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Parental sensitivity, family alliance and infants' vagal tone: Influences of early family interactions on physiological emotion regulation

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Abstract

In this study, we investigated the influence of parental sensitivity and family alliance on infants' vagal tone, considered as a physiological indicator of emotion regulation. Studies on mother–infant interactions have shown that vagal tone can be influenced by the quality of the interaction, such as interacting with a sensitive mother. To date, no study has investigated the influence of paternal sensitivity or family alliance on infants' vagal tone. We hypothesized that maternal sensitivity, paternal sensitivity, and family alliance would be associated with infants' vagal tone during dyadic and triadic interactions. We also explored if family alliance would act as a moderator on the association between parental sensitivity and vagal tone and if the sensitivity of both parents would act as a moderator on the association between family alliance and vagal tone. This study took place in Switzerland and included 82 families with their 3–4-month-old infants. Results showed that maternal sensitivity and family alliance were associated with infants' vagal tone, but paternal sensitivity was not. We found no significant moderation effect. However, result tendencies suggested that the contribution of paternal sensitivity to infants' emotion regulation could be influenced by family alliance, whereas maternal sensitivity and family alliance have a unique contribution.

KEYWORDS

emotion regulation, family interactions, heart-rate variability, infancy, parental sensitivity, vagal tone

1 | INTRODUCTION

In primiparous families, early interactions involve either two partners, in dyadic mother–infant, father–infant, or mother–father interactions, or three partners, in triadic mother-father–infant interactions. The quality of these early interactions is critical for infants' socioemotional functioning, as they constitute the main resource for the development of emotion regulation abilities (e.g. Cole et al., 2004; Favez et al., 2006, 2012). As evidenced by physiological studies (Porges et al., 1994), one indicator of the infant's emotion regulation during early interactions is vagal tone, that can be assessed with heart-rate variability (Laborde et al., 2017). It has, for example, been shown that infants' vagal tone varies according to the quality of mother–infant interactions (e.g. Moore & Calkins, 2004; Pratt et al., 2015). However, to date, no study has investigated infants' physiological regulation in association with the quality of father–infant and mother–father–infant interactions. The present study aimed to fill this gap. As dyadic and triadic interactions in a family are interdependent, this study also aimed to investigate how they may jointly act as a factor of influence on infants' physiological regulation.

Emotion regulation is defined as the process responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensity and temporal features, in order to accomplish one's goal (Thompson, 1994). At birth, infants have immature emotion regulation abilities and need the adult to regulate their emotions. Emotions in infants are used as messages sent to the adults who, in response, adapt their behavior directed to the child so that the environment and the internal state of the infant is modified (Cole et al., 2004; Field, 1994; Tronick, 1989). It is through the repetition of this process that infants learn to understand their internal states and how to regulate emotions. After an initial stage during which emotions are entirely regulated by caregivers, a process of co-regulation takes place as infants grow up, and they finally become capable of self-regulation (Sameroff, 2004). Therefore, the quality of the early interactions with caregivers has a major influence on the development of emotion regulation abilities (Cole et al., 2004; Morris et al., 2007), which is crucial for optimal socioemotional functioning (Cole & Deater-Deckard, 2009; Halligan et al., 2013; Thompson, 1991). For that process to be beneficial for the infant, parental responses to infants' signals have to be sensitive. Parental sensitivity refers to the parent's ability to perceive and understand the infant's signals in order to respond to these signals appropriately (Ainsworth, 1967). During an interaction, the parent interprets the infant's signals to provide optimal stimulation and the infant reinforces the parent's behavior by remaining attentive and receptive. For example, if the infant is highly aroused, a sensitive parent might lessen the stimulations so that the infant is able to lower his or her arousal. In contrast, when there is a lack of sensitivity, parents are more likely to exhibit maladjusted behavior (e.g. intrusive behaviors) and will also have difficulties reading their infant's signals. Therefore, they might keep behaving the same way rather than adjusting their behavior to the infant's state. When parents repeatedly do not respond adequately, they do not provide the support for the infant to develop their self-regulation abilities, which might have consequences in the long run. Studies on parental sensitivity and its association with infants' emotional regulation have been mainly conducted in mother–infant interactions. Longitudinal studies have shown that maternal sensitive parenting is associated with better behavioral emotion regulation in infants, either in response to stressful social interactions and frustration tasks, or during free face-to-face interaction (e.g. Braungart-Rieker et al., 2014; Frick et al., 2018; Gable & Isabella, 1992; Spinrad & Stifter, 2002).

KEY FINDINGS

- Maternal sensitivity is associated with infants' vagal tone in mother–infant interactions.
- Family alliance is associated with infants' vagal tone in mother–father–infant interactions.
- Paternal sensitivity is not associated with infants' vagal tone, and fathers' contribution to infants' emotion regulation should be further investigated.

Even though mothers still assume most of the parenting duties, the increase in women's employment has been accompanied by an increase in fathers' participation in childcare (Bonoli, 2007). As a consequence, there has been increasing interest in father–infant relationships and fathers' contribution to infants' development. The way that fathers interact with their infants tends to be more physical and less predictable (Lewis & Lamb, 2003), which has been shown to promote the development of infants' emotion regulation (Parke, 2002; Pleck, 2007). Although studies on father–infant dyads are less numerous than those on mother–infant dyads, a meta-analysis showed that paternal sensitivity is associated with child's emotion regulation (Rodrigues et al., 2021). However, studies were conducted with children 8 months and older at the time of the paternal sensitivity assessment. To date, no study has investigated the association between paternal sensitivity and emotion regulation in the first 3 months of life. The few studies on early paternal sensitivity have shown that fathers can be sensitive from the very beginning of their relationship with their infant (Lamb et al., 2017; Parke & Sawin, 1976; Sawin & Parke, 1979). Thus, even though mothers tend to spend more time with the infant in the first months after birth for various reasons, such as socially expected gender roles, maternity leave, or breastfeeding, early interactions with fathers might already have an influence on the development of emotion regulation. Investigating the contribution of paternal sensitivity during the early period after birth could provide a better understanding of the role of sensitive parenting behavior (or lack thereof) by each parent in the development of infant emotion regulation.

Although most studies have been conducted in parent–infant dyads, infants' social experiences are not limited to interactions with one parent only. Many infants experience complex social interactions such as triadic interactions on a daily basis, for example, when both parents are present. Studies have shown that the relational processes in triadic interactions have unique qualities; their contribution to infants' socioemotional functioning seems to run above and beyond parenting behaviors only (Belsky et al., 1996; Teubert & Pinquart, 2010) and cannot be inferred from the study of dyadic interactions only (McHale & Lindahl, 2011). Indeed, whereas dyadic interactions allow the study of how parents are with their infant, triadic interactions allow the study of how parents are *together* with the infant. The quality of the triadic relationship involving two parents and a child can be captured through the construct of family alliance (FA). It is defined as the degree of coordination reached by the two parents and the child when they complete a task (Fivaz-Depeursinge & Corboz-Warnery, 1999), such as during the Lausanne Trilogue Play (LTP; Fivaz-Depeursinge & Corboz-Warnery, 1999). The quality of the FA depends on the achievement of four hierarchically imbricated, interactive functions (participation, organization, focus, and affective sharing) that are analyzed throughout the LTP. The FA can be categorized as being "cooperative," "conflicted," or "disordered." Cooperative families are characterized by cooperation, support, and cohesion. Conflicted families are characterized by competition, conflict, and difficulties of the parents to cooperate. Finally, disordered families are characterized by exclusion and disengagement. Conflicted and disordered families are considered problematic alliances (Favez et al., 2011) and are indicative of difficulties in creating an optimal context for triadic interactions. Longitudinal studies have shown that FA is associated with infants' socioemotional outcomes (Favez et al., 2006, 2012). However, the processes explaining the association between FA and infants' outcomes are not yet known. As emotion regulation abilities are crucial for infants' socioemotional functioning, infants' emotion regulation might be the process underlying these associations. It is thus necessary to investigate whether, similar to parental sensitivity, the quality of triadic interactions has an influence on infants' emotion regulation.

A high quality of dyadic and triadic interactions is crucial for infants' healthy development. As parental sensitivity and FA have been shown to be fairly stable across time (Behrens et al., 2014; Favez et al., 2006; Kemppinen et al., 2006; Towe-Goodman et al., 2014), they are representative of the relational contexts in which infants grow up and will influence the development of emotion regulation abilities. These relational contexts are not totally independent from one another. Indeed, according to the family systems theory (Minuchin, 1974), the different relationships within the family constantly influence each other. Studies have confirmed this assumption by showing that parental sensitivity is associated with family functioning (Olhaberry et al., 2022; Tissot et al., 2015; Uldry-Jorgensen et al., 2016). Moreover, high parental sensitivity is also important in order to reach a cooperative FA in the first 3 months after the birth of a child (Tissot et al., 2015). Therefore, the quality of each context of interaction might have an influence on infant's emotion regulation beyond the context where it has been directly observed. For example, the effect of FA on infants' emotion regulation might not be limited to the proper context of mother–father–infant interactions, but might interact with parental sensitivity to predict infants' emotion regulation during mother–infant or father–infant interactions. This interrelatedness underlines the importance of investigating the influences of the different contexts of family interactions on infants' emotion regulation, not only separately but also in interaction with one another. Indeed, growing up in an optimal triadic context could give the infant additional resources to cope with a lack of sensitivity of one parent, or could enhance the contribution of sensitive parenting in the development of emotion regulation. Similarly, parental sensitivity could also influence the association between FA and infants' emotion regulation. Sensitive parenting might protect infants from difficulties in cooperation between parents during triadic interactions or might increase the contribution of a cooperative FA to infants' emotion regulation. To date, no study has investigated the potential moderation effect of FA on the association between parental sensitivity and infants' emotion regulation in dyadic interactions, or the moderation effect of parental sensitivity on the association between FA and infants' emotion regulation in triadic interactions.

In order to understand infants' emotional experience during interactions, studies have used a physiological indicator related to the regulation of the parasympathetic branch of the autonomic nervous system (ANS): the vagal tone (Feldman et al., 2010; Ham & Tronick, 2009; Moore et Calkins, 2004; Pratt et al., 2015; Provenzi et al., 2015). The ANS has two subsystems: the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS; McCorry, 2007). The PNS is associated with growth and restoration, while the SNS is associated with the mobilization of the physiological resources required by the environmental demands. The regulation of these antagonistic subsystems allows for a physiological state appropriate to the situation. Vagal tone is a measure of the modulating activity of the PNS on the organs via the vagus nerve that can be indexed by heart rate variability

(Laborde et al., 2017). The vagus nerve is the tenth cranial nerve, originating in the brain stem and projecting to the various organs, including the heart and digestive system (Porges et al., 1994). It contains efferent and afferent fibers, allowing physiological regulation by dynamic feedback between the brain and the organs. The vagus nerve is composed of two branches, each of which is related to specific adaptive functions and behavioral strategies (Porges et al., 1994). The dorsal branch of the vagus nerve is associated with the regulation of visceral functions, and the ventral branch is associated with attention, emotion, and communication processes. Therefore, the regulation of the parasympathetic branch of the ANS through vagal tone is an indicator of emotion regulation abilities (Santucci et al., 2008; Stifter et al., 2011). The polyvagal theory (Porges, 1995, 2001) postulates that when the environment is safe, the autonomic nervous system, through activation of the vagus nerve, exerts a parasympathetic influence on the heart (Porges, 1995, 2007). Through elevated vagal tone, the heart rate is slowed down, allowing for a state of calm that promotes social engagement (Porges, 1991). In the face of an increase in environmental demand, vagal tone decreases, resulting in a decrease in parasympathetic influence that allows for the engagement of metabolic resources required to cope with the situation and the adoption of appropriate behavior. When the demand decreases, vagal tone quickly resets to inhibit the influence of the sympathetic nervous system. Because vagal tone responds to changes in the body's needs, increasing or decreasing its influence, it was proposed as an indicator of emotion regulation (Gentzler et al., 2009; Gottman & Katz, 2002; Porges et al., 1994; Zisner & Beauchaine, 2016) and was shown to be associated with behavioral measures of reactivity, emotional expression, and self-regulatory abilities, such as the ability to self-soothe or to use regulatory behaviors (Rattaz et al., 2022). According to the polyvagal theory, vagal regulation has a strong social component. Sensitive interactions with caregivers facilitate the development of the vagal system that will subsequently improve the modulation of physiological arousal and enable the infant to behaviorally regulate and engage in positive social interactions (Porges & Furman, 2011).

Several gaps in the existing literature were identified throughout this introduction. First, on the one hand, most studies on parental sensitivity and infants' emotion regulation have been conducted on mother–infant dyads and, on the other hand, the few studies on paternal sensitivity have not been conducted during the first months after birth. Second, even though studies have brought forward evidence that FA is associated with infants' socioemotional functioning, no study has investigated its association with infants' emotion regulation. Moreover, although physiological studies have investigated the association between the quality of mother–infant interactions and infants' vagal tone, such an association has never been studied in father–infant dyads or mother-father–infant triads. Finally, no study has investigated how parental sensitivity and triadic interactions might act conjointly on infants' physiological regulation.

In this study, we aimed to fill these gaps by investigating the association between the quality of the parent–infant interactions and infants' vagal tone in mother–infant, father–infant, and mother–father–infant interactions and how these different contexts of interaction might influence each other and act jointly. We first hypothesized that (1) maternal sensitivity would be positively associated with infants' vagal tone during mother–infant interactions, such that greater maternal sensitivity would predict higher vagal tone; (2) paternal sensitivity would be positively associated with infants' vagal tone during father–infant interactions such that greater paternal sensitivity would predict higher vagal tone; and (3) FA would be positively associated with infants' vagal tone during mother-father–infant interactions, such that greater FA would predict higher vagal tone. Second, as these contexts of interaction are not independent and might interact with one another, we explored how FA might moderate the association between parental sensitivity and infants' vagal tone in dyadic interactions and how parental sensitivity might moderate the association between FA and infant's vagal tone in triadic interactions.

2 | METHOD

2.1 | Population

The participants were a convenience sample of 82 dual-parent families. The mean age of parents was 34 years for the mothers (M = 33.74, SD = 4.01) and 36 years for fathers (n = 78 due to missing data, M = 35.95, SD = 5.69). The infants were 43 boys and 39 girls (M = 15.4 weeks, SD = 1.26). Mothers (n = 70 due to missing data) had mostly completed a college degree (65%) and 80% were employed prior to maternity leave, 57% full time. Among the fathers (n = 65 due to missing data), 53% had completed a college degree and 95% were employed, 85% full time.

2.2 | Procedure

The parents were recruited during pregnancy at the maternity department of the Geneva University Hospitals by a midwife around the 37th week of pregnancy. The research was presented to the mothers and fathers and a consent form signed. Families were invited to a laboratory session when the infant was between 3 and 4 months old. At their arrival, the infant was placed on a changing table and the experimenter installed three pediatric electrodes on the infant's chest, connected to a wireless device, in order to record an electrocardiogram (ECG). Parents were then asked to play with their infant by following a paradigm in four parts, inspired by the LTP (Fivaz-Depeursinge & Corboz-Warnery, 1999). The LTP is the observational paradigm that was specifically designed to assess FA. In the original LTP, the parents and the infant are seated in an equilateral triangle. Parents sit on regular chairs, whereas the child sits in a swivel and reclining chair, which allows parents to adjust its position according to the child's motor development and to orient the chair toward one parent or the other. The family is asked to interact following a four-part scenario. In the first part, one parent is asked to interact with the child while the other parent simply remains present. In the second part, they switch roles, and then move on to the third part in which the triad interacts together. Finally, the parents are asked to have a conversation with each other and it is the child's turn to simply remain present. The original LTP paradigm was modified in this study for two reasons. The first was related to the collection of physiological data. In the LTP, the infant is seated in a pediatric chair designed to hold a 3-month-old infant in a sitting position. However, in this position, we were not able to get a clear ECG signal. Therefore, we decided to lay the infant down on a changing table, which is also a validated setting to assess FA (Rime et al., 2018). Second, we decided to modify the first and the second parts of the LTP in order to obtain separate dyadic and triadic interactions. These adaptations were made for feasibility reasons, following the previous adaptations, such as the LTP with Still-Face (Fivaz-Depeursinge et al., 2010) or the Diaper Change Play (Rime et al., 2018), which have shown the validity of the assessment of FA in modified settings. The parents were asked to interact as follows: In the first part, one parent played with the infant for 2 min, while the other parent was outside the room. In the second part, the parents switched roles. During the third part, the two parents played together with the infant for 2 min. Finally, parents had a discussion together with the infant on the changing table next to them for 2 min. The duration of each of the four parts has been set to 2 min in order to have four comparable parts in terms of duration. The duration was decided according to the naturalistic duration of the parts in the less standardized classical LTP and because it is a suitable time frame for 3-months-old infants. At the end of the interaction, the electrodes were removed from the infant and parents had to fill in a form to receive online self-report questionnaires.

The study and its protocol were approved by the Ethical Committee of the State of Geneva.

2.3 | Measures

2.3.1 | Parental sensitivity

We assessed maternal and paternal sensitivity with the infant CARE-Index (Crittenden, 2006). The CARE-Index is an adult-infant interaction assessment that can be used from birth to 25 months. The coding system assesses two dyadic constructs, the adult's sensitivity to the infant and the infant's cooperation with the adult. The present study focused on only the adult's sensitivity. The interaction is assessed according to seven variables: facial expression, vocal expression, position and body contact, expression of affection, turn-taking contingencies, control, choice of activity. For each of the seven variables, two points are distributed between three parental scales: sensitive, controlling, and unresponsive. An overall score is computed on each parental scale. The global score of parental sensitivity is obtained by summing the points attributed to the sensitive scale (range from 0 to 14). Parental sensitivity was assessed for each parent during the 2-min dyadic parent–infant interaction of the modified LTP. This interval corresponds to the minimum duration indicated by the CARE-Index manual for the assessment of sensitivity. As there are no breaks between the four parts of the LTP, increasing the length of the dyadic parts would have been too demanding for the infant.

The sample was coded by a certified coder while a second coder double coded 24% of the sample (20 videos in a total sample of 82). The intraclass correlation (two-way random, absolute agreement) on the sensitivity scores was excellent with a coefficient of .964 (Koo & Li, 2016).

2.3.2 | Family alliance assessment scale

We assessed the FA through observation during the third and fourth parts of the modified LTP. The Family Alliance Assessment Scale (FAAS; Favez et al., 2011) is an observation tool for mother-father–infant interactions that aims to assess FA. The first part of the assessment consists of the classification of the interactive patterns observed in the triadic interaction into three different alliance categories (cooperative, conflicted, or disordered alliance). The second part of the assessment consists in rating specific behaviors shown by families during the modified LTP on 3-point scales (from 0 = inappropriate to 2 = adequate): gazes, postures, implication of each partner, co-construction, parental scaffolding, family warmth, validation of the child's emotional experience, authenticity of the expressed affects, communication mistakes during shared activities. Two scales of the original FAAS (respect for the task's structure and time frame, interactional mistakes during transitions) were removed as these scales are specifically designed to assess how the triad can organize a time frame when it is not set by the experimenter. The total score is computed by summing the scores on the nine scales (range 0–18, $\alpha = .87$). A higher score indicates a high FA. Families with a high FA score are families in which every member of the family is participating in the interaction, every member of the family plays a role in the interaction, everyone's attention is focused on the interaction and emotions are shared. Either the FA category or the FA score can be used as an index of the quality of the FA. In the present study, we choose to use the FA score. The sample was coded by a senior coder, while a second coder double coded 46% of the sample (41 videos in a total sample of 88). The intraclass correlation coefficient (two-way random, absolute agreement) on the FA score was good with a coefficient of .79 (Koo & Li, 2016).

2.3.3 | Vagal tone

The infant's cardiac activity was recorded during all parts of the paradigm by using an ECG. Data were collected with a Biopac MP160 system (Biopac Systems, Inc.) and recorded on AcqKnowledge 5.0 software (Biopac Systems, Inc.). The ECG signal was processed on Kubios HRV v2.2 software to obtain the cardiac variability indicators, which reflect vagal tone. Analyses allowed us to derive the root mean square of successive differences (RMSSD), which represents the activity of the parasympathetic system and is therefore widely considered to be a valid measure of vagal activity (Laborde et al., 2017).

2.4 | Statistical analysis

Descriptive statistics were computed for all variables. We used the PROCESS macro for SPSS (Hayes, 2012, 2017) to test for moderation effects (Model 1 and Model 2). A bootstrapping procedure with 5000 bootstrap resamples was used to estimate 95% confidence intervals (CIs). The macro creates mean-centered variables to calculate the interaction product terms. Three models were run: (1) infants' RMSSD during mother–infant interactions as a dependent variable, maternal sensitivity as an independent variable, and FA as the moderator; (2) infants' RMSSD during father–infant interactions as a dependent variable, paternal sensitivity as an independent variable, and FA as the moderator; and (3) infants' RMSSD during mother-father–infant interactions as a dependent variable, FA as an independent variable, and both maternal sensitivity and paternal sensitivity concurrently as moderators.

TABLE 1 Descriptive statistics.

Variable	*n*	Min.	Max	*M*	*SD*
FA score	82	3	18	12.30	3.89
Maternal sensitivity	82	1	14	8.50	3.21
Paternal sensitivity	82	1	14	8.11	3.37
RMSSD mother–infant	82	2.95	19.80	11.07	3.41
RMSSD father–infant	82	3.42	20.07	11.16	3.90
RMSSD mother-father–infant	82	2.80	16.97	10.44	3.89

Note: FA = family alliance; RMSSD = root mean square of successive differences.

3 | RESULTS

3.1 | Descriptive statistics

The descriptive statistics for the study variables can be found in Table 1.

Normative values of RMSSD during infancy are mostly based on 24-h ECG recordings (Massin & von Bernuth, 1997; Patural et al., 2019), making them difficult to compare with the 2-min segments in the present study. However, studies for small segments of 10- or 2-min ECG recordings when infants were at rest (Arce-Alvarez et al., 2019; Zeegers et al., 2017) reported similar or a little higher values than those of the present sample. This slight difference might be because the ECG was recorded during social interactions and not during the resting state.

Correlations between the variables can be found in Table 2. Maternal and paternal sensitivity were positively correlated and both positively correlated with FA scores. There were significant positive correlations between maternal sensitivity and infants' RMSSD during mother–infant, and mother-father–infant interactions. FA scores were also positively correlated with infants' RMSSD during mother–infant, father–infant, and mother–father–infant interactions. Finally, infants' RMSSD in the different parts of the paradigm were highly correlated. Infants' gender and age were not correlated with any of the variables; therefore, we did not include them in subsequent analyses.

3.2 | Moderation analyses

There was a significant main effect for maternal sensitivity on infants' RMSSD during the mother–infant interactions ($\beta = .222$, $p = .04$, 95% CI = .002–.471), whereas the main effect for FA scores on infants' RMSSD was not significant ($\beta = .182$, $p = .10$, 95% CI = −034 to .355). There was no significant interaction effect between maternal sensitivity and FA scores ($\beta = .721$, $p = .14$, 95% CI = −.014 to .100).

There was no significant main effect for paternal sensitivity on infants' RMSSD during father–infant interactions

TABLE 2 Correlation matrix for study variables.

Variable	1.	2.	3.	4.	5.	6.
1. FA score	1					
2. Maternal sensitivity	.285**	1				
3. Paternal sensitivity	.356**	.397**	1			
4. RMSSD mother–infant	.225*	.262*	.203	1		
5. RMSSD father–infant	.273*	.214	.052	.727**	1	
6. RMSSD mother-father–infant	.387**	.251*	.051	.700**	.756**	1

Note: FA = family alliance; RMSSD = root mean square of successive differences.
*$p < .05$.
**$p < .01$.

($\beta = -.025$, $p = .82$, 95% CI = −.297 to .238). However, there was a significant main effect for FA scores on infants' RMSSD ($\beta = .342$, $p = .004$, 95% CI = .110–.576). There was a marginally significant interaction effect between paternal sensitivity and FA scores ($\beta = .799$, $p = .055$, 95% CI = −.001 to .111).

There was a significant main effect for FA scores on infants' RMSSD during mother-father–infant interactions ($\beta = .366$, $p < .001$, 95% CI = .176–.557). There was a marginally significant effect of maternal sensitivity ($\beta = -.168$, $p = .08$, 95% CI = −.030 to .439) on infants' RMSSD and no effect of paternal sensitivity ($\beta = -.143$, $p = .16$, 95% CI = −.401 to .068) on infants' RMSSD. There was no significant interaction effect between FA scores and maternal sensitivity ($\beta = .456$, $p = .31$, 95% CI = −.030 to .093) or between FA scores and paternal sensitivity ($\beta = .291$, $p = .44$, 95% CI = −.033 to .074).

4 | DISCUSSION

The first aim of this study was to investigate the association between the quality of the parent–infant interactions and infants' vagal tone. Our hypotheses were partially confirmed. Results showed that maternal sensitivity predicted infants' vagal tone during mother–infant interactions; greater maternal sensitivity was associated with infant's higher RMSSD. Paternal sensitivity did not predict infants' vagal tone during father–infant interactions. As expected, FA predicted infants' RMSSD during mother–father–infant interactions, such that greater FA predicted higher infants' RMSSD.

Results regarding the association between maternal sensitivity and infants' vagal tone during mother–infant interactions were in line with the idea that sensitive parenting contributes to the development of physiological regulation of vagal tone through positive social interactions (Porges & Furman, 2011). The exposure to sensitive interactions with the mother, in the first months after birth, might set the physiological basis for positive socioemotional development. Regarding the nonsignificant association between paternal sensitivity and infants' vagal tone, a few explanations can be put forward. First, contextual factors need to be taken into consideration. In Switzerland a 14-week maternal leave is mandatory, whereas paternal leave is almost nonexistent, being only 1–3 days at the time of the study (this has since evolved to 2 weeks of paternal leave). As our study took place during the first 3–4 months after birth, mothers spent most of their time with their infant. It is therefore likely that the quality of mother–infant interactions was associated with infants' physiological response, unlike that of fathers, who spent much less time with their infant. Because of this societal context, mothers are the primary source of caregiving and emotion regulation. Infants might be more physiologically reactive to adjusted or unadjusted behaviors from the mothers than from the fathers, as they are used to relying on mothers for regulation. It would be particularly interesting to investigate the influence of the length of the paternity leave on the association between paternal sensitivity and infants' physiological regulation. As studies have shown that fathers' involvement in childcare was increased when paternity leave was longer than two weeks (Huerta et al., 2014; Nepomnyaschy & Waldfogel, 2007), a higher involvement in childcare might increase the influence of paternal sensitivity on infants' emotion regulation. However, in Switzerland the duration of the paternity leave is fixed and is the same for all fathers, which does not allow a comparison of different lengths of paternity leave. Second, as maternal and paternal roles differ, infants might develop different expectations in their interactions with one parent or the other. Mothers tend to engage in caregiving functions when interacting with their infants, whereas fathers tend to play with them (Lamb, 1977). Infants might be expecting mothers to be sensitive to their emotional signals and needs that require regulation, whereas infants might not be expecting the same from fathers and, again, be less physiologically reactive to sensitive or insensitive paternal behaviors. This explanation also raises the question about the use of the CARE-Index in father–infant interactions. As we mentioned, fathers' parental behaviors, even though sensitive, are known to be different from mothers' behaviors. We could therefore question the use of an assessment tool initially developed for mother–infant interactions. It could be particularly interesting to use assessment scales developed specifically for father–infant interaction, in order to confirm, or not, the relevance of using the CARE-Index to assess paternal sensitivity. Third, as mentioned before, studies that have shown an influence of paternal sensitivity on infants' emotion regulation have so far been conducted with older infants (Rodrigues et al., 2021). Our results suggest that paternal sensitivity might not be implicated in infants' emotion regulation at such an early age. The influence of paternal sensitivity on emotion regulation and socioemotional outcomes might take place at later stages of life, perhaps when parents more equally spend time with their infant. Finally, regarding the influence of FA, results showed that FA during mother-father–infant interactions is associated with infants' vagal tone. This result confirms that families with a better alliance can set a more optimal context for social interaction (Fivaz-Depeursinge & Corboz-Warnery, 1999) in which infants can stay engaged and regulated. Being exposed to positive triadic interactions might benefit infants' physiological regulation, which, in turn, could lead to better socioemotional outcomes. Further studies should investigate physiological emotion regulation as a process involved in the association between FA and infants' socioemotional functioning.

Our second aim in this study was to investigate potential moderation effects of parental sensitivity and FA in the different contexts of interaction. Results showed no moderation effects of FA on the association between maternal sensitivity and infants' RMSSD during mother–infant interactions. We found a significant main effect of FA and a marginally significant moderation effect of FA on the association between paternal sensitivity and infants' RMSSD during father–infant interactions. Finally, results showed a marginally significant effect of maternal sensitivity on infants' RMSSD during triadic interactions and no moderation effect of both maternal and paternal sensitivity on the association between FA and infants' RMSSD.

Regarding mother–infant interactions, results showed that the association between maternal sensitivity and infants' emotion regulation is not influenced by FA. Again, as the study took place during maternity leave, mothers might have been used to spending time and interacting alone with their infant, making the influence of maternal sensitivity on infants' emotion regulation independent of family functioning. Concerning father–infant interactions, results suggested that triadic processes have an influence on the dyadic context of father–infant interactions. The first interesting conclusion that can be drawn from these results is that there seems to be something different at play in father–infant interactions. Indeed, family functioning is more predictive of infants' vagal tone during father–infant interactions than is paternal sensitivity. This effect might be explained by the fact that fathers might spend time with their infant when the mothers are also present, as mothers are still on maternity leave. Therefore, infants might be more exposed and more reactive to family-level aspects of interaction, such as FA, than to dyadic processes such as paternal sensitivity. The second interesting aspect is that the marginally significant interaction effect between paternal sensitivity and FA suggests that a better FA fosters the association between paternal sensitivity and infants' physiological regulation. It seems that for paternal sensitivity to be a determining process for infant physiological regulation, fathers should evolve with optimal family functioning. Fathers might thus be more influenced than mothers by family-level relationships in their involvement in childcare in the first months of the transition to parenthood. Finally, considering mother-father–infant interactions, we found a marginally significant main effect of maternal sensitivity on infants' vagal tone during triadic interactions. This suggests that maternal sensitivity assessed during mother–infant dyadic interactions might have an influence on infants' physiological regulation as long as the mother is present, such as in mother-father–infant interactions. Results also showed that the association between FA and infants' vagal tone is independent from maternal or paternal sensitivity. This result demonstrates that what is at stake in triadic interactions cannot be captured by the addition of mother–infant and father–infant dyads. There are interactional processes specific to the triad that need to be considered when studying family relationships. The quality of FA might have a specific contribution to the development of infants' physiological emotion regulation. This justifies the need to study triadic processes for the understanding of infants' emotion regulation and socioemotional functioning.

This study has several limitations. First, for feasibility reasons, we have assessed parental sensitivity on the minimum length recommended in the CARE-Index manual (2 min) and not on the usual duration of 3 min used in most studies. Despite this short time frame, the mean score of parental sensitivity in our sample did not differ from other studies (Kemppinen et al., 2007; Udry-Jorgensen et al., 2016). However, further studies might want to replicate these findings with a longer time frame. Second, as the LTP has been modified, the assessment of family alliance has been coded during the last two parts of the LTP only (i.e. the mother-father–infant interaction and the discussion between the parents). Again, when compared to mean FA scores in another study (Favez et al., 2014), we did not find any differences on the mean scores, which suggests that coders were able to reliably assess the FA. Third, although the recruitment targeted a general population, most of the participants were highly educated, which reduces the generalizability of the results. Finally, the results are limited to heterosexual families and are therefore not generalizable to all family configurations. Despite these limitations, it is the first study to investigate physiological regulation during three contexts of family interaction, as well as how family processes might influence each other in infants' physiological emotion regulation.

5 | CONCLUSIONS

This study underlines the importance of the quality of triadic interactions in the development of infants' emotion regulation, in addition to what has been already shown in mother–infant interactions. It also stresses the differences between mother–infant and father–infant interactions, their associations with infants' emotion regulation, and the need for a better understanding of the processes underlying the contribution of fathers.

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CONFLICT OF INTEREST STATEMENT

The authors declare no competing interests.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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