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Contributions of maternal and infant factors to infant responding to the Still Face paradigm: A longitudinal study

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Abstract

Early mother-infant interactions are characterised by periods of synchronous interaction that are interrupted by periods of mismatch; the experience of such mismatches and their subsequent repair is held to facilitate the development of infant self-regulatory capacities (Tronick, 1978). Infant responding to such interactive challenge is assumed to be a function of both maternal behaviour and pre-existing infant characteristics. However, the latter has received relatively little attention. In a prospective longitudinal study of a sample comprising high and low adversity dyads (n=122), we examined the contributions of both maternal sensitivity and neonatal irritability to infant behavioural and physiological responding to the interactive challenge of the Still Face paradigm adversity. Results indicated that higher levels of maternal sensitivity were associated with more regulated infant behaviour during the Still Face paradigm. Neonatal irritability also predicted poorer behavioural and heart rate recovery following the still face challenge. Furthermore, there was an interaction such that irritable infants with insensitive mothers showed the worst behavioural outcomes. The findings highlight the importance of the interplay between maternal and infant characteristics in determining dyadic responding.

Keywords

Still Face paradigm; infant self-regulation; neonatal irritability; maternal behavior; longitudinal

1. Introduction

The development of the infant's capacity to regulate behavioural and physiological responses to the environment, and particularly to challenges, is hypothesised to be fundamental to subsequent satisfactory emotional and behavioural development (Rothbart, Ziaie, & O'Boyle, 1992; Eisenberg et al., 1996; Kochanska, Murray, & Harlan, 2000; Cole, Michel, & Teti, 1994). The extent to which this capacity is a function of the infant's own early response style, the caregiver's behaviour, or some combination of infant and maternal characteristics is therefore an important topic for research. For example, it has been proposed that caregiver sensitivity may mitigate the negative effects of difficult infant temperament, whereas insensitive parenting, particularly in the context of an already difficult infant, may be important in the development of later child emotional-behavioural difficulties (Belsky, 1997; Belsky & Pluess, 2009; Pluess & Belsky, 2010). Nevertheless, so far, knowledge about the contributions of infant and parenting factors, both separately and in combination, to the early development of infant regulatory capacities is limited.

'Temperament' has been described by Kagan as a set of biases in behaviour and/or feelings which are thought to be biological in origin and appear early in development (Kagan, 2005). The degree to which infants are highly reactive or irritable in their responses to changes and challenges in their environments and how easily the infant regulates and returns to a calm state are thought to be examples of such a temperamental bias (Rothbart & Derryberry, 1981). It has been suggested that early individual differences in this domain may have long term consequences including differences in adult brain structure (Schwartz et al., 2010; Schwartz et al., 2012) although little is known of the developmental mechanisms hypothesised to mediate this relationship.

Mother-infant interactions provide one of the earliest external sources of both potential challenge and support in relation to the young infant's regulatory capacities.

Investigation of face-to-face interactions has shown that, rather than being characterised by perfect contingency and synchrony between mother and infant, cycles of well-matched behaviours are often followed by periods of mismatch and repair. Thus, Tronick and colleagues, in the Mutual Regulation Model (MRM) (Tronick & Gianino, 1986), note that breaks in contingency commonly occur which are followed by the recovery of smooth, matched interaction, facilitated by maternal sensitive support of the infant (Beebe & Lachmann, 1998; Cohn & Tronick, 1987; Weinberg, Tronick, Cohn, & Olson, 1999). Recovery following mismatch has been considered particularly important to the infant's acquisition of regulatory skills, since it involves the experience of transition from dysregulated to regulated behaviour.

While the study of factors that reduce maternal sensitivity and thereby increase the frequency of mismatch (e.g., high levels of adversity) is well represented in the literature (e.g., (Murray, FioriCowley, Hooper, & Cooper, 1996), the role of infant characteristics, particularly temperamental differences, has received surprisingly little attention. In particular, individual differences in the developing infant's reactivity profile~~, an aspect of temperament reflected in the latency and intensity of response to stimulation (Rothbart & Derryberry, 1981),~~ may be particularly important in determining infant responses to periods of interaction mismatch. An interaction between infant and maternal characteristics also seems likely. In particular, an infant who experiences many episodes of mismatch due to compromised maternal responding, and who has a higher reactivity to these episodes may become overwhelmed, unable to reduce negative responding, and consequently may be less available for further episodes of good interaction. Although these moment-to-moment adjustments may be of a relatively brief duration, their frequency and their cumulative effects may have long term consequences.

The Face-to-Face-Still-Face procedure (FFSF) is a well-established paradigm which involves a perturbation in maternal communication that has been found to be behaviourally

and physiologically stressful for the infant (Tronick, Als, Adamson, Wise, & Brazelton, 1978); the infant is confronted first with a two-minute period of normal mother-infant play, followed by two minutes of the mother's neutral, silent face (the Still Face episode; SF), before infant and mother finally resume normal play (the reunion or recovery episode). The infant's response to the SF episode has been extensively described in the literature. A recent meta-analysis (Mesman, van IJzendoorn, & Bakermans-Kranenburg, 2009) confirmed the robustness of the classic SF effect of a decrease in infant positive affect and gaze to mother coupled with an increase in negative affect. In the recovery episode, while infants show an increase in positive bids, they nevertheless maintain a raised level of negative affect (the 'carry-over' effect). Individual differences in infant responding have been noted (e.g. (Braungart-Rieker, Garwood, Powers, & Wang, 2001; Braungart-Rieker, Garwood, Powers, & Notaro, 1998; Cohn, Campbell, & Ross, 1992), and behavioural responses to the SF episode have been related to other measures of emotionality (Forman et al., 2003). Some studies have also investigated physiological responses, including heart rate (Haley, Handmaker, & Lowe, 2006; Haley & Stansbury, 2003; Ham & Tronick, 2006) and respiratory sinus arrhythmia (Bazhenova, Plonskaia, & Porges, 2001; Ham & Tronick, 2006; Weinberg & Tronick, 1996; Moore et al., 2009). The combined evidence suggests that the SF episode elicits increased heart rate, reflecting increased physiological arousal, and a decrease in respiratory sinus arrhythmia, which is presumed to facilitate self-regulation in response to environmental challenge (Mesman et al., 2009).

Although Weinberg and Tronick (1996) stated that the recovery episode was a critical component FFSF responding, until relatively recently most research has focused on infant responses to the SF episode itself, and studies that have looked at the recovery episode have typically concentrated on parental contributions (Mesman et al., 2009). Infant responses during the recovery episode are thought to represent the infant's attempts to return to homeostasis following the disruption to behavioural and physiological functioning associated

with the SF episode. As disruptions to infant behavioural and physiological responses are typically pronounced during the SF phase of the procedure, individual differences in the infant's capacity for emotional regulation may be swamped, and it is possible that they will be better elucidated in the recovery episode. To date, this issue has not been widely examined; moreover, the determinants of the infant's capacity to regulate his state following psychosocial challenge remain to be fully clarified. Nevertheless, one previous study that examined recovery responses (Bendersky & Lewis, 1998) suggested that they may be particularly useful in characterising high-risk (cocaine exposed) infants.

In sum, the FFSF procedure represents a paradigm in which the influences on infant responding to the perturbations that typically characterise mother-infant interactions can be examined in a controlled manner. Observations of responding in this context are significant, as they index infant responding in the context of the social interactions that are held to be key to the development of infant self-regulation. However, to date, studies utilising the FFSF paradigm have typically focused on maternal behaviour as a predictor of infant responding, with the possible contribution of infant temperament being largely ignored. ~~Two p~~Prior studies that have ~~addressed this issue have indicated that~~examined infant responding in the FFSF in relation to measures of~~s related to maternal reports of~~ infant temperament (maternal report) have yielded mixed findings (Braungart-Rieker et al., 1998; Tarabulsy et al., 2003). ~~In the first of these~~While Braungart-Rieker et al. (1998) reported that~~,~~ difficult infant temperament was associated with less optimal responding to the still face, Tarabulsy et al. (2003) ~~(Braungart-Rieker et al., 1998). By contrast, Tarabulsy et al. (2003)~~ found no main effect of infant difficultness on FFSF responding, but ~~there~~ they identified ~~was~~ an interaction such that less difficult infants seemed to benefit more from positive maternal behaviour. Finally, Conradt and Ablow (2010) did not find an association between parental reports of infant temperament and infant behaviours in the FFSF recovery episode. All of these studies

were cross-sectional in design, and observational measures of infant characteristics were not obtained.

~~However, both studies were cross-sectional in design, and observational measures of infant characteristics were not obtained.~~

The primary aim of the current study was to examine the role of both neonatal characteristics – in this case, reactivity indexed via 'irritability' - and maternal communication style, as well as their interaction, in influencing infant responses to this interactive challenge. We used a prospective, longitudinal design, in which mothers were recruited in pregnancy, and newborn irritability, as an index of reactivity, was assessed objectively using a standard observational measure. At 3 months, mothers and their infants took part in the FFSF procedure. The initial period of face-to-face interaction was used to determine the mother's sensitivity to the infant, and infant behavioural and physiological regulatory responses were analysed for each phase of the FFSF procedure. The prediction of infant responding the FFSF by both neonatal reactivity and maternal sensitivity was examined. We hypothesised that:

1. Newborn irritability and low maternal sensitivity would each predict a reduced infant capacity to recover following the SF episode.
2. There would be an interaction between irritability and maternal sensitivity, such that any adverse effect of newborn irritability on 3 month regulation in the recovery phase of the FFSF would be further magnified in the context of low maternal sensitivity.

In order to obtain a sample that included sufficient variability in terms of both maternal sensitivity and neonatal behaviour, we recruited families experiencing both high and low levels of adversity. Thus, previous research has highlighted less optimal maternal responding in the context of psychosocial adversity, and indeed, we did observe reduced maternal sensitivity in high risk mothers in the current sample (Halligan et al., 2012). Moreover, a growing body of evidence suggests that aspects of psychosocial adversity, such

as depression and anxiety in pregnancy, are related to foetal responding (Allister, Lester, Carr, & Liu, 2001; Monk et al., 2004), and postnatal infant behaviour (Van den Bergh, Mulder, Mennes, & Glover, 2005). Finally, less regulated responding to the FFSF procedure has previously been found in other sets of high risk infants (e.g., following cocaine exposure) (Bendersky & Lewis, 1998; Tronick et al., 2005). As such, our sample of both high and low risk families provided a suitable context for investigation of the role of disturbances in maternal sensitivity, as well as in neonatal reactivity, in contributing to infant responding to interactive challenge.

2. Material and Methods

2.1 Participants

Primiparous mothers completed a 17 item questionnaire to measure the level of psycho-social adversity at their routine 20-week antenatal scan clinic at the Royal Berkshire Maternity Hospital in Reading, UK[1]. 67 mothers scoring above a cut off defining the 20% highest scores (high adversity group), were recruited, along with 68 mothers with scores in the 40% lowest scoring range (low adversity group). After excluding those delivering prematurely or withdrawing from the study, numbers in high and low adversity groups were 58 and 63 respectively. On the questionnaire's principal demographic indices of adversity, high adversity women were, compared to the low adversity group, younger [M = 19.7, SD = 3.3 *vs.* M = 30.6, SD = 3.3 years; $t_{120,}$ = 18.3, $P < 0.001$], more often single [31 (53.4%) vs. 0; χ^2 (1)= 45.9, $P < 0.001$], and unemployed [36 (63.2%) vs. 2 (3.1%), χ^2 (1) = 50.4, $P < 0.001$] and fewer were educated beyond 16 years [8 (14.8%), vs. 61 (96.8%), χ^2 (1) = 80.8, $P < 0.001$] (see (Cronin, Halligan, & Murray, 2008; Halligan et al., 2012; Sheridan et al., 2012).

Groups were similar in terms of infant characteristics including gender [31 (51.7%), vs. 33 (51.6%) females, in high and low risk groups, respectively], gestational age (high risk M = 280.2, SD = 10.0 days, low risk M = 279.6, SD = 10.4), and 1 minute Apgar scores

[1] Questionnaire available form last author

(median = 9, range = 7 for both groups); but the high adversity group had lower birth weights [$M = 3.30$, $SD = 0.57$ vs. $M = 3.51$, $SD = 0.50$ kg, $t_{120} = 2.09$, $P < 0.05$].

Overall, the sample reflected the demographic mix of the local population, being predominantly Caucasian (86%), with a minority of black (3%), Asian (2%) and mixed race (8%) families.

2.2 Measures

2.2.1 Neonatal Behavioural Assessment Scale (NBAS) (Brazelton & Nugent, 1995)

The NBAS is a standard assessment of newborn behaviour, with ratings on dimensions of habituation, orientation, motor organisation, range and regulation of state, autonomic stability and reflexes. The assessment was conducted in the maternal home by one of two ~~trained researchers.~~ NBAS certified researchers, who attained the required level of 90% agreement in training assessments of reliability. Scores on measures of 'peak of excitement', 'rapidity of build-up' and 'irritability' were combined to form a general 'irritability' cluster (Kaye, 1978), denoting high reactivity and poor regulation. In common with other research (Crockenberg, 1981; van den Boom & Hoeksma, 1994; Murray, Stanley, Hooper, King, & Fiori-Cowley, 1996)), a cut off score of greater than or equal to 6 was used to define infant irritability: 88 infants were classified as non-irritable (74.6%) and 30 as irritable (25.4%).

2.2.FFSF Procedure (Tronick et al., 1978)

At 3 months (mean age 12 weeks 4 days) the FFSF procedure was conducted in the home. Once the infant was alert and contented he/she was placed in a supportive seat with the mother seated opposite so that eye-contact was possible. A video camera was placed behind the mother and a mirror adjacent to the infant to give a full body image of the infant, the mother's profile, and her full-face reflection in the mirror. The procedure consisted of 2-minutes of normal face-to-face interaction during which the mother interacted with her infant without toys, followed by 2-minutes where the mother was instructed to keep a 'still face'

(i.e., to look at the infant but to refrain from smiling at, touching or talking to him), then a final reunion episode of 2-minutes where the mother was instructed to return to normal interaction. Five dyads were excluded as mothers were unable to sustain a still face, a rate comparable to that in other studies (Moore, Cohn, & Campbell, 2001; Cohn & Tronick, 1983) and 2 due to maternal refusal to be filmed.

2.2.3 Coding of maternal and infant behaviour

The videotaped FFSF interactions were coded blind to NBAS scores and adversity status. Maternal behaviour was scored for the initial face-to-face interaction episode using the Global Rating Scales (GRS) (Murray et al., 1996). The five-point scale rating maternal behaviour on the principal dimension of sensitivity (i.e., warm, accepting, responsive, non-demanding, appropriately attuned to the infant) was used. The GRS are reliable, and discriminate a range of maternal and infant populations (Gunning et al., 2004). Ten videotapes were rated by a second rater: the intra-class correlations showed acceptable reliability, mean = .76, range .66-.90.

Infant behaviour during the FFSF was scored by a second coder, blind to maternal ratings, using a regulatory scoring system devised for the current study, but informed by the NBAS, the Infant Regulatory Scoring System (Tronick & Weinberg, 1994), and regulatory behaviours described in the wider FFSF literature (Braungart-Rieker et al., 2001; Lamb, Morrison, & Malkin, 1987; Murray & Trevarthen, 1985; Weinberg et al., 1999). Using the Noldus Observer 4.0, ~~the following~~ dysregulated behaviour~~s~~ ~~were~~ was scored for each 2 minute episode of the FFSF, using ~~both~~ duration and event codes that incorporated the following:

~~(i)~~ gaze (duration) ~~Gaze – (duration) gaze~~ that ~~was either flat and withdrawn~~showed an lack of clear focus or active scanning~~,~~ ~~;~~ ~~gaze accompanied by~~

~~significant~~ fussing or crying (duration), ranging from low-level to~~, or~~ full crying with eyes closed; agitated activity (duration) including

~~(ii) Vocalisations (duration) low-level fussing, and crying~~

~~(iii) Activity - (duration)~~ rapid, non-exploratory head turns, agitated thrashing of limbs, or arching and twisting of the body; negative ~~-~~

~~(iv) Facial expressions (events)~~ facial expressions (events) ~~negative expressions~~such as~~,~~ grimaces or cry-face expressions that were *not* directed at the mother; and

~~(v)~~ ~~A~~autonomic indicators (events), including~~-~~ sighs, hiccups, ragged breathing episodes, gagging, disorganized mouthings, straining, sneezing and startles.

A second rater scored a subsample of 11 (10%) infants. Agreement was defined as both coders scoring the same code within the same 1-second interval and reliability calculated as: agreements / (agreements + disagreements). This ranged from .74 to .98 (M = .84) for the different behaviours. Standardized scores were calculated for each code, and were combined to form an overall dysregulated behaviour dimension, with higher scores indicating more dysregulated behaviour.

2.2.4 Heart Rate Measurement

Infant heart rate (HR) was recorded from one minute before the onset of the FFSF and then throughout the FFSF itself. A Polar R-R recorder (Polar Electro Oy, Kempele, Finland) was attached to the infant's upper chest using two ECG electrodes. MXedit software version V2.19 (Delta-Biometrics Inc. Bethesda, Maryland, USA) was used by a trained researcher to calculate heart rate for each phase of the FFSF procedure. For the 114 infants for whom the FFSF procedure was completed successfully, heart rate data were excluded in 8 cases due to high levels of artefact, and 8 infants were unable to take part in heart rate assessments due to skin sensitivity to the electrodes.

2.3 Analyses

Following inspection of variable distributions, effects of neonatal irritability on infant behavioural regulation during the different phases of the FFSF were examined using Mann-Whitney U tests, while its effects on heart rate were investigated by repeated measures analysis of variance (ANOVA); effects of maternal sensitivity on infant behaviour and heart rate were examined by means of bivariate correlations. The possible interaction between neonatal irritability and maternal sensitivity in predicting infant behaviour and heart rate was also examined. For the non-parametric behavioural dysregulation data, 4 groups were created comprising combinations of high/low sensitivity and irritable/non-irritable status. Kruskal-Wallis ANOVA then examined the prediction of infant dysregulation by the resultant dummy coded variable, with Mann-Whitney U follow-up tests based on *P* set at 0.01. For the parametric heart rates outcomes, ANOVA examined their prediction by maternal sensitivity (dichotomised around the top quartile) and infant irritability status, and the interaction of these two. Finally, since we also expected adversity to be associated with neonatal and maternal behaviour, we examined its effects by comparing our two recruitment groups in secondary analyses; and possible mediation of associations between adversity and infant responding during the FFSF procedure by maternal behaviour was also examined according to the steps specified by Baron and Kenny (1986).

3. Results

3.1 Neonatal irritability effects on infant behavioural regulation and HR responding to the FFSF

Overall, 30 infants (25.6%) were identified as being irritable as newborns. Preliminary analyses examined whether irritability was related to potential confounds, i.e., infant gender, gestation, birth weight, 1-minute Apgar scores, and ethnicity. No such effects were identified, and these were not therefore included in subsequent analyses. Before investigating the effects of neonatal irritability on infant behavioural dysregulation during the

FFSF procedure, we first examined infant behaviour through the different phases: as expected, Wilcoxin ranked signs tests indicated that infant dysregulation increased from the play to the still face episode (Z = -8.42, P < 0.001), and decreased from still face to recovery (Z = 2.88, P = 0.004), while still remaining significantly higher than during the initial play episode (Z = -7.00, P < 0.001). Then, we examined infant dysregulated behaviour during the three episodes of the FFSF in relation to neonatal NBAS irritability status, using Mann-Whitney U tests (see Table 1 for descriptive statistics). As can be seen from Table 1, there were no differences in infant responding during the SF period itself according to neonatal irritability. However, in line with hypotheses, compared to non-irritable neonates, infants who had been irritable as newborns showed significantly higher rates of dysregulated behaviour during the recovery period, and a trend (P = 0.052) for the same effect during the initial play period.

An examination of heart rate in relation to neonatal irritability yielded similar findings (see Figure 1). Repeated measures ANOVA, with irritability status as the independent variable and heart rate during the three FFSF episodes as the repeated measure, indicated a significant main effect of perturbation episode ($F_{2,92}$ = 12.0, P < 0.001, partial η^2 = .21), with HR increasing from the play to the still face episode (play M = 152.2, SD = 9.8 BPM; still face M = 156.3, SD = 11.3 BPM; recovery M = 155.6, SD = 12.0 BPM). There was no between subjects effect of irritability on HR ($F_{1,93}$ = 0.14, P = 0.71, partial η^2 = .001~~ns~~). However, there was a significant episode by irritability group interaction ($F_{2,92}$ = 4.74, P = 0.011, partial η^2 = .09). As illustrated in Figure 1, post hoc ~~*t* test~~ANOVAs examining HR change scores across episodes indicated that irritable and non-irritable infants showed a similar increase in HR in response to the SF itself ($F_{1,93}$ = 0.51, P = 0.48, partial η^2 = .005~~t_{93} = 0.71, ns~~). However, the change in HR from the SF to the recovery period distinguished the groups, with irritable infants showing a further increase, versus a slight

decrease for non-irritable infants ($F_{1,93}$ = 9.32, P = 0.003, partial η^2 = .09~~t_{93} = -3.05, P = 0.003~~).

3.2 Maternal sensitivity and infant FFSF responding

With regard to effects of maternal sensitivity on infant behaviour during the FFSF, correlational analyses showed that greater maternal sensitivity was associated with lower levels of infant dysregulated behaviour in the play (r = -0.31, N = 112, P = 0.001) and still face (r = -0.34, N = 112, P < 0.001) episodes of the FFSF, but not with recovery behaviour (r = -0.15, N = 112, ns). Similar analyses of infant HR showed no significant associations with maternal behaviour in any FSFF phase (all r < 0.17).

Combined effects of neonatal irritability and maternal sensitivity on infant FFSF regulation

We examined the question of whether any adverse effects of neonatal irritability on infant regulation in the FFSF might be exacerbated in the context of low maternal sensitivity, by testing for the interactive effects of the two predictor variables. Analyses focused exclusively on the recovery period, where main effects of irritability status were observed. With respect to dysregulated infant behaviour, Kruskal-Wallis ANOVA was used to compare four groups, representing all combinations of high/low neonatal irritability and high/low sensitivity. Results indicated an overall group effect (χ^2 = 13.4, df = 3, P = 0.004) (see figure 2). Post hoc Mann-Whitney U tests indicated that infants who were irritable as neonates, and whose mothers showed low levels of sensitivity had higher levels of behavioural dysregulation in the recovery episode than both the high sensitivity/not irritable (Z =-2.92, P = 0.003, r = .28) and the low sensitivity/not irritable (Z = -2.98, P = 0.003, r = .29) groups, while the difference relative to the high sensitive/irritable group finding was not significant (Z = -0.79, ~~ns~~P = 0.43 , r = .08). ANOVA examining the prediction of HR in the recovery episode by high/low sensitivity and irritable/non-irritable status did not show a significant maternal sensitivity by irritability interaction ($F_{1, 92}$ = 0.~~03~~02, P = 0.88, partial η^2 ~~ns~~< .01)~~)~~.

3.3 Effects of psychosocial adversity

No significant association between psychosocial adversity and neonatal irritability was identified, rates being 12 (20.7%) and 18 (30.5%) in high and low adversity groups, respectively, χ^2 (1) = 1.48, P = 0.22~~ns~~, r_ϕ = -.11. However, both maternal and infant behaviour in the FFSF paradigm showed associations with adversity status. With regard to maternal behaviour, mothers in the high adversity group were significantly less sensitive during the face-to-face interaction phase than those with a low level of adversity (M = 3.59, SD = 0.56 and M = 4.04, SD = 0.48, respectively; ~~t~~$F_{1,114}$ = ~~4.65~~16.1, P < 0.001, partial η^2 = .12). With regard to infant behavioural responding, a series of Mann-Whitney U tests indicated that maternal adversity was associated with significantly higher levels of dysregulated behaviour during the initial play period (low adversity M = -.45, SD = 0.28; high adversity M = -.38, SD = 0.32; Z = -2.05, P = 0.040, r = .19), but was unrelated to infant behaviour across the still face (Z = -0.66, P = 0.51, r = .06~~ns~~) or recovery (Z = -0.64, P = 0.52, r = .06~~ns~~) episodes. Infant heart rate was similarly examined in relation to adversity status, using repeated measures ANOVA with heart rate by episode (play, still face, recovery) as the repeated measure. Results indicated that there was a significant effect of perturbation episode on heart rate ($F_{2,95}$ = 14.1, P < 0.001, partial η^2 = .23), as already described; however, there was no interaction between perturbation episode and maternal adversity group ($F_{2,95}$ = 1.09, P = 0.34, partial η^2 = .02~~ns~~), and no between subjects effect of adversity ($F_{1,96}$ = 0.67, P = 0.41, partial η^2 = .01~~ns~~).

Given that both adversity and low maternal sensitivity predicted infant dysregulated behaviour in the FF condition, and that these two variables were themselves significantly associated, we conducted analyses to examine the possibility that associations between maternal sensitivity and infant responding are an artefact of adversity associations on both variables. This was not the case. Rather, using logistic regression, with infant dysregulation during play dichotomised at the 75th percentile as the dependent variable, results were

consistent with mediation of the effects of adversity by low maternal sensitivity (Baron & Kenny, 1986). Thus, adversity status was a significant predictor of infant dysregulation when entered into the regression equation in the first step [Exp(B) = 2.61; Wald = 4.54, df =1, P = 0.033]. However, when maternal sensitivity was added in the second step, the adversity effect was reduced to non-significant [Exp(B) = 1.45; Wald = 0.56, df =1, P = 0.46], and sensitivity itself was a significant predictor of infant behaviour [Exp(B) = 0.18; Wald = 12.2, df =1, P < 0.001].

4. Discussion

The current paper reports on a prospective, longitudinal investigation of the effects of newborn reactivity- regulation style and parenting difficulties on infant dysregulation during mother-infant interactions at 3 months of age, using a sample including both high and low levels of adversity. The findings from this study emphasise the role of infant and maternal factors in the development of infant regulation. Using the interactive stress of the FFSF procedure as a challenge for the infant's regulatory systems, we found that both maternal sensitivity and neonatal irritability were significant predictors of infant dysregulation. Thus, lower maternal sensitivity was also associated with elevated infant dysregulation across play and SF episodes of FFSF procedure. In addition, highly reactive, irritable behaviour in the newborn period was also found to affect FFSF behaviour and physiological responses. Specifically, infants who had been irritable as neonates showed poorer recovery from the still face perturbation than their non-irritable counterparts. Tentatively, there was also an interaction between neonatal irritability status and maternal sensitivity in predicted infant responding, such that irritable neonates who had mothers low in sensitivity showed the poorest behavioural recovery following the still face perturbation. As a secondary question, we considered maternal psychosocial adversity status as a risk factor for poor outcomes. Differences in irritability between high and low risk neonates were not significant, which was

perhaps ~~–~~surprising, given previous research suggesting that demographic factors can impact upon newborn behaviour (Fink, Tronick, Olson, & Lester, 2012). However, as expected, mothers in the psychosocial adversity group were significantly less sensitive than control group mothers when interacting with their infants at 12-weeks postpartum during the play phase of the FFSF. Furthermore, high risk infants showed more behavioural dysregulation during the play phase of the FSFF, an effect that was mediated by reduced maternal sensitivity in the high risk group.

Consistent with previous research (Beebe & Lachmann, 1998; Cohn & Tronick, 1987; Weinberg et al., 1999; Lowe et al., 2012), maternal sensitivity was found to be a significant predictor of infant dysregulation in the current study. Thus, lower maternal sensitivity was associated with higher infant behavioural dysregulation during the play and still face phase of the FFSF, but not during the recovery episode. Our findings are in line with those of Conradt and Ablow, who did not find any relationship between maternal sensitivity in play and infant recovery behaviours (infant behaviour in play and still face episodes was not recorded) (Conradt & Ablow, 2010). Interestingly, Conradt and Ablow reported that maternal sensitivity in the reunion phase was more strongly related to infant heart rate across all episodes and with infant behaviour in the recovery episode, suggesting that maternal behaviour during distress is a particularly important determinant of infant regulation. ~~O~~More broadly, our observations of concurrent associations between maternal behaviour and infant behavioural dysregulation support models of infant regulatory development that emphasise the significance of caregiving behaviours as a key source of input (Kopp, 1982; Tronick & Gianino, 1986; Calkins & Hill, 2007). Although the current observations are cross-sectional, longer term implications are likely, and may begin to describe a route for recent reports suggesting the effects of early infant reactivity on adult brain structure (Schwartz et al., 2010). Early infant dysregulation that occurs in the context of mother-infant interactions may become established in the longer term, particularly if maternal insensitivity persists.

Moreover, dysregulated child behaviour later in development has been associated with multiple adverse outcomes, particularly the expression of externalising psychopathology (Eisenberg et al., 2001; Kochanska & Knaack, 2003).

Associations between maternal behaviour and infant responding in the current study did not extend to infant behaviour during the recovery episode of the FFSF, or to infant physiological responding during the FFSF procedure as a whole. Rather, neonatal irritability emerged as a significant predictor of infant responding during the recovery episode. Consistent with previous research (Mesman et al., 2009), the FFSF procedure elicited elevations in behavioural dysregulation and heart rate from the initial play to the still face phase, followed by declines in both these indices during recovery across the sample as a whole. However, neonates who were classified as irritable at 10-days post-delivery did not show the typical pattern; both heart rate and behavioural dysregulation failed to decrease during the recovery episode in this group. Thus, this group was not so much characterised by enhanced reactivity to interpersonal challenge, as by a failure to effectively dampen down responses once the stressor was removed. While heart rate may conceivably have increased due to increased motor activity, t~~T~~he fact that a neonatal characteristic, rather than extrinsic factors of maternal sensitivity and psychosocial adversity, predicted infant heart rate responding in the FFSF context provides support for the assumption that self-regulatory capacities early in development are rudimentary, and largely a function of innate physiological mechanisms (Kopp, 1982; Kopp, 1989). To our knowledge, there is little previous direct evidence relating to the neonatal precursors of infant dysregulation, although there is increasing evidence to indicate that relevant aspects of infant functioning may be determined prior to birth, as a consequence of genetic and/or intrauterine factors (Lester, Marsit, Conradt, Bromer, & Padbury, 2012; Bergman, Sarkar, O'Connor, Modi, & Glover, 2007). Our observations suggest that neonatal characteristics represent an important determinant of infant responding to psychosocial challenge.

An analysis of the combined effects of maternal sensitivity and infant regulatory capacities on FFSF recovery responses yielded particularly interesting effects. Specifically, the combination of neonatal irritability and maternal insensitivity appeared to be particularly problematic, with infants in this group showing the poorest behavioural recovery. Conclusions in this respect are necessarily ~~tentative, due to limited~~limited by the modest ~~power to test for such effects in the current~~ sample size, which correspondingly restricted our power to test for moderated effects. Nonetheless, our observations are consistent with a broader literature that increasingly highlights the potential for interaction between infant characteristics and the environment. It has been hypothesised that infants who are more reactive may be more susceptible to the effects of differences in their environments, be they positive or negative (Belsky & Pluess, 2009). ~~The results of our study are in partial support of this hypothesis, as~~We found that behavioural dysregulation in the recovery episode of the FFSF procedure was greate~~st~~r for neonatally irritable infants of mothers who were low in sensitivity, relative to non-irritable infants of either sensitive or insensitive mothers, consistent with this differential susceptibility hypothesis. However, we did not find any evidence to suggest that irritable neonates paired with sensitive mothers fared better than their non-irritable counterparts, which is a key component of the hypothesis.

In the context of mother child interactions, our observation that a more reactive neonatal temperament is associated with reduced ability dampen down responding following negative arousal in the FFSF is likely to extend to infant capacity to recover from episodes of mismatch that occur in the course of normal interaction. Thus, a reactive infant paired with a less sensitive mother may generate a communication pattern characterised by frequent mismatches from which the infant cannot recover. The opportunity for the infant to experience a behaviour-response exchange that is attuned and contingent to his states and activities will be correspondingly greatly reduced. If a positive experience of repair of

communicative mismatches in sensitive mother-infant interaction enables the infant to develop a sense of self as an effective agent, mismatch that is persistently unsettling may severely restrict this pathway to optimal development.

The current study utilised a sample of mothers experiencing high and low levels of psychosocial adversity. Consistent with previous reports, high adversity mothers were less sensitive in interacting with their infants during the play phase of the FFSF at 3 months postpartum than their low risk counterparts (Halligan et al., 2012). Neonatal irritability was not significantly related to adversity status; however, high versus low adversity infants showed more dysregulation during the play phase of the FFSF paradigm, an association that was mediated by maternal sensitivity. If patterns of problematic engagement characterise high risk dyads in early development, in principle these may contribute to the longer term emotional and behavioural difficulties evidenced in later development in association with psychosocial adversity (Shaw, Winslow, Owens, & Hood, 1998; Rutter, Giller, & Hagell, 1998).

5. Conclusion

In conclusion, the current findings demonstrate that neonatal characteristics, as well as maternal sensitivity, may be an important contributor to early infant responding in the context of social interactions. Moreover, the combination of pre-existing irritable behaviour and low maternal sensitivity may be particularly problematic for the development of infant self-regulation. Strengths of the current study include the use of observational measures of infant and maternal characteristics, the longitudinal design, and the examination of both behavioural and physiological responding across all phases of the FFSF paradigm. Nevertheless, the findings are limited by the relatively small sample size and correspondingly limited power to examine interactions between maternal behaviour and neonatal irritability. It is also the case that we conducted fairly limited exploration of the physiological measures

examined. Future investigations would benefit from consideration of measures of both physiological and autonomic functioning including skin conductance and neuroendocrine system responses. Nonetheless, our findings have potential implications for the delivery of early interventions which focus on maternal sensitivity to improve infant outcomes. Evaluations of interventions should take individual differences such as irritability into account rather than considering the average effect across all groups. Similarly, this study suggests that the design of early interventions with infants would benefit from considering the impact of infant individual differences. Further studies examining the interplay between maternal and infant characteristics in the interpersonal context are indicated.

Table 1

Associations between neonatal irritability and infant behavioural regulation during the FFSF procedure; means and standard deviations (in parentheses)

	Episode		
	Play	Still Face	Recovery
Overall	-0.42 (0.30)	0.29 (0.94)	0.13 (1.02)
Neonatal Irritability, *M (SD)*			
Non-irritable (N = 81)	-0.45 (0.28)	0.24 (0.95)	-0.07 (0.81)
Irritable (N = 29)	-0.33 (0.35)	0.43 (0.92)	0.74 (1.33)
Group comparison	$Z = -1.94^{+}$	$Z = -1.49$	$Z = -3.68$***
Effect Size	$r = .18$	$r = .14$	$r = .35$

v

Figure 1.

Figure 1

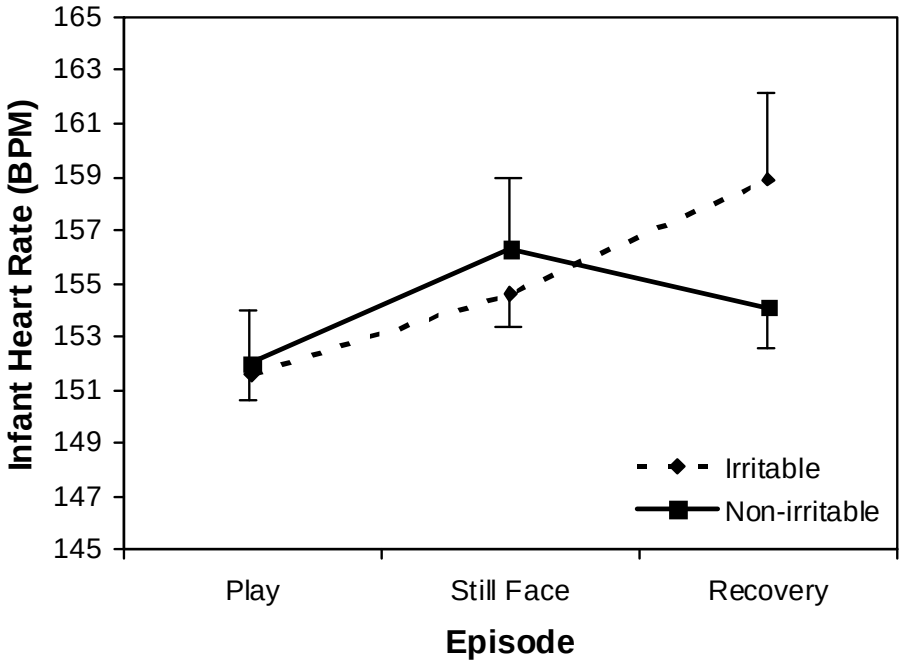

Figure 2

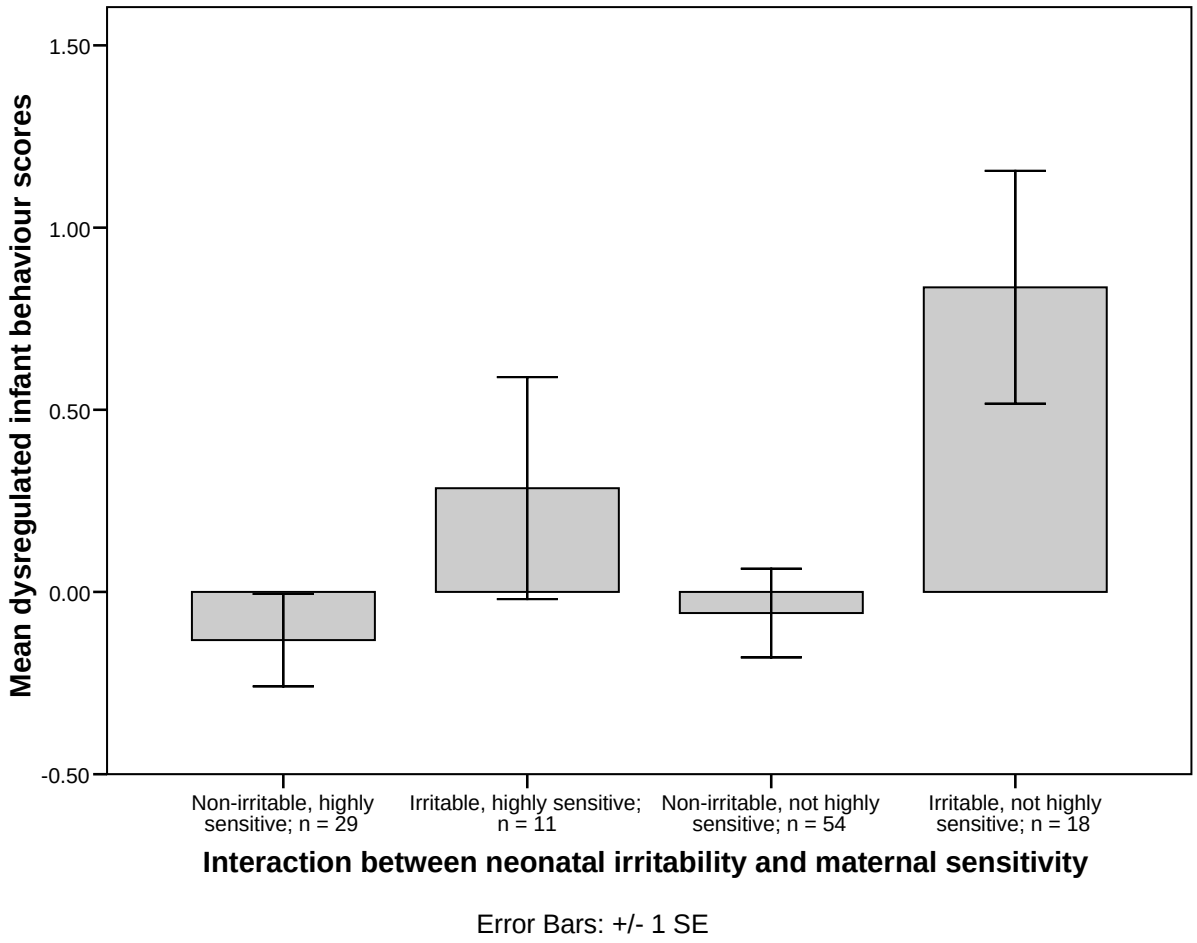
1.50
1.00
0.50
0.00
-0.50
Mean dysregulated infant behaviour scores
Non-irritable, highly sensitive; n = 29
Irritable, highly sensitive; n = 11
Non-irritable, not highly sensitive; n = 54
Irritable, not highly sensitive; n = 18
Interaction between neonatal irritability and maternal sensitivity
Error Bars: +/- 1 SE

Figure 1 Title

Infant heart rate responding to the still face perturbation in relation to neonatal irritability status: Error bars denote standard errors

Figure 2 Title

Dysregulated behaviour in the recovery episode by maternal sensitivity and infant irritability

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