

Two-month-olds' attention and affective response to maternal still face: A comparison between term and preterm infants in Taiwan

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Abstract

Maternal still face is a robust experimental procedure designed to examine infants' sensitivity to social contingency and reactivity to its violation. To extend earlier research on the still-face effect on term infants in Western cultures, the present study compared Taiwanese term and preterm infants' attention and affective response to and recovery from a modified maternal still-face procedure that used an additional still-face reengagement sequence at 2 months of age (corrected age for preterm infants). Infants' gaze and facial affect were coded from videos. Results showed that preterm infants were as sensitive as term infants to the interruption to social contingency. Both groups of infants reacted with decreased gaze and positive affect across episodes, together with a decreased latency to gaze aversion and an increased latency to positive affect. Both term and preterm infants also demonstrated a W-shaped pattern of decline-followed-by-recovery in their latency to negative affect. However, compared to term infants, preterm infants became distressed faster and stayed in a negative affective state longer after the first exposure to maternal still face. Effects of prematurity on infant attention and affect regulation were discussed. Implications of preterm infants' heightened affective negativity to mild stress for intervention studies were also addressed.

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1. Introduction

As early as 2 months of age, normally developing infants begin to engage in reciprocal interaction with their caregivers (e.g., Lavelli & Fogel, 2005) and are able to detect the lack of contingency in a social partner's responsiveness (e.g., Murray & Travarthen, 1985; Nadel, Carchon, Kervella, Marcelli, & Réserbat-Plantey, 1999; Soussignan, Nadel, Canet, & Gerardin, 2006). By contrast, infants born prematurely (gestational age <37 weeks), who are less optimal in their behavioral organization, are less likely to engage in synchronized interaction with their mothers (Feldman, 2006). However, little is known about whether and how preterm infants differ from their term counterparts in sensitivity to social contingency and reactivity to social interruptions. In this study, we compared Taiwanese term and preterm infants' attention and affective response to and recovery from the interruption to contingent interactions with their mothers at 2 months of age (corrected age for preterm infants).

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1.1. *Developmental risks of premature birth*

At birth, compared to full- and near-term infants, preterm infants performed significantly poorer in their neurobehavioral functioning indexed by autonomic modulation, motor modulation, state modulation, affectional availability, and self regulation (Mouradian, Als, & Coster, 2000). Preterm infants, particularly those with very low birth weight, are at risk for later problems in physical growth (DeWitt, Sparks, Swank, & Smith, 1997), motor skills (Greenberg & Crnic, 1988; van Beek, Hopkins, Hoeksma, & Samsom, 1994), attention (Landry, 1995), cognition (Ment et al., 2003), academic performance (van Baar, van Wassenauer, Briet, Dekker, & Kok, 2005), language, and social communicative skills (van Beek, Hopkins, & Hoeksma, 1994). The negative consequences of prematurity persist into childhood (Aylward, 2005; Ment et al., 2003; van Baar et al., 2005), adolescence (Roth et al., 2001), and adulthood (Allin et al., 2004).

1.2. *Attention and affect development in term and preterm infants*

Although preterms are responsive to auditory, visual, and tactile stimulation, they are easily stressed by low levels of social stimulation such as being talked to and/or touched prior to term age (Eckerman, Oehler, Hannan, & Molitor, 1995; Eckerman, Oehler, Medvin, & Hannan, 1994). In reviewing studies of infant attention, arousal, and affect, Field (1981) delineated a model describing preterm infants as having a narrow range of stimulation that is compatible with their attention and positive affect. Preterms tend to show a pattern of either under-responding (i.e., hypo-reactive) or over-responding (i.e., hyper-reactive) to social stimulation. As a result, they have been characterized as difficult social partners (McGehee & Eckerman, 1983). Experimental studies have further demonstrated that preterm infants spent less time than term infants in looking at their partner's face and showed less positive affect and more negative affect during game playing with an adult (e.g., Eckerman, Hsu, Molitor, Leung, & Goldstein, 1999). Observations of social exchanges between mothers and infants have also revealed that compared to term infants, preterm infants look less at their mothers, exhibit more gaze aversion and negative affect, and display less positive affect (e.g., Crnic, Ragozin, Greenberg, Robinson, & Basham, 1983; Field, 1979; Garner & Landry, 1992; Malatesta, Grigoryev, Lamb, Albin, & Culver, 1986). Compared to term infants and low-risk preterm infants, high-risk preterm infants tend to be the poorest in attention and most negative in affect during social interaction (Eckerman et al., 1999; Garner & Landry, 1992; van Beek, Hopkins, & Hoeksma, 1994). Together, these findings suggest that preterm infants are not as competent as term infants in organizing their attention and affective response during social interaction.

1.3. *Maternal still-face effects*

A variety of paradigms have been developed over the last decades to establish the early development in sensitivity to social contingency and reactivity to its perturbation. The widely used maternal still-face paradigm (Shapiro, Fagen, Prigot, Carroll, & Shalan, 1998; Tronick, Als, Adamson, Wise, & Brazelton, 1978), for example, assesses infants' behavioral response to an interruption to the contingency in parental behavior. In this paradigm, an infant engages in a routine play with her parent for a few minutes. This dyadic social exchange is halted when the parent suddenly poses a neutral still face. Research shows that maternal still face is stressful to young infants because it violates their expectations for contingent responsiveness. Normally developing infants between 3 and 6 months of age react to the still face with reduced smiling and gazing, together with increased negative affect, motor activity, and physiological regulation (e.g., Moore & Calkins, 2004; Toda & Fogel, 1993; Weinberg, Tronick, Cohn, & Olson, 1999). After mothers reengage their infants in play again, there is a slight recovery in infant positive affect and looking (e.g., Bazhenova, Plonskaia, & Porges, 2001; Moore & Calkins, 2004; Toda & Fogel, 1993; Weinberg et al., 1999). Although the robust still-face effect of increased negativity can also be detected in infants the earliest at 1.5 months, no clear signs of recovery in attention and affect are noted at this age (Bertin & Striano, 2006).

Despite extensive research with term infants, little is known about preterm infants' sensitivity and reactivity to the still-face challenge. To our knowledge, only one study compared term and preterm infants' behavioral response to maternal still face. In this study with 7-month-old American Black infants (Segal et al., 1995), both term and preterm infants decreased their smiling in response to the still face and displayed a rebound in smiling during the reengagement. However, preterm infants displayed fewer smiles, particularly those more pronounced smiles, than normal term infants. Surprisingly, both groups of infants did not show the expected still-face effect of increased negative affect. These findings

suggest that by 7 months of age, preterm infants may be as competent as term infants in regulating their distress, but less effective in modulating their positive arousal. However, it is unclear prior to this age whether preterm infants are as sensitive and reactive as their term counterparts in attention and affective response to the still-face challenge. In light of the recent evidence of a first developmental transition in infant behavioral organization occurs at the second month (Herschkowitz, Kagan, & Zilles, 1997; Hsu & Porter, 2004), the present study compared 2-month-old preterm and term infants' attention and affective response to the still-face challenge.

Although culture may play a role in the development of attention and affect (e.g., Chavajay & Rogoff, 1999; Super & Harkness, 1991), research on infant attention and affective response to the maternal still face is almost exclusively done with Western populations. To date, only one study investigated non-Western infants' response to the challenge of maternal still face. In this study, the still-face effect was replicated with Chinese term infants between 3- and 6-month of age: they showed a reduction of looking and smiling in response to the still face posed by their mother, their father, and a stranger, which is followed by a recovery of looking and smiling during the reengagement of play (Kisilevsky et al., 1998). This initial evidence of universality in infants' attention and affective response to social interruption needs to be further validated. To fill this gap in research, the present study focused on term and preterm infants born in Taiwan.

1.4. *The present study*

The present study was designed to: (1) examine the effect of prematurity on infants' sensitivity and reactivity to interruptions to their interaction with mothers, and (2) extend earlier research findings on the still-face effect on infant attention and affect based on term infants in Western cultures. Following the study by Haley and Stansbury (2003), a modified version of still-face procedure was implemented, which included an additional still-face reengagement sequence. This extended sequence elicited nonlinear changes in 5- to 6-month-olds' attention and affect: whereas a W-shaped decline-followed-by-recovery pattern was found in infant attention, an M-shaped rise-followed-by-decline pattern was detected in infant negative affect. Such findings explicate that by 6 months, infants are not only distressed by a violation to social contingency, but also capable of making a recovery from distress after repeated exposures to a mild challenge such as maternal still face. In this study, we investigated the response and recovery pattern in 2-month-old term and preterm infants' attention and affect. It was expected that similar to term infants, preterm infants would also demonstrate sensitivity to social contingency by responding to the maternal still face with decreased attention and positive affect, together with increased negative affect. However, because of their difficulty in behavioral organization and proneness to negativity, preterm infants' reactivity and recovery patterns would be either attenuated (social gaze at mother and positive affect) or heightened (negative affect and gaze aversion) as compared to those of term infants.

2. Method

2.1. *Participants*

A total of 40 Taiwanese mothers and their infants initially participated in this study when the infants turned 2 months of age (corrected age for preterm infants). Immediately after delivery, 20 mothers and their healthy singleton term infants were recruited from the maternity ward of a major teaching hospital in Taipei, the capital city of Taiwan. Twenty mothers and their preterm infants were recruited from the Newborn Observation Room of the same hospital before they were discharged. Preterm infants with congenital abnormalities, major central nervous system insult, gastrointestinal or cardiac anomalies requiring surgery were excluded from the study in order to increase the homogeneity of the sample.

With the exception of the mother of a term infant, all mothers were married and in their early thirties ($M = 32.79$ years, $S.D. = 4.35$). The majority of mothers had college education or higher (75.7%) and over half of them were employed (63.7%). The two groups of mothers were comparable on all demographic characteristics except for their education and employment status. Mothers of preterm infants ($M = 13.50$ years, $S.D. = 2.24$) had significantly less education than those of infants born at term ($M = 16.53$ years, $S.D. = 1.40$), $t(38) = 4.69$, $p < 0.01$, and were less likely to work outside of home, $\chi^2(1, N = 40) = 12.97$, $p < 0.01$.

Infants' perinatal data including gestational age, birth weight, birth length, Apgar scores at 1 and 5 min, and duration of oxygen use and hospital stay were obtained from medical charts. Preterm infants were significantly lower than term infants on all these measures (see Table 1). Nine of the preterms were very premature infants whose gestational age

Table 1
Perinatal measures for term and preterm infants

Perinatal measure	Term infants		Preterm infants	
	Mean (S.D.)	Range	Mean (S.D.)	Range
Gestational age (weeks)	39.00 (0.88) ^a	38–41	30.29 (3.10) ^b	24–34
Birth weight (g)	3139.89 (262.14) ^a	2514–3650	1392.71 (362.01) ^b	690–1922
Birth length (cms)	48.87 (1.47) ^a	46.0–51.6	38.75 (3.98) ^b	43–52
Apgar scores				
1-Min	8.89 (0.32) ^a	8–9	6.36 (2.41) ^b	1–9
5-Min	9.00 (0.00) ^a	9	8.14 (1.35) ^b	6–10
Duration of oxygen use (days)	–	–	33.93 (55.10)	0–169
Duration of hospital stay (days)	–	–	51.50 (33.38)	15–119
Neonatal neurobehavioral examination	68.28 (3.94) ^a	62–74	65.92 (3.84) ^a	60–70

Note: Mean values with different superscripts are significantly different.

was less than 32 weeks. The preterm infants also varied in their birth weight: 7 were classified as low-birth-weight (1500–2499 g), 5 as very-low-birth-weight (1000–1499 g), and 2 as extremely-low-birth-weight (<1000 g). Both term and preterm infants were evaluated using the Neonatal Neurobehavioral Examination-Chinese version (NNE-C) (Jeng, Tsao, & Chen, 1996; Jeng, Yau, & Teng, 1998), which assesses newborn infants' neurobehavioral functioning. Preterm infants were examined at 40 weeks of postconceptional age, whereas term infants were examined within 12–48 h after delivery. The NNE-C consists of a total of 27 items grouped into three sections: tone and motor patterns, primitive reflexes, and behavioral responses. Each item is scored on a three-point scale. This behavioral assessment has adequate internal consistency, inter-rater reliability, and test-retest reliability (Jeng et al., 1996). A licensed pediatric physical therapist served as the NNE-C examiner, who attained reliability agreement with the author (SFJ) prior to testing. In this study, there was no significant difference between preterm and term infants in their scores, $t(29) = 0.85$, ns, indicating that preterm infants included in this study suffered no major neurological dysfunction.

2.2. Experimental procedure

A modified still-face procedure was conducted in a laboratory room. The infant was placed in an infant seat sitting across from his/her mother at an eye level with no toys. A mirror was placed slightly behind the infant seat so that the face and upper body of both mother and infant were captured by a digital camera. During this procedure, mothers first interacted with their infants normally for 2 min and then ceased all interactive behaviors for 1.5 min. After the brief still-face interruption, mothers resumed normal play with their infants for 2 min, which was followed by a second still face episode. After the second still face, mothers reengaged their infants for interaction again. Thus, a total of five episodes of experiment were implemented. The still face and reengagement of play episodes were curtailed when the infant exhibited continuous crying for 30 s. The procedure with six preterms and four term infants was terminated early because they fell asleep or were extremely fussy. As a result, the final sample size for data analysis was 14 (8 females) and 16 (10 females) for preterm and term infants, respectively. The direction of infant gaze and the valence of infant affective expression were coded from videos.

2.3. Infant gaze

The direction of infant gaze was coded as either looking at mother's face (social gaze), looking away from mother's face (gaze aversion), or eyes closed for at least 1 s. The total duration of infant social gazing at mother was derived separately for each episode of the still-face experiment. Because the duration of each episode varied in length, the proportion of the episode was computed as the index for infant social gaze. Given that the infants tended to engage in an extended period of social gazing at mother, the latency time (in seconds) to the first gaze aversion was derived as the index for response latency. Twenty-four percent of infants were randomly selected and coded by a second coder for reliability checks. The average percentage of agreement was 98% and the average kappa was 0.90.

2.4. Infant affect

Facial expressions in infants were coded second-by-second from videos. The expression of positive affect was defined as the contraction of zygomatic major muscle, which retracts the lip corners back and upward (e.g., Fogel, Hsu, Shapiro, Nelson-Goens, & Secrist, 2006). Other facial actions such as cheek raising and/or mouth opening might co-occur with the contraction of zygomatic major muscle. Infant negative affect was defined as a cry face with knitted eyebrows and squinted eyes. Facial actions such as cheek raising and mouth opening with lip corners turned down and outward could also co-occur with the cry face. A neutral face was identified when the infant's facial muscles were relaxed. Measures of the total amount of infant positive and negative affect were derived separately as the proportion of each episode of the still-face procedure. Response latency (in seconds) to the onset of the first positive and negative affect was also derived separately for each episode. Twenty percent of infants were randomly selected for checking coding reliability. The average percentage of agreement was 97% and the average kappa was 0.78.

3. Results

3.1. Preliminary analysis

The effect of infant sex on the 3 duration and 3 latency measures of infant attention and affective response was examined in separate 2 (infant sex) \times 2 (birth status) \times 5 (experiment episode) mixed-design ANOVAs. No significant main or interaction effect involving infant sex was found. Consequently, data from male and female infants were combined for subsequent data analysis. Separate 2 (birth status) \times 5 (experiment episode) mixed-design ANOVAs were performed to compare preterm and term infants' social gaze as well as positive and negative affective response across episodes.

Furthermore, preterm infants varied greatly in their birth weight and gestational age. Thus, the associations between their birth weight and gestational age with the latency and duration measures of gaze and affective response were explored. Results from correlational analysis revealed that none of the bivariate correlations was statistically significant. Thus, preterm infants in different birth-weight groups were combined.

3.2. Social gaze

3.2.1. Total duration

Test results showed that term and preterm infants did not differ in the total time spent in looking at their mothers' face, $F(1,28) = 2.34$, ns. The main effect for experiment episode approached significance, Wilks' $\Lambda = 0.699$, $F(4,25) = 2.69$, $p < 0.06$, partial $\eta^2 = 0.30$. The follow-up polynomial analysis revealed a significant linear decrease in infants' social gaze, $F(1,28) = 7.15$, $p < 0.05$, partial $\eta^2 = 0.20$. Planned contrasts further revealed the change pattern in two consecutive episodes. As illustrated in Fig. 1(1a), results indicated that although infants did not change the total duration of their social gaze during the first still-face sequence, they significantly decreased their social gaze from the first reengagement of play to the second still face, $F(1,28) = 6.91$, $p < 0.05$, $\eta^2 = 0.20$; and slightly increased social gaze from the second still face to the second reengagement of play, $F(1,28) = 3.55$, $p = 0.07$, $\eta^2 = 0.11$. These change patterns suggested that the second sequence of maternal still face evoked the typical decline-followed-by-recovery in social gaze. Furthermore, the interaction between birth status and experiment episode was not significant, Wilks' $\Lambda = 0.876$, $F(4,25) = 0.89$, ns, suggesting that preterm and term infants demonstrated a similar pattern in their social gaze across episodes.

3.2.2. Latency to gaze aversion

Test result showed that term and preterm infants did not differ in the time it took for them to look away from their mothers, $F(1,28) = 1.54$, ns. By contrast, the latency time for both groups of infants to first look away from their mothers changed significantly across episodes, Wilks' $\Lambda = 0.592$, $F(4,25) = 4.30$, $p < 0.01$, partial $\eta^2 = 0.41$. The follow-up polynomial analysis revealed the best fitting model was a linear pattern of decrease, $F(1,28) = 6.68$, $p < 0.05$, partial $\eta^2 = 0.19$. As shown in Fig. 1(1b), planned contrasts revealed a significant decrease in the latency of infant gaze aversion from routine play to the first still face, $F(1,28) = 11.90$, $p < 0.01$, partial $\eta^2 = 0.30$. This suggested that although

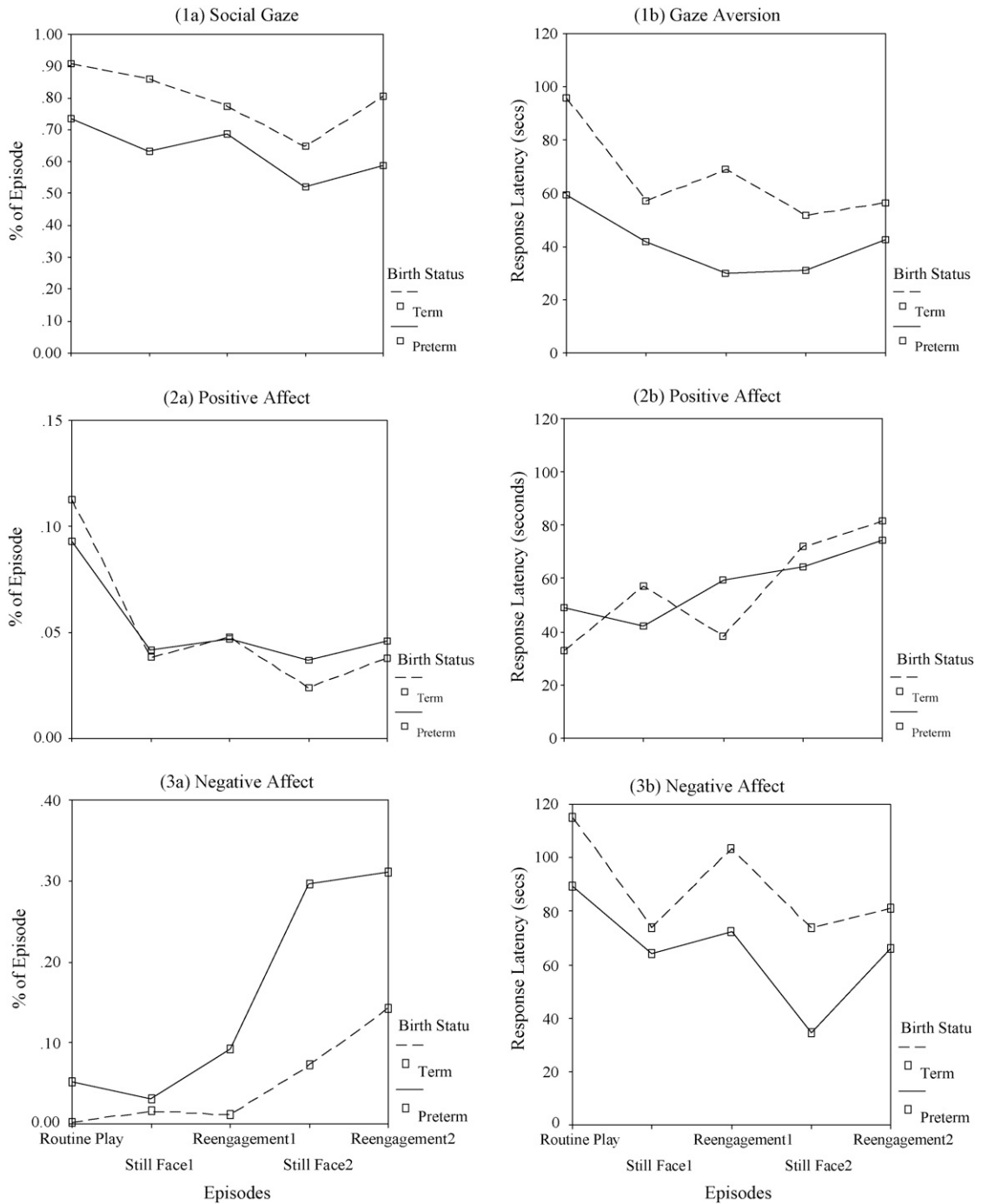


Fig. 1. Infant behavioral response to maternal still face: (1a) total duration of social gaze, (1b) latency to the first gaze aversion, (2a) total duration of positive affect, (2b) latency to the first positive affective display, (3a) total duration of negative affect, and (3b) latency to the first negative affective display.

the first sequence of still face was effective in eliciting an increase in infant gaze aversion, there was no evidence of recovery. Moreover, the interaction effect for birth status by experiment episode was not significant, Wilks' $\Lambda = 0.829$, $F(4,25) = 1.29$, ns. Both groups of infants showed a similar pattern of change in the latency of gaze aversion across episodes.

3.3. Positive affect

3.3.1. Total duration

Term and preterm infants did not differ in the total duration of their positive affect, $F(1,28)=0.001$, ns. By contrast, the total duration of infant positive affect changed significantly across episodes for both groups of infants, Wilks' $\Lambda=0.643$, $F(4,25)=3.47$, $p<0.05$, partial $\eta^2=0.36$. The follow-up polynomial analysis further revealed a linear decrease pattern, $F(1,28)=15.28$, $p<0.001$, partial $\eta^2=0.35$. As illustrated in Fig. 1(2a), planned contrasts revealed a significant decrease in the total duration of infant positive affect from routine play to the first still face, $F(1,28)=7.12$, $p<0.05$, partial $\eta^2=0.20$. This suggested that although the first sequence of still face was effective in eliciting a decrease in infant positive affect, there was no evidence of recovery. Furthermore, the interaction effect for birth status by experiment episode was not significant, $F(4,25)=0.26$, ns, indicating that there was no difference in the two groups of infants' response pattern across episodes.

3.3.2. Latency to positive affect

Analysis results showed that the amount of time it took for term and preterm infants to display the first positive affect was similar, $F(1,28)=0.02$, ns. However, the latency to the first positive affect changed significantly across episodes, Wilks' $\Lambda=0.63$, $F(4,25)=3.68$, $p<0.05$, partial $\eta^2=0.37$. The follow-up polynomial analysis further revealed a linear pattern of increase in the time it took for preterm and full-term infants to display their first positive affect, $F(1,28)=14.21$, $p<0.001$, partial $\eta^2=0.34$. As seen in Fig. 1(2b), planned contrasts revealed a marginal significant increase in the latency of infant positive affect from the second still face to the second resumption of play, $F(1,28)=3.16$, $p<0.10$, partial $\eta^2=0.10$. This pattern indicated that the second sequence of still face was effective in eliciting an increase in response latency; however, there was also no sign of recovery. Finally, the interaction between birth status and experiment episode was not significant, Wilks' $\Lambda=0.852$, $F(4,25)=1.08$, ns, indicating that preterms and terms were similar in the change pattern of delay time in displaying their first positive affect across episodes.

3.4. Negative affect

3.4.1. Total duration

The main effects for infant birth status, $F(1,28)=3.91$, $p<0.10$, partial $\eta^2=0.12$, and experiment episode, Wilks' $\Lambda=0.729$, $F(4,25)=2.32$, $p<0.10$, partial $\eta^2=0.27$, were marginally significant. Overall, preterms tended to exhibit more negative affect than term infants. The follow-up polynomial analysis also revealed an overall linear increase pattern in both groups of infants' negative affect across episodes, $F(1,28)=8.44$, $p<0.01$, partial $\eta^2=0.23$. As shown in Fig. 1(3a), planned contrasts further revealed a significant increase in infant negative affect from the first still face to the first reengagement of play, $F(1,28)=5.82$, $p<0.05$, partial $\eta^2=0.17$, and a further increase from the first reengagement of play to the second still face, $F(1,28)=6.81$, $p<0.05$, partial $\eta^2=0.20$. This pattern suggested that after the first exposure to maternal still face, infants became visibly distressed and remained in a negative state regardless of changes in maternal contingency. Additionally, the interaction between birth status and experiment episode was marginally significant, Wilks' $\Lambda=0.738$, $F(4,25)=2.22$, $p<0.10$, partial $\eta^2=0.26$. The follow-up polynomial analysis revealed that the interaction was significant for a cubic pattern (3rd order), $F(1,28)=6.47$, $p<0.05$, partial $\eta^2=0.19$, indicating that preterm infants became significantly more distressed than term infants after the first exposure to the maternal still face.

3.4.2. Latency to negative affect

Analysis showed that compared to term infants, it took less time for preterm infants to exhibit negative affect, $F(1,28)=7.18$, $p<0.05$, partial $\eta^2=0.20$. By contrast, the latency time for both groups of infants to display the first negative affect changed significantly across episodes, Wilks' $\Lambda=0.167$, $F(4,25)=31.12$, $p<0.001$, partial $\eta^2=0.83$. Follow-up polynomial analysis revealed a significant quatic (4th order) pattern, $F(1,28)=27.96$, $p<0.001$, partial $\eta^2=0.50$. As illustrated in Fig. 1(3b), planned contrasts further indicated that infants decreased their latency in displaying negative affect from routine play to the first still face, $F(1,28)=18.02$, $p<0.01$, partial $\eta^2=0.39$; they increased the latency from the first still face to the first reengagement of play, $F(1,28)=4.87$, $p<0.05$, partial $\eta^2=0.15$; they decreased the latency again from the first reengagement of play to the second still face, $F(1,28)=18.46$, $p<0.01$, partial $\eta^2=0.40$; finally, they increased the latency again from the second still face to the second reengagement of play,

Table 2
Summary of findings

Behavior	Measure	Group difference	Overall change pattern across episodes	Evidence of recovery (sequence)
Social gaze	Duration	No	Linear, increase	Yes ^a (2nd sequence)
	Latency	No	Linear, decrease	No
Positive affect	Duration	No	Linear, decrease	No
	Latency	No	Linear, increase	No
Negative affect	Duration	Preterms > Term infants ^a	Nonlinear, cubic	No
	Latency	Preterms < Term infants	Nonlinear, quatic	Yes (1st and 2nd sequence)

^a Marginally significant.

$F(1,28) = 11.09, p < 0.01$, partial $\eta^2 = 0.28$. A W-shaped, decline-followed-by-recovery pattern in response to maternal still face was evident. Additionally, the interaction between birth status and experiment episode was not significant, Wilks' $\Lambda = 0.775, F(4,25) = 1.816$, ns, suggesting the two groups of infants were similar in their response pattern across episodes.

3.5. Summary of findings

The findings regarding preterm and term infants' attention and affective response to the challenge of maternal still face are summarized in Table 2. Overall, both 2-month-old term and preterm infants reacted to the interruption to social contingency with significant changes in the duration and latency of their social gaze, positive affect, and negative affect. Whereas both groups of infants demonstrated a similar response pattern of decreased social gaze and positive affect across episodes, preterm infants became distressed faster and stayed in a negative state longer than term infants. Both groups of infant also showed a trend of recovery in the total duration of social gaze; they increased gazing at mother from the episode of still face to reengagement of play during the second sequence. Finally, it was evident that both groups of infants made a recovery in the latency response to negative affect; they increased the time it took to show a negative face after both the first and second exposure to maternal still face.

4. Discussion

Premature birth greatly increases the risk for later physical, neurological, and psychological impairments in infants. A behavioral profile of poor attention and negative emotionality has been thought to characterize preterm infants (e.g., Crnic et al., 1983; Field, 1979; van Beek, Hopkins, & Hoeksma, 1994; van Beek, Hopkins, Hoeksma, & Samsom, 1994). Because of their difficulty in achieving and maintaining adequate state regulation, preterm infants have generally been described as less responsive, less active, and less clear in their social signals than term infants (e.g., Eckerman et al., 1999). With the goals of replicating and extending previous research, the present study compared Taiwanese term and preterm infants' sensitivity and reactivity to interruptions to their interaction with mothers. Our findings demonstrated that as their full-term counterparts, healthy 2-month-old preterm infants demonstrated sensitivity to social contingency by responding to maternal still face with marked changes in their attention and affect. Unexpectedly, compared to term infants, preterm infants' attention and positive affect was not attenuated. Both groups of infants decreased their social gaze and positive affect across episodes, with a shortened latency to gaze aversion and an increased latency to positive affect. On the contrary, although both groups of infants became more distressed across episodes, preterm infants' negative affect was heightened. Compared to term infants, preterm infants' negative reactivity was longer in duration and shorter in latency.

4.1. Attention response and recovery

Previous research shows that term infants younger than 2 months of age respond to the still-face challenge with a decreased social gaze. Yet, they are unable to make a recovery during maternal reengagement of play (Bertin & Striano, 2006). By contrast, 3- and 4-month-olds not only decrease their social gaze in response to maternal still face, but also demonstrate a slight increase in social gaze in response to maternal reengagement (Kisilevsky et al.,

1998; Moore & Calkins, 2004; Toda & Fogel, 1993; Weinberg et al., 1999; Weinberg & Tronick, 1996). By 6 months, a robust recovery is observed even after infants experience repeated exposures to the still-face challenge (Haley & Stansbury, 2003). Our findings showed that Taiwanese term and preterm 2-month-olds did demonstrate a pattern of decreased social gaze with a slight rebound prior to the second exposure to maternal still face. Although a decrease in the latency to gaze aversion was evident in the first exposure to maternal still face, no recovery was observed. Taken together, it appears that 2-month-olds are responsive to perturbations to maternal contingency indexed by social gaze, but are unable to make a strong recovery from the stress of maternal still face as 6-month-olds. Such differential pattern found between 2- and 6-month-olds may be explained by the emergence of infant self-regulation.

The ability to shift attention away from a distressing stimulus is considered part of the early developing system of self regulation (Harman, Rothbart, & Posner, 1997). Infants younger than 2 months tend to engage in obligatory looking indicating a great difficulty to shift gaze away from stimulation (Harman & Fox, 1997; Ruff & Rothbart, 1996). Dramatic decline in visual fixation on mother's face occurs at around the second month (Lavelli & Fogel, 2005). By 4 months, those who are better at refocusing their attention have been shown to be less distressed in laboratory situations (Rothbart, Ziaie, & O'Boyle, 1992). The presence of a distracter can calm distressed infants aged 3–6 months (Harman et al., 1997). By 6 months, infants use gaze aversion as their primary self-regulation strategy to cope with mild stress (Mangelsdorf, Shapiro, & Marzolf, 1995; Stifter & Braungart, 1995). Thus, it appears that the emergence of self regulatory ability beginning at 2 months of age allows infants to avert gaze away from a distressing stimulus. With age, infants spend less time in looking at their mothers in response to both maternal engagement and still face (Moore, Cohn, & Campbell, 2001; Toda & Fogel, 1993). The ability to intersperse periods of visual attention with gaze aversions may be the most effective means for attention regulation (Field, 1981; Stifter & Moyer, 1991).

Although retinopathy is known to be one of the medical complications associated with prematurity, little is known about visual development in preterm infants who have not experienced cerebral or retinal injuries (Madan, Jan, & Good, 2005). In this study, our finding of no difference in social gaze between term and preterm infants is consistent with previous evidence that low-risk preterm infants' social gaze and gaze aversion patterning begin to diverge from those of term infants after 2 months of age (van Beek, Hopkins, & Hoeksma, 1994). By 3 months of age, preterm infants look at their mothers less (Field, 1979; Malatesta et al., 1986) and show more frequent gaze aversion (Crnic, Ragozin, Greenberg, Robinson, & Basham, 1983; Field, 1979). The development of social attention in preterm infants needs to be examined in future research.

4.2. *Affective response and recovery*

4.2.1. *Positive affect*

Three- to 6-month-old term infants' typical response to the still-face challenge is also characterized by a decline-followed-by-recovery pattern in positive affect (e.g., Haley & Stansbury, 2003; Moore & Calkins, 2004; Toda & Fogel, 1993; Weinberg et al., 1999). In this study, we found that 2-month-old term and preterm infants showed a similar decrease pattern in their positive affect, with a drastic decline in response to the first still-face perturbation. They also exhibited an increase pattern in the latency time to the first positive affective displays, with a drastic increase in response to the second still-face perturbation. However, there was no sign of recovery in infant positive affect indexed by total duration or response latency. Taken together, it is evident that 2-month-olds' positive affective response to the still-face challenge is similar to that of 1.5-month-olds (Bertin & Striano, 2006). One explanation for the lack of recovery is because infants at this age cannot effectively mobilize their behavioral and physiological regulation. In a similar vein, maternal regulatory support during reengagement is also not sufficient to restore infants' positive affect. It is plausible that only after the 2-month developmental transition marked by the emergence of cortical inhibition of brainstem structures (Herschkowitz et al., 1997), infants become more responsive to maternal regulation of affect and effective in self regulation of affect.

Previous findings with 7-month-olds indicated that the difference between term and preterm infants' positive affective response was limited to pronounced smiles (Segal et al., 1995). It seems that the quality, not quantity, of infant positive affect differentiates between term and preterm infants. A more fine-grained analysis of infant positive facial expressions may be necessary to reveal the configural difference between term and preterm infants' response. Recent studies on infant positive emotion indicate that infants may experience qualitatively different types of positive affect (Fogel et

al., 2006). Specifically, the cheek-raise and open-mouth dimensions of smile expressions have been suggested to be associated with the processes of affect sharing in mother–infant interaction (cf. Messinger, Fogel, & Dickson, 2001). Prematurity may be likely to alter certain types of positive affect expressed by infants. Future research needs to further differentiate among different types of smiles when examining premature infants' positive affective response to and recovery from social perturbations.

4.2.2. *Negative affect*

We found that both term and preterm infants became progressively more negative in affect after repeated exposures to the still-face perturbation. Compared to term infants, preterm infants became distressed sooner and stayed in such aroused state longer. Heightened distress in preterm infants was further exacerbated by the repeated exposure to the maternal still face. This finding is consistent with previous research that preterm infants have difficulty in achieving and maintaining adequate regulation of arousal state and are unable to modulate distress once aroused (Barnard, Bee, & Hammond, 1984; Greene, Fox, & Lewis, 1983).

It has been theorized that mothers provide external support to regulate infant affect (Calkins & Fox, 1992; Spangler, Schieche, Ilg, & Maier, 1994). Mothers of preterm infants have been described as more active and intrusive than mothers of term infants during social interaction (Field, 1979; Goldberg & DiVitto, 2002). One explanation for preterm infants' heightened negative response to social interruptions may be the combination of poor behavioral organization in preterm infants with less optimal support from their mothers. Future research is needed to closely examine the dynamic process in social exchanges between preterm infants and their mothers in response to interruptions to social contingency.

Individual differences in infant affective response to maternal still-face are linked to later development such as attachment quality (Braungart-Rieker, Garwood, Powers, & Wang, 2001) and behavior problems (Moore et al., 2001). The response pattern of high negative affect and low positive affect to the perturbation of maternal still face tend to be associated with suboptimal social development. Given the theorization that infants with heightened affect negativity are more susceptible to caregiving influences (cf. Belsky, 1997; Belsky, Hsieh, & Crnic, 1998), intervention studies designed for preterm infants may need to focus on negative affect as a target variable (Blair, 2002). Behavioral interventions designed to enhance mothers' sensitivity to infant signals such as attentive monitoring, accurate recognition, and contingent and appropriate response (cf. van den Boom, 1994) may be a more direct strategy to benefit highly reactive preterm infants.

In summary, findings from the present study with 2-month-old infants in Taiwan revealed that healthy preterm infants are as sensitive to social contingency as their term counterparts. Compared to term infants, although preterm infants were not significantly different from term infants in their response pattern of gaze and positive affect, they exhibited an elevated level of negative affect. Such attention and affective response to social interruption may be similar among 2-month-olds across cultures. However, future cross-cultural research is needed for validation. Also, the nonsignificant findings in this study should be viewed with caution because of the concerns related to adequacy of statistical power (e.g., small sample size). Only large effect sizes can be detected in the current study. Moreover, a large number of analyses were performed in this study, which might inflate the chance of detecting significance. Varying in their biological risks, preterms are not a homogenous group. High-risk preterm infants tend to show a greater sensitivity to distress and less ability to regulate distress once aroused (Feldman, 2006; Stiefel, Plunkett, & Meisels, 1987). Consequently, future studies need to examine whether preterm infants varying in birth risks would differ in their attention and affective response to and recovery from social perturbation.

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