Universidade do Porto

Faculdade de Psicologia e de Ciências da Educação

THE IMPACT OF MATERNAL SENSITIVITY ON 3-MONTH INFANTS' SELF-REGULATORY AND SOCIAL ENGAGEMENT BEHAVIORS

Ana Teresa Martins Loureiro

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AVISOS LEGAIS

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Resumo

A autorregulação tem um papel central no desenvolvimento das capacidades do bebé em envolver-se numa interação social. Com a maturação, os bebés são munidos de uma plataforma neuronal que sustenta as suas capacidades regulatórias. Neste contexto, os *mecanismos dependentes da experiência* surgem como suporte ao seu desenvolvimento social. Tais processos só poderão ser compreendidos num puzzle complexo de transações multidimensionais entre fatores intrínsecos (e.g., fisiológicos) e extrínsecos (e.g., ambiente social) onde a sensibilidade materna é crucial para o desenvolvimento das capacidades autorregulatórias e de envolvimento social. Para compreender em que medida a sensibilidade materna e a autorregulação do bebé influenciam o desenvolvimento social precoce, um estudo foi conduzido com 41 díades mãe-bebé. De modo a aumentar a variabilidade da idade pós-natal, foram selecionados bebés saudáveis nascidos entre as 34 e 41 semanas. Aos $3^{1/2}$ meses (idade corrigida), as díades foram filmadas durantes 5 minutos em interação livre e na situação *Face-to-Face-Still-Face*. As classificações da sensibilidade materna e os resultados dos comportamentos autorregulatórios e de envolvimento social foram obtidos. Recorrendo a uma análise de trajetórias, foram encontrados efeitos diretos significativos da idade pós-natal e da sensibilidade materna no envolvimento social do bebé. A autorregulação mediou parcialmente os efeitos da sensibilidade materna no envolvimento social, mas não os efeitos da idade pós-natal. Os efeitos da idade pós-natal no envolvimento social são moderados pela sensibilidade materna. Estes resultados suportam a hipótese de que o desenvolvimento da autorregulação tem um papel central no desenvolvimento social precoce. Efeitos diretos e moderados da sensibilidade materna no envolvimento social do bebé estão de acordo com a hipótese de que o comportamento social do bebé depende não só das suas capacidades de autorregulação mas também da co-regulação com o *caregiver*.

Palavras-chave: bebé, desenvolvimento social precoce, autorregulação, comportamento de envolvimento social, sensibilidade materna.

Abstract

Self-regulation plays a central role in the development of infants' ability to engage in social interactions. With maturation infants become equipped with a neural platform which fosters their self-regulation capabilities. In this context *experience-dependent mechanisms* come into play supporting infants' social development. Such processes can only be understood within an intricate puzzle of multidimensional transactions between intrinsic (e.g., physiological) and extrinsic factors (e.g., social environment) where maternal sensitivity is crucial for the development of infants' self-regulation and social engagement skills. To understand how maternal sensitivity and infants' self-regulation influence early social development, a study was conducted with 41 mother-infant dyads. In order to increase postnatal age variability, we selected healthy infants born between 34 and 41 weeks. At $3^{1/2}$ months (corrected age) dyads were videotaped in a 5-minute unstructured play-session and in the Face-to-Face-Still-Face situation. Ratings of maternal sensitivity and scores of infants' self-regulation and social engagement behavior were obtained. Using path analysis, we found direct significant effects of postnatal age and maternal sensitivity on infants' social engagement. Infants' self-regulation partially mediated the effects of maternal sensitivity on social engagement, but not the effects of postnatal age. Effects of postnatal age on social engagement were moderated by maternal sensitivity. These results support the hypothesis that the development of self-regulation plays a role in early social development. Direct and moderating effects of maternal sensitivity on infants' social engagement are in agreement with the hypothesis that infant social behavior depends on both the infant`s regulatory capabilities and on the regulatory scaffolding provided by the caregiver.

Key-words: infant, early social development, self-regulation, social engagement behavior, maternal sensitivity.

Introduction

1.1 A Neural Platform for Infants` Social Development

In the field of Developmental Affective Neuroscience, early social development can only be fully understood considering the complex maturational processes and the onset of *experience-dependent* mechanisms conveyed by interactions with the social environment (Fox, Henderson & Marshall, 2008). Within this general framework Porges, (2003) presents a biobehavioral model of the ontogeny of infants' social engagement skills. According to this perspective, the early development of the Autonomic Nervous System (ANS) is conceived as a neural platform for enabling social interactions. The biological maturation process starts from conception with early synaptogenesis events and evolves during pregnancy and after birth through different stages of neocortex development (Bourgeois, 2001). Initially, this process is mainly regulated by *experience-independent mechanisms*. However, as the process evolves into the final stages of pregnancy, *experience-expectant mechanisms* as well as *experience-dependent mechanisms* assume an increasingly important role (Fox, Henderson & Marshall, 2008). Thus, throughout this process, intrinsic mechanisms become epigenetically modulated by experience coming to the neocortex arriving from the outside world (Feldman, 2009). Importantly, this phase coincides with the emergence of the sensitive periods, where the neural development itself is dependent on external cues and social triggers modulated by the different social experiences provided by caregivers (Porges, 2003, 2011; Bourgeois, 2001).

Accordingly, in what concerns *experience-expectant* mechanisms, previous studies have shown that the newborn was already modulated before being born, resulting from extra-uterine stimulation (Brazelton & Nugent, 2011; Kisilevsky et al., 2009). In this vein, this is also a critical period for the development of social skills, with the fetus showing evoked activity in response to maternal voice (e.g., Kisilevsky et al., 2009). After birth, when *experience-dependent* mechanisms start to unravel, newborns can ear and locate sounds (Muir & Field, 1979) and seem to prefer to look at faces (Bigelow & Power, 2014).

If initially the purpose of engaging with others is to guarantee safety and survival, from 2-months forward, infants demonstrate a particular interest in social partners and start engaging in reciprocal interactions (Brazelton & Nugent, 2011; Porges, 2011). This ability is supported by the development of various skills, regarding for example, visual attention – ability to maintain visual attention for longer periods, being even able to explore the face

features of the social partner - as well as the ability to be in an alert state, and to sustain the posture (Bigelow & Power, 2014). The infant is also more capable of displaying positive manifestations, through smiles and *non-distress* vocalizations which allows to initiate behaviors that facilitate regulation (ibd.).

1.2 Infants` Emotional Self-Regulation

Emotional self-regulation is considered a key concept to normal development and is generally defined considering three major dimensions: (1) excitation and inhibition mechanisms - *"ongoing interplay between mechanisms of excitation and those of inhibition that operate at each level from cell to behavior to mental representations"* (Feldman, 2009, p. 544), (2) activation or dampening of arousal - "*the activation or dampening of arousal and the capacity to downregulate negative affect"* (Beebe et al., 2008, p. 445) and finally (3) as *"behaviors, skills, and strategies, whether conscious or unconscious, automatic or effortful, that serve to modulate, inhibit, and enhance emotional experiences and expressions"* (Calkins & Hill, 2007, p. 229).

The ability to regulate state follows a developmental hierarchical trajectory during the early part of life, where lower level physiological systems support the emergence of higher order mechanisms of cognitive control (Feldman, 2009). Brazelton, in the Neonatal Behavioral Assessment Scale Manual (Brazelton & Nugent, 2011), conceptualized this hierarchical development in four stages of increasing complexity and difficulty: 1) Autonomic/physiological regulation (monitoring of respiratory activity and control of cardiac activity and vascular reactivity) ; 2) Motor organization (control of muscle tone, posture and reflexes); 3) State organization and regulation (control of the processes of differentiation sleep/wake and the organization processes of calm waking phases); and 4) Attention/social interaction (control of the processes of *"extraction"* of information, control of the processes of retaining and use information, and control of goal-oriented activity).

Usually, infant's emotional regulation is evaluated using Tronicks` empirically validated observational paradigm, the Face-to-Face/Still-Face (Tronick, Als, Adamson, Wise, & Brazelton, 1978), which offers an ecologically meaningful context in which stress reactions (behavioral and physiological) can be observed. In the FFSF, infants are observed during a three-step face-to-face interaction with the mother: (1) a regular interaction episode, (2) the *"still-face episode"*, in which mothers are asked to be unresponsive and maintain a neutral face expression, and (3) the reunion episode in which mothers return to the interaction. The second episode specifically, is characterized by interactive

mismatching, i.e., by the loss of social interaction and simultaneously by conflicting messages of the adult resulting in a violation of infants` expectancy (Jaffe et al., 2001; Tarabulsy et al., 2003). As Tronick et al. (1978, stated, the mother is *"communicating hello and goodbye at the same time"* (p. 11), challenging the infant to cope with an unresponsive mother, resulting in a difficult preverbal monologue for the baby.

When in stress, infants can display a range of regulatory behaviors such as arching their body as avoidance, looking or leaning toward the mother to exhibit social orientation, recurring to self-comforting behavior (e.g., hand suction), display of body-self stimulation through arm movement or banging, among other behaviors (Fuertes, Beeghly, Lopes-dos-Santos, Tronick, 2011; Rothbart, Ziaie, & O`Boyle, 1992).

The ability to successfully regulate emotions early in life has long-term implications for children`s behavioral and social functioning, specifically, socio-emotional outcomes (Calkins & Hill, 2007; Feldman, 2007; Feldman, 2009; Montirosso et al., 2010). Emotional regulation has been previously linked with the development of social expertise (Feldman, 2009), resiliency in childhood (Eisenberg et al., 1997) and with development of secure attachments (e.g., Brangaurt-Rieker, Garwood, Powers, & Wang, 2001). Furthermore, regulation problems or deficits are, normally, correlated with various developmental disabilities such as attention deficit hyperactivity disorder, and later externalized problems (e.g., Calkins & Fox, 2002).

1.3 Infants Social Engagement System

Since birth, newborns already engage in rudimentary forms of social engagement, showing, for example, a preference for the mother`s voice and face (Brazelton & Nugent, 2011; Kisilevsky et al., 2009). Actually, mother`s voice, gaze and touch are the first signals and social cues that eventually modulate infants` ability to interact with others and with the expanding complex world around them, stablishing the roots of an early social behavior.

As the infant becomes capable of self-regulating his/her behavior supported by the development of the ability to attend to visual and auditory stimuli and to stay alert (Bigelow & Power, 2014), he/she also becomes interested in the surrounding environment and starts taking an active role in engaging with others, trying to reduce social and physical distance and developing the ability to establish pair bonds (Porges, 2003).

Physiologically, the improvement of infants` abilities to both spontaneously engage and to be soothed by others, is supported by a cortex control over the brainstem, specifically, involving the regulation of eyelids, muscles of facial expression, mastication,

head turning and tilting, as well as the middle ear, laryngeal and pharyngeal muscles. Those mechanisms allow the infant to show the first signs of social gaze and gesture, emotional expression, the ability to extract the human voice from the background sounds, to vocalize towards the adult and manifest social gesture and orientation (Porges, 2011).

Conjointly, these muscles function as filters for social stimuli and they enable the expression of the motor behavior essential for engagement with the social environment.

Feldman and Eidelman (2006) studied this construct – infant`s social engagement - dividing it in (1) infant alertness, (2) fussiness (negative), (3) social initiation, (4) vocalization, (5) gaze, and (6) positive affect. Generally, these behaviors are operationalized in two categories - attention-seeking and avoidance/resistance strategies (Conradt & Ablow, 2010).

Previous research that focused on infants` affective-social behaviors throughout the FFSF found that: (1) infant gaze and positive affect decreases from baseline to the still-face episode, while negative affect increases; (2) infant gaze and positive affect increases from the still-face episode to the reunion, while negative affect decreases; and (3) infant gaze and positive affect are higher and negative affect lower in the baseline episode than during the reunion (Mesman et al., 2009). Additionally, a few studies (e.g., Feldman & Eidelman, 2006; Field, 1994) indicate a relation between infants' self-regulatory and social engagement behaviors. Specifically, a rapid recovery in reunion, i.e. infants` that social elicited the mother in episode 3, was related to the ability to regulate behavioral activity and to recover from stress (Conradt & Ablow, 2010). Nonetheless, the majority of studies do not address the possible relation between infants` social behaviors and infants` self-regulation behaviors evaluating both in the FFSF paradigm.

1.4 The Mutual Regulation Model: a mother-infant dialogue

Infants' self-regulatory and social skills improvement does not occur in a vacuum. Tronick (Gianino & Tronick, 1988; Tronick & Weinberg, 1997) acknowledged the within-context dimension of infants' self-regulation in his model of mutual regulation. According to this model, dyadic regulatory or co-regulatory processes take place between the mother and the infant (Bigelow & Power, 2014). Thus, the extent to which self-regulatory behaviors results from infants own early response style, the mothers` behavior, or some combination of infant and maternal characteristics is therefore an important topic of research and so far the knowledge concerning the contributions of both agents is limited.

Maternal sensitivity is broadly defined as mothers' ability to respond promptly, contingently and adequately towards infants` solicitations, which has implicit mother`s capability to adapt to her infant, moment-by-moment, through on-off cycles of vocalizing and pausing or of looking and looking away throughout dyad interaction (Enlow et al., 2014). Besides warm responses, maternal sensitivity also involves mother`s ability to engage with infants at their level and current focus and to structure interactions to allow infants to achieve levels of development beyond those they could achieve on their own – through a *scaffolding* effect (Bigelow et al., 2010).

One of the measures frequently used to evaluate maternal sensitivity is the Care-index (Crittenden, 2003), a scale that codes infant`s and mother`s interactive behaviors during a free unstructured play situation. This scale classifies mothers` interactive behaviors in three categories – sensitive, controlling and unresponsive – and infants` interactive behaviors in four categories – cooperative, compulsive, difficult and passive.

Generally, maternal interactive behavior, particularly, maternal sensitivity seems to have an influence on infants' social experience, socio-emotional development and the infant-mother relationship (Conradt & Ablow, 2010). Moreover, maternal interactive behavior has been, particularly, studied as a predictor of infants` behavior in FFSF, i.e., with their self-regulatory behaviors (Brangaurt-Rieker, Garwood, Powers, & Wang, 2001; Fuertes, Lopes-dos-Santos, Beeghly, & Tronick, 2009; Lowe et al., 2006). Infants of sensitive mothers showed more positive affect and less avoidance and negative affect during the still-face and reunion episodes (Lowe et al., 2006). Finally, maternal sensitivity has been associated with a lot of positive outcomes, such as infant`s self-efficacy, language acquisition, maturity of object play (Bigelow & Power, 2014) and attachment security at 12-months (Fuertes, Lopes-dos-Santos, Beeghly, & Tronick, 2009).

1.5 The current study

Studying infant`s development of self-regulatory and socialization behavior, through an integrative perspective is of most importance. We chose an inclusive, multidimensional approach, where both mother and infant variables are considered in this complex dyadic equation, entering gestational age as a continuous variable.

Overall, we aim to characterize a sample of Portuguese infants concerning their self-regulatory and social engagement behaviors at 3-months corrected age. We are also interested in understanding mothers' contributions within dyad interaction evaluating their maternal sensitivity. Particularly, we wonder if maternal sensitivity, evaluated in dyads

free-play, is a predictor of infants' individual differences in self-regulation and social engagement behaviors during the still-face paradigm.

Secondly, is maternal sensitivity affected by clinical variables such as maternal anxiety or postpartum depression?

Finally, we aim to understand if infants' gestational age has an impact on infants' self-regulatory skills and maternal sensitivity.

The novelty of our study relies on: 1) the inclusion of a wide range of different infants' gestational ages at birth and consequently a variety of postnatal ages, in order to study in a continuous way, the impact of a preterm birth on infants social and self-regulatory skills development and mothers' sensitivity; 2) the evaluation of infants' behavior in Face-to-Face-Still-Face Paradigm (Tronick, Als, Adamson, Wise, & Brazelton, 1978) in two separate dimensions – infants regulatory behaviors and infants social interactive behaviors, because we wanted to study the impact of both independently; 3) the results statistical analysis with structural equation modelling, specifically a path analysis model, to test how the constructs are related to each other. Is the theoretical model formulated according to the literature review supported by our sample data? To our knowledge never a study before, with a Portuguese sample, has studied the impact of postnatal age on preterm and term infants regulatory and social behaviors, both evaluated with FFSF.

2. Method

2.1 Participants

Participants were 41 infants (20 male, 21 female; 20 first born) and their mothers (*M* age = 31.98 years; *SD* = 4.81; range: 20-37). Infants were born between 34th and 41th weeks (*M*=38.15, *SD*=1.93) and their birth weight ranged from 2200 to 4100 grams (*M* = 3048.32; *SD* = 467.74). First minute Apgar scores ranged from 7 to 10 (M = 8.95; SD = 0.59). All infants were healthy and clinically normal at delivery and in the neonatal period no infants revealed signs of sensory or neurological abnormalities, as well as other illnesses or congenital anomalies.

Mother-infant dyads were recruited after delivery at the Hospital Pedro Hispano (Matosinhos) and at the Hospital de São João (Porto). Recruitment was authorized by both Hospitals administration boards based on favorable reports of their respective ethical

committees. Pregnancies had been monitored according to recognized obstetrical standards and mothers didn't have major medical complications associated with delivery.

All infants lived with both parents in the same household. Families were from urban, middle-class socioeconomic backgrounds. No parent had any known serious physical illness, psychiatric condition, or drug/alcohol addiction problems. Most mothers (N = 25) completed a College/University degree, while 14 completed the 12th year (upper secondary school level) and 1 attained the 9th year (third grade of basic schooling).

2.2 Procedure

Under the protocols established with the Unidade Local de Saúde de Matosinhos (Local Health Unit of Matosinhos) and the Centro Hospitalar de São João (Hospital Center of São João) potential participant mothers were contacted in the neonatal obstetric units within the first 72 hours after infants' birth. The study's purpose and procedures were then explained and mothers were asked about their willingness to participate. Those who had shown interest in participating, were administered a brief interview to collect demographic information. With the mothers' consent, data concerning infants' perinatal health status was abstracted from medical records. Demographic and health information was checked to determine eligibility. Of 54 mother-infant dyads, two were not eligible for health reasons; after rethinking, five mothers did not want to participate and six were not available to attend the observation sessions. Therefore, the final sample was of 41 mother-infant dyads with complete data collected. All participant mothers signed an informed parental consent form. Procedures were followed to ensure the confidentiality of collected data.

When infants were 54 weeks gestational age (i.e., 3-months and a half corrected age for a birth at 40 weeks), dyads participated in one laboratory session at the Faculdade de Psicologia e de Ciências da Educação da Universidade do Porto (School of Psychology and Education of the University of Porto). In this session mothers reported on their infants' temperament and filled normed Portuguese versions of the Edinburg Depression Postpartum Scale (Augusto, Kumar, Calheiros, Matos & Figueiredo, 1996) and of the State-Trait Anxiety Inventory (Silva & Spielberger, 1983). Mother-infant dyads were also videotaped during a 5-minute unstructured play situation and during the laboratorial paradigm known as Face-to-Face/Still-Face (FFSF) (Tronick, Als, Adamson, Wise, & Brazelton, 1978). The FFSF is a well-established and reliable paradigm which was designed to evaluate infants` communicative abilities, sensitivity to changes in maternal behavior and their capacity to regulate affect and stress. The FFSF paradigm includes three

successive 3-minute episodes: 1) Play: consists in a unstructured face-to-face interaction in which the mother interacts normally with the infant, without using toys, pacifier or other objects; 2) Still-Face: consists in the introduction of an interactional disturbance during which the mother remains completely unresponsive to the infant, with a flat expressionless face; this episode is expected to last for 3 minutes; nevertheless, if the infant starts to cry or show a higher level of discomfort, the time is shortened; 3) Reunion: resumes the type of interaction held in the first episode.

2.3 Measures

2.3.1 Medical and Sociodemographic/Familial information

Medical and Socio-Demographic Information concerning the mother and the infant was collected during the initial contact at the Hospital. Gathered data included mothers' age and formal education, parents' marital status, delivery method, infant Apgar score at the 1st and 5th minute, gestational age at birth, birth weight, sex and parity.

Mothers' formal education was coded as a scale variable, ranging from 1 to 4 points. The highest score was assigned for the academic qualifications of Master or PhD; the 3 points score was assigned to College/University undergraduate degree; attainment of the upper secondary school level (i.e., 12th year) was rated with 2 points and the third grade of basic schooling (i.e., 9th year) with 1 point.

2.3.2 Maternal reported measures

STAI-Y – The State-Trait Anxiety Inventory: mothers filled the Portuguese version of the STAI-Y (Silva & Spielberger, 1983). This measure assesses two types of anxiety: anxiety as a trait of personality, and anxiety as a state circumscribed to a temporary condition (Gunning et al., 2010; Silva & Spielberger, 1983). The inventory is divided in two 20 items sections: The STAI Y – 1 and the STAI Y – 2). Items are rated from 1 to 4 in a Likert-type scale. High levels of anxiety in mothers are correlated with difficult child temperament and behavior (Feldman et al. 2009), and seem to be associated with the overstimulation of their infants, displays of intrusive behavior and with lower levels of sensitivity to infants' cues (Feldman 2007; Feldman et al. 2009).

EDPS - Edinburg Depression Postpartum Scale: mothers also filled the Portuguese version of EDPS (Augusto et al., 1996), which screens postpartum depressive symptomatology. The prevalence of depressive symptomatology during the first year

postpartum is around 10 to 15% (Lovejoy et al. 2000; Paulson et al. 2006), and has an impact on maternal and behavior such as warmth, and irritability (Seymour et al., 2014).

Maternal Representations of Infant Temperament: mothers reported representations of their infants' difficult temperament using the Escala de Temperamento do Bebé (Lopes-dos-Santos, Fuertes, & Sanches-Ferreira, 2005). This 9-item scale assesses the easiness/difficulty of infants' behavior using Likert-type scales ranging from 1 ("very easy") to 7 ("very difficult") points.

2.3.3 Observational measures

Infant social engagement: infant social engagement behavior was evaluated using the *Scale to Assess Infant Social Engagement* (Fuertes & Lopes-dos-Santos, 2015). Based on the infant social engagement system construct (e.g., Porges, 1997, 2003; Porges & Furman, 2011), this scale rates infant social responsiveness in episodes 1 and 3 of the FFSF. Ratings rely on detailed narrative descriptions of infant interactional behavior from which scores are assigned. Scores range from 1 (*low quality of interactive participation with evident signs of elevated disturbance in the first and last episode*) to 7 (*positive and prolonged social responsiveness behavior in the first episode with immediate recovery in the third episode*), indicating how positive or negative are infant social engagement responses. All cases were scored independently by two coders. Intercoder reliability was evaluated computing the intraclass correlation coefficient (ICC) between coders' ratings. According to Cicchetti (1994) inter-rater reliability is poor for ICC values less than .40, fair for values between .40 and .59, good for values between .60 and .74, and excellent for values over .74. In this case, the obtained ICC was .94. After estimating reliability between observers' ratings, the few disagreement cases were resolved in conference with coders reviewing the videos together and agreeing on a common score.

Infant regulatory behavior: infant regulatory behavior was evaluated during episode 2 of the FFSF using the *Self-Regulation Scoring System* (Fuertes & Lopes-dos-Santos, 2014). This scoring system assesses the intensity of the infant's efforts to maintain or to regain a calm behavioral state in face of environmental challenges. Higher scores indicate increased difficulties to regulate bodily and behavioral and lower ratings signal an improved ability to self-regulate. The use of the scoring system requires dividing the total duration of the episode in 10-second intervals. In each interval is counted the occurrence

frequency of several behaviors such as gaze aversion, distancing, hand-to-mouth, blocking, and self-clasping (the full range of behaviors and the respective coding procedures are described in the user's manual). To obtain the self-regulation score, the number of occurrences in all intervals is then summed and the total is divided by the number of intervals recorded in the episode. All cases were independently scored by two coders. Observers' agreement was evaluated computing the ICC between coders' ratings. An ICC of .89 has been obtained, which is excellent. After evaluating inter-rater reliability, disagreements were resolved in conference.

Maternal sensitivity: each dyad was videotaped for about 5-minutes during an unstructured free play situation. Mothers were given instructions to play freely with their infants as they would do normally at home. The room was equipped with a mattress, cushions and a standard set of toys appropriate for younger infants. Dyadic interactive behaviors were scored from the videos using the Child-Adult Relationship Experimental Index (CARE-Index) (Crittenden, 2003). The CARE-Index assesses the quality of parent-infant interaction, focusing on seven dimensions of each partner interactive behaviors, leading to a final score regarding three maternal scales (Sensitivity, Control, and Unresponsiveness) and four infant Scales (Cooperation, Compulsive-Compliance, Difficulty, and Passivity). Considering the purposes of this study only ratings of maternal sensitivity were retained for analyses. Two coders scored independently all cases. Intercoder reliability was evaluated computing the ICC between ratings of maternal sensitivity. The intercoder reliability was excellent (ICC = .96). Disagreements between coders' ratings were resolved in conference until the primary and second coder agreed on common scores.

3. Results

A multi-step set of analyses was carried out to address the goals of our study. First, bivariate associations between infants' social engagement behaviour in episodes 1/3 of the FFSF and each potential predictor variable were evaluated. Potential predictor variables included infant gender, weight and gestational age at birth, Apgar scores, infant post-natal age (weeks after birth), maternal age, maternal educational attainment, mothers' anxiety (trait and state) and depression, maternal representations of infants' difficult temperament,

scores of infants' regulatory behaviour during episode 2 of the FFSF, and ratings of mothers' sensitivity observed in the free-play situation. Relationships among variables identified as significant predictors were also examined.

Second, to determine whether specific predictors made unique contributions in explaining infants' social engagement, a univariate multiple regression analysis was computed. All predictor variables entered simultaneously into the regression model.

Finally, based on structural equation modelling (SEM), path analyses were conducted for estimating hypothetical direct and indirect causal pathways influencing infants' social engagement. In these analyses both mediating and moderating pathways have been examined using the software AMOS (Arbuckle, 2014). Following common suggestions (e.g., Hair, Black, Babin, & Anderson, 2010; Marôco, 2010), path models were evaluated with several fit measures: The χ^2 goodness-of-fit test (good fit is indicated by a *p* value greater than .05), the comparative fit index (CFI), the goodness of fit index (GFI), the Tucker-Lewis index (TLI), and the root mean square error of approximation (RMSEA). CFI, GFI, and TLI values above .90 are seen as indicating adequate fit while values over .95 indicate a very good fit. The RMSEA indicates adequate fit when values are between .05 and .10 whereas values less than .05 are regarded as indicating a very good fit.

3.1 Bivariate Association between Social Engagement and Potential Predictor Variables

Infants' social engagement behaviour observed in both interaction episodes of the FFSF was not significantly associated with infant gender, birthweight, and Apgar scores at the first and fifth minute post-delivery. Similarly, no significant associations were found between social engagement scores and most maternal variables including mothers' age, level of educational attainment, trace and state anxiety, degree of depressive symptomatology, and maternal representations of infants' difficult temperament.

As shown in Table 1, gestational age at birth, infants' chronological age, self-regulation behaviour during episode 2 of the FFSF, and ratings of maternal sensitivity were significantly related with infants' social engagement. This variable was inversely related with gestational age indicating that infants whose gestation lasted less weeks were more likely to be socially engaged in the interactional episodes of the FFSF. Social engagement was also negatively correlated with self-regulation behaviour, but positively associated with maternal sensitivity and infant post-natal age. Moderate negative correlations were

found between self-regulation and both post-natal age and maternal sensitivity. In turn, these latter variables were not significantly associated.

Table 1. *Correlations (Pearson's r) among gestational age, infants' chronological age, infants' self-regulation behaviour, maternal sensitivity, and infants' social engagement.*

	1	2	3	4	5
1. Social engagement	1.00				
2. Gestational age	-.46**	1.00			
3. Chronological age	.56***	-.71***	1.00		
4. Self-regulation	-.73***	.28	-.34*	1.00	
5. Maternal sensitivity	.65***	-.17	.18	-.48**	1.00

*p< .05 **p< .01 ***p< .001

Since, in our study, observations took place when infants were aged around 3 months and 2 weeks (corrected for gestational age), it makes sense that chronological age was negatively correlated with gestational age. Actually, by calculating infants' age from birth, those who were born earlier were also "older" at the data collection time.

3.2 Multiple Regression Analysis Results

Based on the results of the bivariate analyses, a univariate multiple regression analysis was computed to test for independent predictors of infants' social engagement. Only those variables identified as being significantly associated with social engagement were retained in the regression. Four variables met this criterion: Gestational age, chronological age, infant self-regulation, and maternal sensitivity. These variables entered in one single block.

Statistic values of z for the skewness and kurtosis of each variable were computed. Concerning skewness, *z* scores ranged from ±2.03 to ±0.39; *z* values for kurtosis oscillated between ±1.47 and ±0.43; in both cases, calculated z values did not exceed the critical value of ±2.58 indicating that the assumption about the normality of the variable distributions could not be rejected at the .01 probability level. The potential presence of leverage points from the predictors (i.e., outliers) was examined using the Mahalanobis distance (D^2). On the other hand, the assumption of non-multicollinearity was checked calculating for each predictor the *variance inflation factor* (VIF) and *tolerance* values (Field, 2013; Hair et al., 2010). No cases were found with D^2 values suggesting the

presence of outliers. Moreover, the average VIF was 1.64 with no value exceeding the cutoff point of 10.0, and all tolerance scores ranged from .51 to .76, well above the threshold value of 0.20; therefore we can conclude that collinearity did not biased our data. Regression results are presented in Table 2.

Table 2. *Summary of the Univariate Multiple Regression Analysis Predicting Infant Social Engagement.*

Variable	*B*	SE B	*β*	*t*	*p*
DV: Social engagement					
(Constant)	2.48	3.81	—	0.65	n.s.
Post-natal age	0.18	0.05	.37	3.44	$p < .005$
Self-regulation	-1.97	0.39	-.46	-5.01	$p < .001$
Maternal sensitivity	0.20	0.03	.36	4.05	$p < .001$
Gestational age	0.00	0.08	.00	0.01	n.s.

Although the bivariate correlation between gestational age and social engagement was statistically significant, gestational age failed to be a significant predictor in the regression when effects of the other variables were controlled. Conversely, regression data indicated that post-natal age, infant self-regulation and maternal sensitivity had unique contributions in predicting infant social engagement.

3.3 Path Analyses: Direct and Indirect Effects on Infant Social Engagement

SEM-based path analysis was chosen as the most appropriate procedure for estimating the magnitude and significance of hypothesized direct or indirect causal relationships among study variables. Commonly, path analyses using SEM rely on large samples. Even though sample size plays an important role on statistical power, several authors (e.g., Hair et al., 2010; Marôco, 2010) contend that the required minimum sample size is a ratio of at least 5 observations for each estimated parameter. In the present study this minimal requirement has been met.

A mediation model was constructed in which maternal sensitivity and post-natal age were selected as exogenous variables, and self-regulation and social engagement chosen as endogenous variables. The model assumed self-regulation as the hypothetical mediator of effects of the exogenous variables on social engagement. Analyses were conducted using the maximum likelihood estimating procedure. Since no significant

correlation was found among post-natal age and maternal sensitivity in bivariate analyses, the model did not consider any covariance path between these two variables. The tested model is presented in Figure 1.

The independence model which tests the assumption that all variables are uncorrelated was rejected, $\chi^2(6, N= 41) = 74.19$, $p<.001$, CFI= .00, GFI= .56, TLI= .00, RMSEA= .53. By contrast, most fit measures for the hypothesized model revealed a very good fit, $\chi^2(1, N= 41) = 1.29$, $p > .259$, CFI= .99, GFI= .98, TLI= .97, RMSEA= .08.

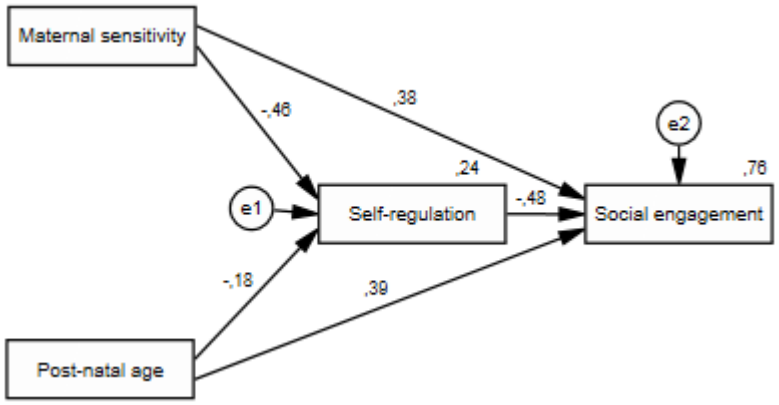

Figure 1. *Hypothesized model of direct and indirect effects on infant social engagement*.

The global model explains 76% of the variance of infant social engagement. Table 3 presents direct, indirect, and total effects for each predictor variable (standardized coefficients).

Table 3. *Direct, Indirect, and Total Effects on Infant Social Engagement.*

Variables	Direct effect	Indirect effect	Total effect
Maternal sensitivity			
MS→SE	.38**	.22*	.59**
MS→SR	-.46**	NA	-.46**
Post-natal age			
PA→SE	.39**	.09	.48**
PA→SR	-.18	NA	-.18
Infant self-regulation			
SR→SE	-.48**	NA	-.48**

MS = Maternal sensitivity; SE = Infant social engagement; SR = Infant self-regulation;

PA = Post-natal age. NA = Not applicable. *p<.01; ** p<.001.

Analyses of direct effects showed that maternal sensitivity and post-natal age were strongly predictive of infant social engagement behaviour. This indicates that both variables are likely to have an additive influence upon the development of infants' social engagement skills. Furthermore, the significant indirect effect linking maternal sensitivity to social engagement revealed a partial mediation from self-regulation, suggesting that the quality of mother's interactive behaviour fosters infant's regulatory capabilities that, in turn, favour the expression of social engagement responses. Such mediating effects have not been observed for post-natal age.

Variability in post-natal age indicates that infants have different amounts of experience in dealing with stimuli coming from their social environments. However, when evaluating the impact of experience, analyses should take into consideration the distinction between quantitative and qualitative aspects. Actually, larger amounts of poor quality experience may be less developmentally appropriate than smaller amounts of good quality experience. Although post-natal age and maternal sensitivity were not significantly associated in bivariate analyses, the possibility of a bilinear moderating effect between these two variables was examined. In other words, it was specifically evaluated whether or not the slope of the relationship between post-natal age and infant social engagement changed across values of maternal sensitivity.

For evaluating moderation effects, a model was constructed including infant social engagement as endogenous variable and three exogenous variables. The exogenous variables were post-natal age, maternal sensitivity and a last one which was established by multiplying the scores of the former two variables (maternal sensitivity×post-natal age). Covariance paths linking the new variable to both maternal sensitivity and post-natal age were considered in the model. The path between social engagement and the aforementioned third predictor evaluates the hypothetic moderation effect.

To reduce possible multicollinearity problems that often occur as a consequence of the creation of new predictors resulting from the product of other predictors, all variables in the model were rescaled by subtracting from each score the variable mean value. This centred the variables around 0, with scores above the mean being positive and scores below the mean being negative.

Since a variable has been created and others have been rescaled, data was reexamined for checking normality and the potential presence of leverage points. Statistic values of z were computed for the skewness and kurtosis of each variable. No z value exceeded the critical score of ±2.58, rejecting the non-normality hypothesis at $p< .001$.

Similarly, there was not a single case with a Mahalanobis D^2 value suggestive of outliers' presence. The moderation model is represented in Figure 2.

The contrasting independence model which assumes that all variables are uncorrelated was fully rejected, $\chi^2(6, N= 41) = 47.87$, $p<.001$, CFI= .00, GFI= .69, TLI= .00, RMSEA= .42. Concerning the hypothesized model, most fit measures revealed a very good fit, $\chi^2(1, N= 41) = 1.26$, $p >.259$, CFI= .99, GFI= .99, TLI= .96, RMSEA= .08.

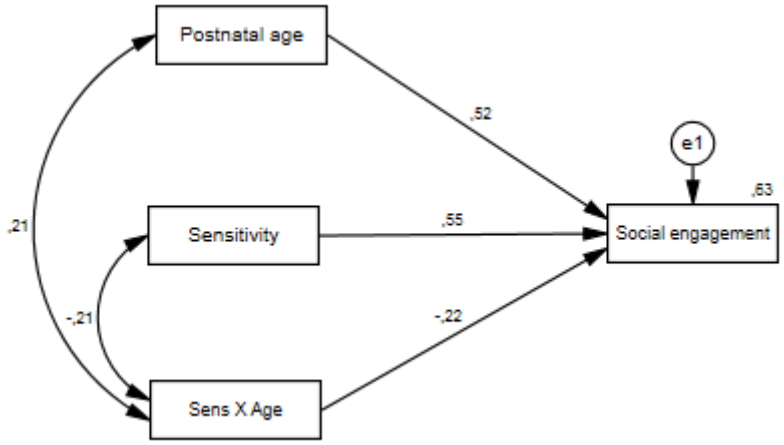

Figure 2. *Hypothesized model of the moderation effect on infant social engagement*.

Analyses revealed that there was a significant moderation effect between maternal sensitivity and post-natal age (standardized coefficient = -.22, $p<.05$). To better understand how these variables interacted with each other in predicting infant social engagement, post-natal age was decomposed into three conditions: The first one including scores located below the lowest point of the standard deviation around the mean (Age SD-); the second including scores ranged within the standard deviation around the mean (Age SD); the third including scores above the upper point of the standard deviation around the mean (Age SD+).

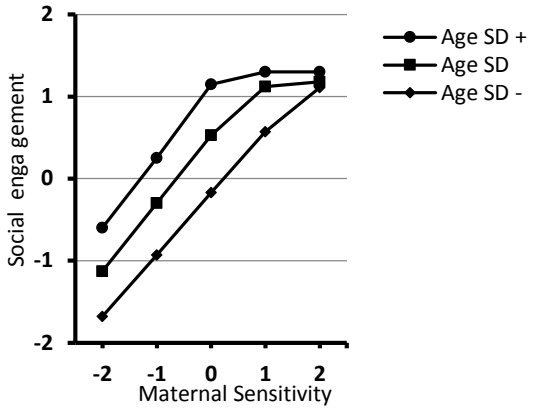

Figure 3. *Infant social engagement as a function of post-natal age and maternal sensitivity.*

As shown in Figure 3, the effects of post-natal age on infant social engagement seem to be different across values of maternal sensitivity. The effect is higher when maternal sensitivity is lower and decreases as maternal sensitivity increases.

4. Discussion

We already expected from previous research that maternal sensitivity would have an impact on infant`s self-regulatory behaviors (e.g., Brangaurt-Rieker, Garwood, Powers, & Wang, 2001). Several studies have shown that, during the FFFS, infants of sensitive mothers showed more effective behavioral regulatory strategies, increased displays of positive affect, less avoidance and negative affect (Lowe et al., 2006). These effects at the behavioral level have been corroborated at the biological level. For instance, Conradt & Ablow (2010), evaluating the physiological component of infant`s regulation, found that infant heart rate increased from the still-face to the reunion episode (an atypical pattern) with decreased levels of maternal sensitivity in the reunion episode.

One interesting finding of our study was the mediation effect of self-regulation on social engagement behavior. This, mediating effect seems in line with Porges' hypothesis that the development of competencies to self-regulate is crucial for the enhancement of skills to social interact in a pleasant way (Porges, 2003). Like others have argued (e.g., Tronick, 2007), one may possibly conclude that infants' resistance to social engage with

the mother, specifically in the FFSF reunion episode, is a behavioral response to patterns of mother-infant interaction that reflect some level of disorganized self-regulatory behavior.

Analyses revealed that there was a direct impact of maternal sensitivity on infants' social engagement. This result is consistent with data presented by Conradt and Ablow (2010). The authors found that maternal sensitivity during the reunion episode was predictive of infant behaviors during the same episode. Specifically, higher levels of maternal sensitivity were associated with greater infant attention to the mother and lower levels of maternal sensitivity were associated with more infant resistance to socially engage. Accordingly, from the literature, one can argue that maternal sensitivity really has a distinctive special feature as it relates to infants' ability to engage with social partners, even throughout time. Notably, Feldman (2009) also found significant correlations between maternal sensitivity and child social engagement, at different time-points, from birth to 5 years, demonstrating that this is a strong, clear, long-term developmental effect.

Theoretically, our results are also in accordance with Mutual Regulation Model assumptions (Gianino & Tronick, 1988). Caregivers' responses are guided by infants' cues (e.g., social gaze, smiles, gestures, or vocalizations). Conversely, infants' states are affected by expressive displays of their caregivers (e.g., smiles, laughter, exaggerated expressions). From this perspective, the quality of interaction is determined by the ability of each participant to regulate emotional states, express communicative messages, and respond to the partner`s affective communications.

Together, our results indicate that maternal sensitivity seems to impact on both self-regulation and social engagement, regardless of infant`s post-natal age. Remarkably, we found that this impact occurs independently of infant`s gestational age at birth. In other words, a late preterm birth may not have a direct effect on infant`s self-regulation and social engagement abilities, when mothers show higher levels of sensibility. This non-effect of postnatal age is supported by previous studies (e.g., Gurka, LoCasale-Crouch, & Blackman, 2010; Segal et al., 1995) and by a meta-analysis (Mesman et al., 2009) concerning the still-face effect on infants that did not found differences between late-preterm and term infants.

From a developmental point of view this finding may reflect more time and more learning opportunities through interaction with the social environment. From this perspective, preterm born infants are in advantage when compared with term infants, to benefit from *experience-dependent mechanisms* that support the development of social-engagement abilities.

Nonetheless, this does not mean that late-preterm infants are not at risk for negative outcomes, namely the possibility of developing some medical problems that can jeopardize their developmental trajectories. Also, these results do not mean that early delivery is better. The keyword here is healthy, as our sample did not include infants which weighed less than 2200g, which did not stay at the hospital longer than expected (normally, 48h for eutocic delivery and 72h for caesarean) and finally, that did not present health complications after hospital discharge. As we see it, this study may provide some relief and security for both parents and professionals, since it points on the direction of minor, or even none, disadvantages in healthy late preterm as they develop.

4.1. Study limitations and future directions

One limitation of the current study is the sample characteristics, namely, the sample size and the fact that mothers with higher academic degrees participated in the study, compromising the composition of a sample that would include families from different social backgrounds. Furthermore, the relatively small sample size could affect statistical power. A larger sample could increase the sensitivity of statistical procedures to detect further differences among the data. That is possibly a reason why we could not find significant associations related with mothers` perception of infant temperament, maternal anxiety and depressive mood.

The inclusion of extremely to moderate preterm born infants, with or without medical conditions would also be of great importance, in order to understand the real impact of a preterm birth with all the challenges associated with it.

Few previous studies have tried to approach the mother-infant relationship combining different evaluation methods. Subsequent prospective studies should use an integrated multi-method perspective, including behavioral, physiological and neuroimaging measures, taking advantage of theoretical contributions from different scientific areas. Physiological measures such as, cardiac activity and vagal tonus, and cortisol collection (usually, collected through salivary samples) could be used as reliable stress indicators for both mother and infant, for example, in the course of the FFSF. Thus, behavioral information on infants` self-regulatory behaviors could be amplified by considering biological markers.

Finally, the most important issue would be to continue to study the significant effects found in this study within longitudinal approaches.

4.2 Concluding remarks

Overall, building up a social organism in a social world is a complex, multicomponent holistic process, concerning the infant and the mother. In other words, infant coping shapes parenting that, in turn, in a reciprocal and transactional way, shapes infant regulatory skills. Therefore, we investigated the roots of attachment, infant coping skills, and parenting. Since the literature provides only limited guidance, the resulting data will broaden our understanding of how emotion regulation and attachment develop. Nonetheless, further studies should continue to shed light into these important constructs, with larger samples, in order to deepen our knowledge.

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