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The Dynamic Still-Face Effect: Do Infants Decrease Bidding Over Time When Parents are Not Responsive?

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Abstract

The Still-Face Paradigm (SFP) was designed to assess infant expectations that parents will respond to infant communicative signals. During the still-face (SF) episode, the parent ceases interaction and maintains a neutral expression. Original, qualitative descriptions of infant behavior suggested changes within the SF episode: infants decrease bidding and disengage from their impassive parent. Research has documented changes in mean levels of infant behavior between episodes of the SFP. The hypothesis that infant behavior changes *within* the SF episode has not been empirically tested. In this study, hierarchical linear modeling indicated that infant gazing at the parent, smiling, and social bidding (smiling while gazing at the parent) decreased with time in the SF episode, while infant cry-face expressions increased. Changes in infant behaviors within the SF episode were associated with infant attachment and infant internalizing problems. The dynamic still-face effect quantifies infant initiation of interaction in the face of parental unresponsiveness, and is a potential predictor of individual differences in development.

Keywords

still-face paradigm; still-face episode; infancy; temporal dynamics; social behavior

Young infants and their parents engage in complex patterns of action and reaction during early face-to-face interactions. However, the degree to which infants initiate social behaviors with the expectation of a parental response is unclear. The Still-Face Paradigm (SFP) was designed to assess the extent to which infants initiate bids for social interaction to a parent who suddenly becomes impassive (Tronick, Als, Adamson, Wise & Brazelton, 1978). Original, qualitative descriptions of the SFP indicated that infants initially bid to their unresponsive parent, but that bidding declined with time as infants became dejected and withdrew. Analyses of the SFP, however, typically compare changes in mean levels of infant behaviors from an initial face-to-face interaction to the still-face episode (Adamson & Frick, 2003; Mesman, Van IJzendoorn, & Bakersman-Kranenburg, 2009). There is a paucity of empirical research examining the temporal dynamics of behavior *within* the still-face episode. The current study addressed this critical gap in the literature.

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Infant Behavior during the Still-Face Paradigm

During the SFP, the parent transitions from typical interaction to unresponsiveness--which allows the infant to attempt to initiate interactions that are not affected by adult behavior--and then resumes interaction. The SFP typically consists of three episodes during which the parent is asked to engage in typical face-to-face interaction (FF episode), to cease interaction and maintain a neutral expression (SF episode) and, finally, to resume interaction (RE episode). Extensive research has described changes in overall levels of infant behavior between these episodes (e.g., Toda & Fogel, 1993; Tronick et al., 1978; Weinberg & Tronick, 1996). Compared to the initial interaction episode, there is generally a decrease in mean levels of infant smiles and gazes towards the parent during the SF episode, and an increase in mean levels of negative facial expressions (Mesman et al., 2009).

Studies employing the SFP typically report on mean differences in infant behavior between the FF, SF, and RE episodes and occasionally describe individual or group differences in predictors or sequelae of still-face behavior. Almost never, however, do these studies report the proportion of infants who, in fact, exhibited the “still-face” effect. An exception is a small study by Fogel and colleagues (1982) who found that eight of ten infants showed the expected drop in interactive behaviors from the FF to the SF episode. In the current study, we examined individual variability in overall changes in infant behavior between episodes.

Infant Behavior Within the Still-Face Episode

Infant behavior may change within, as well as between, episodes of the SFP. Little is known, however, about the time course of behavior change during the SF episode. Utilizing a sample of seven infants, Tronick and colleagues (1978, p. 8) provided the following rich qualitative description of the time course of infant behavior in the SF episode: The infant initially orients toward the mother and greets her, possibly in an attempt to reengage the mother. When the mother fails to respond the infant “sobers and looks wary.” The infant then “alternates brief glances toward her with glances away from her.” Finally, “as these attempts fail, the infant eventually withdraws, orients his face and body away from his mother with a hopeless expression, and stays turned from her.” Cohn and Tronick (1983) examined 3-month-old infant reactions during a modified SFP wherein the mother simulated depression (i.e., spoke in a flat monotone, minimized touch with the infant, and remained expressionless). Infants in the simulated depression condition exhibited more bidirectional transitions among states of wary, protest, and looking away from the mother than during typical interactions. We are not aware, however, of any studies that formally analyze the time course of infant behavior in the SF episode. A more general example of the temporal unfolding of infant behavior during a SFP conducted with a female experimenter was provided by Goldstein and colleagues (2009). They found that rates of smiling over 15 second epochs of the SF episode quickly declined below baseline rates assessed in the last 15 seconds of the FF episode. The time course of smiling during the SF episode itself appeared to decline, but this possibility was not examined statistically.

Several explanations have been offered for changes in infant behavior during the SFP (Adamson & Frick, 2003; Gianino, Tronick, Field, McCabe, & Schneiderman, 1988; Mesman et al.,, 2009). During typical social interaction, the infant and the parent are responsive to one another’s behavior (Tronick et al., 1978). In the first six months of life, infants develop expectations concerning parental responses to their behavior (Beebe et al., 2007; Cohn & Tronick, 1988; Messinger, Ruvolo, Ekas, & Fogel, 2010). In the SF episode, however, the infant’s expectations about the parent’s behavior are violated. The parent provides conflicting messages by gazing at the infant, signaling a readiness to engage, while remaining unresponsive, signaling unavailability. Tronick and colleagues (1978) believed

that continuing parental unresponsiveness led infants to gradually cease attempts at re-establishing interaction and explained infants' decrease in social bidding from the FF to the SF episode. However, this hypothesis has not been tested. Instead, previous research has only examined differences *between* episodes of the SFP, and not focused on changes occurring *within* the SF episode.

Another explanation of infant behavior during the SF episode focuses on the role of the parent in helping infants regulate their emotions during typical interaction (Kopp, 1982). Field and colleagues (Field, 1994; Stoller & Field, 1982) argue that the parent typically provides an optimal level of stimulation that encourages infant positive engagement and minimizes infant negative engagement. During the SF episode, when the parent is unresponsive and not performing this function, the infant gradually becomes dysregulated. This would lead to expectations of an increase in negative affect over the course of the SF episode. Unfortunately, there have been no studies examining the dynamic changes in infant negativity during the course of the SF episode to ascertain whether and how this dysregulation unfolds across time.

Infant Behavior During the Still-Face Paradigm and Developmental Adaptation

As the SFP is believed to provide a window into infant emotion regulatory capacities (e.g., Kogan & Carter, 1996; Haley & Stansbury, 2003) a number of studies have examined the predictive significance of infant behavior in the SF episode for later child adaptation. Two key areas of inquiry have been the development of attachment security (Braungart-Rieker et al., 2001) and problem behaviors (Moore, Cohn, & Campbell, 2001) as both constructs reflect aspects of the young child's capacity for emotion regulation. Using the Toddler Behavior Checklist, Moore et al. (2001) found that infants who failed to smile at 6 months in the SF episode exhibited more externalizing-type behaviors than other toddlers at 18 months, while infants who failed to cry during the SF episode at 6 months exhibited fewer internalizing-type behaviors. In line with these findings, a meta-analysis by Mesman et al., (2009) indicated a link between infant behavior in the SF episode and later attachment security (see also Cohn, Campbell, & Ross, 1991 and Braungart-Rieker et al., 2001). In general, greater infant eliciting behavior and positive affect (e.g., smiling) during the SF episode was associated with later attachment status. These studies utilize summary measures of infant behavior in the SFP as predictors of later adaptation. We extend this previous research by asking whether dynamic changes within the SF episode are associated with infant attachment and infant behavior problems.

The Current Study

Noting a paucity of information on how individual infants respond to the SFP, we examined the percentage of infants who exhibited those changes in behavior that indexed the SF effect. Next we turn to changes in infant behavior within the SF episode. Tronick et al.'s original predictions—and subsequent explanations of SF effects—suggest dynamic changes in infant behavior during the SF episode. Yet there have been no systematic examinations of whether infants decrease social bidding and increase negativity over the course of the SF episode. The current study addressed this gap in the literature by examining the temporal dynamics of 6-month-old infant behaviors during a period of parental unresponsiveness. We modeled changes in infant social behaviors over the course of the SF episode using mixed effects models. This modeling determined whether and how the frequency of infant smiles, gazes to the parent, and positive bids to the parent declined with time during the SF episode, and whether and how infant negative facial expressions increased. Based on the descriptions provided by Tronick and colleagues (1978) we expected infants to begin the SF with high

levels of social behaviors (e.g., positive social bids to the parent) that would then quickly decline. More formally, we expected logarithmic change in which the rate of decline would be proportional to the level of behaviors at a given moment during the still-face. An opposite pattern—logarithmic increase—was expected for infant negative facial expressions. These analyses were the first to address the hypothesis that infants have expectations of maternal responsiveness, and respond to violations of these expectations by decreasing their attempts to engage the parent and by becoming upset. Building on pioneering work examining infant behavior in the SFP and later attachment security (e.g., Braungart-Rieker et al, 2001; Cohn et al., 1991; Kiser et al., 1986) and behavioral problems (e.g., Moore et al., 2001), we next examined the predictive significance of these patterns of change within the SF episode for later social and behavioral adaptation.

Method

Participants

Fifty-four parents and their six-month-old infants ($M = 5.84$, $SD = .39$) participated in the study. Three infants interacted with their father and the remaining 51 interacted with their mother. Infants were at least 36 weeks gestation at birth, had a birth weight greater than 2500g, and had an older sibling. Thirty-three infants had an older sibling with an autism spectrum disorder (ASD-sibs). Twenty-one infants had an older sibling without an ASD diagnosis. There were no significant differences related to the older sibling ASD diagnosis on any of the measures reported in this study. Twenty-four infants were female. Infants were 36% Caucasian, 32% Hispanic, 6% African American, 4% Asian, and 23% other. Half (50% of mothers and 44% of fathers) reported completing an advanced or professional degree and another 49% of mothers and 54% of fathers had some college or completed college. Eighty-six percent of families reported earning more than $50,000 per year.

Procedure

All dyads participated in the Still-Face Paradigm (SFP; Adamson & Frick, 2003; Tronick et al., 1978). Parents were asked to play with their infant without toys for 3 minutes (FF episode), stop playing and maintain a still-face with a neutral expression for 2 minutes (SF episode), and then resume play for another 3 minutes (RE episode). A 2-s tone sounded at the beginning of each episode to inform parents when a new episode had begun. This allowed for a maximum still-face episode of 118 seconds. Episodes were curtailed if infants cried steadily for 30 seconds. The SF episode ranged from 37 118 seconds ($M = 115.19$, $SD = 12.47$). Infants were placed in an elevated car seat and the parent sat directly opposite in the en-face position. The interaction was recorded with a camera directed at the infant's face for coding infant facial actions, a camera directed at the parent's face for coding potential violations of the still-face, and a camera that captured both the infant and the parent for coding the direction of infant gaze.

Behavior Coding

Infant gaze was coded as either at the parent's face or away from the parent's face. Twenty-five percent of the videos were randomly coded by a second, trained coder, and reliability was calculated using individual video frames as the unit of analysis ($\kappa = .90$). That is, agreement and disagreement were tabulated for each frame of video. Separate coders certified in the Facial Action Coding System (FACS; Ekman & Friesen, 1978) and trained in its application to infants (Oster**,** 2006) coded infant smiles (Action Unit 12, AU12) and cry-face expressions (involving brow lowering, AU4, lip stretching, AU 20, and typically involving mouth opening and mid-face actions such as upper lip raising). Thirty-three percent of the videos were randomly coded by a second coder (smile $\kappa = .70$; cry $\kappa = .78$). Mother smiles (AU 12) –a control variable—were also coded by FACS-certified coders.

Twenty-one percent of the videos were randomly coded by a second coder (κ = .77). Coding was performed in slow-motion for each frame and yielded a count of the number of frames per second (maximum 30) in which infants engaged in each behavior. A variable reflecting infant positive social bids (gazing at the parent while smiling) was also created. This procedure enabled examination of changes in the frequency of each behavior over successive seconds of the SF episode.

Attachment Classification

At 15 months, security of attachment was assessed using the Strange Situation Paradigm and classification guidelines (SSP; Ainsworth et al., 1978). SSP data were available for 42 infants. No significant differences on study variables were found between the 54 infants who had only SFP data and the 42 infants with SFP and attachment data ($p < .10$). Classifications were made for the three organized categories: (A) avoidant; (B) secure; and (C) resistant. Attachment was coded by an experienced coder who successfully passed a centralized reliability exam. Thirty-seven percent of the sample was double-coded by an expert attachment coder. Satisfactory agreement was reached on three-way attachment classifications (85% agreement; κ = .61).

Behavior Problems

When infants were 18 months old, behavior problems were assessed by maternal report on the Child Behavior Checklist 1.5–5 year version (CBCL; Achenbach, 2000). CBCL data were available for 37 infants. No significant differences on study variables were found between the 54 infants with only SFP data and the 37 infants with SF episode and CBCL data ($p < .10$). The CBCL contains a list of 99 items reflecting behavior problems, which are rated by parents on a 3-point scale from 0 (not true) to 2 (very true or often true) for their child. These scores are summed to produce a total raw score, which is then standardized against established norms to generate T-scores. Cronbach's alpha was .76 for the internalizing behavior scale and .88 for the externalizing behavior score. The internalizing and externalizing behavior summary T-scores were used in the present study.

Analytic Plan

A repeated measures ANOVA was conducted to test for mean differences in behavior between episodes. This is typically referred to as the SF effect (Mesman et al., 2009). In addition to assessing the standard SF effect in the sample, we calculated the number of infants who displayed the typical SF effect as an index of individual variability. To test for changes in behavior as a function of the time elapsed during the SF episode, we used hierarchical linear modeling implemented through Hierarchical Linear Modeling 6.06 (HLM; Raudenbush & Bryk, 2002). Our model specification was as follows:

$$Predicted\ Infant\ Behavior = b_0 + b_1(Log\ Seconds) + e$$

where b_0 represents the infant's behavior at the beginning of the SF episode, $b_1(Log\ Seconds)$ is the time elapsed during the SF episode in log10 seconds, and e is a residual component. This model was specified for each of the infant behaviors separately. Time was modeled as a logarithmic function because we expected curvilinear changes in infant behaviors where the rate of change was proportional to the current level of the behavior (see Figure 1). We did not center the time variable, because the start of the SF episode is a meaningful zero point from which infant affective change commenced. Centering the time variable would have hindered model interpretation and has no effect on significance levels (Kreft, de Leeuw, Aiken, 1995). Our models specified each coefficient as random, allowing us to test for individual variance in the slopes of infant behaviors over time. Each HLM

model produced an individual slope for each infant. We utilized these slopes, indexing the direction and strength of change over time in the SF episode, to predict infant attachment and behavior problems.

Results

Preliminary Analyses

Preliminary analyses indicated that infant gender and parent gender were not significantly related to infant behaviors during the SFP. Parental age, education, ethnicity, and family income were also not related to infant behavior. Although previous studies using this sample containing ASD-sibs (see Cassel et al., 2007 and Ibanez, Messinger, Newell, Lambert, & Sheskin, 2008) revealed some differences in responding to the SFP compared to infants with typically developing older siblings, there were no significant differences related to older sibling ASD diagnosis on any of the measures reported in the current study. These variables were not included in subsequent analyses. We next examined the standard still-face effect.

Mean levels of infant behaviors between episodes of the still-face paradigm— We conducted repeated measures analyses of variance (ANOVA) to examine infant behavior between episodes of the SFP. These ANOVAs indicated that mean proportions of all infant behaviors varied between SFP episodes (see Table 1 for *M* and *SD* of all variables). Between the FF and SF episodes, mean levels of infant gazes at the parent's face, $F(2, 104) = 33.98$, $p < .001$, $\eta_p^2 = .40$, smiles, $F(2, 104) = 49.93$, $p < .001$, $\eta_p^2 = .49$, and positive social bids, $F(2, 104) = 40.20$, $p < .001$, $\eta_p^2 = .44$, declined, while infant cry-faces, $F(2, 104) = 11.68$, $p < .001$, $\eta_p^2 = .18$, increased. Between the SF and RE episodes, mean levels of infant gazes at the parent, smiles, and positive social bids increased. Infant cry-faces, however, remained at a similar level between the SF and RE episodes. There were significantly fewer infant smiles and positive social bids in the RE than the FF episode; by contrast, infant cry-faces were higher in the RE than the FF episode. Comparisons of mean levels of infant gaze and smiling between episodes of the FFSF have been presented in previous studies for 31 (Cassel et al., 2007) and 34 (Ibanez et al., 2008) of the 54 infants. This is the first report of changes in infant behaviors over the course of the still-face.

Next, we examined individual differences in changes in behavior from episode to episode during the SFP. We calculated the number of infants who showed the expected direction of change from the FF to SF episode, SF to RE episode, and FF to RE episode. From the FF to the SF episode, 83.3% of infants decreased gazes at the parent, 92.6% decreased smiles, 88.9% decreased positive social bids, and 51.9% increased cry-faces. From the SF to the RE episode, 85.2% increased gazes at the parent, 75.9% increased smiles, 81.5% increased positive social bids, and 38.9% decreased cry-faces. Finally, from the FF to the RE episode, 48.1% showed fewer gazes at the parent, 61.1% fewer smiles, 61.1% fewer positive social bids, and 61.1% increased cry-faces.

Change with Time in Infant Behaviors during the Still Face Episode

We began by examining a variety of alternate models. These included hierarchical linear models based on a Poisson distribution of the dependent variable, and models controlling for the effect of maternal violations of the still-face (i.e., smiles). In both cases, results were equivalent to those reported here. We also tested models that did not include logarithmic transformations of elapsed time. Results were similar to the final models utilizing the log transformation although somewhat fewer infants exhibited coefficients indicating change with time over the course of the still-face episode.

Results of the final HLM models are presented in Table 2 and Figure 1. The significant intercept terms indicate that infants began the SF episode with gazes at the parent, smiles, and positive social bids that were significantly greater than zero. The significant slope terms in Table 2 indicate that infant gazes at the parent's face declined with time during the SF episode, with time accounting for 7.3% of the variance in infant gazes. Infant smiles and positive social bids to the parent also declined during the SF episode, and time accounted for 11.1% and 14.2% of the variance in infant smiles and positive social bids, respectively. Finally, infant cry-faces increased during the SF episode, and time accounted for 15.9% of the variance in infant cry-faces. The variance component of each of the slopes was significant (see Table 2), indicating individual variability in how infant communicative behaviors changed with time in the SF episode. Using the individual slope values from the HLM models we found that 63% of infants (n = 34 of 54 who exhibited the behavior) exhibited a decline over time in gazes at the parent, 72% (n = 33 of 44 who exhibited the behavior) exhibited a decline in smiles, and 81% (n = 30 of 37 who exhibited the behavior) exhibited declines in social bidding. Eighty-four percent (n = 26 of 31 who exhibited the behavior) of infants exhibited an increase in cry-faces over the course of the SF episode. Infants who did not exhibit a given behavior during the SF episode were excluded from these calculations because they did not have a slope coefficient. Arguably, however, infants who did not engage in any instances of the behavior in question exhibited no change in slope. Analyzed in this fashion, the percentage of infants (63%) who exhibited a decline in gazes at the parent is unchanged while 61% of infants displayed a decline in smiles, 56% exhibited a decline in positive social bids, and 48% exhibited an increase in cry-faces over the duration of the SF episode.

Infant Behavior and Later Adaptation—We examined associations between dynamic changes in behaviors within the SF episode at 6 months and attachment at 15 months of age (Secure n = 29; Resistant n = 8; Avoidant n = 5). In these analyses, separate ANOVAs were calculated for each infant behavior using the slope values from the previous HLM. The slopes indexing change in gazing at the parent over the SF episode differed significantly by attachment status, $F(2, 39) = 3.76$, $p < .05$, $\eta_p^2 = .16$ (n = 42). LSD contrasts indicated that infants later classified as avoidant ($M = -4.14$, $SD = 2.39$) displayed a significantly greater negative slope than infants later classified as secure ($M = -1.14$, $SD = 2.79$) or resistant ($M = -.07$, $SD = 2.22$). Infants classified as secure displayed a significantly greater negative slope than infants classified as resistant. No significant differences emerged for infant smiles, $F(2, 32) = .45$, $p > .05$, $\eta_p^2 = .03$ (n = 35), positive social bids, $F(2, 29) = .73$, $p > .05$, $\eta_p^2 = .05$ (n = 32), or cry-faces, $F(2, 26) = .65$, $p > .05$, $\eta_p^2 = .05$ (n = 29). Infants who did not exhibit a given behavior during the SF episode were excluded from the relevant analysis because they did not have a slope value. We repeated the analyses including infants who did not exhibit the behavior using a zero for their slope coefficient. The significant finding for gaze at the parent remained unchanged because all infants had a slope value for that behavior. The results for infant smiles, $F(2, 39) = .40$, $p > .05$, $\eta_p^2 = .02$, positive social bids, $F(2, 39) = .67$, $p > .05$, $\eta_p^2 = .03$, and cry-faces, $F(2, 39) = .86$, $p > .05$, $\eta_p^2 = .04$ remained unchanged (n = 42 for all analyses).

Finally, we examined the association between infants' dynamic changes in behaviors within the SF episode and behavior problems at 18 months. In these analyses, correlations were calculated between the slope values obtained from the previous HLM models and the CBCL. Increases in the frequency of cry-faces during the SF episode were associated with fewer internalizing problems (n = 21, $r = -.52$, $p < .05$). No significant associations with internalizing problems were found for infant smiles (n = 32, $r = .26$, $p > .05$), positive social bids (n = 26, $r = .22$, $p > .05$), or gazes at the parent (n = 37, $r = -.14$, $p > .05$). Likewise, we did not find significant associations between changes in infant behaviors within the SF episode and later externalizing behaviors. Infants who did not exhibit a given behavior

during the SF episode were excluded from these analyses because they did not have a slope value. We then repeated the analyses including infants who did not exhibit the behavior using a zero for their slope coefficient. The pattern of results with respect to internalizing behaviors remained unchanged for infant cry-faces ($n = 37$, $r = -.36$, $p < .05$), smiles ($n = 37$, $r = .19$, $p > .05$), positive social bids ($n = 37$, $r = .19$, $p > .05$), and gazes at the parent ($n = 37$, $r = .00$, $p > .05$). As in the previous analyses, there were no significant associations with externalizing behaviors.

Discussion

In this study, we examined infant's interactive competencies with dynamic analyses of infant social behavior during the SF episode of the SFP. Since Tronick et al.'s (1978) original descriptions, explanations of the impact of the SF episode have assumed that infant behavior changes over time as infants decrease bidding to an unresponsive parent. Testing this hypothesis for the first time we found that infant gazing at the parent's face, smiles, and positive social bids (gazing at the parent's face while smiling) decreased as parents remained impassive; infant negative expressions increased. There was, however, considerable individual variability in these dynamic still-face effects. Between one-half and two-thirds of infants exhibited the hypothesized changes with time. These individual differences, in turn, were associated with attachment patterns and internalizing behavior problems.

The SFP produces robust and marked changes in behavior between SFP episodes. Infants typically transition from positive engagement during the FF to negative, withdrawn behaviors during the SF, with a partial rebound in these behaviors during the RE episode (Mesman et al., 2009). We replicated these patterns and examined the individual variability associated with the SF effect. Over three-quarters of infants displayed the expected changes in pattern of gazes to the parent, smiles, and positive social bids in transition to and from the SF episode. Only half of infants, however, displayed the expected pattern of cry-faces. Infants showed the expected pattern of increased cry-faces from the FF to the SF episode, but remained at heightened levels from the SF to the RE episode. Weinberg and colleagues (1996) argued that the RE episode continues to be stressful for the infant because the parent and infant must work to reestablish interactive patterns. Consistent with this interpretation, we found that approximately half of infants decreased levels of gazing from the FF to the RE, and 60% decreased smiling. This documentation of individual differences in the standard still-face effect provided a basis for exploring how the still-face effect occurs in time.

The Dynamic Still-Face Effect

In the SF episode, the parent becomes impassive while gazing at the infant. The parent's en face position presumably invites infant social behavior, while the parent's lack of response depresses that behavior (Adamson & Frick, 2003; Tronick et al., 1978). If this is the case, infant social behaviors should decline with time in the face of a continuing lack of parental responsiveness. In line with this hypothesis, infant gazes to the parent, smiles, and positive social bids declined logarithmically as the SF episode progressed. The logarithmic decrease means that higher levels of social behavior at earlier time points were followed by relatively sharp decreases in behavior at subsequent time points. It is noteworthy that there was significant variability in the time course of these behaviors. Among infants exhibiting a given social behavior, approximately one-third of infants did not exhibit a time-based decline in that behavior. The psychological meaning of the still-face for these infants—and for infants who did not exhibit the behavior at all is not clear.

Overall, the current results are consonant with the position that, during the SF, infant's expectations that the parent will respond to their social behaviors were violated. The

temporal decrease in smiling we documented is similar in form to that described by Goldstein et al. (2009) during a SFP conducted with an experimenter. These researchers also examined non-cry vocalizations in the SF. Non-cry vocalizations were higher during a two-minute SF episode than during naturalistic interaction and appeared to peak during the middle of this still-face period. Although we did not examine non-cry vocalizations in this study and although they were not among the behaviors Tronick and colleagues (1978) hypothesized would decline in response to parental unresponsiveness, the time-course of vocalizing in response to the SF manipulation is worthy of additional attention. Finally, we did not detect ethnicity differences in this diverse sample, suggesting the generalizability of effects. Nevertheless the sample was predominantly well-educated and middle to upper class, limiting the generalizability of results to other socioeconomic groups.

Infant expressions of negative emotion (i.e., cry-faces) increased throughout the SF episode. This finding is consistent with theory regarding parent responsiveness and infant emotion regulation (Field, 1994). In the SF, the parent is precluded from helping infants regulate their emotions by responding to social overtures or comforting (Kopp, 1982). Over time, infant negative emotion increases. It is noteworthy that only half of the individual infants in the sample displayed this pattern of increased negative expressions. This suggests the need for explicit recognition of infant variability in explanations of the SF effect that suggest infants are becoming dysregulated. It is noteworthy, in this context, that increases in frank expressions of negative affect were not a feature of Tronick and colleague's (1978) original description of infant behavior in the still-face.

In this study we were primarily interested in examining the potential variability in infant responses during the SF episode. The original descriptions of changes in infant behavior during the SF episode, provided by Tronick and colleagues (1978), relied on the observation of only seven infants and did not indicate whether all infants displayed the same pattern. We found that a majority, but not all, of the infants in our sample showed a decline in gazes at the parent, smiles, and positive social bids across the SF episode. Slightly less than half of the infants showed the pattern of increased cry-faces across time. Further, the elapsed time of the SF episode only accounted for a small proportion of variance in each of the infant behaviors. Although Tronick and colleagues (1978) were largely correct in their original descriptions of infant behavior during the SF episode, infant responses are not uniform. This variability in the temporal course of infant behavior has not been previously documented. One possibility is that variability in infant responses reflects the development of distinct patterns of response to parental unavailability and other elicitors of negative emotion.

The Dynamic Still-Face Effect and Later Adaptation

The current study also provides evidence for the predictive significance of within SF episode change dynamics and indices of later developmental adaptation, specifically attachment security and parent-reported behavior problem symptomatology, both of which index aspects of the developing child's emotion regulation capacities. With respect to attachment security, we found that infant gaze slopes during the SF episode were associated with later organized attachment categories such that infants later judged avoidant showed the strongest decline in gazing within the still-face followed by infants later judged as secure, and resistant, respectively. This finding converges well with the notion of second-order attachment regulatory strategies of deactivation and hyperactivation in response to parental unavailability (Main, 1990; Kobak et al., 1993). In this sense, avoidant infants would be expected to be most likely to deactivate (i.e., steeper declines in gazing behavior) and resistant infants least likely to deactivate (i.e., shallower declines in gazing) attachment regulatory strategies in the face of parental unresponsiveness, with secure infants showing an intermediate regulatory profile. These within SF episode findings provide some evidence

that attachment-like behaviors (i.e., gaze) at six-months may be conceptualized as precursors to later, consolidated attachment patterns (Kogan & Carter, 1996).

With respect to later problem behavior, we found that increases in cry faces within the SF episode were associated with fewer mother-reported internalizing symptoms when toddlers were 18-months old. Moore et al. (2001) found that infants who did not cry during the still-face had lower internalizing scores on the Toddler Behavior Checklist (TBC; Larzelere, Martin, & Amberson, 1989) than those who did cry. These findings are somewhat orthogonal in that analyses of change in cry-faces over time can only be performed for infants who exhibited the behavior. While Moore et al.'s finding implicates a potential benefit of not crying, the current results suggest that when cry-faces are present, increasing levels of cry-faces—which we interpret as an active attempt at interactive re-engagement in the face of maternal unresponsivity—reflect a dynamic behavioral response that is unlikely to be consonant with later internalizing-type behaviors which often involve passive and withdrawn features. These preliminary findings with respect to infant attachment and infant behavior problems merit further attention and replication.

Future Research and Conclusions

By charting new terrain in describing the dynamics of the SF effect, the current study generates new research questions and hypotheses. If it is the case that infant bids are declining in response to continued lack of parental responding, researchers might manipulate the SFP by allowing parents to briefly resume responding to their infant in the middle of a standard SF episode. Our findings suggest that infants would respond by renewing their positive social bids, which would then decline again with time after parent responding stopped for the second time. Another approach would be to utilize fine-grained coding of infant behavior to determine whether the *intensity* of infant positive and negative infant expressions change with time in the still-face. Researchers might also build on previous research (Cohn & Tronick, 1983) to ask whether infants' coordinate multiple behavioral signals changes with time during the SFP. Longitudinal investigations could address the hypothesis that infant bidding during the still-face will decline more rapidly with time among older infants (Lamb, Morrison, & Malkin, 1987).

In summary, we modeled dynamic changes in infant behavior during a period of parent impassivity describing a phenomenon we have labeled the *dynamic still-face effect.* Infant gazes at the parent, smiles, and positive social bids declined as time progressed, while infant negative expressions increased. These patterns of change quantify early descriptions provided by Tronick and colleagues (1978). They highlight the importance of temporal dynamics in understanding early behavior and provide a conceptual basis for understanding overall changes in infant behavior in the transition from the FF to the SF episode. Individual variability in the dynamic change was linked to later infant adaptation as indexed by attachment status and behavior problems. This dynamic still-face effect, then, is a potential index of functionally important individual differences in infant responses to the age-appropriate stressor of parental unresponsiveness.

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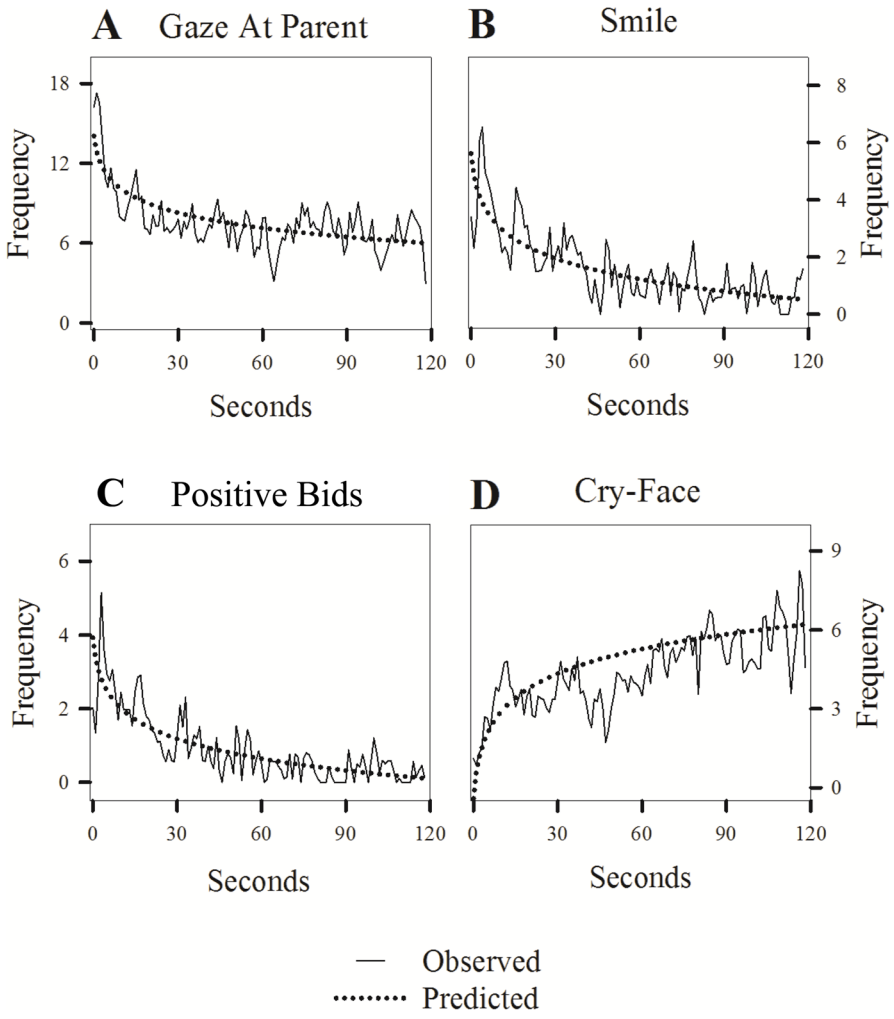

Figure 1.

Observed and predicted mean frequencies of A) Gazes at parent, B) Smiles, C) Positive social bids, and D) Cry-face expressions over time in the still-face episode. Frequencies refer to the number of frames per second (maximum 30) in which a particular behavior occurred. Social bids were defined as smiles in the presence of gazing at the parent. Predicted refers to the expected frequency based on a hierarchical linear model containing an intercept and a linear term indexing behavior change proportional to log10 transformation of the number of seconds elapsed. Although the model only contains linear terms, the log transformation allows for curvilinear change over seconds.

Table 1

Changes in infant behaviors across episodes of the SFP

	Episode		
	Face-to-Face	**Still-Face**	**Reunion**
Infant Behaviors	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Gaze At Parent	.47 (.22)	.26 (.18)	.48 (.23)
Smile	.28 (.18)	.05 (.07)	.21 (.17)
Positive Social Bids	.20 (.14)	.03 (.05)	.15 (.14)
Cry-Face	.03 (.12)	.16 (.26)	.17 (.28)

Table 2

Change in infant behaviors during the SF episode as a function of elapsed time

	Intercept	Slope			
Variable	**Est. (*SE*)**	**Est. (*SE*)**	**Variance Accounted For**	**Variance Component of Intercept**	**Variance Component of Slope**
Gaze At Parent	14.06 (1.82)***	−1.68 (.39)***	7.3%	162.70***	7.08***
Smile	5.62 (1.16)***	−1.07 (.25)***	11.1%	67.70***	3.20***
Positive Social Bids	3.93 (1.02)***	−.80 (.22)**	14.2%	54.15***	2.48***
Cry-Face	−.41 (1.33)	1.38 (.40)**	15.9%	88.24***	8.13***

Note.

* $p < .05$;

** $p < .01$;

*** $p < .001$.