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Emerging patterns of infant regulatory behavior in the Still-Face paradigm at 3 and 9 months predict mother-infant attachment at 12 months

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ABSTRACT

Prior research described three stable patterns of organized behavior employed by infants to manage stressful interactive situations with their mothers in the Face-to-Face Still-Face paradigm (FFSF) at 3 and 9 months postpartum. The current longitudinal study expands this research by examining the extent to which these patterns predict infants' later attachment quality. For that purpose, 108 full-term infants and their mothers participated in the FFSF at 3 and 9 months, and in the Strange Situation at 12 months. Cross-tabulation analyses indicated a significant association between (1) the Social-positive oriented pattern and secure attachment, (2) the Distressed-inconsolable pattern and insecure-ambivalent attachment, and (3) the Self-comfort oriented pattern and insecure-avoidant attachment. Our results contribute to a growing body of studies suggesting that patterns of infants' regulatory behavior assessed during the FFSF during the first year, may be early developmental precursors of attachment patterns at 12 months.

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Infant self-regulation; still-face; attachment; strange Situation; socioemotional development

Introduction

Self-regulation in childhood is broadly defined as children's ability to gain control of bodily functions and arousal, manage emotions (modify, inhibit, or maintain), and sustain focus of attention (Eisenberg & Spinrad, 2004; Shonkoff & Phillips, 2000). Yet, this definition implies a considerable maturity that young infants have not yet fully developed (Kopp, 1989). Rather, young infants achieve self-regulation with their caregivers gradually via an infant-caregiver co-regulatory (Fogel, 1993) or mutual regulatory system (Tronick & Beeghly, 2011). This dyadic co-regulation plays a crucial role in scaffolding infants´ limited regulatory capacities and, over time, contributes to the development of dyadic-specific regulatory patterns that shape infants' experiences in the world (Beeghly et al., 2016). Dyads' successful repair of interactive errors (mismatches) during repeated, routine everyday infant-caregiver social interactions provides an opportunity for infants to develop interactive and self-

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regulatory skills. These interactive experiences also contribute to infants growing sense of efficacy in the interactive sphere (Tronick & Beeghly, 2011).

The constellation of emotional expressions and behaviors displayed by infants during caregiver-infant interactive reparations not only convey information about their internal states, but also function as communicative signals to their caregivers. Tronick and colleagues labeled these affective and behavioral communicative signals "other-directed regulatory behaviors" because they act to influence caregivers' behavior (Gianino & Tronick, 1988; Tronick, 1989).

Gianino and Tronick (1988) also proposed that infants exhibit "self-directed regulatory behaviors" (e.g., looking away from a distressing stimulus, engaging in self-comforting behaviors, such as sucking on a hand, or self-stimulation) during caregiver-infant interaction. Although infants display both types of regulatory behaviors (other- and self-directed) during caregiver-infant interactions in early infancy (Barbosa et al., 2019), self-directed regulatory behaviors are especially likely to occur when dyadic regulatory processes fail, and infants attempt to control and transform their affective states on their own (Tronick, 1989).

During caregiver-infant interactions, infants gradually develop *organized patterns of regulatory behavior* with their caregivers (M. Fuertes et al., 2009) that reflect their repeated experiences of co-regulating distress and sharing affect with their caregivers, along with infants' attempts to self-regulate and modulate their own arousal. Infants and their caregivers also co-create sensorimotor and affective "meanings" during social interactions that reflect the unique characteristics of their emerging relationship. These are hypothesized to contribute to the increasing complexity and coherence of the dyadic system (Tronick & Beeghly, 2011). Over time, infants are thought to internalize these dyadically formed regulatory strategies and use them to achieve their attachment needs and interactive goals in other contexts (M. Fuertes et al., 2009).

Few studies have evaluated whether these early-emerging patterns of regulatory behavior, especially those assessed during stressful caregiver-infant interactive contexts such as the Face-to-Face Still-Face paradigm (FFSF), predict infants' later attachment organization. In contrast, a large literature suggests that mothers' sensitive responsiveness to their infants during the first year of life is a robust predictor of secure attachment in later infancy (Bigelow et al., 2010; J. M. Braungart-Rieker et al., 2001; De Wolf & van IJzendoorn, 1997). In turn, secure attachment predicts children's positive socioemotional outcomes in later childhood, including a greater capacity for emotion regulation in stressful contexts, positive close relationships, and fewer behavior problems (e.g., Bo-Ram et al., 2014; Qu et al., 2016; see DeKlyen & Greenberg, 2016; Thompson, 2016, for reviews).

Infants' behaviors in the FFSF and links to later attachment

The FFSF is a well-described social interaction task designed to examine infants' responses before, during, and after exposure to a social stressor, in which the caregiver temporarily adopts behavioral and affective unavailability (Tronick et al., 1978). Although the FFSF is widely used to assess infant social and self-regulatory behaviors (e.g., social vs. object engagement, affect, and self-comforting behaviors) and dyadic interaction quality (e.g,, interactive synchrony, dyadic mismatches, and dyadic reparation), relatively few longitudinal studies have evaluated whether infants' behaviors during the FFSF predict their later attachment organization at the end of the first year (Adamson & Frick, 2003), typically

assessed during the Strange Situation (Ainsworth et al., 1978). Among these few, most studies have evaluated discrete infant behaviors during the FFSF (e.g., changes in gaze direction, attempts to re-engage the caregiver's attention, or social bids, and positive or negative affect) at different infant ages (from 3 to 10 months) as predictors of later attachment (e.g., J. M. Braungart-Rieker et al., 1999, 2001, 2014; Cohn et al., 1991; Ekas et al., 2013; Kiser et al., 1986; Kogan & Carter, 1996; Tronick et al., 1982). Findings from these studies provide only weak support for a link between discrete infant behaviors during the FFSF and later attachment. Moreover, among the few studies reporting a significant association, specific findings vary.

In a meta-analytic review of the FFSF literature, Mesman and colleagues evaluated eight longitudinal studies that examined the association between infant behavior in the FFSF and later attachment (Mesman et al., 2009). Results indicated that infants' affect during the FFSF was the most reliable predictor of later attachment. Specifically, infants who exhibited more positive (d =.23) and less negative affect (d = .24) during the FFSF were more likely to be securely attached at 12 months of age. However, the magnitude of these effects is relatively small.

Findings from more recent studies evaluating these associations continue to yield mixed findings. Ekas et al. (2013) found no significant association between infant positive affect displayed during the still-face episode of the FFSF at 6 months and attachment classifications at 15 months. Similarly, in her doctoral research, Mcquaid (2011) reported that infants' social bids during the still-face episode of the FFSF at 4–5 months were not significantly associated with secure attachment in the Strange Situation at 12 months. Mixed findings are also reported for infant negative affect during the FFSF in recent studies. In two longitudinal studies, no significant associations between infant negative affect during the FFSF and later attachment were found (Ekas et al., 2013; J. M. Braungart-Rieker et al., 2014). In contrast, Mills-Koonce et al. (2012) report that more infant negative affect exhibited during the reunion episode of the FFSF predicted a greater likelihood of insecure-ambivalent attachment in later infancy. In other studies, infants who engaged in more self-comforting behaviors in all three FFSF episodes at 3 months (Fuertes & Lopes Dos Santos, 2009; M. Fuertes et al., 2006) or who looked away more from the caregiver during the still-face episode at 6 months (Ekas et al., 2013) were more likely to develop an insecure-avoidant attachment in later infancy.

Although the reasons for the mixed findings and small effect sizes in this literature are not fully understood, one possible explanation may be methodological variations across studies. For instance, the age at which infants are assessed in the FFSF and/or Strange Situation often differs. Moreover, most investigators have focused on just one or specific episodes of FFSF, whereas fewer have evaluated infant behavior across all episodes of the FFSF. Additionally, many have evaluated discrete rather than organized patterns of infant regulatory behavior in the FFSF.

Here, we argue that evaluating organized regulatory patterns across all episodes of the FFSF may prove to be a more fruitful approach than focusing on discrete behaviors in specific episodes. That is because several investigators (e.g., Cox et al., 2010; Tronick & Beeghly, 2011) suggest that infants acquire adaptive self-regulation skills gradually in dyadic contexts (e.g., during routine parent-infant interactions). Over time, the repetition of the regulatory processes (e.g., matching, mismatching, and repair) generate patterns in which infants recognize, remember, and/or expect certain dyadic behaviors to occur. Yet, few studies have evaluated the potential link between early *patterns* of infant regulatory

behavior, assessed during dyadic interactive contexts, and later attachment. The current study attempts to fill this gap in the literature by evaluating whether organized patterns of infant regulatory behavior in the FFSF, assessed at two time points during the first year (3 and 9 months) are linked to later attachment classification in the Strange Situation at 12 months. This analysis builds on findings from prior programmatic research in our lab, as described in the next section.

Organized patterns of infant regulatory behavior in the FFSF and their links to attachment

An early goal of this line of research was to evaluate whether infants exhibit organized patterns of regulatory behavior during the FFSF at multiple time points during infancy. In subsequent analyses, we evaluated whether these patterns are stable over time, associated with demographics, infant or maternal behavior in other contexts, or with later attachment organization.

Using data collected in a longitudinal sample of prematurely born infants and their mothers (M. Fuertes et al., 2006, 2009), the authors developed a reliable scoring system and used cluster analyses to discriminate specific styles of infant regulatory behavior during the FFSF at 3 months postpartum. The first step in this analysis was to code infants' behaviors micro-analytically during each episode of the FFSF, and then classify them into one of three summary categories reflecting infants' coping style: *Positive other-directed coping, Negative other-directed coping, and Self-directed coping*. In classifying infants, several dimensions of infants' patterns of responses across the three episodes of the FFSF were considered, including the quality of their discrete regulatory behaviors (positive affect, negative affect, self-comforting), the intensity of their regulatory behavior, and the orientation of behavior (self- oriented vs. other-oriented).

This original classification was then contrasted with that produced through a Discriminant Function Analysis (DISCRIM) procedure. The agreement between results from both analyses was very good (85%). Accordingly, we used these three infant regulatory groups in subsequent analyses (Fuertes, 2005). Prematurely born infants who exhibited more Positive other-directed coping during the FFSF at 3 months of age were more likely to experience greater maternal sensitivity during mother-infant free play with toys at 9 months of age, and to be classified as securely attached during the Strange Situation at 12 months of age (Fuertes & Lopes Dos Santos, 2009; M. Fuertes et al., 2006). In contrast, prematurely born infants who exhibited more Negative other-directed coping in the FFSF at 3 months were less likely to experience sensitive parenting during play at 9 months and more likely to be classified as insecure ambivalent in the Strange Situation at 12 months. Moreover, prematurely born infants who engaged in more Self-directed coping in the FFSF at 3 months experienced less maternal sensitivity during play at 9 months and were more likely to be classified as insecure-avoidant in the Strange Situation at 12 months. Notably, both infant regulatory patterns and maternal sensitivity were each unique predictors of later attachment. Results from this research provides initial evidence that infants' early styles of regulatory behavior (assessed at 3 months in the FFSF) are linked to their later attachment organization, and these associations held even after controlling for maternal sensitivity, at least in a sample of prematurely born infants.

In subsequent work, Fuertes and Lopes Dos Santos (2009) expanded this scoring system by focusing on infants' ability to engage, reengage, recover, and cope with stress across episodes of the FFSF, in the context of the caregiver's behavior, in addition to evaluating the quality, intensity, and self-/other orientation of infants' behavior. That is, in scoring, they considered the quality of dyadic interaction during the first FFSF episode (synchrony, mutuality, shared pleasure), the level of infants' distress and regulatory capacity during the still-face episode, and infants' ability to recover and contribute to dyadic reparation in the reunion episode.

In later work, M. Fuertes et al. (2014) applied this scoring system in a sample that included both prematurely born and full-term infants at 3 months (corrected age). They described three similar yet distinct patterns of regulatory behavior to those described by M. Fuertes et al. (2006), Fuertes & Lopes Dos Santos (2009)): *Social-positive oriented, Distressed-inconsolable, and Self-comfort oriented*. In this system, infants who exhibited positive engagement with the caregiver during the first episode of the FFSF but who grew progressively negative after exposure to maternal unavailability during the still-face episode, and who were unable to recover during the reunion episode were coded as *Distressed-inconsolable*. In the previous system, these infants would have obtained high scores in both the Positive other-oriented as well as in the Negative other-oriented behavior categories. Thus, Fuertes and Lopes Dos Santos (2009) new system captures more than just the frequency of discrete behaviors or the simple aggregation of behaviors, or even the intensity of infants' responses. Instead, the new system captures the behavioral *organization* of infants' responses in the context of the social partner and other contextual variables.

Building on this body of research, Barbosa et al. (2019) applied Fuertes and Lopes Dos Santos (2009) typology to score infants' regulatory patterns during the FFSF at 3 months of age in a longitudinal sample of healthy, full-term infants and their mothers. Three patterns of infant regulatory behavior were observed: Social-positive oriented, Distressed-inconsolable, and Self-comfort oriented. These patterns were significantly associated with maternal reparatory sensitivity and infant behavior scored during an independent free play context at the same age, but were not related to family demographics, newborn behavior, or parent-reported infant temperament.

In a follow-up of this sample at 9 months of age, Barbosa et al. (2018) evaluated the stability of infant regulatory patterns during the FFSF from 3 to 9 months of age, and additionally evaluated whether they were associated with infants' cardiac responses during the FFSF at 3 months. This research demonstrated that infants' regulatory patterns were robustly stable from 3 to 9 months (Cohen's $k = .72$), and were associated with different infant cardiac responses during each FFSF episode at 3 months. Together, these results suggest that infants exhibit distinct and stable regulatory behavioral patterns during the FFSF during the first year. Moreover, these patterns may reflect different emergent biobehavioral strategies that infants may use for managing the interactive stress of maternal unavailability and subsequent process of dyadic reparation during the FFSF.

The Present Study. The goal of the present study was to build on our prior research findings by evaluating whether the three infant regulatory patterns assessed at 3 and 9 months of age in the FFSF in prior research are associated with infants' attachment classification at 12 months of age, using data collected in our longitudinal sample of full-term healthy sample of infants and their mothers. Guided by theoretical work suggesting infants build regulatory skills in dyadic contexts (e.g., Beebe et al., 2010; Beeghly et al.,

2016; Cox et al., 2010; Tronick & Beeghly, 2011), we hypothesized that early-emerging individual differences in self-regulatory patterns would indeed predict infants' attachment style by the end of the first year. Based on our prior research findings with prematurely born infants, we expected that the Social-positive oriented pattern at 3 and 9 months would predict secure attachment at 12 months, whereas the Distressed-inconsolable pattern would predict insecure-ambivalent attachment, and the Self-comfort oriented pattern would predict insecure-avoidant attachment. In a separate set of analyses, we also evaluated whether stronger associations between infant regulatory patterns at each age and their attachment classifications would be observed for the subset of infants who exhibited stable regulatory patterns over time (at both 3 and 9 months).

We also evaluated a secondary aim in order to better understand the association between these patterns of infant self-regulation and attachment behaviors. Specifically, we determined whether infants' patterns of regulatory behavior observed in the FFSF at 3 and 9 months were associated with ratings of infants´ interactive behaviors with the mother during the reunion episodes of the Strange Situation (i.e., proximity-seeking, contact-maintaining, resistance, and avoidance).

Method

Participants

Analyses in the present study were based on data collected for 108 mother-infant dyads with complete FFSF data at 3 and 9 months, and attachment data at 12 months of age. Dyads were participants in a larger (N = 162) longitudinal study in which mother-infant dyads were recruited from an urban Portuguese public hospital in Lisbon during their stay in the maternity ward after the infant's birth. Of these, 26 cases dropped out or could not be reached for follow-up at 3 or 9 months. Of the 136 remaining cases, 25 were excluded because mothers violated procedure instructions (e.g., smiled and/or touched the baby during the still-face episode of the FFSF), or infants were too distressed to participate in the FFSF, resulting in a final sample of 108 mother-infant dyads.

There was no evidence for differential attrition between the dyads who were included in the current analyses, and those who were not, based on their demographic characteristics (i.e., infant gestational age at delivery, gestational birth weight, infant gender, or maternal age).

Sample characteristics

All infants were full-term and healthy at the time of their delivery (≥ 37 and < 42 gestational weeks), and all had an appropriate birth weight for their gestational age (birth weight ≥ 2500 g). All infants continued to be healthy and normally developing during their follow-up visits at 3, 9, and 12 months of age. About half (53.7%) were male.

Their mothers were also healthy at the time of the infant's birth and had no self-reported or medical history of chronic diseases, mental health disorders or alcohol/drugs abuse. All mothers were married or living in cohabitation with the infant´s father. About half (51.9%) of the mothers were primiparous, and 93.5% self-reported as being Portuguese Caucasian in race/ethnicity. Mothers´ average years of completed education was 14.76 (SD = 3.41, range = 6–23) and their average age at the time of the infant's birth was 31.57 years (SD = 4.08, range = 20–39 years), which is very similar from the average

age of Portuguese (31.2 years) and European Union (30.7 years) mothers at the birth of a child (FFMS, 2019).

Procedures

All procedures were approved by the Ethics Committee of the Centro Académico de Medicina de Lisboa (Consent at 06/2010). Parents provided written informed consent to participate at the first visit, prior to data collection.

Mothers who were recruited in the original study and participated in the newborn study visit were re-contacted near the time of their infant's 3-, 9- and 12-month birthdays to schedule a follow-up visit to the laboratory. At the 3- and 9-month visits, mother-infant dyads were videotaped in the FFSF (Tronick et al., 1978). At the 12-month visit, dyads were videotaped in the Strange Situation (Ainsworth et al., 1978).

Face-to-Face Still-Face Paradigm (FFSF, Tronick et al., 1978). The FFSF is a videotaped, structured observational interaction task that includes three successive two-minute episodes: (a) a face-to-face baseline interaction during which mothers are seated facing their infant and instructed to play with their infant as they normally would, albeit without toys or pacifiers; (b) a still-face perturbation, during which mothers were instructed to keep a "poker face" while continuing to look at the infants, and to refrain from smiling, talking, or touching the infant; and (c) a reunion episode, during which mothers were instructed to resume their normal play interaction with the infant.

Strange Situation (Ainsworth et al., 1978). At the 12-month visit, mother-infant dyads were videotaped during the Strange Situation, a 21-minute laboratory paradigm consisting of a sequence of eight episodes designed to place mild but increasing levels of stress on the infant and dyad (i.e., being introduced to an unfamiliar play room, interacting with an unfamiliar adult stranger, and brief separations from and reunions with the mother).

Measures

Coding System for Regulatory Patterns in the FFSF (Fuertes & Lopes Dos Santos, 2009a). This coding system describes three patterns of infants´ regulatory behavior: *Social-positive oriented, Distressed-inconsolable* and *Self-comfort oriented*, which were classified using four *a priori* dimensions of infants´ behavior scored across the three episodes of the FFSF: (a) behavior organization (e.g., the infant exhibits predominantly social positive behavior or distressful behavior or self-comforting behavior, or mixed behavior); (b) behavior intensity (e.g., the infant displays prolonged and intense crying); (c) behavior quality (e.g., the infant reacts by displaying signals denoting pleasure such as smiles, laughter, and reciprocal neutral or positive vocalizations); and (d) infants' ability to recover from negative affect during the reunion episode of the FFSF.

Infants with a *Social-positive oriented pattern* predominantly exhibit positive behaviors during high/moderately reciprocal interactions with their mothers, and the interactive errors they experience with their mothers are easily repaired. In the still-face episode of the FFSF, these infants tend to react to their still-faced mother with positive behaviors (e.g., smiling) that progressively decrease during the episode and may be replaced by negative affect, followed by a clear recovery in the reunion episode.

In contrast, infants with a *Distressed-inconsolable pattern* display conspicuous negative behaviors when reciprocity fails, and the repair of interactive mismatches becomes more challenging. During the still-face episode of the FFSF, they react immediately to their still-faced mother with negative affect that persists or increases during the reunion episode, protesting or resisting adult attempts to reengage the infant in the interaction.

In turn, infants with a *Self-comfort oriented pattern* tend to exhibit conspicuous avoidance of the caregiver in the first and third episodes of the FFSF (e.g., ignoring the adult's interactive initiatives, looking away, turning away). These infants also display a high frequency of self-comforting behaviors during all FFSF episodes.

The videotapes of the FFSF were scored for infant regulatory patterns by three trained, reliable coders. Coders 1 and 2 were blinded to the study's hypotheses and other study variables, and each scored all cases independently (i.e., all cases were double-coded). Coder 3, an expert "gold standard", trained Coders 1 and 2 and evaluated their scoring reliability.

Intercoder agreement was calculated using Cohen´s kappa, and results indicated good agreement for each regulatory pattern. The Cohen´s kappa coefficient for inter-coder agreement for the 3- and 9-month data was .78 and .75, respectively. The final scores for discrepant cases were discussed and agreed upon by conferencing with the expert coder.

Attachment Classifications

Videotapes of infants' attachment behavior during the Strange Situation were scored by trained, reliable coders following the procedures developed by Ainsworth et al. (1978) and Main and Solomon (1990). Infants were classified as either securely attached (B), insecure-avoidant (A), insecure-ambivalent (C), or insecure-disorganized/disoriented (D). The Cohen´s kappa coefficient for ABCD classification (.90) indicated excellent intercoder reliability. The final scores for discrepant cases were discussed and agreed upon by conferencing with an expert Strange Situation coder.

Three of the 108 infants were coded as insecure-disorganized/disoriented (D). However, these cases were not included in the final analyses because their mothers violated the protocol instructions of the FFSF.

In addition to the ABCD classifications, the coders rated infants' interactive behaviors with the mother during both reunion episodes of the Strange Situation using four 7-point Likert scales created by Ainsworth et al. (1978): proximity and contact seeking, contact maintaining, resistance to contact/comforting, and avoidance of proximity/contact. The ratings of each scale were averaged across the two reunion episodes for analytic purposes in the present study. This was done because infants' interactive behavior in both reunion episodes are important in classifying infant attachment patterns, based on results of a discriminant function analysis reported by Ainsworth et al. (1978).

Analytic plan

Aim 1: To investigate the associations between infants' patterns of regulatory behavior in the FFSF at 3 and 9 months and their attachment classification in the Strange Situation at 12 months, two 3-way cross-tabulations were carried out. These analyses summarized the number of times each of the possible pattern combinations occurred in the sample. The chi-square test was used to determine whether patterns were independent or correlated. Additionally, Cohen´s Kappa was used to measure the strength of association among

patterns, assigning the same code to Social-positive oriented pattern and secure attachment, Distressed-inconsolable pattern and insecure-ambivalent attachment, and Self-comfort oriented pattern and insecure-avoidant attachment. Goodman-Kruskal tau was used as a proportional reduction in error measure to predict patterns of attachment at 12 months based on patterns of regulatory behavior at 3 and 9 months. Cramér's V was used to measure effect size.

Aim 2: One-way analyses of variance (MANOVA) were used to determine whether there were differences in the means of the ratings of infants' interactive behaviors toward the mother during the reunion episodes of the Strange Situation (i.e., proximity seeking, contact maintaining, resistance to contact/comforting, and avoidance of proximity/contact) among the three patterns of regulatory behavior in the FFSF at 3 and 9 months. Tukey´s post hoc tests were used to examine all possible pairwise comparisons between FFSF patterns (Lee & Lee, 2018). The Bonferroni correction was also run to control for possible effects of multiple testing. Partial eta squared was used to assess effect size.

Results

Distribution of patterns of regulatory behavior and attachment

Infant regulatory patterns in the FFSF at 3 and 9 months. Of the 108 infants who participated in this longitudinal study, 59 (54.6%) were classified as Social-positive oriented at 3 months, 37 (34.3%) as Distressed-inconsolable, and 12 (11.1%) as Self-comfort oriented. A similar distribution of patterns, $\chi^2(2, N = 216) = 0.96$, $p > .10$, was observed at 9 months: 56 (51.9%) were classified as Social-positive oriented, 43 (39.8%) as Distressed-inconsolable, and 9 (8.3%) as Self-comfort oriented.

Evidence for significant cross-age stability in infants' regulatory patterns was observed. The Pearson's chi-square value was highly significant ($p < .001$), indicating a non-random association between the three patterns of regulatory behavior at 3 and 9 months. The Cohen´s Kappa value of .71 also showed a substantial strength of concordance between the regulatory patterns across the two age periods (Landis & Koch, 1977). Similarly, a Goodman-Kruskal tau of .65 indicated a strong association, in which error in predicting regulatory patterns at 9 months was reduced by 65% when information from regulatory patterns at 3 months was used.

Infant attachment classifications at 12 months

Seventy-two of the 108 infants (66.7%) were classified as securely attached in the Strange Situation, 25 (23.1%) as insecure-ambivalent, and 11 (10.2%) as insecure-avoidant at the 12-month lab visit. This distribution of attachment classifications is generally consistent with the distributions reported in a meta-analytic review of the attachment literature by Van IJzendoorn and Kroonenberg (1988).

Association between patterns of regulatory behavior in the FFSF and patterns of attachment in the Strange Situation

The associations between the three patterns of regulatory behavior at 3 months and attachment classifications at 12 months are summarized in Table 1. A significant

Table 1. Association between infant´s regulatory patterns at 3 months and attachment at 12 months.

		Attachment classification at 12 months			
		Secure	Ambivalent	Avoidant	Total
Patterns of regulatory behavior at 3 months	Social-positive oriented	55 (93.2%) 6.4	3 (5.1%) −4.9	1 (1.7%) −3.2	59
	Distressed-inconsolable	14 (37.8%) −4.6	18 (48.6%) 4.5	5 (13.5%) −4.6	37
	Self-comfort oriented	3 (25%) −3.2	4 (33.3%) 0.9	5 (41.7%) 3.8	12
Total		72	25	11	108

Note. Percentage of attachment classifications at 12 months by 3 months regulatory patterns in the Face-to-Face Still-Face paradigm (FFSF); each cell contains the frequency, percentage and adjusted residuals; Pearson Chi-Square = 49.48, DF = 4, p <.001.

association between patterns of regulatory behavior at 3 months and attachment status was found, χ^2 (4, N = 216) = 49.48, p < .001, ϕcramer = .48. A Cohen's Kappa value of .49 indicated moderate concordance (Landis & Koch, 1977) and a Goodman and Kruskal's tau value of .30 indicated a proportional reduction in error of 30%.

The associations between patterns of regulatory behavior at 9 months and patterns of attachment at 12 months are summarized in Table 2. A significant association between patterns of regulatory behavior at 9 months and patterns of attachment at 12 months was found, χ^2 (4, N = 216) = 64.37, p < .001, ϕcramer = .55. A Cohen´s Kappa value of .55 indicated a moderate association and the Goodman and Kruskal tau value of .32 indicates a proportional reduction in error of 32%.

A second analysis was then carried out to evaluate the possibility that stronger associations between regulatory patterns and attachment would be observed in the subset of infants (n = 90) who exhibited stable regulatory patterns over time (i.e., had the same regulatory pattern at 3 and 9 months). Results of that analysis confirmed this hypothesis. In this subset of "stable" infants, Cohen´s Kappa increased to .60 and the Goodman and Kruskal tau value increased to .39).

Association of infant regulatory behavior patterns in the FFSF at 3 and 9 months and infant attachment behavior ratings in the Strange Situation at 12 months

9-month infant regulatory patterns in FFSF and interactive behavior ratings in Strange Situation

Descriptive statistics for the averaged ratings of infants´ attachment behavior toward the mother during the reunion episodes of the Strange Situation, as broken down by the three patterns of regulatory behavior in the FFSF at 3 months, are presented in Table 3. Results of one-way MANOVAs indicated that infant regulatory patterns at 3 months were significantly associated with infants' resistance and avoidance behaviors during the

Table 2. Association between infant´s regulatory patterns at 9 months and attachment at 12 months.

		Attachment classification at 12 months			
		Secure	Ambivalent	Avoidant	Total
Patterns of regulatory behavior at 9 months	Social-positive oriented	53 (94.6%) 6.4	2 (3.6%) −5.0	1 (1.8%) −3.0	56
	Distressed-inconsolable	15 (34.9%) −5.7	23 (53.5%) 6.1	5 (11.6%) 0.4	43
	Self-comfort oriented	4 (44.4%) −1.5	0 (0%) −1.7	5 (55.6%) 4.7	9
Total		72	25	11	108

Note. Percentage of attachment classifications at 12 months by 9 months regulatory patterns in the Face-to-Face Still-Face paradigm (FFSF); each cell contains the frequency, percentage and adjusted residuals; χ^2 = 64.37, DF = 4, p <.001.

Table 3. Means, standard deviations, and MANOVA results for Infant Interactive Behavior Ratings during the Strange Situation at 12 months, according to patterns of infant regulatory behavior at 3 months.

Interactive Behavior Ratings	Social-Positive Oriented *M (SD)*	Distressed-Inconsolable *M (SD)*	Self-Comfort Oriented *M (SD)*	*F*(2, 105)	Partial η2
Proximity seeking	4.42 (1.64)	4.16 (1.86)	3.50 (2.11)	1.40	.03
Contact maintaining	2.90 (1.90)	3.68 (2.16)	2.83 (1.90)	1.93	.04
Resistance	2.05 (1.33)[a]	2.86 (1.72)	2.00 (1.48)	3.71*	.07
Avoidance	1.66 (1.06)[a]	2.05 (1.51)	2.67 (1.72)	3.30*	.06

Note. Means with a different subscript are statistically different at $p < .05$, Tukey HSD procedure.
*$p < .05$.

reunion episodes of the Strange Situation. Specifically, results of Tukey post-hoc tests showed that infants with a Distressed-inconsolable pattern in the FFSF displayed more resistance to contact/comforting during reunion with their mother in the Strange Situation, compared to infants with a Social-positive oriented pattern. In contrast, infants with a Self-comfort oriented pattern displayed more avoidant behavior during reunion with their mother, compared to infants with the Social-positive oriented pattern.

When Bonferroni correction was applied, findings for the former association between the Distressed-inconsolable pattern in the FFSF at 3 months and resistance to contact/comforting with the mother during the Strange Situation remained statistically significant. However, the latter association between the Self-comfort oriented pattern in the FFSF and avoidant behavior with the mother in the Strange Situation was reduced to statistical non-significance.

9-month infant regulatory patterns in FFSF and interactive behavior ratings in Strange Situation

Descriptive statistics for the averaged ratings of infants' attachment behavior toward the mother during the reunion episodes of the Strange Situation, as broken down by the three patterns of regulatory behavior in the FFSF at 9 months, are presented in Table 4. Results of one-way MANOVAs indicated statistically significant differences between infant regulatory patterns at 9 months and infants' level of contact maintaining, resistance, and avoidance behavior with the mother during the reunion episodes of the Strange Situation at 12 months. Specifically, results of Tukey post-hoc tests showed that infants with a Distressed-inconsolable pattern in the FFSF at 9 months displayed more contact maintaining and more resistance toward the mother during the reunion episodes of the Strange Situation at 12 months,

Table 4. Means, standard deviations, and MANOVA results for Infant Interactive Behavior Ratings during the Strange Situation at 12 months, according to patterns of regulatory behavior at 9 months.

Interactive Behavior Ratings	Social-positive oriented *M (SD)*	Distressed-inconsolable *M (SD)*	Self-comfort oriented *M (SD)*	*F*(2, 105)	Partial η2
Proximity seeking	4.41 (1.69)	4.23 (1.81)	3.11 (1.89)	2.11	.04
Contact maintaining	2.75 (1.89)[a]	3.86 (1.89)	2.33 (2.18)	4.91**	.09
Resistance	1.95 (1.30)[a]	2.98 (1.70)	1.56 (.73)[a]	7.61***	.13
Avoidance	1.64 (1.07)[a]	1.93 (1.24)[a]	3.44 (2.19)	7.98***	.13

Note: Means with a different subscript are statistically different at $p < .05$, Tukey HSD procedure.
*$p < .05$; ** $p < .01$; ***$p < .001$.

compared to infants with a Social-positive oriented pattern or infants with a Self-comfort oriented pattern at 9 months. In contrast, infants with a Self-comfort oriented pattern in the FFSF at 9 months displayed more avoidance toward the mother during the reunion episodes of the Strange Situation, compared to infants with a Social-positive oriented pattern or infants with a Distressed-inconsolable pattern in the FFSF at 9 months. Each of these results remained statistically significant after applying the Bonferroni correction.

Discussion

The goal of the present longitudinal study was to investigate whether infants' organized patterns of regulatory behavior assessed in the FFSF at 3 and 9 months are associated with their later attachment classification in the Strange Situation at 12 months in a full-term healthy sample. Results indicate a significant association between the Social-positive oriented pattern during the FFSF at both ages and secure attachment at 12 months. In turn, the Distressed-inconsolable pattern during the FFSF at both ages is linked to an insecure-ambivalent attachment at 12 months, whereas the Self-comfort oriented pattern during the FFSF at both ages is associated with insecure avoidant attachment at 12 months. Moreover, these associations are stronger when these analyses are conducted on the subset of infants showing stable regulatory patterns at 3 and 9 months.

Together, these findings suggest that infants' organized patterns of regulatory behavior observed during the FFSF, a dyadic interaction paradigm, can be identified in full-term infants as early as 3 months or as late as 9 months of age (Barbosa et al., 2019, 2018), and both are associated with infants' attachment classification in the Strange Situation at the end of the first year. Future research should address the mechanisms underlying these individual differences in infants' organized patterns of regulatory behaviour, and the infant, maternal/familial, and contextual factors that may be contributing to their stability or change over time.

A secondary goal of the study was to evaluate whether the three patterns of regulatory behavior in the FFSF at 3 and 9 months were associated with ratings of infants' attachment behavior with the mother during the reunion episodes of the Strange Situation (i.e., proximity and contact seeking, contact maintaining, resistance to contact/comforting, and avoidance of proximity/contact). Infants classified with a Distressed-inconsolable pattern in FFSF at either 3 or 9 months exhibited more contact maintaining behavior and more resistance with the mother during the reunion episodes of the Strange Situation at 12 months. In contrast, infants with a Self-comfort oriented pattern at either age displayed more avoidance of proximity/contact with the mother during the Strange Situation at 12 months. These findings provide further support for the hypothesis that early emerging infant regulatory patterns, assessed during dyadic interaction contexts in the first year of life, are associated with infants' later attachment behavior.

To the best of our knowledge, this is the first longitudinal study to assess the association between early organized patterns of regulatory behavior observed during the FFSF during the first year of life, and infant attachment at the end of the first year, in a full-term healthy sample of infants. These findings provide further support for the predictive validity of the *Coding System for Regulatory Patterns in the FFSF* (Fuertes & Lopes Dos Santos, 2009). This holistic perspective captures infants' ability to regulate their emotions and to organize their behavior in the context of social interaction in the FFSF, and their

attempts to regain caregiver availability and regulate emotions during a maternal still-face perturbation, and to restore dyadic engagement following this disruption in social engagement.

In previous research, a few investigators reported significant associations between discrete infant behaviors, such as positive elicits of the mother during the FFSF at 6 months of age and their later attachment security; however, these associations were not significant when infants' positive elicits were assessed at other ages (3 or 9 months; Cohn et al., 1991; Tronick et al., 1982). Similarly, investigators in several other studies reported positive associations between infants' positive or negative affect in the FFSF at 4 months of age and later attachment, but not when infant affect was assessed at other ages (J. M. Braungart-Rieker et al., 2001; Kogan & Carter, 1996). Moreover, the effect sizes of the associations are relatively small. For instance, in the meta-analytic review by Mesman et al. (2009), infants who exhibited more positive (d = .23) and less negative affect (d = .24) during the FFSF were more likely to be securely attached at 12 months of age. In contrast, the effect sizes between the organized patterns of regulatory behavior at 3 (ϕcramer = .48) and 9 (ϕcramer = .55) months and attachment classifications at 12 months in the current study are larger than those reported in these prior studies.

The mixed findings and small effect sizes in prior literature may stem in part from researchers' focus on discrete infant behaviors rather than organized patterns of regulatory behavior. Results of the current study suggest that infants exhibit organized patterns of regulatory behavior in dyadic interactive contexts as early as 3 months of age. Moreover, these regulatory patterns are stable from 3 to 9 months and are associated infants' attachment classification at 12 months. We speculate that these associations may reflect heterotypic rather than homotypic continuity. In contrast to studies evaluating isolated, discrete infant behaviors during the FFSF as predictors of later attachment, we evaluated patterns of regulatory behavior, which reflect qualitative dimensions of infant regulatory behaviors across the three episodes of the FFSF. Critically, the discrete infant behaviors contributing to these patterns may change and become more complex with increasing age (Rutter et al., 2005). Despite these developmental changes, the regulatory functions served by infants' regulatory behavior patterns (i.e., to re-engage the still-faced mother, or to re-establish dyadic engagement following a disruption caused by this social stressor) appear to remain the same over time and may operate to achieve the same interactive or attachment goals (Beeghly et al., 2016; Tronick & Beeghly, 2011). In other words, although the repertoire of infants´ regulatory behaviors becomes more complex as infants mature, the regulatory functions served by these different behaviors (i.e., to achieve a state of mutual regulation or restore the feeling of safe and security) tend to remain the same. We suggest that infants´ sensory-affective "expectations" about how caregivers respond to their emotional needs are already operating in an organized way as early as 3 months, long before the standard age at which attachment pattern measures can be administered. These patterns may be a more reliable index of the "attachment-in-the-making" phase of attachment formation, proposed by Bowlby (1969) than discrete infant behaviors.

Our findings need replication in larger samples in other geographic and sociodemographic contexts before firm conclusions can be made. However, they suggest that infants' organized patterns of regulatory behavior observed in the FFSF at 3 and 9 months of age may reflect their early-emerging procedural representations of mother-infant

interaction patterns, which over time may contribute to the gradual establishment of infants' internal working models of attachment relationships postulated in attachment theory (Beebe et al., 2010; Bowlby, 1969; Tronick & Beeghly, 2011). Some support for this idea comes from a recent study by Barbosa et al. (2019), in which mothers' interactive behaviors with their infants during a free play session were associated with infants' regulatory behavior patterns in the FFSF. In contrast, in the same study, multiple measures of infant temperament and family demographics were not significantly associated with infants' regulatory patterns in the FFSF. This finding indicates that variations in infant temperament or social strata alone are not driving these associations. Rather, the results suggest that infants' early self-regulatory patterns reflect a behavioral organization that likely stems from an emerging dyadic relationship in which maternal sensitivity plays a crucial role (Barbosa et al., 2019; M. Fuertes et al., 2011).

Limitations, strengths, and future directions

The present study has both limitations and strengths that should be considered when evaluating the results. One limitation is that the current sample of Portuguese mother-infant dyads were from mostly low-risk socioeconomic backgrounds and homogeneous in race/ethnicity. Another limitation is that our observations of mother-infant interaction were conducted in a laboratory setting during structured interactive contexts (FFSF and Strange Situation). Thus, our findings may not generalize to mother-infant dyads in other ethnic/racial groups, geographic locations, or settings (such as the infants' homes), and may not characterize infants' social interactions with other caregivers such as fathers or extended family members. A third limitation is the relatively small sample size (N = 108), which may have limited statistical power and our ability to identify less prevalent regulatory patterns that might exist. For instance, the prevalence of infants exhibiting a Self-comfort pattern in the current study was relatively small. Replication of the current study in larger, more sociodemographically and racially diverse samples and in other contexts is needed. Primary strengths of the current study include its prospective, longitudinal design, inclusion of well-described observational interaction paradigms at multiple infant ages, and use of detailed behavioral coding systems.

Future longitudinal research should explore how other infant, maternal, and contextual variables may contribute to infant regulatory patterns. For instance, future research should include observational measures of infant temperament in non-interactive contexts, observations of parenting quality in other contexts (e.g., parental sensitivity in the home) across infancy. The inclusion of measures of parents' attachment representations, psychosocial well-being, and personality, marital relationships and social support, and life circumstances, and evaluation of how these variables may mediate or moderate the relationship between patterns of regulatory behavior and later attachment, would also be beneficial.

Despite its limitations, the results of the current study lend support to the hypothesis that early-emerging differences in infants' self-regulatory patterns, assessed in dyadic interactive contexts, are associated with infants' attachment classifications by the end of the first year. If replicated, our results may be helpful to practitioners who provide early intervention services to infants with regulatory difficulties and their parents, and may

contribute to the development of new evidence-based practices to promote attachment security in higher-risk populations (Tronick & Beeghly, 2011).

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