during periods of maternal unavailability, or whether the use of independent strategies increases in this context as infants are better able to recognize which behaviours would be most appropriate given the context. Given the use of two different disrupted interaction periods, this direct comparison was not possible in the current study.

Individual Stability and Trajectories of Sources of Emotion Regulation

Understanding the developmental trajectories of dyadic and independent regulation behaviours also requires an understanding of the relationship between them across development. By examining the use of these behaviours in individuals over time, we gain a better understanding of whether infants are transitioning from one source of regulation to another, or remaining consistent in their use of a given source.

Contrary to hypotheses, there was no individual-order stability in self- and environment-reliant strategies (as measured). There was moderate stability in mother-reliant strategies from 5 ½ to 12 months of age, but not from 12 to 18 months. Some researchers posit that the lack of individual stability is due to the different maturational rates of behavioural and neurobiological capabilities contributing to changing emotion regulation (Thompson & Goodman, 2010). Indeed, infants are undergoing major changes to their attentional and social abilities during this time period (Brownell & Kopp, 2007; Ruff & Rothbart, 2001), potentially accounting for the lack of stability across development. Along these same lines, the lack of stability in mother-reliant behaviours between 12 and 18 months may be related to major changes occurring in toddlers' social and communicative abilities in the second year of life, including increased ability and motivation for joint attention (Akhtar & Martínez-Sussmann, 2007).

Rather than mother-reliant behaviours predicting future use of independent regulation, our results revealed the opposite pattern: increased use of self-reliant strategies at both 5 ½ months and 12 months predicted increased mother-reliant behaviours at the following time point. As was the case for the first objective, the results suggest that there is not a unidirectional relationship between sources of regulation, such that dyadic behaviours predict the emergence of independent behaviours, but rather a more complicated relationship that is likely influenced by individual and contextual factors.

There are several possible reasons for our findings. Given the relationship between emotion regulation and social competence (Leerkes et al., 2009; Penela et al., 2015), it is possible that infants who were better able to self-regulate made for better interaction partners, thus encouraging greater use of dyadic behaviour at subsequent time points. It is also possible that infants who are more adept at self-soothing at a younger age are more adept at seeking their mothers' assistance in regulation at older ages, as they increase their repertoire of strategies and their ability to deploy them selectively. Alternatively, these infants may have learned early in development that self-reliant strategies were less effective than mother-reliant behaviours and increased their use of dyadic strategies over time. Future studies should examine whether this relationship holds during periods of parent unavailability to determine whether these infants are selectively using more mother-reliant strategies when it is adaptive, or whether they are implementing them indiscriminately. Given the use of varying interaction tasks, such a comparison was not possible in the current study. Future studies should also examine whether infants who use more self-soothing behaviour in early life develop a larger repertoire of strategies than infants who are less adept at self-soothing in early life.

Effect of Interaction Context on Emotion Regulation Behaviours

Our third objective was to extend results of a previous study demonstrating that, at 5 ½ months, infants used increased self-comforting, attention-seeking, and escape behaviours during a period of maternal unavailability, and increased their engagement with mothers following that disruption to the interaction (Jean & Stack, 2012). Consistent with hypotheses, at 12 and 18 months toddlers responded to the interference task with increased attention-seeking and independent behaviours such as self-comforting and independent play. Switching to self- and environment-reliant strategies during periods of emotional unavailability is likely an adaptive and effective response in infants (Kim et al., 2014). Toddlers engaged the most with their mothers and used the highest percentage of dyadic exchange behaviours during the puzzle task, an interaction context that is designed to stimulate social exchange, teaching, and dyadic play. At all three ages, the use of emotion regulation behaviours was determined in part by interaction context.

The differences that were observed between the normal and reunion-normal periods at 5 ½ months (i.e. Jean & Stack, 2012) were not present in the free play and reunion-free play periods at 12 and 18 months, perhaps because the interference task was less distressing than the SF period. Unlike the SF period, the interference task does not involve complete non-responsiveness on the part of the mother and is instead designed to simulate naturalistic situations in which the mother must divide her attention, potentially lessening the need of the toddler for dyadic regulation. Toddlers may also have been using the standardized toys provided rather than their mothers to regulate following the interference task, whereas this was not a possibility for infants at 5 ½ months given the nature of the interaction period. Finally, this finding may be reflective of true developmental changes, such that younger infants are more likely to reengage with their mothers following a disruption to the interaction than are older infants, who may be more capable of regulating to this disruption independently.

Differences Between Full-term and VLBW/Preterm Infants' Emotion Regulation

Our final objective was to examine the differences between full-term and VLBW/preterm toddlers' use of emotion regulation behaviours. Contrary to our hypotheses, there were no significant group differences between full-term and VLBW/preterm toddlers at 12 or 18 months. At 18 months, there was a marginally significant effect, such that full-term toddlers used more attention-seeking behaviour than VLBW/preterm toddlers during the interference task, but not during other interaction periods. This effect should be interpreted with caution. However, this finding is consistent with prior findings from our laboratory demonstrating that at 5 ½ months, full-term infants continued to rely on independent regulation strategies after their mothers' availability was renewed (Jean & Stack, 2012). This transition between emotional availability and unavailability, and between dyadic and independent strategies, is likely difficult for infants and toddlers, however it is unexpected that full-term infants would have more difficulty than VLBW/preterm infants. It is possible that this represents an adaptive strategy on the part of full-term infants; perhaps they engage in more attention-seeking behaviour because they have generally been more successful in regaining their mothers' attention and resuming dyadic play. Indeed, infants who experience more coordinated interactions with their mother are more likely to persist longer in trying to reinstate this normal interaction when it is disrupted (Tronick & Gianino, 1986). Future studies should distinguish between positive and negative attention-seeking, as well as measure the effectiveness of these strategies in reengaging the mother in full-term and preterm infants and toddlers.

As previously discussed, differences between full-term and preterm infants tend to be more pronounced at earlier ages (Feldman, 2009; Hall et al., 2015). It is possible that differences between full-term and preterm infants in emotion regulation have largely dissipated by toddlerhood. Indeed, most studies examining these differences have done so using samples of nine months or younger (Bozzette, 2007). If it is the case that differences observed in early infancy have decreased by toddlerhood, it offers promising insight into the ability of healthy VLBW/preterm infants to "catch up" to their full-term counterparts in terms of socioemotional development.

The lack of differences between full-term and VLBW/preterm toddlers may also be due in part to the nature of our sample. Although VLBW infants are considered a high-risk population (Hack et al., 2002), the current sample was carefully screened for medical issues and corrected for gestational age in order to provide a conservative estimate of group differences and attempt to disentangle medical risk from VLBW and prematurity. As such, there may have been fewer biological differences between the samples than there would be in a typical preterm sample. This is in line with findings that abnormalities in cerebral white matter are one of the strongest predictors of impairments in emotion regulation in preterm infants (Clark et al., 2008), a difference that may be absent in our relatively healthy sample.

The absence of medical conditions has biological implications beyond differences present at birth. Recent epigenetic studies have suggested that early adverse experiences associated with premature birth, such as exposure to prolonged hospitalization and painful procedures, affect developmental trajectories of preterm infants via alterations of stress-related genes (Provenzi, Guida, & Montirosso, 2018). The stringent exclusion criteria applied in the current study enabled us to control, at least in part, for the impact of these stressful experiences on socioemotional development.

Aside from biological factors, psychosocial factors may also have played a role. Deficits in preterm infants' emotion regulation abilities are often conceptualized as resulting from decreased parental sensitivity; however, findings on parenting behaviours in parents of preterm infants have been mixed. Although there is evidence that parents of preterm infants tend to be less sensitive and more controlling (Forcada-Guex et al., 2011; Muller-Nix et al., 2004), other studies have found no differences in parenting behaviour (Korja et al., 2008; Montirosso et al., 2010). One meta-analysis including studies from 1980-2014 concluded that mothers of preterm infants are neither less sensitive nor less responsive toward their children than mothers of full-term children (Bilgin & Wolke, 2015). Given the relationship between parental sensitivity and children's emotion regulation (Clark et al., 2008; Conradt & Ablow, 2010), it is important to understand whether and under what circumstances differences in sensitivity occur in parents of preterm infants. This may explain, at least in part, when deficits in emotion regulation are seen in preterm infants. Given the reduced medical risk in our sample as compared to typical preterm samples, it is possible that maternal sensitivity was less affected by parental stress, potentially contributing to the lack of differences in infant emotion regulation. Future studies should examine the relationship between infant medical risk, parental stress, and parental sensitivity, to potentially explain the discrepancy in past findings.

Another possible explanation for the discrepancy between our findings and past studies that have found deficits in preterms' emotion regulation abilities (e.g. Montirosso et al., 2010; Mouradian et al., 2000; Wolf et al., 2002) is that we did not include any measures of distress or emotionality. Thus, our study does not speak to the *effectiveness* of the employed emotion regulation behaviours. It is possible that VLBW/preterm infants are using the same strategies as their full-term counterparts, but are using them in a less effective manner, leading to increased dysregulation. Future studies should simultaneously code emotion regulation behaviours and infant affect in order to address the effectiveness of regulation in both groups.

Limitations and Future Directions

Limitations of the current study include the small sample size, especially in regards to the path analysis. Although evidence suggests that path models are valid even in smaller samples (Iacobucci, 2010; Wolf et al., 2013), a larger sample would provide more power, and thus the results of our path analysis should be interpreted with caution. The difference in interaction periods between Time 1 versus Times 2 and 3 was also a limitation of the study. Using an interference task rather than the SF procedure enabled us to examine mother-toddler interactions in a more naturalistic context and was reflective of developmental changes occurring between 5 ½ and 12 months. Although developmentally more appropriate, using different interaction contexts prevented us from making direct comparisons of regulatory behaviour during periods of maternal emotional unavailability. Future research should examine the effect of maternal emotional availability on infant emotion regulation longitudinally during the same contexts.

The use of healthy VLBW/preterm infants who were corrected for gestational age was a strength of our study, as it allowed us to control for the potentially confounding effect of medical illness. However, it also limits the generalizability of our findings to healthy preterm infants, who represent a lower-risk group than typical samples of VLBW/preterm infants. Future research should examine whether VLBW/preterm infants at higher medical risk exhibit the same deficits in emotion regulation as have been found in prior studies of premature infants (e.g. Montirosso et al., 2010; Mouradian et al., 2000; Wolf et al., 2002).

As is the case with most developmental research, a limitation of the current study was the inclusion of mothers but not fathers. The inclusion of fathers would be of interest, as relationships with both parents are integral to the early development of emotion regulation and may affect the use of parent-reliant regulation strategies (Diener et al., 2002). Future research should examine differences between strategies used with both parents.

Finally, although the focus of the current study was on examining emotion regulation behaviours over time, future research would benefit from the inclusion of infant and maternal characteristics in order to understand individual differences in the development of emotion regulation. Examining the impact of infant characteristics, such as temperament and executive function, maternal characteristics, such as emotionality, stress, and sensitivity, and characteristics of the dyad, such as goodness of fit, would allow for a more comprehensive understanding of the development of emotion regulation behaviours in the infant.

Conclusions

Taken together, our findings provide a number of contributions to the literature. Firstly, the early development of emotion regulation appears to be characterized by change at both group and individual levels. That is, our findings suggest a lack of both group mean-level continuity and individual-order stability in the use of independent and dyadic emotion regulation strategies from infancy to toddlerhood. This may be explained by the major maturational changes occurring during this stage of development, including alterations to attentional, behavioural, social, and neurobiological capabilities (Brownell & Kopp, 2007; Thompson & Goodman, 2010).

Second, traditional models of emotion regulation development which posit that infants transition from dyadic to independent emotion regulation strategies may be overlooking the importance of the ongoing development of dyadic strategies. Our findings suggest that from infancy to toddlerhood, children actually use *increasing* amounts of parent-reliant regulation strategies as they become increasingly adept at social signalling and replace less effective strategies with more effective ones. This is in keeping with the Transactional model (Sameroff, 2009), which posits that developmental changes are driven by adaptations to the environment and to interactions with parents. As infants accumulate experiences of successful regulation by their parents, they may adjust their strategies accordingly, prompting the increased use of dyadic strategies across early development. Further, rather than a unidirectional relationship in which dyadic strategies predict the development of independent strategies, it appears that self-regulatory strategies may predict use of parent-reliant strategies. The Mutual Regulation model (Tronick & Beeghly, 2011; Tronick & Gianino, 1986) contends that infants are simultaneously regulating their own internal state and their parent's behaviours. In keeping with this model, our findings may suggest that infants who are more adept at using self-soothing strategies make for better interaction partners, or are more active in seeking parental involvement in regulation.

Our results also point to the importance of considering context when examining emotion regulation behaviours. Given that many studies of emotion regulation induce infant distress by briefly depriving them of maternal interaction, it is easy to overlook the importance of mother-reliant strategies. However, dyadic regulation is an integral piece of self-regulation according to both the Transactional (Sameroff, 2009) and Mutual Regulation (Tronick & Beeghly, 2011; Tronick & Gianino, 1986) models of regulation. According to Sameroff (2009), regulation by others provides the context for self-regulation. Tronick and Gianino (1986) posit that infants' independent regulatory capacities are augmented by parental involvement. Indeed, when parents are available to their infant, these parent-reliant strategies may be more effective and more adaptive than independent strategies (Diener et al., 2002; Khoury et al., 2016). Findings from our study suggest that these are used to a greater extent than self- or environment-reliant strategies by both infants and toddlers. Rather than the use of dyadic or independent strategies on their own, it is likely the ability to adapt to the context and be flexible in their use of emotion regulation strategies that is adaptive for an infant. Future studies should examine the ability of infants to transition between dyadic and independent strategies depending on the availability of their parent.

Finally, our results provide preliminary evidence that, in the absence of medical risk, prematurity may not be as disruptive to the development of emotion regulation as hypothesized, at least in the way it was measured. By using stringent inclusion/exclusion criteria and correcting for gestational age, we were able to control for the effects of medical illness, and in doing so we did not replicate previous findings of deficits in premature infants' emotion regulation abilities (e.g., Montirosso et al., 2010; Mouradian et al., 2000; Wolf et al., 2002). It is possible that some differences in early life are dissipating as infants age. It is also possible that in the absence of medical risk, preterm infants do not differ as much from their full-term counterparts in the development of emotion regulation strategies. Future research should aim to isolate the factors involved in disrupting the development of adaptive emotion regulation in preterm infants by examining the effects of different types of medical risk, as well as parenting factors such as stress and sensitivity, and infant factors such as temperament and executive function.

Results from the current study extend prior knowledge of early development of emotion regulation by examining developmental changes and individual trajectories of regulation longitudinally from infancy to toddlerhood. By using naturalistic interaction contexts and systematic observational coding systems, we were able to capture ecologically valid snapshots of how infants and toddlers regulate in everyday life. Further, by including periods of both maternal availability and unavailability, we were able to capture a range of regulation behaviours that occur in contexts of both positive and negative emotions. Finally, by examining the effects of prematurity in healthy VLBW/preterm infants, the current study challenged the conceptualization of premature birth as a risk factor for the development of emotion regulation in the absence of medical illness.

Given the implications of maladaptive early regulation for socioemotional, behavioural, and psychological functioning in later life (e.g. Crespo et al., 2017; Di Maggio et al., 2016; Penela et al., 2015; Rawana et al., 2014), an understanding of normative and disrupted developmental patterns of regulation is central to early identification and intervention for at-risk dyads. Longitudinal studies beginning early in life may aid in long-term prediction of socio-emotional competence, as well as adaptive and maladaptive psychological outcomes throughout the lifespan.

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Table 1

Demographic and Medical Characteristics of Full-term and VLBW/PT Infants at Birth

	Full-term (n = 46)		VLBW/PT (n = 56)	
	M	*SD*	*M*	*SD*
Maternal age (years)	30.13	5.19	32.12	5.79
Maternal education **	14.46	2.08	13.20	2.08
Infant birthweight (grams) ***	3533.70	413.62	1110.13	269.31
Infant gestational age (weeks) ***	39.57	1.05	28.66	2.33
Emergency C-section (%) ***	37.00		80.00	
One-minute APGAR ***	8.61	.99	5.96	2.25
Five-minute APGAR ***	9.20	.55	7.89	1.44
Length of hospital stay (days) ***	3.46	2.64	63.32	31.05
Infant length (cm) ***	50.82	4.44	37.48	3.48
Infant head circumference (cm) ***	35.07	1.51	26.63	2.36

Note. ** $p < .01$, *** $p < .001$.

Table 2

Brief Operational Definitions for the Toddler Self-Regulation System Behaviours (Atkinson & Stack, 2017)

Toddler behaviour	Operational Definition
Engagement	
Engaged	Attending to or engaged in common activity with mother. e.g., Joint play.
Disengaged	Not attending to mother. e.g., Ignoring mother, engaged in solitary play.
Self-reliant behaviours	
Self-comfort – Regulatory	Using touch or self to independently self-regulate. e.g., Mouthing, self-directed vocalizations.
Over-activity	Displaying heightened activity. e.g., Flailing arms, kicking, bouncing.
Mother-reliant behaviours	
Attention-seeking	Trying to get mother's attention when mother is not interacting with child. e.g., Pulling at mother, vocalizing insistently.
Dyadic exchange	Regulating by engaging with mother. e.g., Cooperative play, joint attention.
Environment-reliant behaviours	
Self-comfort – Exploratory	Using environment to independently self-regulate. e.g., Exploring environment, seeking a toy.
Escape	Attempting to distance self from mother. e.g., Walking/crawling away, ignoring mother.
Independent play	Engaging in a task alone, without the help or involvement of mother. e.g., Parallel play, solitary play.

Table 3

Inter-rater Agreement for the Toddler Self-Regulation System Behaviours

Emotion Regulation Behaviour	Kappa
12 months	
Engagement	.77
Self-comfort – Regulatory	.84
Self-comfort – Exploratory	.80
Attention-seeking	.89
Escape	.75
Dyadic Exchange	.88
Independent Play	.75
Over-activity	.80
18 months	
Engagement	.76
Self-comfort – Regulatory	.82
Self-comfort – Exploratory	.78
Attention-seeking	.85
Escape	.76
Dyadic Exchange	.89
Independent Play	.78
Over-activity	.83

Table 4

Mean Percent Durations and Standard Deviations of Emotion Regulation Behaviours

	5 ½ months		12 months		18 months	
	Full-term	VLBW/PT	Full-term	VLBW/PT	Full-term	VLBW/PT
Engaged						
Normal/Free play	-	-	57.86 (24.80)	66.25 (23.14)	78.59 (26.02)	66.10 (33.09)
Puzzle	-	-	83.87 (18.19)	79.03 (19.54)	93.01 (11.35)	82.93 (20.00)
Still-face/Interference	-	-	24.04 (20.46)	22.94 (19.02)	26.79 (24.29)	23.77 (19.91)
Reunion	-	-	62.90 (23.42)	68.41 (21.08)	78.51 (20.50)	76.85 (21.88)
Self-comfort Regulatory						
Normal/Free play	12.55 (15.10)	9.52 (12.32)	8.25 (13.33)	5.67 (12.08)	1.02 (2.38)	1.43 (3.25)
Puzzle	-	-	6.75 (11.73)	3.99 (5.88)	.66 (2.12)	.77 (1.85)
Still-face/Interference	37.46 (23.57)	38.83 (23.91)	8.99 (14.86)	5.77 (9.56)	4.26 (7.09)	2.46 (5.00)
Reunion	19.40 (24.83)	7.29 (8.00)	5.02 (8.02)	4.98 (9.37)	.33 (.67)	.62 (1.56)
Self-comfort Exploratory						
Normal/Free play	2.69 (4.39)	2.58 (4.81)	7.23 (11.21)	5.11 (6.30)	3.53 (4.84)	3.68 (5.04)
Puzzle	-	-	3.02 (4.13)	2.06 (2.86)	1.93 (4.31)	2.20 (3.30)
Still-face/Interference	14.87 (18.74)	10.38 (16.58)	12.56 (11.52)	7.78 (8.29)	10.77 (11.52)	10.34 (13.98)
Reunion	1.50 (3.08)	1.49 (3.00)	6.79 (6.98)	3.15 (3.72)	5.77 (7.03)	3.85 (5.47)
Attention-seeking						
Normal/Free play	.00 (.00)	.00 (.00)	.03 (.16)	.03 (.16)	.00 (.00)	.00 (.00)
Puzzle	-	-	.06 (.28)	.09 (.39)	.00 (.00)	.00 (.00)
Still-face/Interference	2.73 (4.10)	1.80 (3.15)	12.20 (13.97)	14.95 (16.66)	18.10 (19.37)	10.60 (13.32)
Reunion	.00 (.00)	.00 (.00)	.15 (.43)	.16 (.56)	.07 (.28)	.07 (.28)
Escape						
Normal/Free play	.14 (.45)	.06 (.25)	2.83 (5.58)	.93 (2.60)	3.34 (8.76)	4.33 (8.20)
Puzzle	-	-	1.20 (3.53)	3.41 (6.11)	.77 (2.62)	1.85 (3.77)
Still-face/Interference	1.58 (3.08)	1.60 (2.85)	.39 (.81)	.08 (.33)	1.34 (3.40)	.87 (2.73)
Reunion	.16 (.43)	.20 (.55)	4.43 (6.60)	3.25 (5.01)	2.45 (6.28)	3.79 (7.40)

Gaze aversion						
Normal/Free play	32.44 (23.82)	38.79 (24.43)	-	-	-	-
Puzzle	-	-	-	-	-	-
Still-face/Interference	33.67 (22.88)	37.71 (23.05)	-	-	-	-
Reunion	22.85 (18.88)	28.19 (20.89)	-	-	-	-
Bidirectional/Dyadic						
Normal/Free play	48.65 (24.58)	46.73 (23.78)	46.13 (26.96)	54.32 (26.66)	69.43 (30.08)	59.25 (35.44)
Puzzle	-	-	76.48 (19.90)	68.40 (22.85)	89.27 (11.76)	77.18 (24.10)
Still-face/Interference	.00 (.00)	.00 (.00)	2.14 (4.05)	1.19 (2.41)	1.54 (3.40)	2.10 (4.09)
Reunion	52.15 (27.27)	60.71 (23.33)	49.53 (22.96)	54.85 (21.57)	68.37 (24.34)	67.09 (23.29)
Independent play						
Normal/Free play	-	-	20.18 (21.08)	18.65 (21.25)	10.73 (20.24)	18.28 (26.67)
Puzzle	-	-	5.60 (9.30)	10.81 (14.71)	2.48 (4.92)	5.50 (7.95)
Still-face/Interference	-	-	45.73 (27.70)	53.99 (25.74)	48.49 (27.63)	52.88 (26.43)
Reunion	-	-	12.42 (16.48)	16.08 (14.95)	7.42 (9.55)	10.74 (13.66)
Over-activity						
Normal/Free play	-	-	.76 (1.74)	1.64 (2.85)	.26 (.70)	.24 (.73)
Puzzle	-	-	.33 (.65)	.37 (.80)	.10 (.44)	.26 (.62)
Still-face/Interference	-	-	.47 (.79)	.63 (1.04)	.42 (.89)	.41 (.67)
Reunion	-	-	1.11 (2.08)	1.25 (2.36)	.20 (.53)	.29 (.61)
Source of regulation						
Self-reliant						
Normal/Free play	12.55 (15.10)	9.52 (12.32)	9.01 (13.51)	7.31 (13.28)	1.58 (2.76)	2.01 (3.50)
Puzzle	-	-	7.08 (11.74)	4.36 (6.12)	.77 (2.16)	1.02 (1.93)
Still-face/Interference	37.46 (23.57)	38.83 (23.91)	9.46 (15.04)	6.40 (9.50)	4.69 (7.06)	2.87 (5.14)
Reunion	19.40 (24.83)	7.30 (8.00)	6.13 (8.38)	6.23 (10.35)	.77 (1.43)	3.05 (9.31)
Mother-reliant						
Normal/Free play	48.65 (24.58)	46.73 (23.78)	46.15 (26.93)	53.34 (26.66)	69.43 (30.08)	59.25 (35.44)
Puzzle	-	-	76.54 (19.89)	68.49 (22.85)	89.27 (11.76)	77.18 (24.10)
Still-face/Interference	2.73 (4.10)	1.80 (3.15)	14.34 (14.64)	16.14 (17.08)	19.64 (19.72)	12.70 (13.46)
Reunion	52.15 (27.27)	60.71 (23.33)	49.67 (23.01)	55.01 (21.62)	68.44 (24.36)	67.15 (23.28)

Environment-reliant						
Normal/Free play	35.27 (23.79)	46.73 (23.78)	30.24 (20.89)	54.25 (35.44)	17.60 (21.88)	59.25 (35.44)
Puzzle	-	-	9.82 (12.89)	16.28 (16.60)	5.18 (9.93)	9.55 (11.11)
Still-face/Interference	50.12 (24.42)	49.68 (22.08)	58.68 (23.28)	61.85 (23.43)	60.59 (24.58)	64.09 (21.98)
Reunion	25.52 (18.96)	49.68 (22.08)	23.64 (16.79)	22.48 (17.30)	15.64 (15.53)	18.37 (18.86)
Total behaviour						
Normal/Free play	96.46 (12.41)	97.69 (5.83)	85.40 (19.45)	86.33 (19.83)	88.61 (16.17)	87.54 (16.25)
Puzzle	-	-	93.45 (11.18)	89.13 (12.53)	95.21 (6.07)	87.75 (15.46)
Still-face/Interference	90.31 (11.09)	90.31 (9.91)	82.48 (18.60)	84.39 (11.08)	84.91 (15.49)	79.65 (15.86)
Reunion	97.06 (11.55)	97.88 (6.48)	79.44 (17.45)	83.72 (14.55)	84.84 (13.58)	88.57 (14.04)

Table 5

Zero-Order Correlations between Sources of Emotion Regulation Behaviours at 5 ½, 12, and 18 Months

		5 ½ months			12 months			18 months		
		Self-reliant	Mother-reliant	Environment-reliant	Self-reliant	Mother-reliant	Environment-reliant	Self-reliant	Mother-reliant	Environment-reliant
5 ½ months	Self-reliant	1.0								
	Mother-reliant	-.32**	1.0							
	Environment-reliant	-.08	-.86**	1.0						
12 months	Self-reliant	-.43	.01	.07	1.0					
	Mother-reliant	.19*	.13	-.21	-.07	1.0				
	Environment-reliant	.03	-.14	.12	-.18	-.72**	1.0			
18 months	Self-reliant	-.06	.17	-.23	-.28*	.17	-.11	1.0		
	Mother-reliant	.04	-.03	.02	.22	-.03	-.01	-.39**	1.0	
	Environment-reliant	-.05	.02	.02	-.10	-.04	.06	.09	-.85**	1.0

Note. * $p < .05$, ** $p < .01$.

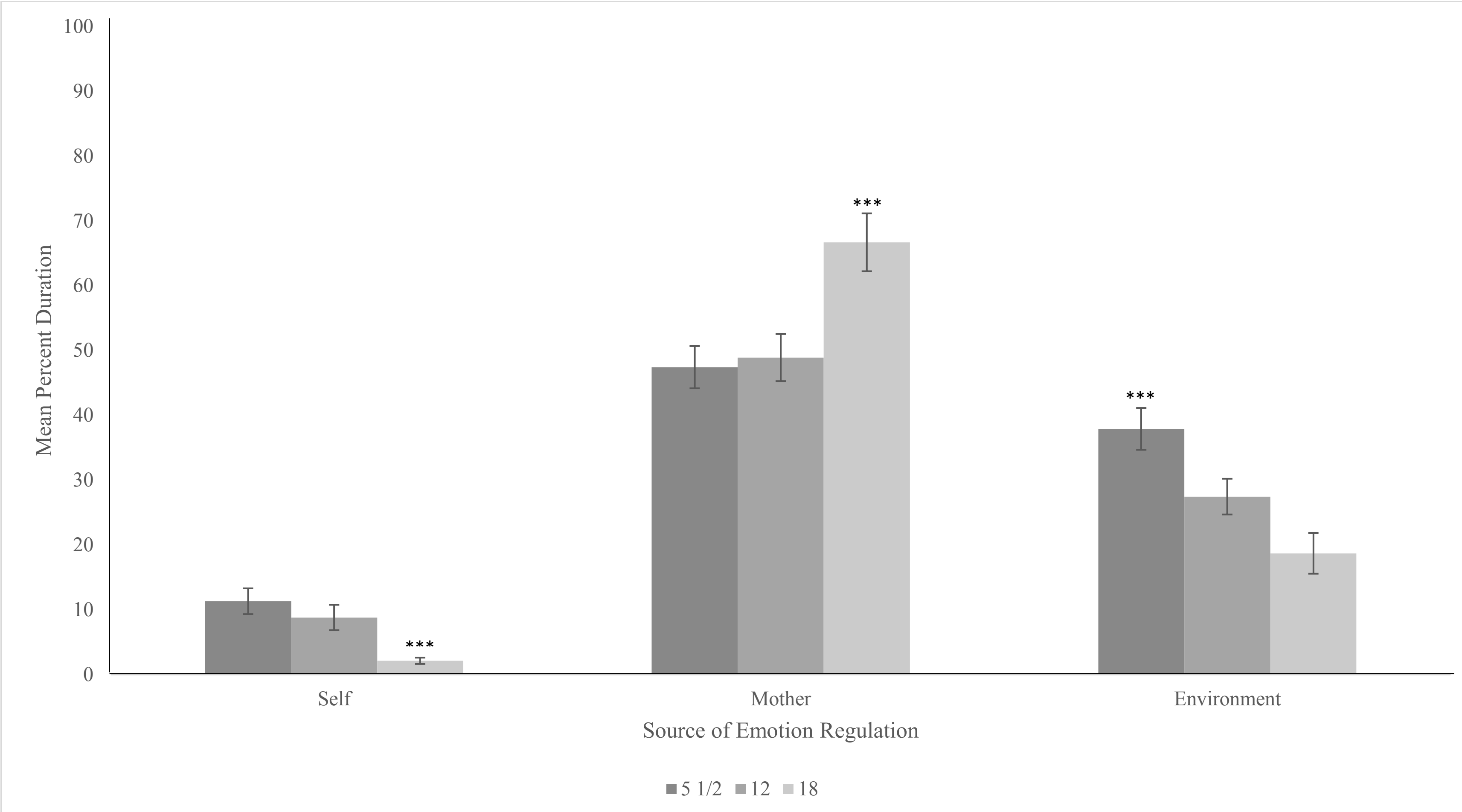

Figure 1. Source of emotion regulation behaviours across age (collapsed across full-term and VLBW/preterm groups). Error bars represent standard errors. Asterisks directly above bar indicate a significant difference with all other ages. *** $p < .001$.

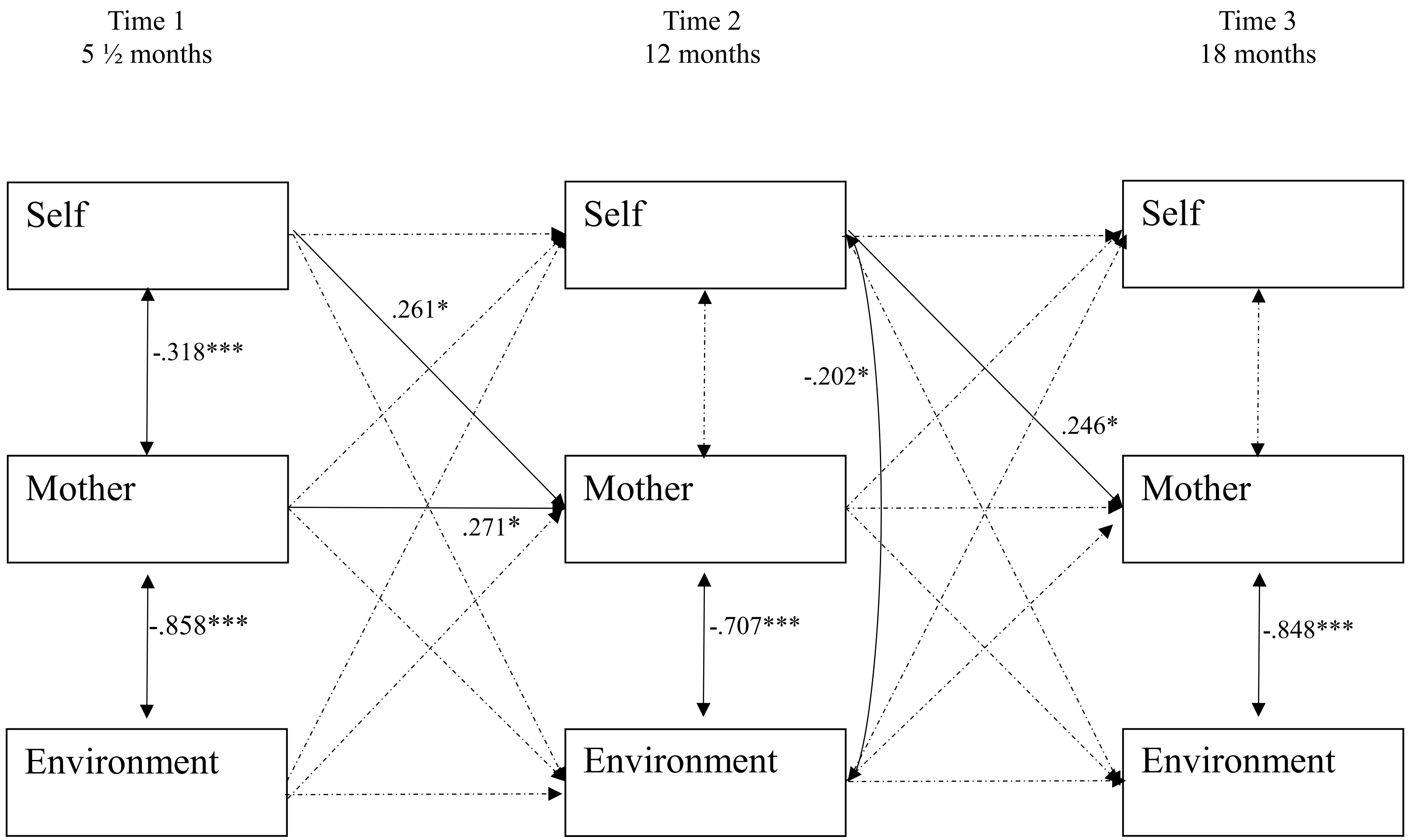

Figure 2. Standardized coefficients of individual trajectories of emotion regulation behaviours. Model fit: $\chi^2(9) = 4.665$, $p = .8625$; CFI = 1.000; RMSEA = .000 (.000-.059); SRMR = .029. * $p < .05$, ** $p < .01$, *** $p < .001$.

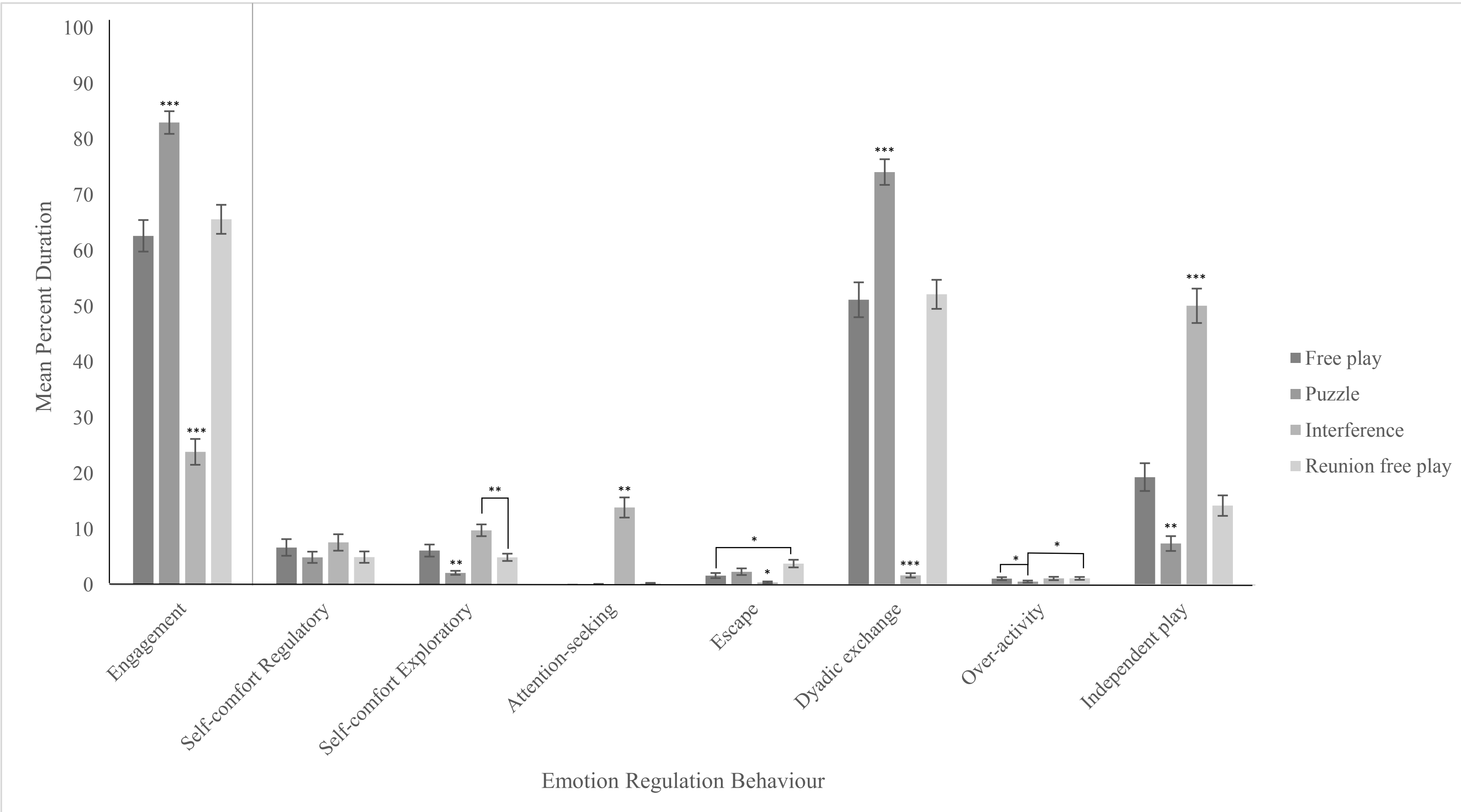

Figure 3. Emotion regulation behaviours across interaction periods at 12 months. Error bars represent standard errors. Asterisks directly above bar indicate a significant difference with all other behaviours. * $p < .05$, ** $p < .01$, *** $p < .001$.

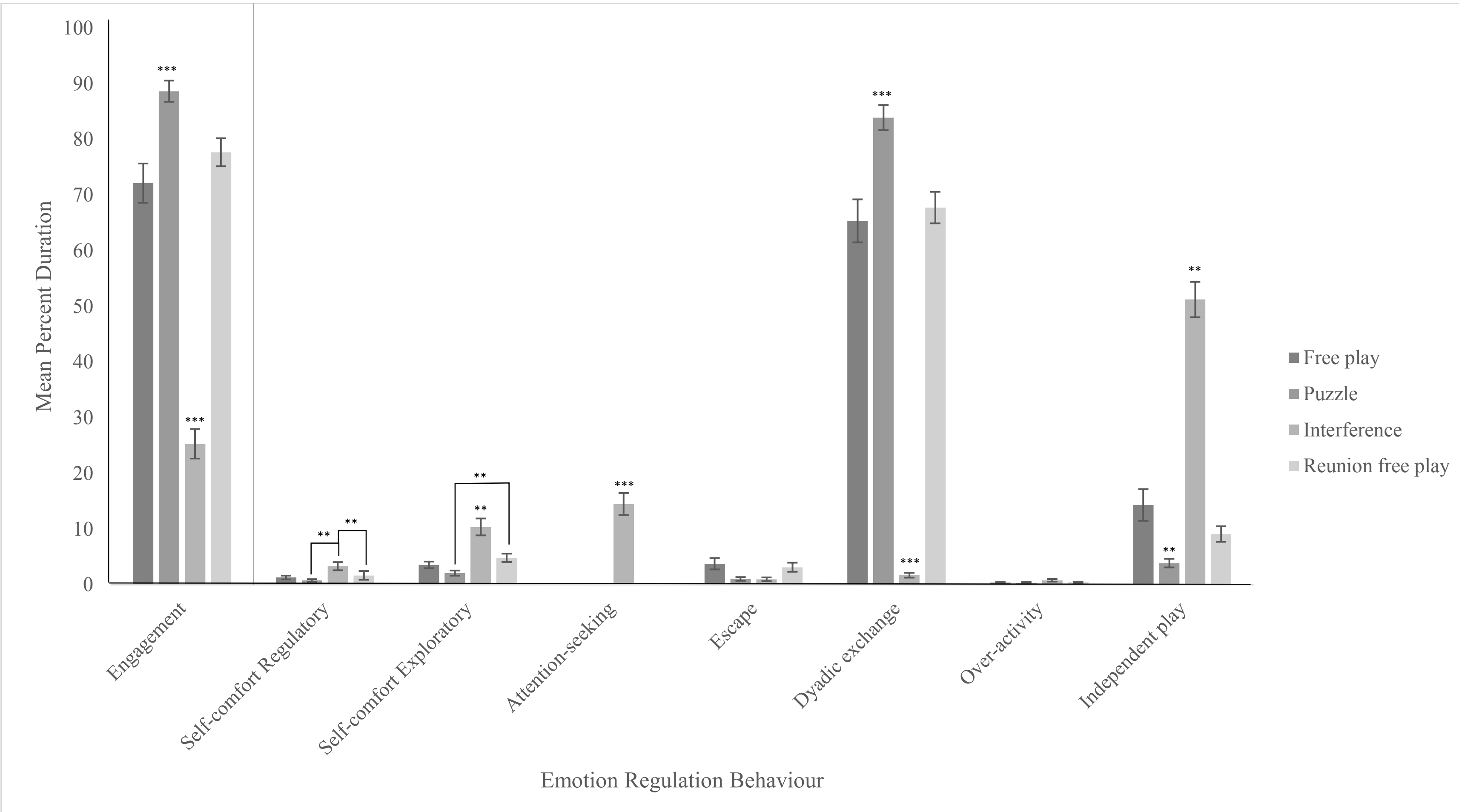

Figure 4. Emotion regulation behaviours across interaction periods at 18 months. Error bars represent standard errors. Asterisks directly above bar indicate a significant difference with all other behaviours. * $p < .05$, ** $p < .01$, *** $p < .001$.

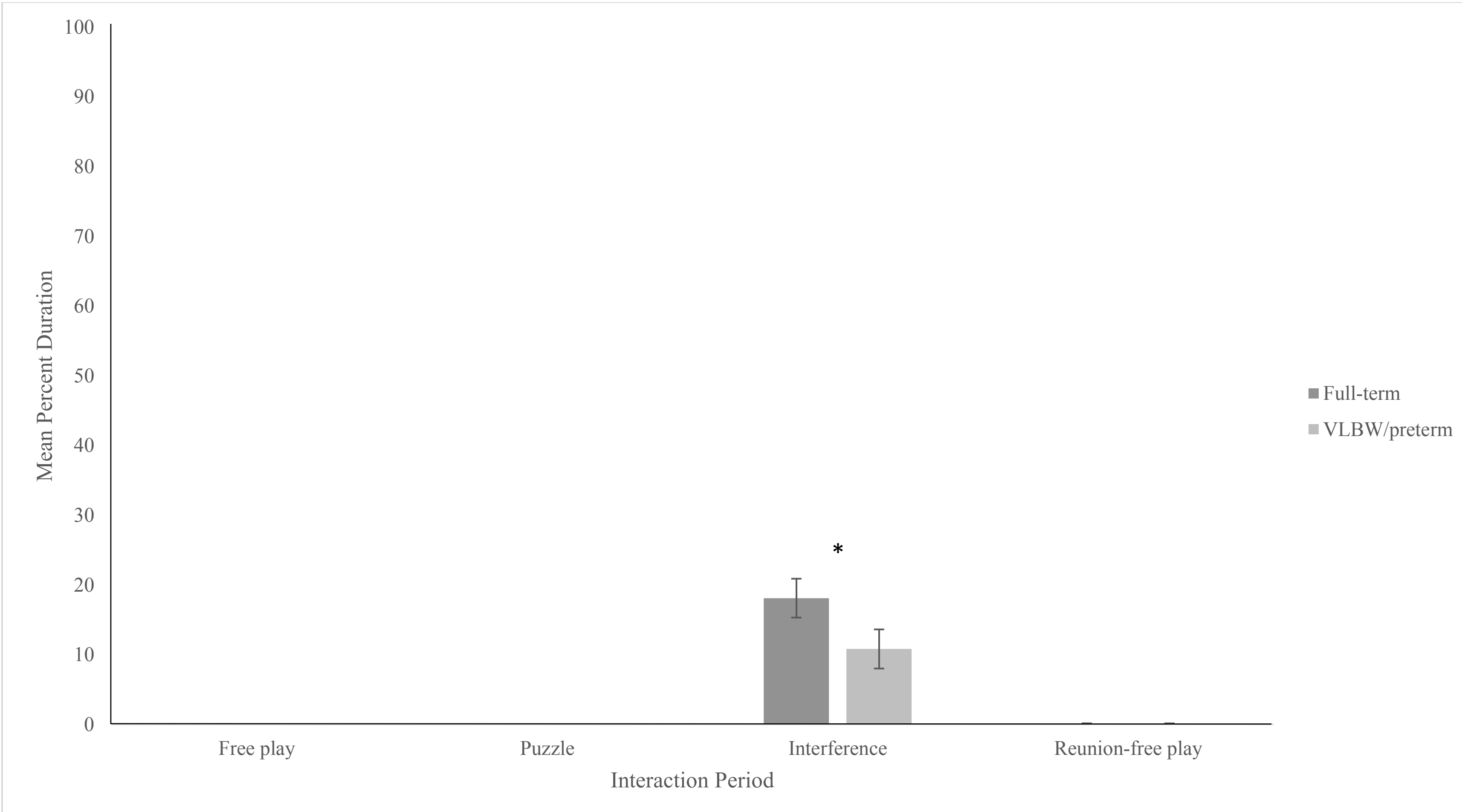

Figure 5. Attention-seeking behaviour in full-term and VLBW/preterm toddlers at 18 months. * $p < .05$. Note: this finding should be interpreted with caution, as the multivariate effect was marginally significant ($p < .10$).

APPENDIX A

CONSENT FORMS

Consent Form
Mother-Infant Interactions

This study is designed to look at infants' responses during social interaction and to study the different types of interaction used by caregivers and their role in social exchange.

I understand that my baby and I will participate in a study lasting approximately 60 minutes. In the first part, my baby will be seated in an infant seat directly facing me. The procedure will consist of several interaction periods, each lasting two to three minutes in length, during which time I will be asked to interact in different ways with my baby. During some periods I will be asked to interact with my baby as I normally do, while in others I will be asked to pose a neutral, still facial expression and remain silent for a brief period. There will be brief breaks separating the interaction periods. In the second part, my baby and I will play together on a carpeted floor for approximately 8 minutes in a designated area, during which time I will be asked to play with my baby as I normally would at home. Under no circumstances will any manipulation be harmful to my baby. Finally, I will be asked to complete several brief questionnaires.

The entire session will be videotaped so that at a later point my baby's responses may be scored. However, these recordings are kept in the strictest confidence and are not shown to others without my permission. I understand that my participation in this study is totally voluntary. I know that I may withdraw at any time and for any reason. I also understand that I may request that the videotape recording of my baby be erased. In the event that the results of the study are published, my name and the name of my baby will be kept confidential. I am also aware that I may be asked to participate again when my baby is 12 and 18 months of age.

In the event that I have any unanswered concerns or complaints about this study, I may express these to Dr. Dale Stack (848-2424, ext. 7565), Dr. Lisa Serbin (848-2424, ext. 2255) or Dr. Alex Schwartzman (848-2424, ext. 2251) of the Psychology Department at Concordia University. In addition, the patient representative of the Jewish General Hospital is Mrs. Laurie Berlin (340-8222, ext. 5833). She can be contacted should I have any questions regarding my rights as a research volunteer.

Thank you for your cooperation.

I, ___________________________, do hereby give my consent for my baby __________________ to participate in a study conducted by Dr. Dale Stack at Concordia University, and with the cooperation of the Jewish General Hospital. A copy of this consent form has been given to me.

Parent's signature on behalf of child: _________________________ Date:______________
Parent's signature: ____ Date:______________
Witness: ____ Date:______________

Consent Form
Mother-Infant Interactions

This study is designed to look at infants' responses during social interaction and to study the different types of interaction used by caregivers and their role in social exchange.

I understand that my baby and I will participate in a study lasting approximately 60 minutes, divided into two main parts. The first part will consist of a period of free play in which my child and I will play together for approximately 15 minutes. The second part will also be a play period, but it will include a series of different activities lasting approximately three minutes for each activity. These observation periods will be separated by short pauses. Under no circumstances will any manipulation be harmful to my baby. Finally, I will be asked to complete several brief questionnaires.

The entire session will be videotaped so that at a later point my baby's responses may be scored. However, these recordings are kept in the strictest of confidence and are not shown to others outside without my permission.

I understand that my participation in this study is totally voluntary. I know that I may withdraw at any time and for any reason. I also understand that I may request that the videotape recording of my baby be erased. In the event that the results of the study are published, my name and the name of my baby will be kept confidential.

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Thank you for your cooperation.

I, ____, do hereby give my consent for my baby to participate in a study conducted by Dr. Dale Stack at Concordia University, and with the cooperation of the Jewish General Hospital. A copy of this consent form has been given to me.

Parent's signature on behalf of child: ___________________________________ Date:

Parent's signature: ____ Date:

Witness: ____ Date:

(October 25, 1999)