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The many faces of the Still-Face Paradigm: A review and meta-analysis

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ABSTRACT

The Still-Face Paradigm (SFP) designed by Tronick, Als, Adamson, Wise, and Brazelton (Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). Infants response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child and Adolescent Psychiatry, 17, 1–13)* has been used for many different purposes in over 80 empirical studies. In the current paper, the nature and correlates of infant behavior in the SFP were examined in a systematic narrative review and a series of meta-analyses. The results of the meta-analyses confirmed the classic still-face effect of reduced positive affect and gaze, and increased negative affect, as well as a partial carry-over effect into the reunion episode consisting of lower positive and higher negative affect compared to baseline. The still-face effect is very robust as it was found regardless of most sample variations such as infant gender and risk status, and regardless of most procedural variations, such as the length of the SFP episodes and the use of intervals between episodes. The few moderator effects that were found in the meta-analyses tended to put findings from the narrative review in a new perspective. Additional meta-analyses confirmed the narrative review in finding that higher maternal sensitivity predicted more infant positive affect during the still-face. Infants' higher positive affect and lower negative affect during the still-face were predictive of secure attachment at age 1 year. The meta-analytic results for maternal depression were equivocal. Implications for future research include a need for studies testing the role of the adults' identity (parent versus stranger, mother versus father) to elucidate the relationship-specificity of the still-face effect. Also, the role of maternal sensitivity and temperament as potential moderators of the still-face effect need to be examined further. On a procedural

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level, the effects of the timing of the still-face and of the duration of the reunion on infant responses deserve future research attention.

Introduction

The Still-Face Paradigm (SFP) was first introduced by Tronick, Als, Adamson, Wise, and Brazelton (1978) to test the hypothesis that infants are active contributors to social interaction. In the SFP, infants are generally observed in a three-step face-to-face interaction with an adult: (1) a baseline normal interaction episode, (2) the 'still-face' episode in which the adult becomes unresponsive and maintains a neutral facial expression, and (3) a reunion in which the adult resumes normal interaction. The still-face has been found to evoke marked changes in infant behavior, now known as the still-face effect. Infants typically show increased gaze aversion, less smiling and more negative affect during the still-face compared to during normal face-to-face interaction (e.g., Gusella, Muir, & Tronick, 1988; Kisilevsky et al., 1998; Toda & Fogel, 1993). Since its introduction, many studies have used the SFP for a wide variety of research purposes, showing the versatility of the paradigm. Infant responses to the SFP have not only been found to be related to the quality of parental care-giving (e.g., Tarabulsy et al., 2003), but are also associated with future adaptation, such as attachment quality (e.g., Braungart-Rieker, Garwood, Powers, & Wang, 2001) and behavior problems (Moore, Cohn, & Campbell, 2001). On the other hand, considerable variations in design, procedures, and outcome measures combined with the lack of a single widely accepted theoretical framework that may explain the still-face effect, make it rather difficult to provide an all-inclusive synthesis of this growing body of research.

The review of the SFP literature by Adamson and Frick (2003) provided an insightful historical overview and a comprehensive global picture of the development of the SFP. Their description of the experimental precursors of the still-face effect places the SFP in a valuable historical perspective. Further, they show how contemporary research has contributed to our understanding of infant–adult interaction. However, their review was not intended to give an exhaustive review of all research results regarding the SFP. Thus, specific results are discussed very briefly and for some issues it is only noted that several studies have been conducted, without presenting the results. In addition, the authors noted that their review "(...) is a complement to, not a substitution for, theoretical interpretations of robust findings or meta-analyses of the empirical literature (...)" (Adamson & Frick, 2003, p. 453). In the first part of the current paper we provide a narrative review of the results of all empirical studies using the SFP. This review aims to provide a structured insight into the themes that have been addressed using the SFP, as well as clarify reasons for and consequences of variations in the basic SFP procedure. In the second part we present the results of a series of meta-analyses that examine the magnitude and potential sample and procedural moderators of the still-face and reunion effects with respect to a variety of infant behaviors. In the third part, major themes from the narrative review are examined in three additional sets of meta-analyses testing the associations of infant behavior in the SFP with quality of attachment, maternal behavior, and maternal depression.

Several theoretical explanations for the classic still-face effect on infants have been proposed. In the first report of the still-face effect, Tronick et al. (1978) proposed that the procedure violates the 'rules' of face-to-face communication because the adult partner conveys contradictory information to the infant. The adult looks at the infant, but is completely unresponsive. Eye contact signifies openness to interaction, which is belied by the lack of responsiveness when the infant attempts to engage the adult. As Tronick et al. (1978) put it, the mother is "communicating Hello and Goodbye simultaneously" (p. 11). As a result of this contradiction, the infant reacts with confusion and initially tries to re-establish reciprocity, but eventually grows wary and withdraws from the situation by actively avoiding the sight of the adult and looking away. Apparently, young infants have already formed clear expectations of social interactions, and find even short temporary violations of these expectations upsetting.

In later publications, Tronick and his colleagues formulated the Mutual Regulation Model (MRM) to explain the still-face effect in more detail (Gianino & Tronick, 1988; Tronick & Weinberg, 1997). The

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MRM describes mother–infant interaction as jointly regulated toward a state of reciprocity through a process of feedback that operates primarily on an affective level. Infants' affective displays reflect their appraisal of the interaction, and function as powerful communicative messages to the adult partner. Reciprocity is not always achieved however. In fact, imperfect interaction and mismatching of communication is the rule rather than the exception in mother–infant interactions (Tronick & Gianino, 1986). When interacting with a sensitive adult partner, the infant can repair these mismatches by showing affective displays that send the right signal to the adult who will then adjust his or her behavior accordingly. Successful repair gives infants a sense of efficacy for having achieved a change in interaction, and allows them to develop self-regulatory skills (Gianino & Tronick, 1988). This chain of events is applicable to 'normal' mismatches that happen regularly in interaction, but in the still-face episode of the SFP, the mismatch is more prolonged, and more intense. Infants' attempts to repair the mismatch by showing negative affect as a message to the adult partner will obviously fail as long as the still-face episode persists. This failure of the infants' interactive regulatory capacities may lead to self-regulation and coping strategies such as gazing away to avoid the stressful stimulus, or self-soothing behavior (e.g., hand-to-mouth actions).

Since then, Tronick has advanced the Dyadic States of Consciousness Model (DSCM) as an elaboration of the MRM (Tronick, 2005; Tronick et al., 1998). A state of consciousness (SOC) is described as an individual's continuously developing knowledge of the world and his relationship to that world. This state is psychobiological as it encompasses a complex organization of body, brain, behavior, and experience (Tronick, 2005). An important feature of a SOC is that it can only be 'age-possible' in the sense that the individual's knowledge is constrained by his developmentally determined capacities at a certain time point. A dyadic state of consciousness is formed when successful mutually regulated interactions are achieved. Then, the meanings of the partner's SOC is assimilated into the infant's own SOC which will lead to the infant gaining a more coherent and complex knowledge of the world. This is achieved through affective exchanges that inform the infant of his own self, characteristics of the other person and of his relationship with that person. For example, a mother smiling in response to an infant smile sends the message that he himself is happy, that his mother is friendly and responsive and that the relationship is positive and warm. In the still-face episode of the SFP, a dyadic state of consciousness is impossible because of the unresponsiveness of the adult partner which does not allow for exchanges of affective meaning. This idea is similar to the notion of the confusing simultaneous messages of "hello" and "goodbye" that Tronick et al. (1978) put forward in their original paper. The infant is forced to rely on its own SOC, which may start to lose coherence as the partner's input is contradictory and impossible to assimilate (Tronick, 2005).

An alternative theory to explain the still-face effect was proposed by Field (1994; Stoller & Field, 1982), who states that the parent is an important modulator of infant emotion regulation and will ideally provide optimal stimulation and synchronous interaction. If the parent is unavailable, synchrony is lost and the infant's emotions become dysregulated. This leads to changes in the infant's behavior, emotions, and physiological state. In other words, the infant needs an external regulator to achieve optimal arousal levels, and will show disorganization of emotion and behavior when the regulator is absent or non-optimal. According to this model, strangers are less capable at providing optimal stimulation because they are less familiar with the infant's preferences and stimulation thresholds. Field (1994) focuses on the effects of parental depression as an example of emotional unavailability and presents evidence that its effects are more severe than those of parental physical absence. In the former case, stimulation is not missing, but is disruptive and noncontingent. In these cases, infants are faced with a chronic lack of an external regulator, which may explain the long-term detrimental effects of parental depression on infants' emotion regulation capacities (e.g., Field, 1995). The still-face effect is of course more short-lived, but according to this model it is caused by the same mechanism of non-optimal stimulation that leads to emotional disorganization in infants.

Several similar general models about early emotional development and communication have been applied to the SFP. Fogel (1982) hypothesized an affective tolerance model, based on the work of Solomon (1980). Fogel's model describes how infants become increasingly more capable of tolerating high-intensity stimulation without withdrawing from the interaction. Infants develop skills to regulate the arousal caused by face-to-face interaction, as evidenced by so-called tension-release cycles as proposed by Sroufe and Waters (1976). These cycles are characterized by initial attentive behavior accompanied by increased tension as shown by increases in heart rate, followed by a release of tension in the form of smiling or laughter (Brazelton, Koslowski, Main, Lewis, & Rosenblum, 1974; Sroufe & Waters, 1976). The smile seems to function as a regulator of arousal, and as a communicative signal toward the adult partner who can infer that the infant is at an optimal level of arousal. Using these signals, a sensitive and responsive adult can facilitate regulation, which will increase the infant's capacity to tolerate affective arousal. In the SFP, the tension-release cycle is marred by the unresponsive adult and leads to negative affect and attempts to 'escape' by gaze aversion. In a similar vein, Trevarthen's (1977) description of intersubjectivity in mother–infant communication contains clear examples of the mother as a regulator of infant affect. Mothers monitor their infants' reactions, imitate them, and adapt the level of stimulation to the expressions of the infants. During these exchanges, mother and infant share affect and intention with each other, fostering the development of infant emotional competence. When mother stops sharing and her intentions are paradoxical, as in the still-face, the infant's attempts at communication fail and lead to confusion and distress (Trevarthen, 1977).

In sum, several elements of infant emotional development have been proposed to explain the still-face effect. Most emphasize the importance of an adult as a regulator of infant arousal who shares meaning and intent with the infant such that the infant may use the adult as an aid to increasing his self-regulation skills. Further, the infant is an active contributor to the interaction as evidenced by clear signaling to elicit optimal responses from the caregiver. When failing to do so during the still-face episode, the infant is left to regulate its own emotions, which is reflected in increases in negative affect and gaze aversion as the infant has only a limited array of regulatory capacities.

As we have seen, the theoretical explanations of the still-face effect show many similarities, but also differ in their primary focus and details of the processes involved. Just as the theories to explain still-face effect are not definitive, the practical procedure of the SFP is not set in stone. Researchers who are interested in finding out more about the SFP as a procedure may end up as confused as the infants for whom the paradigm was designed. Studies vary considerably in the ways that the SFP is conducted and the paradigm is used for a multitude of purposes. Although most studies use the three-step procedure described above, there are many variations on this basic format. Actually, in the original Tronick et al. (1978) paper, the still-face procedure consisted of only two episodes: normal interaction and the still-face episode, separated by an interval of 30 s during which mother would turn away from the infant. The two episodes were presented in counterbalanced order. In the literature since then, most studies use the three-step procedure, and many do not use intervals between phases anymore. However, even within and around the basic three-step procedure, many minor and major variations have been used since 1978. Studies aimed at exploring the effects of specific aspects of the SFP have to vary or add certain elements to find out what their effects are. For instance, touch has been added to the still-face episode (e.g., Stack & Arnold, 1998), adults have been asked to pose with other facial expressions such as sad or happy (D'Entremont and Muir, 1997; Rochat, Striano, & Blatt, 2002), and a physical separation from the adult has been added (e.g., Field, Vega-Lahr, Scafidi, & Goldstein, 1986). In other studies, the SFP has been used as a tool for other purposes or special samples that require changes in the procedure. Such variations include having two adults interact with the infant to examine triadic social behavior (Fivaz-Depeursinge, Favez, Lavanchy, de Noni, & Frascarolo, 2005), or adding an imitation phase in a sample of children with Autism (Nadel et al., 2000). Variations on the basic procedure have also been used without a clear reason to do so, such as including toys during normal interaction (Garrity-Rokous, 1999), or having the child on the mother's lap during an SFP with a stranger (Hobson, Patrick, Crandell, Garcia-Perez, & Lee, 2005).

Because of the lack of a uniform approach, a systematic review of all the studies that have used the SFP in some way can provide insight into the reasons for and the consequences of these variations. Nevertheless, a substantial body of research has used a relatively common procedure, using the SFP as a standardized measure of infant–adult interaction. A meta-analysis of these studies can contribute to our understanding of the still-face effect (baseline to still-face), the subsequent recovery effect (still-face to reunion), and a potential carry-over effect (comparing reunion to baseline) in terms of their magnitude for different behaviors, and of potential sample and procedural moderators of these effects.

Narrative review

Studies employing the SFP were collected by systematically searching the databases PsycInfo, Web of Science, Dissertation Abstracts International, ERIC, and PAIS, using the keywords 'still-face' and 'still-face'. The majority of publications found in the first three databases were relevant to our meta-analyses. The latter two databases yielded mostly irrelevant publications because of sentences like "Minorities *still-face* considerable prejudice." We also conducted a Web of Science search for publications citing the Tronick et al. (1978) paper that first described the still-face effect. For this review, we included all studies that use some form of adult still-face with children in combination with an episode of normal interaction, regardless of the specific procedures used. The last searches were completed on October 16, 2007 resulting in a total of 85 studies for the narrative review (some with multiple publications). The review is organized according to salient themes and issues in still-face research. Our first broad categorization of the literature distinguished three types of studies: (1) studies that investigate infant responses to the SFP using different procedures and different samples; (2) studies that examine infant responses to the SFP in relation to some external variable; and (3) studies that go beyond the original SFP to explore new avenues of research. Because these broad categories included too many studies to provide a clear overview of the literature, we then subdivided the categories into more specific themes. Within the first category, we identified the following themes: (A) clarifying the elements of the still-face effect; (B) infant physiological responses to the still-face (C) stability of infant responses to the SFP; (D) infant characteristics in relation to the still-face effect. Within the second category we distinguished the themes of (E) maternal behavior in relation to infant responses in the SFP (F) maternal psychopathology in relation to infant responses in the SFP; (G) infant behavior in the SFP in relation to attachment; (H) infant responses to the SFP in relation to other behaviors. Finally, within the third category, two more themes were identified: (I) adaptations of the SFP to special populations of children; and (J) the SFP as a method for other research questions. Each publication was read carefully and labeled according to these nine themes (multiple labels were possible). We will now review the studies according to the nine themes. Studies addressing multiple themes are discussed under more than one heading.

Clarifying the elements of the still-face effect

The classic still-face effect is characterized by a decrease in gaze and positive affect and an increase in negative affect from baseline to the still-face episode and (partial) recovery during the reunion episode (Adamson & Frick, 2003; Tronick et al., 1978). Some additional changes in infant behaviors that occur when the adult partner becomes still-faced include an increase in motor activity (e.g., Jamieson, 2004; Lamb, Morrison, & Malkin, 1987; Stoller & Field, 1982) and tactile object- and self-stimulation (e.g., Moszkowski & Stack, 2007; Rosenblum, McDonough, Muzik, Miller, & Sameroff, 2002; Tronick et al., 2005). Regarding neutral affect, some studies reported an increase from baseline to still-face (Abelkop & Frick, 2003; Cassel et al., 2007; Toda & Fogel, 1993), while others report a decrease (Kogan & Carter, 1996; Yirmiya et al., 2006). Focusing specifically on hand and arm movements, Legerstee, Corter, and Kienapple (1990) showed that during the still-face episode, closed hands co-occurred with gaze aversion, and pointing was preceded by distress and vocalizations. One could argue that these behavior changes are due to the mere passage of time, or to boredom during the passive still-face episode. Gusella et al. (1988) presented a between-subjects design comparing the SFP to normal interaction without experimental changes in maternal behavior for the same length of time. Whereas the classic still-face effect and the reunion effect was found for the infants in the SFP-condition, no effects were observed in the no-change condition, which has been confirmed by other studies that included control conditions (Cohn & Elmore, 1988; Haley, 2001; Kisilevsky et al., 1998).

An important issue in clarifying the still-face effect concerns the infant's interpretation of the reason for the break in contact during the still-face. Do infants react simply to the loss of contingent social interaction, regardless of the meaning attached to this loss? Or is the confusion about the adult's intentions (looking at the infant while remaining unresponsive) the main cause of infant distress?

The first evidence in support of the second hypothesis comes from Murray and Trevarthen (1985). They showed that infants are more distressed by a parent's still-face than by the parent turning away from them to chat with another person. In line with these findings, Field, Vega-Lahr et al. (1986) reported that the still-face episode was more stressful to 4-month-old infants than a brief separation from mother, as evidenced by higher increases in negative affect. More recently, Legerstee and Markova (2007) found that infants aged 3, 6, and 9 months only displayed negative affect in response to mothers' regular still-face and not in response to mothers who put on a mask while maintaining eye contact and continuing vocal interaction, or to mothers who drank from a bottle while maintaining eye contact. These studies suggest that the loss of contingent interaction is not solely responsible for the still-face effect, but that the unexpected combination of mothers' gaze and unresponsiveness may play an important role, as infants do not react negatively to breaks in interaction that provide an obvious reason for the cessation of interaction. Three other studies reported different results. Infants' responses to the still-face did not distinguish between an adult gazing at or above the infant during the still-face (Delgado, Messinger, & Yale, 2002), nor between still-face conditions in which the adult either looked at the infant, at a wall, or at another person, or turned toward a sound (Striano, 2004) or between a still-face directed at the infant or directed toward another infant next to the infant (Cleveland, Kobiella, & Striano, 2006). However, the distinctions between the still-face conditions in these studies may have been too subtle to represent variations in adult intention.

The still-face episode represents a sudden change in interaction on several levels. The unresponsiveness and absence of contingent interaction consists of the cessation of vocal cues, facial cues, and tactile stimulation. The question is whether these three elements contribute equally to the still-face effect. Gusella et al. (1988) found that the still-face effect was not present in 3-month-olds when mothers were instructed not to touch their infants during normal interaction. Still-face effect in 6-month-olds was maintained regardless of the absence or presence of touch. In a related vein, two studies by Stack and Muir (1990); (1992) in 3- to 6-month-olds and one by Stack and LePage (1996) in 5-month-olds showed that allowing touch during the still-face episode significantly reduces the still-face effect. Further, mothers were able to elicit specific behaviors from their 5-month-old infants when instructed to do so by using only touch accompanied by a still-face (Stack & Arnold, 1998). In addition to the examination of the role of touch, Gusella et al. (1988) also looked at the contribution of facial and vocal cues to the still-face effect. They used a closed-circuit television setup (infants interacting with mother via a television screen) to test the influence of facial and vocal cues on 6-month-olds. Infants were exposed to the SFP with the second episode varying in the cessation of both vocal and facial cues, cessation of facial cues only, or cessation of vocal cues only. The results showed that the lack of facial cues produced the still-face effect, whereas the lack of vocal cues did not. This finding was replicated by Striano and Bertin (2004) in a sample of 4-month-olds. These results may simply reflect infants' preference for moving stimuli. However, in a study by Ellsworth, Muir, and Hains (1993) infants gazed more at moving than stationary objects or people, but infant positive affect only differentiated between movement and stillness in people, and not in objects. Further, Legerstee, Pomerleau, Malcuit, and Feider (1987) found that at the age of 17 weeks, infants produced negative vocalizations significantly more often to inactive mothers than to inactive or active strangers or dolls. At age 34 weeks these vocalizations occurred with the same frequency toward inactive mothers and strangers and rarely toward the dolls. As Legerstee et al. (1987) state, these findings suggest that a general preference for movement can not explain the changes in affect found with the SFP, but are likely to be due to the reciprocal nature of human interaction.

Elaborating on the importance of facial cues, two studies examined the effect of different facial expressions during the still-face (D'Entremont and Muir, 1997; Rochat et al., 2002). In 4- and 6-month-olds, the type of facial expression (happy, sad, and neutral) did not influence the still-face effect with respect to smiling and gazing, but in 2-month-olds a reduced effect on smiling (i.e., a smaller decrease in smiling from baseline to still-face) was found for infants exposed to the happy still-face (Rochat et al., 2002). In 5-month-olds, differences in facial expressions did not influence the still-face effect regarding infant attention, affect, and grimacing, but did result in somewhat more smiling to the happy still-face than to the sad and neutral faces (D'Entremont and Muir, 1997). In a related vein, Thomas (2002) showed that 3-month-old infants did not display an increase in negative affect when mothers closed their eyes but continued contingent interaction, whereas infants did show more negative affect in a subsequent still-face with mothers' eyes closed. However, Papoušek (1984, cited in Papoušek, 2007) did find increases in negative affect and gaze aversion when mothers were asked to close their eyes but to continue interaction with their 3-month-olds. According to Papoušek, the interaction had lost contingency because the mother could not respond to visual cues anymore, which contradicts the 'continued contingent interaction' of mothers with their eyes closed as presented by Thomas (2002).

Another issue is that of the timing of the break in interaction. As shown in the introduction, mother–infant face-to-face interactions consist of cycles that represent the level of arousal of the infant. In non-distressing interaction, such cycles start with the infant orienting toward the adult, followed by increasing arousal with a peak that is shown by smiling, followed by a decrease in arousal and attention (Brazelton et al., 1974). Considering this, the timing of a break in interaction as in the SFP may be related to different responses from infants. Two studies investigated this issue by prompting mothers to start the still-face episode depending on the behavior of the infant (Fogel, Diamond, Langhorst, & Demos, 1982; Stoller & Field, 1982). One group of mothers was signaled to start the still-face when the experimenter observed the infant's first-look toward mother (low arousal, the beginning of a cycle). The other group was signaled to start the still-face when the infant first smiled (high arousal, peak of a cycle). Results showed that infants in the first-look group were more distressed by the still-face (Stoller & Field, 1982) and during the reunion episode (Fogel et al., 1982) than the first-smile infants. These findings support the idea that although the still-face effect is found in both conditions, the still-face onset at a point when the infant is preparing for interaction is more disturbing than a break after the natural 'end-point' of interaction has already been reached (i.e., when the infant smiles).

A final issue regarding the still-face effect is that of the identity of the adult posing the still-face. In most studies, this is the mother of the infant, but in a substantial number of other studies, an adult stranger conducts the SFP with the infant. Only two studies have directly compared infants' responses to mothers versus strangers in the SFP. Lamb et al. (1987) found few significant effects of adult identity on infant behavior (ages 1–7 months). Infants did exhibit more solicitation/orientation toward strangers than mothers and more aversion to mothers than to strangers. Lamb et al. note that 'infants seemed to enjoy interacting with the novel person, even when she was unresponsive'. Similarly, Kisilevsky et al. (1998) found that infants smiled more at the strangers than at their mothers during baseline and reunion, but that smiling was the same for the two adult partners during the still-face. Infants showed a still-face effect with both partners, but this was less pronounced with mothers than with strangers. Overall, infants grimaced more at their mothers than at the strangers. There were some order effects however, suggesting that infants who first interacted with the stranger subsequently smiled less and grimaced more with their mothers. Only three studies have observed infants with their fathers and their mothers (Braungart-Rieker, Courtney, & Garwood, 1999; Forbes, Cohn, Allen, & Lewinsohn, 2004; Kisilevsky et al., 1998), and only one of those directly compared infant responses to the parents, reporting no differences in infant positive and negative affect in the still-face episode for mother–infant and father-infant dyads (Forbes et al., 2004).

In sum, the studies described in this section suggest that the effect of the still-face is not due to boredom, but is produced by the loss of social interaction with a person, but most importantly by the conflicting messages of the adult who looks at the infant but does not engage in interaction. In terms of aspects of interaction, the effect seems to be for a large part due to the loss of tactile stimulation and facial cues, rather than vocal cues. Initiating the still-face when the infant is about to engage the adult in interaction is more distressing than initiation when the infant has reached a peak in arousal during an interaction sequence. The identity of the adult partner may influence infant responses, but there are too few studies directly comparing the two to draw firm conclusions.

Infant physiological responses to the still-face

The still-face effect has been predominantly described in terms of infant behaviors. To add to our understanding of the nature of infants' responses to the still-face, eight studies examined infant physiological responses during the SFP. Cardiac activity was the focus of seven of the eight studies. Overall, these studies show that heart rate increases from baseline to the still-face episode and decreases again

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in the reunion episode (Haley, Handmaker, & Lowe, 2006; Haley & Stansbury, 2003; Ham & Tronick, 2006; Weinberg & Tronick, 1996). As would be expected, heart rate and vagal tone show the opposite pattern, with decreases from baseline to still-face and increases from still-face to reunion (Bazhenova, Plonskaia, & Porges, 2001; Ham & Tronick, 2006; Moore & Calkins, 2004; Weinberg & Tronick, 1996). Stoller and Field (1982) examined the 5 s prior to the onset of the still-face and the 10 s following the onset of the still-face. By the fourth second after the onset of the still-face, infants showed a heart rate deceleration, followed by an acceleration at 7 s. Stoller and Field suggest that infants first show an orienting response to find out what is happening, followed quickly by the expected aversive response. Only a few studies reported on the baseline–reunion comparison. Two studies show no differences between baseline and reunion in vagal tone (Moore & Calkins, 2004; Weinberg & Tronick, 1996), whereas heart rate was significantly shorter in the reunion than the baseline episode (Moore & Calkins, 2004). Three studies measured cortisol levels in infants before and 20–30 min after the SFP. Two of these studies (Haley et al., 2006; Haley & Stansbury, 2003) modified the basic SFP by adding an extra still-face and reunion sequence in two studies to enhance elicitation of a cortisol response and found significant increases in cortisol levels from before to after the SFP. One study also examined skin conductance and revealed a pattern of increasing skin conductance across the SFP (Ham & Tronick, 2006).

There is evidence that the physiological patterns described above vary depending on infant and mother characteristics and their behavior during the SFP. Ham and Tronick (2006) differentiated between four types of infants: those who protest during the still-face, but less during the reunion ($n = 4$), infants who protest during the still-face and increase protest during the reunion ($n = 2$), infants who do not protest during either the still-face or the reunion ($n = 5$), and infants who did not protest during the still-face, but did protest during the reunion ($n = 1$). Results showed that the infants who increased their level of protest displayed an increase in heart rate from the still-face to the reunion. Further, the decrease in vagal tone from baseline to still-face seemed to occur only in the infants who did not protest during the still-face. In addition, the infant who did not protest during the still-face but started protesting during the reunion showed a decrease of SC across the SFP (Ham & Tronick, 2006). In the study by Moore and Calkins (2004), infants who did not show the suppression of vagal tone from baseline to still-face displayed less positive affect, higher heart rate reactivity and more vagal suppression during the baseline and reunion, as well as lower synchrony with their mothers. In a study by Lewis and Ramsay (2005), infants' cortisol responses were significantly related to their emotional responses to the SFP. Specifically, decreases in joy and increases in sadness were related to increases in cortisol levels, whereas changes in anger and interest were not related to changes in cortisol. Investigating parental responsiveness in relation to heart rate reactivity during the modified SFP (two still-faces, two reunions), Haley and Stansbury (2003), showed decreases in heart rate from the second still-face to the second reunion in infants of responsive parents, whereas increases in their heart rate were found for infants of parents scoring low on responsiveness. Finally, Haley et al. (2006) reported that higher levels of prenatal alcohol exposure were related to greater cortisol reactivity to the SFP.

In sum, these studies provide physiological support for the classic still-face effect in terms of increases in distress from baseline to still-face and a decrease during the reunion. Heart rate increases from baseline to still-face and decreases from still-face to reunion, whereas vagal tone and heart rate show the opposite effect. Cortisol levels and skin conductance appear to increase across the SFP, but these effects require replication. In addition, infant and mother characteristics may influence infant physiological responses to the SFP.

Stability of infant responses to the SFP

Three studies have reported on the longitudinal stability of infant responses to the SFP. Toda and Fogel (1993) found no significant correlations between negative affect, smiling, and gazing during the SFP between ages 3 and 6 months. Similarly, Cossette, Pomerleau, Malcuit, and Kaczorowski (1996) found no significant associations between emotional expressions (joy, negative, neutral, interest) at ages 2.5 and 5 months for any of the SFP episodes. For negative affect, Moore et al. (2001) reported significant stability between 4 and 6 months, but not between 2 and 4 months. Gaze aversion was stable between 2 and 4 months and between 4 and 6 months. Positive affect and crying showed no stability between any of the three ages. Overall, infant responses to the SFP do not seem to be very

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stable. However, the relatively large time intervals in the three studies reviewed here preclude conclusions about test-retest reliability.

Infant characteristics in relation to the still-face effect

Surprisingly, relatively few studies have examined the influence of infant characteristics on the still-face effect. This is probably because historically the still-face literature has predominantly focused on normative development, and therefore less on individual variations. Nevertheless, there are some studies that report on individual variations in the still-face effect as a function of infant characteristics.

First, several studies have compared the still-face effect in infants of different ages, although not as many as might be expected. The original SFP as reported by Tronick et al. (1978) was conducted with infants aged 1–4 months, and the classic still-face effect was observed at all ages in their study. Bertin and Striano (2006) used the SFP with newborns (about 4 days old), 1.5-month-olds, and 3-month-old infants. The two older groups showed the typical decrease in gaze and positive affect from baseline to still-face, whereas the newborns did not. In a longitudinal study by Toda and Fogel (1993), the pattern of increase in negative affect from baseline to still-face and increase from still-face to reunion was significantly less pronounced at age 6 months than at 3 months. Three-month-olds gazed at their mothers three times as much as 6-month-olds during the still-face, a finding which was also reported by Stack and Muir (1990) for the same age groups and by Abelkop and Frick (2003) for 4- versus 6-month-olds. Striano and Liszkowski (2005) also found that the still-face effect for gaze was larger in 3-month-olds than in 6- and 9-month-olds, and that the youngest children smiled more across episodes. Further, smiling was reduced from baseline to still-face only for 3- and 6-month-olds, but not for 9-month-olds. Cossette et al. (1996) also found that the reduction in gaze from baseline to still-face was significant only at age 2.5 months and not for 5-month-olds. Forbes et al. (2004) found that across the SFP, infants spent more time in positive affect at 6 months than at 3 months. Results reported by Lamb et al. (1987) suggest quadratic functions for age-effects on infant behavior during the SFP in a longitudinal study from age 1 to 7 months. Across episodes, there seems to be a peak around 3–5 months for behaviors such as brow knitting, looking at mother, and hand-to-mouth actions. Distress levels did not change significantly across ages, and there was only a chance number of age by episode interactions, suggesting no specific age-effects on changes between episodes. Striano and Rochat (1999) found no significant age-effects on infant behavior in the SFP for 7- versus 10-month-olds.

The second infant variable of interest is gender. Most studies that examine gender do not find main effects on infant behavior during the SFP (Abelkop & Frick, 2003; Cossette et al., 1996; Forbes et al., 2004; Garrity-Rokous, 1999; Haley & Stansbury, 2003; Hart, Carrington, Tronick, & Carroll, 2004; Lowe, Handmaker, & Aragón, 2006; Stack & Muir, 1990; Toda & Fogel, 1993; Weinberg, Olson, Beeghly, & Tronick, 2006; Yirmiya et al., 2006). A few studies do report main effects. In a study of 3-4-month-old infants, Mayes and Carter (1990) reported more intensely negative responses to the still-face in girls than in boys. Similarly, Braungart-Rieker, Garwood, Powers, and Notaro (1998) reported less positive affect and more object orientation for girls compared to boys in the still-face episode at age 4 months, and in another report on the same study, boys showed more negative emotionality during the still-face episode, whereas girls showed more self-comforting (Braungart-Rieker et al., 1999). In a study of 6-month-old infants by Weinberg, Tronick, Cohn, and Olson (1999) however, male infants showed more negative affect than female infants during the still-face episode. Further, Toda and Fogel (1993), report that at age 3–6 months, girls show more looking around the room across the SFP compared to boys. Some interaction effects with gender have been reported. Haley and Stansbury (2003) found a significant gender by episode interaction effect in infants aged 5–6 months, with males showing a decrease and females an increase in negative affect from the still-face to the reunion episode. Weinberg et al. (2006) reported that sons of mothers with high levels of depressive symptoms showed more negative affect during the reunion episode than other infants. Finally, Lowe et al. (2006) reported an interaction of gender by maternal drinking, which showed that more maternal drinking during pregnancy was related to more negative affect during the reunion in girls, but not in boys (age 6 months).

A third infant variable that has been studied in relation to the still-face effect reflect infant risk status. The following risk groups have been examined using the SFP: siblings of children with autism, infants exposed to substances in utero, premature infants, and deaf infants. Three studies compared infants with siblings with autism to infants with typically developing siblings, and all report that the reactions of at-risk infants to the SFP are very similar to those found in comparison infants (Cassel et al., 2007; Merin, Young, Ozonoff, & Rogers, 2007; Yirmiya et al., 2006). One study did report that the infants at-risk for autism were less upset by the still-face as evidenced by significantly less still-face episodes that had to be terminated early because of infant crying (Yirmiya et al., 2006). However, using percentages of time no significant differences between the two groups were found on negative and positive affect. Some other differences in infant behavior between the groups were found, but these pertained to the procedure as a whole, showing general differences in social behavior between the groups, but not differences specific to their response to the still-face.

Prenatal substance exposure is a second infant risk variable. One study investigated the SFP responses of infants exposed to alcohol in utero (Haley et al., 2006; Lowe et al., 2006). During the baseline episode, infant affect was more positive for higher levels of self-reported maternal drinking during pregnancy, but levels of alcohol consumption were related to more negative affect during the reunion episode only in girls. Bendersky and Lewis (1998) reported that infants exposed to cocaine in utero showed more negative affect, but not less positive affect in the reunion episode than non-exposed infants at age 4 months. They found no differences between groups during the still-face episode on positive or negative affect. In a study of a sample of no less than 695 infants aged 4 months, Tronick et al. (2005) reported only differences between infants exposed to cocaine and comparison infants regarding their behavior across the three episodes, with less object engagement, higher social monitoring, more dyadic affective mismatches and fewer autonomic stress indicators in cocaine-exposed infants. When distinguishing different levels of cocaine exposure, infants in the heavy exposure group show more passive-withdrawn behavior. It is unclear whether these results represent differences in these infants' responses in general, or whether they are specific to their reactions to the still-face perturbation.

Finally, two other infant risk variables have been studied in the context of the SFP: prematurity and deafness. Segal et al. (1995) reported that 7-month-old preterm and full-term infants showed the classic still-face effect of decreased smiling from baseline to still-face, and increased smiling from still-face to reunion. The carry-over effect of less big smiles in the reunion episode compared to the baseline was found only in full-term infants. However, this difference is likely to be due to the much lower baseline level of big smiles in preterm infants. In another study the responses of 9-month-old deaf and hearing infants to their hearing mothers' still-face were compared (Koester, 1995; Koester & Meadow-Orlans, 1999). Results showed two groups by episode interactions, indicating that deaf infants use more self-comforting behaviors during the still-face episode than hearing infants, and decrease social signaling when mother assumes the still-face whereas hearing infants increase social signaling at this point. In addition, deaf infants show less social signaling in all episodes.

Surprisingly, we only found two studies that reported on the effects of infant temperament on their responses to the SFP. Braungart-Rieker et al. (1998) found that parent ratings of infant negative temperament were related to lower levels of infant self-comforting behaviors during the still-face at age 4 months. Observed negative temperament predicted lower levels of object orientation during the still-face in a regression model that also included other variables such as maternal sensitivity, and infant gender. In a study by Tarabulsy et al. (2003), maternal ratings of infant difficultness did not predict infant affect or self-soothing during the still-face in a regression model that included five other predictors, including maternal behavior and temperament by maternal behavior interactions that were significant (see section Stability of infant responses to the SFP). Two other studies did assess temperament as well as infant behavior in the SFP, but did not report the link between the two constructs (Fuertes, Lopes dos Santos, Beeghly, & Tronick, 2006; Jamieson, 2004).

Regarding children's ethnicity, it is noteworthy that the large majority of studies using the SFP have been conducted in White samples. Two studies reported on other ethnic groups, including a Chinese sample (Kisilevsky et al., 1998) and an African American sample (Segal et al., 1995). In both samples, the expected still-face effect was found.

The studies reviewed here suggest that the still-face effect is present from age 1 month, but not in newborns, and that the still-face effect and some specific behaviors may become less pronounced from about 6 months onwards. Gender does not have a strong main effect on infant behavior in the SFP, but

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boys and girls may be differentially susceptible to parental risk factors as evidenced by gender-specific influences on their still-face responses. Further, most of the infant characteristics that reflect a risk for problematic development do not seem to specifically affect the infants' responses to the still-face, e.g., prenatal substance exposure, having a sibling with autism, or prematurity. Deafness however, was a significant factor in explaining infant behavior in the SFP which may be a result of the way mothers interact with their deaf infants. Temperament may be an important factor, but has not been studied in relation to the SFP often enough to draw conclusions.

Maternal interactive behavior as a predictor of infant still-face response

We found 14 studies that examine the association between maternal behavior and infant behavior during the SFP. Of these, five investigated maternal behavior in the baseline face-to-face play of the SFP in relation to the infant's response to the subsequent still-face. Tronick, Ricks, and Cohn (1982) showed that maternal sensitivity during the baseline predicted more positive elicits in their 6-month-old infants during the still-face. Infants showing no eliciting behavior during the still-face were more likely to have mothers who were extremely over- or undercontrolling during baseline play. Similarly, Braungart-Rieker et al. (2001) found that 4-month-old infants of mothers who were more sensitive during the baseline showed more positive affect regulation during the still-face. In a study by Carter, Mayes, and Pajer (1990), 3-month-old infants of mothers showing more positive affect during play showed shorter latencies to looking at mother and looked at her longer during the still-face. However, patterns were different for boys and girls, with positive maternal effect predicting neutral affect in girls, and initial positive bids followed by negative affect in boys. Forbes et al. (2004) did not find any significant associations between parents' (fathers and mothers) positive affect during the baseline and infant positive or negative affect during the still-face at 3 or 6 months. Across episodes, maternal and paternal positive affect were positively correlated with infant positive affect and negatively correlated with negative affect, but only at age 6 months. Lowe et al. (2006) found that 6-month-old infants whose mothers showed more interactive behaviors (e.g., mirroring and game-playing) during the baseline episode, displayed more positive affect during the still-face episode. Kogan and Carter (1996) examined maternal sensitivity during the baseline in relation to infant behavior during the still-face and reunion episodes in 4-month-olds. Maternal sensitivity during play was related to more infant regulation and less avoidant and resistant behavior during the reunion. Further, infants of highly intrusive mothers exhibited more negative affect during the still-face. Maternal hostility was related to a shorter latency to look at mother during the still-face, and a longer latency to look at mother during the reunion.

Two studies investigated the association between maternal and infant behavior during the reunion episode. Rosenblum et al. (2002) showed that maternal involvement and positive affect predicted more infant positive affect and attention seeking, and less negative affect. Maternal intrusiveness was related to more infant avoidance, and infants of mothers who showed resignation or anxiety during the reunion exhibited less positive affect and attention seeking, more negative affect, avoidance, and resistance in the same episode. Because both mother and infant behavior were examined during the reunion episode, the direction of these effects remains unclear. In a study by Spitzer (2000) using a sample of 10-month-old infants, maternal comforting and references to positive affect predicted dyad repair as evidenced by the absence of negative affect for at least four consecutive blocks of 10-s intervals (out of 12). Maternal references to labels of negative affect, lack or need predicted the absence of repair. Haley (2001) computed an average score of maternal responsiveness across three free play episodes (which were alternated with two still-face episodes) for mothers of 5–6-month-olds. Infants of mothers showing low responsiveness exhibited low levels of gazing behavior and little change in this behavior across episodes, whereas infants of mothers in the moderate and high responsiveness groups reacted with the expected decrease in gaze during the two still-face episodes, and recovery of gaze during the reunion episodes (Haley & Stansbury, 2003).

Three studies found no associations between maternal behavior and infant responses in the SFP. Kamman (2001) examined maternal contingency during baseline play in relation to changes in infant behavior across the SFP at 6 months, but found no significant results. Hobson et al. (2005) used a modified procedure in a sample of 12-month-olds, starting with a still-face episode conducted by the experimenter while the infant sat on mother's lap, free to engage her or an object lying nearby. They found no association between maternal intrusiveness measured during a task situation after the still-face and infant positive engagement, behavioral organization, or mood during the still-face. Garrity-Rokous (1999) reported that maternal interactive style during baseline and reunion was not related to infant emotion regulation during the still-face and reunion episodes at age 4 months.

Only two studies were found that measured maternal interactive behavior prior to the SFP. Tarabulsy and colleagues (2003) measured maternal interactive behavior during a home visit and conducted the SFP two weeks later in a sample of 6-month old infants and their mothers. They found that maternal sensitivity was related to lower levels of negative affect during the still-face episode, and that this association was stronger for infants with a difficult temperament. Further, maternal sensitivity predicted more infant self-soothing behavior during the still-face, and this effect was stronger for adult than adolescent mothers, and for less difficult infants. In a study by Stanley, Murray, and Stein (2004), observed maternal responsiveness at age 2 months was not related to infants' responses to the SFP at age 3 months.

Finally, three studies examined more indirect measures of maternal care. Rosenblum and colleagues (2002) reported that infants of mothers with balanced representations of their infants showed more positive affect during the reunion episode. Field, Stoller, Vega-Lahr, Scafidi, and Goldstein (1986) compared infants in homecare to infants in daycare on their responses to the SFP, showing that the former displayed more motor activity and distress indicators than infants in daycare. Another study looked at mothers' own reaction to the SFP (Mayes, Carter, Egger, & Pajer, 1991). More than half of the mothers experienced discomfort during the session and they were more likely to do so when their infants showed more negative affect during the still-face. When mothers reported discomfort, they were more likely to pick up their infants and to talk about the situation and their feelings during the reunion episode. It is important to note however, that half of the mothers did *not* experience discomfort, showing that the procedure is not necessarily too stressful for mothers.

Overall, most studies reviewed in this section suggest that maternal behavior is related to infant responses to the SFP, with infants of sensitive mothers showing more regulatory behaviors, more positive affect and less avoidance and negative affect during the still-face and reunion episodes.

Maternal psychopathology in relation to the still-face effect

Studies investigating maternal psychopathology in relation to infant responses to the SFP focus mostly on maternal depression, but show diverging results. Field et al. (2007) reported that 4-month-old infants of mothers currently experiencing high levels of depression symptoms showed less distress during the still-face episode than comparison infants. The infants in the depression group also showed fewer interactive behaviors during the reunion episode. Peláez-Nogueras, Field, Hossain, and Pickens (1996) used a modified procedure with two still-face episodes: a regular still-face followed by a still-face during which mothers were encouraged to touch their infants (age 3 months). Infants of currently depressed mothers did not differ from other infants in their behavior during the regular still-face episode. However, they did react with increased smiling and decreased crying to the change from the regular still-face to the still-face-with-touch episode, whereas infants of non-depressed mothers did not. Infants of depressed mothers also displayed more vocalizing and gazing at mothers' hands, and less grimacing, crying, and gaze aversion during the still-face-with-touch episode and during the reunion episode than infants of non-depressed mothers. Further analyses showed that the amount and type of touch provided by the mothers from the two groups were the same.

In contrast to these findings that infants of depressed mothers react less negatively to a still-face, two other studies report more negative affect in infants of depressed mothers during the SFP. Forbes et al. (2004), reported that infants of parents with a history of depression showed more negative affect during the still-face episode than control infants, but only at age 3 months and not at 6 months. This association was not mediated by parental positive affect. In the study by Weinberg et al. (2006) infants of mothers with and without current depressive symptoms showed the classic still-face effect, but male infants of mothers with high levels of current depression showed more negative affect in the reunion phase than during the reunion play (as did female infants in the low symptom group). Moore et al. (2001) did not find any significant correlations between maternal depressive symptoms and in-

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fant affect during the SFP, but depression was significantly related to gazing away during the still-face. Four studies did not find significant differences between infants of depressed and non-depressed mothers or significant associations between levels of depressive symptoms and infant behavior in the SFP (Garrity-Rokous, 1999; Rosenblum et al., 2002; Segal et al., 1995; Stanley et al., 2004).

Interestingly, most studies that investigated maternal depression in relation to infant behavior in the SFP did find significant associations between depression and maternal behavior during the SFP (Field et al., 2007; Garrity-Rokous, 1999; Rosenblum et al., 2002; Stanley et al., 2004; Weinberg et al., 2006). This means that depressed mothers do behave differently toward their infants, but that this difference is not consistently reflected in the infants' responses to the SFP. Jung, Short, Letourneau, and Andrews (2007) administered the SFP before and after an intervention aimed at increasing maternal understanding and responsiveness to infant signals. They showed that infants of mothers suffering from postpartum depression benefited from the intervention, and that infants showed an increase in joy and interest, but also in sadness and anger during the reunion episode from pre-test (age 3 months) to post-test (appr. 5 weeks later). Although these results are encouraging, they need to be treated with caution as the study lacked a control group and results are based on a very small sample ($N = 11$).

In addition to studies about maternal depression, two studies examined the effect of maternal borderline personality disorders (BPD) on infant behavior in the SFP. Crandell, Patrick, and Hobson (2003) compared eight mothers with BPD to 12 mothers without psychiatric disorders. The 2-month-old infants of mothers with BPD showed more gaze aversion and dazed looks during the still-face episode than the control infants, and less positive affect, and more dazed looks during the reunion episode. In a sample of 12-month-old infants of mothers with BPD, an experimenter engaged in the SFP with the infant (Hobson et al., 2005). Compared with controls, infants with mothers with BPD showed lower availability for positive engagement, lower behavioral organization and less positive mood states. However, this was measured across episodes, which makes it unclear if the infants of mothers with BPD behaved differently in general, or whether they reacted differently to a social perturbation specifically.

In sum, SFP research on the responses of infants of mothers with depressive symptoms has shown equivocal results, but does suggest that at least some infants of mothers with depression may be at-risk for atypical interactive behavior. The studies on mothers with BPD show that this risk may extend to infants of parents with other types of psychopathologies. It is important to note that the different samples used in studies examining maternal psychopathology vary in terms of demographic risk status, with some very disadvantaged samples (e.g., Peláez-Nogueras et al., 1996) and quite advantaged samples (e.g., Forbes et al., 2004).

Infant behavior in the SFP as a predictor of attachment security

We found eight studies examining infant behavior during the SFP as a predictor of infant attachment as assessed in the Strange Situation Procedure (SSP; Ainsworth, Blehar, Waters, & Wall, 1978). The first study investigating this link was conducted by Tronick et al. (1982) who examined infant behavior during the SF in separate samples of 3-, 6-, and 9-month-olds, and infant attachment for each group at age 12 months. Results showed that for the 6-month group, 12 out of 13 infants who tried to elicit some reaction from their mothers during the SF episode were securely attached at 12 months. Conversely, none of the four children who showed no eliciting behavior were securely attached at age 12 months. However, no significant results were found for the 3- and 9-month data in relation to attachment. In a study by Cohn, Campbell, and Ross (1991) the SFP was administered at ages 2, 4, and 6 months and the SSP at 12 months. Positive elicits (e.g., smiling), but not negative elicits during the still-face episode at age 6 months (but not before) significantly predicted secure attachment (versus avoidant attachment), partly confirming the findings by Tronick et al. (1982). Kiser, Bates, Maslin, and Bayles (1986) found that infants who are securely attached at age 12 months showed less distress during the still-face at age 6 months, but more fussing in the SFP reunion compared to infants categorized as ambivalent. Avoidant infants differed from secure and resistant infants in that they showed less positive mutuality during baseline interaction and more positive affect in the reunion of the SFP. No significant effects were found for avoidance and maintenance activity during the SFP.

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Nevertheless, four studies did find associations of 3- and 4-month-olds' behavior during the SFP with attachment at 12 months (Braungart-Rieker et al., 2001; Fuertes et al., 2006; Jamieson, 2004; Kogan & Carter, 1996). In a study by Braungart-Rieker et al. (2001), infants classified as B1 or B2 at age 12–13 months showed more positive affect and less negative affect in the still-face at 4 months compared to infants classified as B3, B4 or C. In addition, future B1/B2 and avoidant infants displayed more self-regulatory behaviors during the still-face episode compared to C infants. However, all these results were only found for mother–infant dyads and not father-infant dyads. In another report on the same study, boys from dual-earner families who were more emotional during the still-face episode were more likely to be securely attached to their fathers eight months later (Braungart-Rieker et al., 1999), whereas this was not found for girls or single-earner families. Jamieson (2004) examined infant SFP behaviors at age 4 months in relation to SSP classifications at age 12 months. Future secure and resistant infants looked away from their mothers quicker than future avoidant infants in the baseline episode, while the future insecure infants looked away quicker in the still-face and reunion episodes than the future secure infants. Future insecure infants grimaced more than future secure children during the still-face episode, and future resistant infants showed more negative vocalizations than other infants, but only during the still-face episode. Fuertes et al. (2006) found that future avoidant infants showed more self-comforting during the still-face, and that future secure infants displayed more positive responses to mother across SFP episodes at 3 months of age. The latter result does not show whether this is specific to the still-face effect, since it includes all episodes in one analysis.

Using a different approach, Bingen (2001) classified infants aged 3 to 9 months as A, B, or C based on their behavior during the SFP at ages 3 and 9 months. Classifications were made based on infants' eliciting behavior during the still-face and affect during the reunion (i.e., B = positive elicits/affect, A = minimal, C = negative). Contrary to expectations, the SFP classifications at ages 3 and 9 months were not significantly related to SSP classifications at age 11–17 months (Bingen, 2001). There were also no significant associations between specific SFP behaviors (positive and negative elicits, positive and negative interactions) and attachment classifications. Kogan and Carter (1996) investigated three scales reflecting infant reengagement during the reunion of the SFP at age 4 months (avoidance, resistance, attention seeking/maintenance) in relation to the four interactive behavior rating scales coded in the reunion episodes of the SSP at age 12 months (proximity seeking, contact maintenance, resistance, avoidance). Results showed that resistance and attention seeking during the SFP reunion at 4 months significantly predicted contact maintenance during the reunion episodes of the SSP at 12 months. None of the other SSP interactive behavior scales were predicted by the SFP reunion behaviors.

The research results described above suggest a link between infant behavior in the SFP to infant attachment behavior at 12 months, with more eliciting behavior and positive affect during the still-face episode for future secure versus insecure infants. Conflicting results are reported concerning the age from which SFP responses become predictive of future attachment quality.

Infant responses to the SFP in relation to other behaviors

Seven studies have investigated the link between infant behavior in the SFP and infant behavior in other situations or later in time. Moore et al. (2001) found that 6-month-old infants who failed to smile during the still-face episode showed more externalizing problems at age 18 months. Further, infants who cried during the still-face at 6 months showed more internalizing problems at 18 months. Hill and Braungart-Rieker (2002) reported that infants who show more attentional regulation (defined as object orientation or gaze aversion) during the still-face at 4 months, show more committed compliance at age 3 years. They also found that still-face attentional orientation predicted assertiveness at 3 years, but only for insecurely attached children (as measured at age 12 months). Yazbek and D'Entremont (2006) reported that 6-month-old infants showing a greater still-face effect were more likely to follow the gaze and point gestures of a stranger during a play session at age 12 months. Similar results had previously been reported in a cross-sectional study by Striano and Rochat (1999) in which 7- and 10-month-olds who attempted to reengage the adult stranger during the still-face were also more likely to show joint attention. Yirmiya et al. (2006) found that in siblings of children with Autism, more neutral affect during the SFP at age 4 months was related to less joint attention at the age of

14 months. This was not found for siblings of typically developing children. Other studies looked at the relation between infant responses to social versus nonsocial situations. Shapiro, Fagen, Prigot, Carroll, and Shalan (1998) administered the SFP as well as an operant extinction task to 3- and 6-months olds and found that infants showed more cross-task stability in their emotional expressions than in their emotion regulation behaviors. Abelkop and Frick (2003) found a relation between infant looking in a visual attention task and in the still-face episode of the SFP. They found that 'short-lookers' showed the classic still-face effect of gaze aversion, whereas 'long-lookers' did not.

Overall, infant responses to the SFP are related to infant behavior in other situations, both social and nonsocial, and even longitudinally, suggesting some coherence of behavior patterns in infancy.

The SFP in children with autism and children with Down syndrome

We found three studies that used the SFP – albeit in modified form – in samples of children with autism. This set of studies did not include infants, but older children since autism can not be diagnosed in infancy. The first study investigated whether children with autism have expectancies about the social behavior of unfamiliar people (Nadel et al., 2000). During the procedure, the children entered a room in which the experimenter was sitting on a sofa who maintained a still-face and body for 3 min, The experimenter then stood up and imitated the child for the next 3 min and would then again sit on the sofa with a still-face and body, followed by a final episode of interactive behavior. The results showed that the children generally ignored the stranger during the first still-face episode, but showed a clear interest in the stranger during the second still-face, They also showed significantly more negative facial expressions during the second compared to the first still-face and the imitation episode. These findings suggest that children with Autism do not have generalized expectancies about strangers' behavior, but do form some expectancies once they have some socially contingent experience with that stranger (Nadel et al., 2000).

Elaborating on the study by Nadel et al. (2000), Escalona, Field, Nadel, and Lundy (2002) used the same basic procedure, but varied the second condition by randomly exposing one group to imitation and another to contingent interaction. Comparing the second to the first still-face, children in both conditions evidenced a decrease in the distance from the adult, and an increase in touching of the adult, with a significantly greater increase in the imitation group. In the contingent condition only, children looked at the adult more and were less silent. In the imitation condition only, children showed decreased motor activity. Escalona et al. (2002) interpret these results as indicating that contingent responsiveness may facilitate distal social behavior (i.e., looking and vocalizing), and that imitation may be more effective in facilitating proximal social behavior (i.e., touching) in children with autism.

Heimann, Laberg, and Nordoen (2006) used the same procedure as Escalona and colleagues, but also observed children's free play with a stranger 4–8 weeks before the experiment (not the same person as the experimenter), and immediately after the experiment (with the experimenter). Children in the imitation group showed an increase in looking at the adult and touching and requesting behaviors from the first to the second still-face, whereas the contingent group did not. In the imitation condition children's own imitation behavior increased from the free play observed 4–8 weeks before the experiment to free play after the experiment. These results confirm the findings by Escalona et al. (2002) and Nadel et al. (2000) regarding the positive effect of imitation on these children's social behavior, regardless of differences in child age and specific procedures between the three studies.

Two studies reported on the SFP in children with Down syndrome (Carvajal & Iglesias, 1997; Legerstee & Bowman, 1989). In the study by Legerstee and Bowman (1989), eight infants with Down syndrome were observed biweekly from 8 to 24 weeks, and monthly up to 48 weeks. At each assessment, the infants were presented with active and passive people (mother and stranger) and objects (a rattle puppet). In the passive person conditions, mothers and strangers were asked not to talk, but to maintain a friendly face. By the age of 4 months, infants discriminated between people and objects as evidenced by more looking, smiling and vocalizing toward the people than the toys. It was not until the second half of the first year that infants also discriminated between the mother and the stranger and between the active and passive conditions. In contrast to findings with typically developing infants, the infants in this study continued to vocalize and sometimes even smile at the passive adults.

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In another study, 15 infants with Down syndrome aged 3–13 months (divided into three age groups) were compared to 15 typically developing infants of the same chronological age (Carvajal & Iglesias, 1997). The procedure consisted of 15 min of normal face-to-face interaction, followed by a 1–2 min rest episode, and ending with a still-face episode. Mothers were allowed to use toys or other objects during normal interaction. There was a main effect of condition on infant smiling, with infants smiling more during normal interaction than in the still-face episode. There was no interaction condition *x* group effect, but the decrease in smiling was only significant for the typically developing infants, and a nonsignificant trend in infants with Down syndrome. No effects of age on changes in smiling between conditions were reported.

The SFP as a method for other research goals

The SFP and still-face conditions within other paradigms have been used as a method for many purposes other than examining the still-face effect in itself. We found five studies that use the SFP to investigate questions about the social-emotional development of infants. Bornstein, Arterberry, and Mash (2004) showed that infants remember social experiences associated with specific individuals for up to 15 months, as evidenced by more gaze aversion at age 20 months with adults that they had seen at age 5 months and adults they had never seen before. This difference was not found for a control group of 20-month-olds who had not participated at age 5 months. In a study by Rochat and Striano (2002), 4- and 9-month-olds differentiated between a live video of another person mimicking them and a live video of themselves, by smiling more and showing more reengagement behaviors toward the other person, but vocalizing more at themselves when the picture was frozen. Hart et al. (2004) reported that 6-month-old infants respond to jealousy evocations (mother playing with another infant) in a similar way as to the still-face, but with a specific component of heightened sadness and interest that exceeded what was found during the still-face. There is also evidence that 4-month-old infants are capable of discriminating between four different situations (including a still-face episode) and coordinating their attention in interaction with two adults at the same time (Fivaz-Depeursinge et al., 2005). Agnetta (2001) showed that 9-, 14-, and 18-month-old children do not show a preference for an adult imitating versus an adult performing control actions (dynamically similar to, but structurally different from the infant's behavior), as evidenced by a lack of differences in responses to a subsequent still-face episode.

In addition to answering developmental questions, researchers have used the SFP or similar still-face procedures as a method for a variety of goals that do not focus on the still-face effect in itself. These goals include the identification affective expressions in infants (Matias & Cohn, 1993; Weinberg & Tronick, 1994), the measurement of infant emotionality (Forman et al., 2003; Forman et al., 2007), and the creation of an emotional challenge variable in combination with other challenges (Miller, McDonough, Rosenblum, & Sameroff, 2002). Several papers report only on the baseline episode of the SFP, using it as a measure of mother–infant interaction (Cohn & Tronick, 1988; Tronick & Cohn, 1989). Overall, this section provides an illustration of the versatility of the SFP, as it is being used to assess a variety of variables and to answer many different types of questions outside that of the still-face effect itself.

Meta-analytic study

The narrative review of the still-face literature illustrates the sheer diversity of research questions that have been addressed, as well as the multitude of procedural variations that have been employed to answer these questions. However, a substantial number of studies have addressed the basic still-face effect in a similar fashion. In the second part of this paper, we will examine the still-face effect in a series of meta-analyses. We will first test the following hypotheses regarding the content, direction, and magnitude of the still-face effect as found in studies employing a relatively uniform SFP procedure (see below).

1. *Infant gaze and positive affect decrease from baseline to the still-face episode, while negative affect increases*.This represents the basic still-face effect described first by Tronick et al. (1978) and replicated in many studies.

2. *Infant gaze and positive affect increase from the still-face episode to the reunion, while negative affect decreases.*The resumption of normal interaction re-establishes the expected social reciprocity and infants (partly) recover from the perturbation of the still-face.
3. *Infant gaze and positive affect are higher and negative affect lower in the baseline episode than during the reunion.*We expected that the perturbation of the still-face would show a carry-over effect into the reunion episode, as reported by Tronick et al. (1978), resulting in less emotionally optimal behavior in the reunion than in the baseline interaction.

Neutral affect (i.e., the absence of positive and negative affect) has not been studied as often as gaze, positive and negative affect and the results have been diverse. However, most of the studies report a pattern of increasing neutral affect from baseline to still-face, and a decrease from still-face to reunion. We therefore hypothesize that neutral affect will follow the same pattern as negative affect.

Selection of studies

For the meta-analytic study, we aimed to select studies that represented the most common use of the SFP in terms of its procedures and that reported on normative samples. By excluding atypical procedures and clinical or at-risk samples, the meta-analyses allow for interpretations about the most basic still-face effect in typically developing children. The results of the studies excluded on these grounds are reported separately. On a procedural level, we selected studies in which the SFP included at least a baseline interaction episode, followed by still-face episode either immediately or after a short interval during which mother turns away from the infant, or briefly leaves the room. Studies using other orders of presentation in counterbalanced fashion were only included if separate results for the baseline followed by still-face order were reported. Studies in which the use of toys was allowed during the normal interactions were excluded. In some studies, infants were seated on an adult's lap during the SFP, with the adult free to engage or soothe the infant. These studies were excluded as well. The still-face episode had to be conducted by one adult posing with a neutral expression while looking at the infant and without touching the infant. We also excluded the one study that conducted the SFP at home rather than in the lab (Moore et al., 2001), because the familiarity of the environment may have influenced children's response to the still-face. Regarding infant responses to the SFP, we selected studies that reported on at least one of the following infant behaviors: gaze (looking at mother), positive affect (e.g., smiling, joy, positive vocalizations), negative affect (e.g., frowning, crying, anger, sadness, fussing, protesting), and neutral affect (not positive and not negative). For gaze, only variables that included gazing at mother's face were included. If the variable was restricted to gazing at mother's body, it was not included. Studies were only included if the results were based on the average duration or percent of time of the behaviors in each episode (rather than percent of children showing the behavior). Several papers reported on independent samples (e.g., boys and girls, or different age groups). These were included as separate studies. Finally, suitable statistical information needed to be available from the publication in the form of means and standard deviations (or standard errors) of the proportion of time that the behaviors were observed per episode, figures showing means and standard errors per episode, t-statistics, F-statistics, or p-values based on analyses with $df = 1$. Application of these criteria yielded 39 studies (Table 1).

Moderators

In addition to coding which phase comparisons and which behaviors were reported in the studies, we coded two types of moderators: procedural and sample characteristics (see Table 2). The procedural moderators included the identity of the adult partner (parent versus stranger), the use of intervals between phases (no/yes), the duration of each phase (<120 s versus ⩾120 s), and whether touching the infant was allowed during the two normal interaction phases (no/yes). The sample moderators included infant age (⩽3 months, 3–6 months, >6 months, and also as a continuous variable in months), and infant gender (continuous: % boys). A categorical variable for gender was not feasible as the percentage of boys was between 40% and 60% in the large majority of studies, with only very few studies reporting on samples consisting of only or predominantly boys or girls. To assess intercoder

Table 1
Studies included in the meta-analyses.

Study	Sub-samples	Phases–behavior[a]	*N*	Infant age (months)	% Boys	Mother/ stranger	Duration baseline	Duration still face	Intervals in SFP	Touch in P1/P3
Abelkop and Frick(2003)		All–All	50	5.2	52	Mother	120	120	No	Yes
Bertin and Striano (2006)	Newborns	All–GP	18	0.1	50	Stranger	60	60	No	Yes
	Age 1.5 months	All–GP	18	1.6	44	Stranger	60	60	No	Yes
	Age 3 months	All–GP	18	3.2	61	Stranger	60	60	No	Yes
Cassel et al. (2007)		All–PNT	19	6.2	NA	Mother	180	120	No	No
Cossette et al. (1996)	Boys	P1P2–All	30	2.6	100	Mother	120	60	Yes	Yes
	Girls	P1P2–All	33	2.6	0	Mother	120	60	Yes	Yes
Delgado et al. (2002)		All–GPN	18	5.9	47	Mother	120	120	No	Yes
Ellsworth et al. (1993)	Stranger	All–GP	32	4.5	50	Stranger	90	90	Yes	No
	Mother	All–GP	32	4.5	50	Mother	90	90	Yes	No
Gusella et al. (1988)	Age 3 months + touch P1P3	All–GP	10	3.0	47	Mother	120	120	Yes	Yes
	Age 3 months – touch P1P3	All–GP	6	3.0	50	Mother	120	120	Yes	No
	Age 6 months + touch P1P3	All–GP	12	6.0	60	Mother	120	120	Yes	Yes
	Age 6 months – touch P1P3	All–GP	6	6.0	50	Mother	120	120	Yes	No
Jamieson (2004)	Age 4 Months	All–GPN	89	4.0	55	Mother	90	90	No	No
	Age 6 months	All–GPN	90	6.0	55	Mother	90	90	No	No
Kamman (2001)		All–G	39	6.2	49	Mother	120	120	Yes	Yes
Kisilevsky et al. (1998)	Mother	All–GP	10	4.9	33	Mother	90	90	Yes	Yes
	Father	All–GP	10	4.9	33	Father	90	90	Yes	Yes
	Stranger	All–GP	20	4.8	70	Stranger	90	90	Yes	Yes
Koester (1995)		All–GPN	20	9.0	NA	Mother	180	120	Yes	Yes
Lewis and Ramsay (2005)		P1P2/P2P3–PN	84	5.9	58	Mother	120	120	No	Yes
Moore and Calkins (2004)		All–N	73	2.8	59	Mother	120	120	Yes	Yes
Rosenblum et al. (2002)		All–PN	100	7.0	NA	Mother	120	120	No	Yes
Segal et al. (1995)		All–PN	16	7.1	63	Mother	180	120	No	Yes
Stack and Muir (1990)		All–GPN	16	4.5	63	Mother	90	90	Yes	Yes
Stanley et al. (2004)		All–GN	48	3.0	50	Mother	180	90	No	Yes
Striano and Bertin (2004)		All–GP	12	4.1	58	Stranger	60	60	No	Yes
Striano and Liszkowski (2005)	Age 3 months	All–GP	13	3.4	NA	Stranger	30	30	No	No
	Age 6 months	All–GP	13	6.6	NA	Stranger	30	30	No	No
	Age 9 months	All–GP	12	9.8	NA	Stranger	30	30	No	No
Striano and Rochat (1999)		All–GP	48	8.7	48	Stranger	60	60	No	No
Toda and Fogel (1993)		All–All	37	3.0	62	Mother	180	120	No	Yes
Tronick et al. (2005); 2007		All–All	459[b]	4.0	54	Mother	120	120	Yes	Yes
Weinberg et al. (1999)	Boys	All–GPN	38	6.0	100	Mother	120	120	Yes	Yes
	Girls	All–GPN	43	6.0	0	Mother	120	120	Yes	Yes
Weinberg et al. (2006)		P1P3–PN	133	3.0	52	Mother	120	120	No	Yes
Yazbek and D'Entremont (2006)		All–GP		6.8	43	Mother	120	60	No	Yes
Yirmiya et al. (2006)		All–All	19	4.4	62	Mother	180	180	No	Yes

[a] All–All = data available for all three phase comparisons (baseline–still face = P1P2, still face–reunion = P2P3, and baseline–reunion = P1P3) combined with all three behaviors (Gaze = G, Positive affect = P, Negative affect = N, Neutral affect = T). If not all phase comparisons are assessed, the specific phase comparisons are indicated by P1P2, P2P3, and/or P1P3. If not all behaviors are assessed, the specific behaviors are indicated by G, P, N, and/or T.

[b] Because this sample size was far bigger than the other sample sizes and met criteria for being an outlier, this sample size was recoded to 200, which is still the largest sample size (the next largest is 133), but less extremely so.

Table 2
Coding system for the characteristics of individual SFP studies.

Variable	Coding	Description
Comparison		
Baseline verses still-face	0 = no 1 = yes	
Still-face verses reunion	0 = no 1 = yes	
Baseline verses reunion	0 = no 1 = yes	
Outcome		
Gaze	0 = no 1 = yes	At mother's face, or face and body (not body only)
Positive affect	0 = no 1 = yes	Smiling, joy, positive vocalizations
Negative affect	0 = no 1 = yes	Crying, fussing, anger, sadness, frowning, distress, grimacing, protesting
Neutral affect	0 = no 1 = yes	Not positive and not negative
SFP procedure		
Adult	0 = parent 1 = stranger	
Intervals between phases	0 = no 1 = yes	Any interval ⩽60 s between phases in which mother either turns away from infant or leaves the room
Touch during baseline and reunion	0 = no 1 = yes	If the use of touch was not addressed, this moderator was set at 1 (=yes)
Duration of each episode	0 = <120 s 1 = ⩾120 s	This variable was also used at an interval level (in seconds)
Sample		
Infant age at testing	0 = ⩽3 months 1 = 3–6 months 2 = >6 months	This variable was also used at an interval level (in months)
Infant gender	% boys	If the percentage of boys was not reported, the percentage was set at 50%

reliability, ten randomly selected studies were coded by two coders. The agreement between the coders for the moderator variables was very high (all kappas 1.00).

Based on the narrative review, several hypotheses about the influence of the moderator variables were formulated. Regarding the procedural moderators, we expected that the effects for all three phase comparisons are larger when the infant interacts with a parent versus a stranger, and when the adult is allowed to use touch during normal interaction. Although we did not find any studies examining the influence of the duration of the episodes, we also expected to find larger effects when the duration of the still-face episode is longer as longer perturbations may have larger negative effects. A longer baseline may allow for more diversity in infant emotion expressions and behavior, including negative expressions, and may thus be related to smaller still-face effects. A longer reunion episode was thought to facilitate recovery from the still-face episode and is expected to be related to a smaller carry-over effect. Further, we expected that the still-face effect is larger when no intervals are used between episodes (no relevant studies found, but sudden change was expected to be more upsetting). Regarding sample moderators, we hypothesized that the still-face effect is larger in younger children, and that there are no differences between boys and girls.

Meta-analytic procedures

In some studies, positive and/or negative affect were represented by more than one variable (e.g., crying and frowning for negative affect). In these cases, the results for variables that represented one overall behavioral category were meta-analytically combined, and the combined effect size was used in the main analyses. Nine meta-analyses were performed to compare each SFP phase pair (baseline–still-face, still-face–reunion, and baseline–reunion) regarding the four infant behaviors (gaze, positive affect, negative affect, and neutral affect). The meta-analyses were performed using the Comprehensive Meta-Analysis (CMA) program (Borenstein, Rothstein, & Cohen, 2005, Version 2). For each study, an effect size (standard difference in means: *d*) was calculated. Positive effect sizes indicate that the effect reflected the directions of the hypotheses, whereas negative effect sizes indicate effects opposite to the hypothesized direction. For the computation of each effect, the correlation between the behavior in the two episodes that are compared is required. However, the large majority of studies did not report these correlations. We found five papers (with seven samples) that did report these correlations for one or more infant behaviors (Abelkop & Frick, 2003; Carter et al., 1990; Haley & Stansbury, 2003; Moore & Calkins, 2004; Weinberg et al., 1999). There were correlations from five studies for gaze, four studies for positive affect, six studies for negative affect and only one for neutral affect. These correlations were averaged for each combination of episode comparison and behavior and used in the meta-analyses for studies that did not report these figures.

Using CMA, combined effect sizes and 95% confidence intervals (*CI*s) around the point estimates were computed. Depending on the homogeneity of the study outcomes, significance tests and moderator analyses were performed through fixed or random effects models. Fixed effects models are based on the assumption that effect sizes observed in a study estimate the corresponding population effect with random error that is only due to the chance factors associated with subject-level sampling error in that study (Lipsey & Wilson, 2001; Rosenthal, 1995). Random effects models do not make this assumption (Hedges & Olkin, 1985) and allow for the possibility that there are random differences between studies that are associated with variations in procedures, measures, and settings, that go beyond subject-level sampling error, and thus point to different study populations (Lipsey & Wilson, 2001). Whether fixed or random models can be used depends on the homogeneity of the set of effect sizes. To test the homogeneity of the overall and specific sets of effect sizes, we computed *Q*-statistics (Borenstein et al., 2005). When the set was homogeneous (nonsignificant *Q*-statistic), effect sizes and *CI*s were based on fixed estimates. In case of heterogeneity of the set (significant *Q*-statistic), we based effect sizes and *CI*s on random estimates. *Q*-statistics and their *p*-values were also computed to assess differences between combined effect sizes for specific subsets of study effect sizes grouped by moderators. Contrasts were only tested when at least two of the subsets consisted of at least four studies (Bakermans-Kranenburg, Van IJzendoorn, & Juffer, 2003). Again, fixed effects model tests were used in the case of homogeneous sets of outcomes, and more conservative random effects model tests were used if one or more subsets showed heterogeneous outcomes. For the continuous variable infant age (in months) and gender (% boys) Fisher's *Z* scores were used in weighted least squares regression analyses. Fisher's *Z* scores were weighted for the inverse variance in order to give studies with larger sample sizes more weight in the analyses. Significance tests were based on corrected standard errors (Lipsey & Wilson, 2001). None of the other moderator variables showed a continuous distribution that was suitable for these analyses.

Funnel plots were examined in order to detect possible publication bias. A funnel plot is a plot of each study's effect size against its standard error (usually plotted as 1/SE, or precision). It is expected that this plot has the shape of a funnel, because studies with smaller sample sizes (larger standard errors) have increasingly large variation in estimates of their effect size as random variation becomes increasingly influential, whereas studies with larger sample sizes have smaller variation in effect sizes (Duval & Tweedie, 2000b; Sutton, Duval, Tweedie, Abrams, & Jones, 2000). However, smaller studies with nonsignificant results or with effect sizes in the nonhypothesized direction are less likely to be published. Therefore, a funnel plot may be asymmetrical around its base. The degree of asymmetry in the funnel plot was examined by estimating the number of studies which have no symmetric counterpart on the other side of the funnel. The "trim and fill" method was used to test the influence of possible adjustments of the sets of studies for publication bias (Duval & Tweedie, 2000a; Duval & Tweedie, 2000b).

No outliers (standardized *z*-values smaller than −3.29 or larger than 3.29; Tabachnick & Fidell, 2001) were found for study effect sizes (examined for the four infant behaviors separately within each episode-comparison). We did find one outlier for sample size in the analyses for gaze, positive and negative affect. This was the study by Tronick et al. (2005) in which a staggering 659 infants were observed in the SFP (the next-highest sample sizes were $N = 133$ for positive and negative affect, and $N = 90$ for gaze). To not lose this unique study by Tronick and colleagues, this sample size was winsorized (i.e., "moved in close to the good data"; Hampel, Ronchetti, Rousseeuw, & Stahel, 1986, p. 69) and replaced by $N = 200$ which was the sample size used in the meta-analyses.

Results

Meta-analyses of the still-face effect in the set of uniform studies

Table 3 shows the results of the meta-analyses that examined changes in infant gaze, positive, negative, and neutral affect from the baseline to the still-face episode. Consistent with our hypotheses, the results show a significant decrease in gaze ($d = 0.72$, 95% $CI = 0.55–0.89$) and positive affect ($d = 0.93$, 95% $CI = 0.78–1.08$), and significant increases in negative affect ($d = 0.52$, 95% $CI = 0.39–0.65$) and neutral affect ($d = 0.42$, 95% $CI = 0.10–0.74$). For each outcome measure, the total set of studies was heterogeneous as evidenced by significant Q-values. Moderator analyses showed that the decrease in gaze was significantly different for different age groups. Follow-up analyses revealed that the effect was stronger for infants 6 months or older ($d = 0.94$) compared to infant aged 4–5 months ($d = 0.65$) ($Q[1,22] = 5.02$, $p < .05$) and infants 3 months or younger ($d = 0.45$) ($Q[1,20] = 6.93$, $p < .01$). There was no difference in effect between the two younger groups ($Q[1,21] = 0.84$, $p = .36$). Further, the drop in gaze from baseline to still-face was less strong when the adult partner was allowed to touch the infant during the baseline episode ($d = 0.97$ versus $d = 0.57$). The decrease in positive affect was also stronger when the infant interacted with a parent ($d = 1.01$) rather than a stranger ($d = 0.57$), and when the baseline was 120 s or longer ($d = 1.12$) rather than shorter ($d = 0.80$). There were no significant moderators for negative affect. For infant age (in months) moderator analyses were also performed using the continuous variable in weighted regression models. The age-effect found for the decrease in gaze from baseline to still-face was confirmed in these analyses, with older children showing a stronger decrease ($p < .01$). The regression analyses did not show any significant effects of gender.

Table 4 presents the results of the meta-analyses that examined changes in infant behavior from the still-face episode to the reunion. Again, the total set of studies for each behavioral outcome was heterogeneous as evidenced by significant Q-values. As expected, infants showed a significant increase in gaze ($d = 0.71$, 95% $CI = 0.51–0.91$) and positive affect ($d = 0.75$, 95% $CI = 0.62–0.87$), and a significant decrease in neutral affect ($d = 0.55$, 95% $CI = 0.22–0.89$). However, we failed to find a significant decrease in negative affect ($d = 0.04$, 95% $CI = -0.07$ to 0.16), suggesting the absence of 'recovery' regarding this behavior. The increase in gaze was significantly related to infant age, with the infants 6 months or older showing a stronger increase compared to infants aged 3 months or younger ($Q[1,18] = 12.82$, $p < .01$), and infants aged 4–5 months ($Q[2,22] = 15.72$, $p < .01$). There was no difference in effect between the two youngest age groups ($Q[1,19] = 0.01$, $p = .91$). Weighted regression analyses revealed the same age-effect that was also found in the categorical analyses, with a stronger increase in gaze for older children ($p < .01$). Whereas the categorical age variable was not a significant moderator for the decrease in negative affect, the continuous age variable was significantly related to a lower decrease in negative affect ($p < .01$). The regression analyses did not show any significant effects of gender.

The results of the meta-analyses of infant behavioral changes from the baseline to the reunion episode are presented in Table 5. We found a significant decrease in positive affect ($d = 0.20$, 95% $CI = 0.11–0.29$), and a significant increase in negative affect ($d = 0.49$, 95% $CI = 0.42–0.56$), but no differences between baseline and reunion for gaze ($d = 0.02$, 95% $CI = -0.10$ to 0.14) and neutral affect ($d = 0.19$, 95% $CI = -0.21$ to 0.60). The Q-value for the total set of negative affect was nearly significant ($p = .055$), suggesting a tendency toward heterogeneous studies. Moderator analyses showed a significant effect of age, with no decrease in gaze for infants aged 0 to 3 months ($d = 0.11$, $p = .16$), a significant decrease for infants aged 4–5n months ($d = 0.22$, $p < .01$), and a significant increase in gaze for infants 6 months or older ($d = -0.22$, $p < .01$), which was significantly different from the effect found in the 0–3-month-olds ($Q[1,18] = 5.83$, $p < .05$) and the 4–5-month-olds ($Q[1,22] = 10.68$, $p < .01$). The difference between the two youngest age groups was not significant ($Q[1,19] = 0.21$, $p = .65$). Further,

Table 3
Meta-analytic results of infant reactions to the Still-Face Paradigm from baseline to still-face.

	k	*n*	*d*	95% *CI*	*Q*[a]	*p*
Gaze decrease (total set)	33	1070	0.72**	(0.55–0.89)	93.23**	
Infant age					7.76	.02
0–3 months	10	231	0.45**	(0.18–0.73)	30.00**	
4–5 months	12	476	0.65**	(0.40–0.89)	25.09**	
6+ months	11	363	0.94**	(0.78–1.11)	11.26	
Adult partner					2.10	.15
Parent	24	894	0.65**	(0.46–0.83)	68.33**	
Stranger	9	176	0.93**	(0.60–1.27)	17.11*	
Length of baseline[a]					3.50	.06
<120 s	16	419	0.88**	(0.69–1.08)	25.26*	
120 s or more	14	564	0.55**	(0.43–0.66)	18.01	
Length of still-face					0.30	.59
<120 s	20	572	0.76**	(0.54–0.98)	71.13**	
120 s or more	13	498	0.52**	(0.40–0.65)	19.28	
Intervals between phases					0.97	.33
No	16	545	0.64**	(0.40–0.88)	64.94**	
Yes	17	525	0.82**	(0.56–1.07)	28.29*	
Touch allowed					8.17	<.01
No	10	309	0.97**	(0.79–1.15)	14.59	
Yes	23	761	0.57**	(0.40–0.75)	56.44**	
Positive affect decrease (total)	35	1259	0.93**	(0.78–1.08)	98.53**	
Infant age					3.12	.21
0–3 months	10	256	0.82**	(0.55–1.09)	29.26**	
4–5 months	13	560	0.85**	(0.62–1.08)	30.37**	
6+ months	12	443	1.10**	(0.86–1.34)	24.05*	
Adult partner					4.61	.03
Parent	27	1095	1.01**	(0.85–1.17)	74.71**	
Stranger	8	164	0.57**	(0.37–0.77)	13.99	
Length of baseline[a]					4.94	.03
<120 s	15	407	0.80**	(0.59–1.02)	33.74**	
120 s or more	17	729	1.12**	(0.94–1.31)	32.75**	
Length of still-face[a]					1.43	.23
<120 s	18	512	0.84**	(0.63–1.05)	37.55**	
120 s or more	17	747	1.02**	(0.81–1.23)	60.66**	
Intervals between phases					0.50	.48
No	18	700	0.89**	(0.69–1.08)	76.59**	
Yes	17	559	0.91**	(0.80–1.03)	20.97	
Touch allowed					0.72	.40
No	10	316	0.97**	(0.81–1.13)	13.04	
Yes	25	943	0.90**	(0.73–1.06)	83.45**	
Negative affect increase (total)[c]	19	1019	0.52**	(0.39–0.65)	62.71**	
Infant age					0.61	.74
0–3 months	5	221	0.56**	(0.31–0.82)	24.29**	
4–5 months	7	476	0.56**	(0.34–0.79)	12.94	
6+ months	7	322	0.45**	(0.24–0.67)	23.20**	
Length of baseline[b]						
<120 s	3	195	0.71**	(0.39–1.03)	–	
120 s or more	12	653	0.52**	(0.36–0.68)	39.02**	
Length of still-face[b]					0.02	.88
<120 s	6	306	0.53**	(0.30–0.77)	19.06**	
120 s or more	13	713	0.51**	(0.36–0.66)	42.30**	
Intervals between phases					0.20	.65
No	11	566	0.49**	(0.32–0.67)	34.09**	
Yes	8	453	0.55**	(0.36–0.75)	28.50**	

(*continued on next page*)

Table 3 (*continued*)

	k	*n*	*d*	95% *CI*	Q[a]	*p*
Touch allowed						
No	3	198	0.65**	(0.34–0.96)	–	
Yes	16	821	0.49**	(0.36–0.63)	49.42**	
Neutral affect increase (total)[d]	6	188	0.42*	(0.10–0.74)	19.04**	

Note: k = number of studies; n = total number of participants; and *CI* = confidence interval.

[a] Q statistics for moderators represent the effect of the subgroup contrasts (df = number of subgroups − 1), Q statistics for subgroups stand for homogeneity ($df = k - 1$). Subgroups with less than four studies were excluded from contrasts and homogeneity.

[b] In some studies only part of the episode was coded and not the entire length. For our analyses regarding episode length, these studies were excluded, yielding lower k and n values.

[c] For negative affect, there were no studies with strangers as the adult partner. Thus, the 'adult partner' moderator was not examined for the negative affect outcome.

[d] For neutral effect, there were not enough studies to conduct moderator analyses. Only the total effect is reported.

* $p < .05$.

** $p < .01$.

the decrease in gaze was stronger in studies with reunion episodes shorter than 120 s than in longer ones ($Q[1,28] = 4.53$, $p < .05$). Weighted regression analyses with the continuous variable infant age confirmed the finding that the decrease in gaze from baseline to reunion is stronger for younger than for older children ($p < .05$). The regression analyses also yielded a significant effect of gender (% boys), showing that studies with more boys report a stronger decrease in positive affect from baseline to reunion ($p < .05$).

Overall, the sets of studies with strangers as the adult partner, and those in which touch was not allowed during normal interaction were the most homogeneous, as evidenced by mostly nonsignificant Q-values. These factors may overlap however, since touch is more often not allowed in studies with strangers (50% of studies) than in studies with a parent as the adult (21% of studies). We therefore also examined the no-touch subset within the set of studies focusing on parents. For studies with parents who were not allowed to touch their infants, the sets for gaze ($k = 5$, $n = 207$) and positive affect ($k = 6$, $n = 226$), were homogeneous in all episode comparisons (all $ps > .46$), whereas all subsets with parents who were allowed to use touch were heterogeneous for gaze and positive affect (all $ps < .01$). The studies examining negative affect were done with parents as the adult partners, and the no-touch subsets were too small for heterogeneity analyses ($k = 3$ for all episode comparisons). The parent-touch subsets for negative affect showed significant heterogeneity in two out of three episode comparisons (baseline–still-face, and still-face–reunion). For neutral affect, only one study examined parents in a no-touch paradigm in each of the episode comparisons, and the subset parent-touch was large enough only for the baseline–still-face comparison ($k = 5$, $n = 169$), and showed significant heterogeneity. For the comparison between baseline and reunion, the subsets of studies with the two younger age groups (i.e., younger than 6 months) and those with reunion episodes shorter than 120 s were homogeneous for gaze, positive, and negative affect.

Using the trim and fill method (Duval & Tweedie, 2000a; Duval & Tweedie, 2000b), some asymmetry was found in the funnel plots (precision plot, random effects), which indicates a potential publication bias. We looked for missing studies to the left of the mean, because we expected studies with small sample sizes reporting small effects would be more likely to end up in the proverbial file drawer. The number of studies found to the left of the funnel plots ranged from zero to ten. The adjusted effect sizes were very close to the observed values when less than five missing studies were identified. For four analyses, there were more than five missing studies, yielding more attenuated adjusted effect sizes, although all retained the same significance level. This was the case for: the decrease in gaze from baseline to still-face (9 missing studies, adjusted $d = 0.56$ verses observed $d = 0.72$), the increase in gaze from still-face to reunion (7 missing studies, adjusted $d = 0.51$ verses observed $d = 0.71$), the decrease in positive affect from baseline to still-face (7 missing studies, adjusted $d = 0.82$ verses observed $d = 0.93$), and the increase in positive affect from still-face to reunion (10 missing studies, adjusted $d = 0.59$ verses observed $d = 0.74$).

Table 4
Meta-analytic results of infant reactions to the Still-Face Paradigm from still-face to reunion.

	k	*n*	*d*	95% *CI*	*Q*[a]	*p*
Gaze increase (total set)	31	1007	0.71**	(0.51–0.91)	166.95**	
Infant age					18.65	<.01
0–3 months	8	168	0.41**	(0.10–0.72)	20.85**	
4–5 months	12	476	0.44**	(0.20–0.68)	41.41**	
6+ months	11	363	1.15**	(0.89–1.42)	22.07*	
Adult partner					1.03	.89
Parent	22	831	0.72**	(0.48–0.96)	133.05**	
Stranger	9	176	0.69**	(0.31–1.07)	31.62**	
Length of still-face					0.00	.78
<120 s	18	509	0.69**	(0.42–0.95)	68.52**	
120 s or more	13	498	0.75**	(0.43–1.06)	87.54**	
Length of reunion[b]					0.77	.38
<120 s	16	419	0.70**	(0.43–0.98)	37.17**	
120 s or more	13	521	0.89**	(0.58–1.19)	94.11**	
Intervals between phases					2.36	.13
No	16	545	0.57**	(0.28–0.85)	80.66**	
Yes	15	461	0.90**	(0.58–1.21)	85.91**	
Touch allowed					2.84	.09
No	10	309	0.95**	(0.61–1.30)	18.33*	
Yes	21	698	0.60**	(0.37–0.82)	118.15**	
Positive affect increase (total)	33	1196	0.75**	(0.62–0.87)	57.33	
Infant age					3.97	.14
0–3 months	8	193	0.77**	(0.55–0.99)	8.96	
4–5 months	13	560	0.58**	(0.46–0.69)	12.07	
6+ months	12	443	0.88**	(0.69–1.06)	25.71**	
Adult partner					1.59	.21
Parent	25	1032	0.79**	(0.65–0.92)	46.94**	
Stranger	8	164	0.55**	(0.34–0.76)	8.26	
Length of still-face					0.10	.75
<120 s	16	449	0.77**	(0.63–0.91)	21.82	
120 s or more	17	747	0.73**	(0.56–0.89)	33.87**	
Length of reunion[b]					1.23	.27
<120 s	16	491	0.63**	(0.51–0.75)	23.66	
120 s or more	16	686	0.82**	(0.64–0.99)	31.07*	
Intervals between phases					0.32	.57
No	18	700	0.72**	(0.56–0.88)	41.43**	
Yes	15	496	0.75**	(0.62–0.88)	14.96	
Touch allowed					0.68	.41
No	10	316	0.81**	(0.64–0.98)	12.49	
Yes	23	880	0.71**	(0.57–0.86)	42.57**	
Negative affect decrease (total)[c]	17	956	0.04	(−0.07 to 0.16)	33.03**	
Infant age					0.47	.50
0–3 months	3	158	0.16	(−0.06 to 0.36)	–	
4–5 months	7	476	0.02	(−0.07 to 0.10)	8.18	
6+ months	7	322	−0.02	(−0.10 to 0.07)	10.36	
Length of still-face					0.36	.55
<120 s	4	243	0.08	(−0.05 to 0.21)	6.62	
120 s or more	13	713	0.02	(−0.08 to 0.12)	25.42*	
Length of reunion[b]					0.22	.64
<120 s	4	279	0.07	(−0.11 to 0.25)	8.19*	
120 s or more	11	610	0.02	(−0.09 to 0.14)	22.41*	
Intervals between phases					0.99	.32
No	11	566	−0.01	(−0.08 to 0.07)	15.72	
Yes	6	390	0.09	(−0.05 to 0.24)	16.26**	

(*continued on next page*)

Table 4 (*continued*)

	k	n	d	95% CI	Q[a]	p
Touch allowed						
No	3	198	0.08	(−0.07 to 0.22)	–	
Yes	14	758	0.03	(−0.07 to 0.13)	27.41*	
Neutral affect decrease (total)[d]	4	125	0.65**	(0.22–0.89)	12.47**	

Note: k = number of studies; n = total number of participants; and CI = confidence interval.

[a] Q statistics for moderators represent the effect of the subgroup contrasts (df = number of subgroups − 1), Q statistics for subgroups stand for homogeneity ($df = k - 1$). Subgroups with less than four studies were excluded from contrasts and homogeneity.

[b] In some studies only part of the episode was coded and not the entire length. For our analyses regarding episode length, these studies were excluded, yielding lower k and n values.

[c] For negative affect, there were no studies with strangers as the adult partner. Thus, the 'adult partner' moderator was not examined for the negative affect outcome.

[d] For neutral effect, there were not enough studies to conduct moderator analyses. Only the total effect is reported.

* $p < .05$.

** $p < .01$.

The fail-safe numbers of studies for the analyses involving gaze, positive, and negative affect were all higher than the $5k + 10$ formula suggested by Rosenthal (1995), ranging from 241 studies with null-results needed to cancel out the significant decrease in positive affect from baseline to reunion, to 4081 studies with null-results needed to cancel out the significant decrease in positive affect from baseline to still-face. For neutral affect, the fail-safe numbers were below the Rosenthal formula, with 29 null-results needed to cancel out the significant increase found from baseline to still-face, and 43 to cancel out the decrease from still-face to reunion.

To provide a global integration of the findings in Tables 3–5, an overall picture of the changes in infant behaviors across the SFP is presented in Fig. 1. The mean occurrence of each behavior (i.e., percentage of time) was calculated per episode across all studies that provided means and standard deviations (or standard errors), applying listwise deletion per behavior. This resulted in a set of 31 studies for gaze, 30 for positive affect, 11 for negative affect, and 4 for neutral affect. The figure shows the general picture of decreasing gaze and positive affect from baseline to still-face, followed by an increase in these behaviors from still-face to reunion. For negative and neutral affect an increase is found from baseline to still-face, and only a slight decrease from baseline to reunion. It has to be noted however, that our meta-analyses showed that some moderator variables (e.g., infant age, episode duration) affect the magnitude of changes in behavior between episodes.

It is also possible that some of these moderators influence the level (proportion of time) of the behaviors within episodes. We therefore tested whether the moderator variables were related to the mean levels of each behavior per episode within the subgroup of studies used for the figure. Infant age (in months) was negatively correlated with gaze duration in the baseline ($r = -.36$, $p < .05$) and still-face episode ($r = -.58$, $p < .01$). There were no significant correlations between the mean rates of infant responses and percentage of boys (all $ps > .22$). The correlation for percentage of boys with negative affect during the still-face episode did approach significance ($p = .06$). Results of t-tests revealed higher levels of gaze if the episode was shorter than 120 s versus 120 s or longer for the baseline ($p < .01$) and the still-face and reunion ($ps < .05$). Further, lower levels of gaze were found in all episodes for interactions with strangers than for interactions with parents ($ps < .01$), and for procedures allowing touch during baseline ($p < .05$). We found no differences in rates of behavior for any episodes when comparing procedures with or without an interval between episodes ($ps > .22$).

Meta-analyses of infant behavior in the SFP in relation to external variables

For the third question of this paper, we conducted an additional set of meta-analyses to test the association of infant behavior in the SFP with other variables of interest. On a theoretical level, the variables maternal parenting behaviors, maternal depression, and quality of attachment are of particular interest in relation to the SFP, as also shown by sufficient numbers of studies for meta-analyses about each of these topics. Associations with these variables represent the link between infant re-

Table 5
Meta-analytic results of infant reactions to the Still-Face Paradigm from baseline to reunion.

	k	*n*	d^{a}	95% *CI*	Q^{a}	*p*
Gaze decrease (total set)	31	1007	0.02	(−0.10 to 0.14)	92.46**	
Infant age					12.76	< .01
0–3 months	8	168	0.11	(−0.04 to 0.26)	11.52	
4–5 months	12	476	0.22**	(0.13–0.31)	13.61	
6+ months	11	363	−0.22**	(−0.39 to −0.05)	35.12**	
Adult partner					1.75	.19
Parent	22	831	−0.03	(−0.17 to 0.11)	82.85**	
Stranger	9	176	0.17*	(0.02–0.31)	7.15	
Length of still-face					1.52	.22
<120 s	18	509	0.09	(−0.08 to 0.25)	29.67*	
120 s or more	13	498	−0.07	(−0.26 to 0.12)	62.51**	
Length of reunion[b]					4.53	.03
<120 s	16	419	0.15**	(0.06–0.25)	14.87	
120 s or more	13	521	−0.12	(−0.30 to 0.06)	65.47**	
Intervals between phases					0.98	.32
No	16	545	0.08	(−0.09 to 0.24)	27.83*	
Yes	15	462	−0.05	(−0.23 to 0.14)	63.68**	
Touch allowed					1.98	.16
No	10	309	0.15**	(0.04–0.27)	6.44	
Yes	21	698	−0.04	(−0.18 to 0.11)	81.79**	
Positive affect decrease (total)	33	1245	0.20**	(0.11–0.29)	46.39*	
Infant age					0.21	.90
0–3 months	9	326	0.22**	(0.09–0.35)	6.55	
4–5 months	12	476	0.22**	(0.12–0.32)	6.87	
6+ months	12	443	0.18*	(0.04–0.32)	32.64**	
Adult partner					0.05	.83
Parent	25	1081	0.20**	(0.11–0.30)	44.63**	
Stranger	8	164	0.18*	(0.01–0.35)	1.68	
Length of still-face					3.72	.05
<120 s	16	449	0.11*	(0.01–0.21)	13.43	
120 s or more	17	796	0.26**	(0.16–0.37)	28.05*	
Length of reunion[b]					1.18	.28
<120 s	15	407	0.15**	(0.04–0.26)	7.77	
120 s or more	17	819	0.24**	(0.13–0.35)	36.23**	
Intervals between phases					0.07	.79
No	17	616	0.21**	(0.09–0.32)	31.84*	
Yes	16	629	0.18**	(0.09–0.27)	14.17	
Touch allowed					0.05	.82
No	10	316	0.20**	(0.07–0.32)	5.00	
Yes	23	929	0.19**	(0.09–0.29)	41.38**	
Negative affect increase (total)[c]	17	1005	0.49**	(0.42–0.56)	25.95	
Infant age					0.11	.95
0–3 months	4	291	0.51**	(0.37–0.66)	4.68	
4–5 months	6	392	0.54**	(0.41–0.67)	2.40	
6+ months	7	322	0.49**	(0.33–0.65)	17.92**	
Length of still-face					0.09	.76
<120 s	4	243	0.49**	(0.33–0.66)	7.43	
120 s or more	13	762	0.49**	(0.42–0.57)	18.52	
Length of reunion[b]						
<120 s	3	195	0.57**	(0.38–0.76)	–	
120 s or more	12	743	0.49**	(0.42–0.57)	18.51	
Intervals between phases					0.33	.56
No	10	482	0.54**	(0.40–0.68)	17.07*	
Yes	7	523	0.46**	(0.37–0.55)	7.40	

(*continued on next page*)

Table 5 (*continued*)

	k	*n*	*d*[a]	95% *CI*	*Q*[a]	*p*
Touch allowed						
No	3	198	0.60**	(0.41–0.79)	–	
Yes	14	807	0.49**	(0.38–0.59)	21.17	
Neutral affect decrease (total)[d]	4	125	0.26	(−0.06 to 0.57)	10.48*	

Note: k = number of studies; n = total number of participants; and *CI* = confidence interval.

[a] Q statistics for moderators represent the effect of the subgroup contrasts (df = number of subgroups − 1), Q statistics for subgroups stand for homogeneity ($df = k - 1$). Subgroups with less than four studies were excluded from contrasts and homogeneity.

[b] In some studies only part of the episode was coded and not the entire length. For our analyses regarding episode length, these studies were excluded, yielding lower k and n values.

[c] For negative affect, there were no studies with strangers as the adult partner. Thus, the 'adult partner' moderator was not examined for the negative affect outcome.

[d] For neutral effect, there were not enough studies to conduct moderator analyses. Only the total effect is reported.

* $p < .05$.

** $p < .01$.

sponses to the still-face and the broader parenting context, and may facilitate the interpretation of different patterns of infant behaviors during the SFP. Maternal parenting and depression have been frequently found to be significant predictors of infant adjustment (e.g., Field, 1995), and we would expect these variables to also be related to infant responses to the SFP (see also the narrative review). Consequently, if infant responses to the SFP can be considered to reflect the quality of mother–infant interaction, it may also predict the quality of later mother–infant attachment (see also narrative review), as the quality of attachment is known to be predicted by early mother–infant interaction (de Wolff & van IJzendoorn, 1997). For the selection of studies for these meta-analyses, we did not

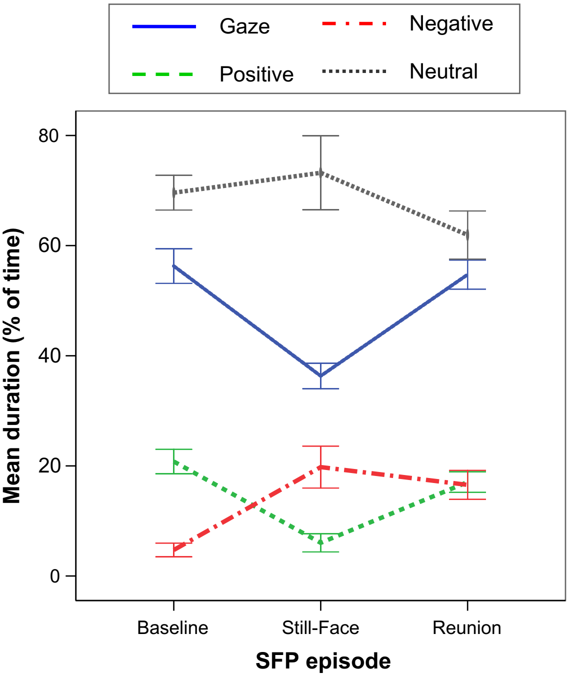

Fig. 1. Summary of meta-analytic findings regarding the changes in gaze, positive, negative, and neutral affect across the three SFP episodes. *Note:* Error bars represent 1 standard error ± the mean.

Table 6
Studies included in the meta-analyses of maternal depression predicting infant affect during the still-face.

Studies	Sub-samples	*N* depressed	*N* control	*N* total	Infant age at SFP (months)	SFP episode	Maternal depression	Effect size for positive affect		Effect size for negative affect	
								d	(95% *CI*)	*d*	(95% *CI*)
Field et al. (2007)[a]		14	14	28	4	Still-face	Current	−1.38	(−2.20 to −0.56)**	−1.05	(−1.61 to −0.50)**
Forbes et al. (2004)[b]		–	–	44	3 and 6	Still-face	Lifetime	0.43	(−0.02 to 0.87)	0.29	(−0.14 to 0.71)
Garrity-Rokous (1999)[c]		21	35	56	4	Still-face/ reunion	Lifetime	0.5	(−0.05 to 1.05)	−0.17	(−0.72 to 0.37)
Moore et al. (2001)[d]		–	–	99	2, 4, 6	Total SFP	Current/recent	0.19	(−0.05 to 0.42)	0.04	(−0.19 to 0.27)
Peláez-Nogueras et al. (1996)[e]		16	16	32	3	Still-face	Current	−0.6	(−1.31 to 0.11)	−0.29	(−0.78 to 0.20)
Rosenblum et al. (2002)		–	–	100	7	Reunion	Current	0.14	(−0.26 to 0.54)	0.14	(−0.26 to 0.54)
Stanley et al. (2004)		67	48	115	3	Still-face	Current	−0.07	(−0.44 to 0.31)	−0.09	(−0.46 to 0.29)
Weinberg et al. (2006)[f]	Boys	26	20	46	3	Reunion	Current	–	–	0.25	(−0.34 to 0.83)
	Girls	19	26	45	3	Reunion	Current	–	–	−0.55	(−1.15 to 0.05)
Results of meta-analyses:				455				−0.01[f]	(−0.33 to 0.31)	−0.11[g]	(−0.36 to 0.15)

[a] Results distress brow and crying were meta-analyzed to obtain 1 effect size for negative affect. The procedure also included a separation.
[b] Results for ages 3 and 6 months were meta-analyzed to obtain 1 effect size because they represent the same sample. Maternal and/or paternal depression was measured.
[c] Parents were allowed to use toys during baseline and reunion. Positive affect (infant responsiveness) in reunion, negative affect (latency of onset and duration) in still-face.
[d] The SFP was administered at home instead of in a lab. Results for ages 2, 4, and 6 months meta-analyzed to obtain 1 effect size, because they were obtained in the same sample. Depression was current for age 2 months, recent or current for ages 4 and 6 months due to change across time.
[e] The procedure included 2 still-face episodes, one with maternal touch. Only the results for the still-face episode without touch were used here.
[f] $Q = 21.57$, $p < .01$.
[g] $Q = 23.77$, $p < .01$.
** $p < .01$.

Table 7
Studies included in the meta-analyses of maternal positive behavior predicting infant affect during the still-face.

Studies	Sub-samples	*N*	Infant age at SFP (months)	Effect size positive affect		Effect size negative affect	
				d	(95% *CI*)	*d*	(95% *CI*)
Braungart-Rieker et al. (2001)		94	4	0.63	(0.20–1.06)**	–	–
Carter et al. (1990)	Boys	25	3	0.02	(−0.82 to 0.86)	−0.75	(−1.64 to 0.15)
	Girls	34	3	0.43	(−0.29 to 1.15)	0.75	(−0.00 to 1.50)
Forbes et al. (2004)		48	3	0.20	(−0.39 to 0.79)	0.43	(−1.03 to 0.17)
Garrity-Rokous (1999)[a]		85	4	–	–	−0.12	(−0.55 to 0.31)
Kogan & Carter (1996)[b]		29	4	1.67	(0.67–2.67)**	–	–
Lowe et al. (2006)		76	6	0.57	(0.09–1.05)*	–	–
Tarabulsy et al. (2003)		76	6	0.16	(−0.30 to 0.62)	0.46	(−0.21 to 0.29)
Results meta-analyses:				0.45	(0.23–0.66)** [c]	0.15	(−0.26 to 0.56)[d]

Note: Maternal behavior was assessed during the baseline of the SFP, except in the study by Tarabulsy et al. (2003) in which maternal sensitivity was assessed at home two weeks prior to the SFP. Infant affect was assessed in the still-face episode of the SFP, except in the study by Kogan and Carter (1996) in which infant affect was assessed during the reunion episode of the SFP.

[a] Parents were allowed to use toys during the baseline and reunion episodes.

[b] Parents were allowed to use toys during the baseline and reunion episodes.

[c] $Q = 9.84$, $p = .13$.

[d] $Q = 9.53$, $p = .049$.

* $p < .05$.

** $p < .01$.

apply the strict criteria for inclusion as we did in the main meta-analyses. All studies that included at least a baseline and still-face episode were eligible. Deviations from the criteria set previously are reported in the notes of the tables.

For maternal depression (Table 6), we found nine relevant studies, all reporting on infant negative affect, and seven reporting also on positive affect. We defined a positive effect as more negative and less positive affect shown by infants with depressed mothers versus infants of non-depressed mothers. The overall effect sizes were not significant for positive affect ($d = -0.01$, 95% $CI = -0.33$ to 0.31, $p = .97$) or for negative affect ($d = -0.11$, 95% $CI = -0.36$ to 0.15, $p = .41$). As can be seen in Table 7, several studies have negative effect sizes, reflecting findings of more positive and less negative affect in infants of depressed mothers. The number of studies was too small to perform moderator analyses, but additional meta-analyses of subsets of studies (still-face or reunion episode only, current depression only, or 3–4-month-olds only) did not yield significant overall effects.

For maternal parenting behavior (Table 7) we found a total of eight studies, with seven reporting on infant positive affect and five on infant negative affect. Based on the narrative review, a positive effect was defined as positive maternal behavior predicting more positive and less negative infant affect in the SFP. A significant overall effect was found for infant positive affect, ($d = 0.45$, 95% $CI = 0.23$–0.66, $p < .01$), but not for infant negative affect ($d = 0.15$, 95% $CI = -0.26$ to 0.56, $p = .49$). The funnel plot for the positive affect analysis revealed no asymmetry, thus no evidence for publication bias.

The eight studies investigating infant responses to the SFP in relation to future quality of attachment are presented in Table 8. Based on the narrative review, a positive effect was defined as future securely attached infants showing more positive and less negative affect during the SFP. The results reveal significant overall effects for infant positive affect ($d = 0.23$, 95% $CI = 0.01$–0.44, $p < .05$), and for negative affect ($d = 0.24$, 95% $CI = 0.04$–0.44, $p < .05$). For positive affect, one missing study was identified to the left of the mean. Duval and Tweedie's trim and fill method yielded an adjusted effect size that failed to reach significance ($d = 0.19$, 95% $CI = -0.06$ to 0.48). Further, only seven studies with null-results would be needed to cancel out the observed effect of more positive affect during the still-face episode for securely versus insecurely attached infants. This fail-safe number is lower than Rosenthal's criterion, suggesting that only a small number of unpublished studies with null-results would cancel out the significant effect found here. For negative affect, the funnel plot revealed no asymmetry, thus no evidence for publication bias.

Table 8
Studies included in the meta-analyses of infant affect during the still-face predicting future attachment security.

Studies	Sub-samples	Infant age at SFP (months)	*N* secure	*N* insecure	Effect size positive affect		Effect size negative affect	
					d	(95% *CI*)	*d*	(95% *CI*)
Braungart-Rieker et al. (2001)		4	20	74	0.17	(−0.32 to 0.67)	0.13	(−0.37 to 0.62)
Cohn et al. (1991)		2, 4, 6[a]	37	29	0.16	(−0.34 to 0.66)	0.00	(−0.50 to 0.50)
Fuertes et al. (2006)[b]		3	32	16	0.62	(0.00 to 1.23)*	0.21	(−0.39 to 0.81)
Jamieson (2004)	SFP without touch	4	19	63	0.18	(−0.34 to 0.69)	0.57	(0.20–0.94)**
Jamieson (2004)	SFP with touch	4	35	46	−0.06	(−0.50 to 0.38)	0.15	(−0.29 to 0.59)
Tronick et al. (1982)[c]	Age 3 months	3	10	2	0.15	(−1.16 to 1.46)	−0.27	(−1.59 to 1.05)
	Age 6 months	6	12	5	1.52	(0.20–2.83)*	−0.49	(−1.56 to 0.59)
	Age 9 months	9	14	5	0.60	(−0.42 to 1.62)	0.79	(−0.27 to 1.84)
Results meta-analyses ($k = 8$):			179	240	0.23	(0.01–0.44)*,[d]	0.24	(0.04–0.44)*,[e]

Note: In all studies, attachment security was assessed when infants were 12 or 13 months of age.
[a] Results for the three age groups were meta-analyzed to provide 1 effect size, because they were obtained in the same sample.
[b] Infant affect was assessed during the entire SFP.
[c] For positive elicits, the contrasting group consisted of infants showing negative or no elicits. For negative elicits, the contrasting group consisted of infants showing positive or no elicits.
[d] $Q = 7.51$, $df = 7$, $p = .38$.
[e] $Q = 7.68$, $df = 7$, $p = .36$.
* $p < .05$.
** $p < .01$.

Discussion

The Still-Face Paradigm has inspired many researchers to study infant interactive behaviors and affect regulation in face-to-face interactions, addressing a wide variety of research questions. In the current paper we presented a narrative review and the results of several meta-analyses on the nature and correlates of the still-face effect. The narrative review of the still-face literature indicated that the still-face effect occurs from age 1 month onwards, is due to the break in normal social interaction rather than boredom, and manifests itself in infant gaze, affect and physiological responses. Infant responses to the still-face do not seem to be very stable over time, and the still-face effect is found across different samples in terms of demographic and risk variables. Infant responses to the still-face are related to maternal sensitivity, infant attachment, and a variety of other infant social and nonsocial behaviors. Maternal depression is however inconsistently related to infant responses to the SFP. The meta-analyses of a subset of studies with relatively similar procedures confirmed the classic still-face effect. Interestingly, the few significant moderator effects found for age, identity of the adult, and the use of touch contradicted those found by individual studies discussed in the narrative review. Additional meta-analyses confirmed the findings from the narrative review regarding infant responses to the still-face in relation to infant attachment, maternal sensitivity, and maternal depression.

The nature of the classic still-face effect

The meta-analyses confirm the classic still-face effect as first reported by Tronick et al. (1978), with decreasing positive affect and gaze, and increasing negative and neutral affect from the baseline to the still-face episode. The hypothesized carry-over effect was found for positive and negative affect. Positive affect showed recovery during the reunion, but remained significantly lower than during baseline. Negative affect did not decrease from still-face to reunion and remained significantly lower than during the baseline. Apparently, infants quickly recover from the still-face perturbation in terms of gaze and neutral affect, but the more pronounced affective responses linger into the reunion episode. It is possible that recovery does take place during the reunion, but only in the second part. If infants also take some time to become upset during the still-face episode, the net result may be that no change in overall level of negative affect is found, whereas a distinction between the first and second halves of the still-face and reunion episodes might present a different picture. Another possibility is that the standard episode duration of 60–180 s is not sufficient for the infant to regain affective composure. Full recovery may be possible, but only after a longer time period. It would be worthwhile to test these hypotheses empirically. As suggested by Cohn (2003), infant behavior in the reunion episode deserves further research attention as it represents an important part of dyadic interaction that parallels the reunion episodes of the SSP. As in the SSP, the quality of the repair after the break in interaction may provide essential information about individual differences that predict future adaptation.

In a different vein, affective recovery may be moderated by infant temperament. Highly reactive infants are generally low on soothability and may therefore show less or no recovery during the reunion than infants with more easy temperaments. Further, differential susceptibility may play a role, in that children with more difficult temperament characteristics are more strongly affected by environmental influences than other children (Belsky, 1997). This increased susceptibility may manifest itself for better and for worse, i.e., more benefit from positive environments and more from negative environments (Van Zeijl et al., 2007). Infant behaviors in each of the three SFP episodes may therefore be different for infants with different temperaments. Unfortunately, only two studies reported on temperament in relation to the SFP. For infants with a negative temperament, lower levels of self-comforting during the still-face episode were found, which may lead to less regulation and therefore less recovery (Braungart-Rieker et al., 1998). In another study, temperament did not predict infant affect or self-soothing during the still-face (Tarabulsy et al., 2003). This issue is therefore still in need of clarification. Other variables that may moderate the recovery from the still-face may include the quality of the parent–child relationship (see discussion of external predictors below).

Several studies discussed in the narrative review have shown that the still-face effect is not limited to infant affect and behavior, but also manifests itself in infant physiological responses. This could not be tested meta-analytically because of the small number of studies and limitations in the way their results were reported. The evidence suggests changes in cardiac activity that mirror the typically found behavioral changes (e.g., Bazhenova et al., 2001; Haley et al., 2006; Ham & Tronick, 2006). The SFP has also been found to increase cortisol levels (Haley et al., 2006) and skin conductance (Ham & Tronick, 2006), but these findings are in need of replication as these variables have each only been investigated by one study. To date, no studies have examined infants' fundamental processing of the still-face on the level of neural activity as measured by Event-Related Potentials (ERPs). Several studies have shown that infants' ERPs vary in response to facial expressions of different emotions (De Haan, Johnson, & Halit, 2003; Nelson & De Haan, 1996). More specifically, Grossmann, Striano, and Friederici (2006) found that infants' ERPs discriminated between emotionally congruent and incongruent stimuli. Because the still-face episode represents an incongruent stimulus, the investigation of ERPs in relation to the different episodes of the SFP may represent a worthwhile avenue for future research as it may provide important information for the interpretation of the behavioral findings. In addition, localization of neural activity during the SFP in terms of electroencephalographic (EEG) activation could tell us more about the underlying neural processes of infant affective responses to the SFP.

Considering that the SFP is clearly distressing to infants, one may ask whether the procedure is hazardous for infant development in the long run. Although no studies have explicitly investigated this issue, longitudinal research on the Strange Situation Procedure (SSP) has not revealed any long-term negative affects of the procedure (Grossmann, Grossmann, & Waters, 2005). Because the SSP is known to be very stressful to young children in a way similar to the SFP and probably even more so as it includes physical separations from the caregiver, we do not expect any long-term hazards of the SFP either.

The universality of the still-face effect

The robustness of the classic still-face effect is shown by the fact that it is found in infants of varying ages and both genders, and for normative samples as well as infants at-risk. Thus, the effect seems to be quite universal, although there are very few studies using the SFP in samples of infants from non-Western societies, limiting the generalization across infants from different cultures. The review showed some evidence for decreasing still-face effects after the age of 6 months (e.g., Striano & Liszkowski, 2005; Toda & Fogel, 1993), but our meta-analyses revealed few age differences, except for the effects on gaze, and these were in the opposite direction. The decrease in gaze from baseline to still-face and the increase from still-face to reunion were significantly stronger in infants aged 6 months or older. These infants also showed the opposite of a carry-over effect, in that they showed an increase in gaze from baseline to reunion. This may be related to previous findings that 6-month-olds gaze significantly less at their mothers than 3-month-olds during the still-face (Stack & Muir, 1990; Toda & Fogel, 1993), which is consistent with our finding that older children show less gaze than younger children in the still-face. These results are likely to reflect the growth of emotion regulation capacity in older versus younger infants that typically occurs in the second half of the first year (Bridges & Grolnick, 1995; Gunnar et al., 1989). Infant gaze aversion in emotionally challenging situations represents a regulation strategy that has been found to be predictive of future regulation and social skills (Hill & Braungart-Rieker, 2002; Yazbek & D'Entremont, 2006). In our meta-analyses, no age differences in the effects of the still-face on infant affect were found, nor on mean levels of affect during each episode. Apparently, increased attentional regulation skills (i.e., gaze aversion) do not translate directly into affective regulation skills. It may be that this step occurs somewhat later in the second half of the first year, and could not be detected because there are only a few studies that have used the SFP for infants older than 6 or 7 months. These findings may have implications for developmental theories of infant regulation in that different aspects of regulation may need to be distinguished to fully understand the nature of regulation at different ages.

Consistent with the narrative review, no effects of gender on the still-face effect were found. The literature does suggest gender to be a potential moderator in the association between parental risk and infant responses to the still-face (e.g., Weinberg et al., 2006), indicating the importance of including gender in that type of SFP studies. The narrative review showed that infant risk status (e.g., prematurity, sibling with Autism, and deafness) was not related to differences in the still-face effect.

This was not tested meta-analytically because of the small number of studies and the wide variations in type of risk. However, the findings discussed in the review are consistent with the overall picture of a robust still-face effect. Different patterns of responding are found in studies with children with severe and pervasive disabilities such as Autism Spectrum Disorder (e.g., Heimann et al., 2006) or Down syndrome (e.g., Carvajal & Iglesias, 1997), suggesting that the classic still-face effect can not be generalized to infants outside the range of normative development (which may include some delays and risk), but not severe disorders.

The still-face effect is not only found irrespective of the characteristics of the infant, but also regardless of procedural variations, including identity of the adult partner, episode duration, the use of intervals between episodes, and the use of touch during normal interaction. The review showed that the influence of the identity of the adult partner (parent versus stranger) has been examined in only two studies (Lamb et al., 1987; Kisilevsky et al., 1998), and these focused mostly on infant behavior in the separate episodes, rather than on changes in behaviors across episodes. Kisilevksy et al. reported a less pronounced effect on smiling (i.e., lower decrease from baseline to still-face, and lower subsequent increase to reunion) when infants interacted with their parents compared to with strangers. In our meta-analyses, the opposite was found, with a stronger decrease in positive affect from baseline to still-face when parents rather than strangers were the adult partners. This may be due to the interaction history that infants have with their parents, but not with strangers. The sudden lack of responsiveness may be more unfamiliar and more upsetting as infants do not expect their mothers to behave like this. With strangers, sudden unresponsiveness may be less surprising, as infants may be used to strange adults making some contact and then withdrawing again (for example, when infants are in the stroller during shopping). The findings by Kisilevsky et al. 1998) that the effect on smiling was less strong with parents than with strangers seemed to be mostly due to less smiling to parents than to strangers during the normal interaction episodes, a finding that was not replicated in our meta-analyses. Our between-subjects comparisons within episodes however were based on a smaller set of studies (those reporting means) than the main meta-analyses, which makes the two findings not fully comparable. The lack of studies examining infant negative affect in interaction with strangers also hampers conclusions in this area, as we do not know if infant negative affect mirrors the findings for positive affect in terms of the difference between interactions with parents and strangers.

The narrative review also indicated that the still-face effect was largely due to the loss of tactile stimulation and facial cues (e.g., Gusella et al., 1988; Striano & Bertin, 2004). In the often-cited study by Gusella et al. (1988), the still-face effect was absent when mothers were instructed not to touch their 3-month-old infants during normal interaction. In our meta-analyses however, touch was a moderator only once, and in the opposite direction, with the exclusion of touch leading to a stronger decrease in gaze from baseline to still-face. This discrepancy could be due to variations in the definition of infant gaze. When adults are not allowed to use touch, the infants are likely to focus their visual attention more on the face of the adult during normal interaction than on the hands or body. In the still-face episode gaze aversion could then manifest itself in gazing away from the face and shifting attention to other body parts such as the hands and body. If gaze is defined broadly as gaze at mother's face, hands or body and combined with the exclusion of touch during normal interaction (as Gusella et al. did), the shift in gaze from face to hands/body would not be noticed, suggesting the absence of a still-face effect. Conversely, most studies in our meta-analyses defined gaze as 'gaze at face'. In that case, mean levels of gaze would be expected to be lower during normal interactions with touch than without touch, which was also found in our own analyses. A shift in infant gaze from face to hands/body would therefore be found only or more clearly when the absence of touch is accompanied by the restricted 'age at face' definition. Researchers need to be aware of this issue, as it may influence their decisions regarding specific combinations of rules about touch and measures of infant gaze. Additionally, the exclusion of touch during normal interaction may also change other aspects of communication, as the adults are forced to alter their normal pattern of behavior with the infant. The question is whether the exclusion of touch increases the use of other modes of communication, and whether this is what may change the still-face effect.

The role of facial cues could not be tested in the meta-analyses as the relevant studies typically employ variations on the basic procedure that make them difficult to compare to other studies. The influence of other procedural variations, such as the duration of episodes and the inclusion of intervals between episodes had never been explicitly tested. Our meta-analyses showed that these variations do not have a major influence on the classic still-face effect. We did not find any effects of intervals between episodes, and only a few of episode duration (significant findings for three out of 18 analyses). Apparently, the disrupting effect of the adults' still-face on infant affect and behavior is not alleviated or made worse by a short break. This suggests that infants respond to the communicative nature of each episode as it occurs, and not necessarily to the suddenness of the change in communication. Longer baseline and still-face episodes are related to a larger decrease in positive affect from baseline to the next two episodes, and shorter reunions lead to larger decreases in gaze from baseline to reunion. Some studies discussed in the review have shown that the specific point of initiation of the still-face episode may influence the strength of the effect on infants (Fogel et al., 1982; Stoller & Field, 1982). These findings could not be tested meta-analytically, but represent an interesting avenue for future research, as this may have important implications for the basic procedure of the SFP. It is also of note that there were no significant moderators for infant negative affect, whereas some (albeit few) were found for positive affect and gaze. This may have been caused by the smaller number of studies available for negative affect and the exclusive use of mothers and not strangers in these studies. However, the lack of moderators can also be seen as evidence for the particular robustness of the SF-effect on infant negative affect.

The issue of adult intentions is also worthy of further investigation. The narrative review suggested that infants do distinguish between different intentions, and become less upset as a result of a break in social interaction if there is a clear reason for the break (e.g., Legerstee and Markova, 2007). The question is which specific aspects of adult communication change the infant's perception of the adult's intentions? Research into this issue will shed more light on infants' interpretations of various adult communicative signals, and what exactly constitutes the conflicting messages of 'Hello" and 'Goodbye" (Tronick et al., 1978) that seem to be at the core of the SF-effect.

External predictors of infant responses to the SFP

The two main variables that have been studied as potential predictors of individual differences in infant responses to the SFP are maternal interactive behavior and maternal depression. The narrative review showed that higher levels of maternal sensitivity or general positive behavior/affect are related to more positive affect and regulatory behavior and less avoidance and negative affect in infants during the still-face and reunion episodes (e.g., Braungart-Rieker et al., 2001; Rosenblum et al., 2002). The findings regarding infant positive affect were confirmed by the results of our meta-analyses. No effect on infant negative affect was found. Most of the studies examining this issue measured maternal behavior during the baseline of the SFP. It is therefore unclear whether the effect on infant responses is only due to the characteristics of the immediately preceding and ongoing interaction, or whether a *history* of sensitive care-giving will also affect infant responses to the SFP. The only two studies that examined maternal behavior prior to the SFP found mixed results. Tarabulsy et al. (2003) reported the expected results for maternal behavior measured two weeks before the SFP, while Stanley et al. (2004) did not find a relation between maternal behavior at age 2 months and infant responses to the SFP at 3 months of age. Another important issue is that all studies in this area only looked at infant responses within episodes, rather than examining maternal sensitivity in relation the *changes* in affect from one episode to the next. This is unfortunate as the within-subject changes in affect across the SFP are at least as important in understanding infant affect regulation as the between-subject differences within episodes.

It would also be interesting to examine whether the sensitivity of a stranger during baseline and reunion is related to infant responses to the still-face, to find out whether the ongoing interaction plays a major role or not. In the case of stranger–infant interactions, previous experiences with the parents may also play a role. There is some evidence that infants react less positively to interactions with strangers whose level of contingent responsiveness is dissimilar to that of the parent, even when it is more optimal than the parent's responsiveness (Bigelow & Rochat, 2006). This means that in interactions with strangers, the responsiveness of the parent may also play an important role in the infants' regulation of affect. However, in this case the hypothesis would not be that infants simply respond more positively to a more responsive stranger, but to those strangers that match the level of responsiveness that the infants are used to from their parents.

A second variable that has been examined as a predictor of infant responses to the SFP is maternal depression. The narrative review and the meta-analyses showed a mixed picture. Some studies have found that infants of depressed mothers react less negatively to the SFP (Field et al., 2007; Peláez-Nogueras et al., 1996), whereas others have found the opposite, albeit only in parts of their analyses (Forbes et al., 2004; Weinberg et al., 2006). Most studies reported no relation between depression and infant responses to the SFP at all (e.g., Rosenblum et al., 2002; Stanley et al., 2004). In our meta-analyses, we found no significant effect of maternal depression on infant affect during the still-face. The large differences between studies are suggestive of moderation effects, but the number of studies was too small to test these. However, a visual examination of the study characteristics (Table 6) did not yield clearly identifiable patterns that might explain the differences between studies. Most studies did find that depressed mothers were less sensitive and less positive toward their infants than non-depressed mothers (e.g., Field et al., 2007; Rosenblum et al., 2002; Weinberg et al., 2006). Because maternal sensitivity is related to infant affect in the SFP, one could hypothesize a mediation model (depression leads to less sensitivity which leads to infant negative affect). However, according to the formal definition of mediation this does not apply, as we did not find an overall effect of maternal depression on infant affect. Instead of the mediation model, a moderation model may also be proposed. Even though there is an association between maternal depression and interactive behavior, not all depressed mothers will show decreased sensitivity in interaction with their infants. It may therefore be possible that maternal sensitivity moderates the relation between depression and infant affect, i.e., maternal depression may only affect infant responses in the case of decreased maternal sensitivity. The degree of generalization of possible effects of depression on infant affect could also be examined by comparing these infants' reactions to mothers and strangers in the SFP. Again, differences in levels of sensitivity between mothers and strangers would have to be taken into account.

Comorbidity should also be considered, as depressive disorders often co-occur with other diagnoses, such as anxiety disorders and personality disorders (e.g., Brown, Campbell, Lehman, Grisham, & Mancill, 2001; Rossi et al., 2001). There is some evidence that the effects of maternal depression on their interactive behavior and on infant development may be due to the comorbid diagnoses (e.g., Carter, Garrity-Rokous, Chazen-Cohen, Little, & Briggs-Gowan, 2001). Some studies have also shown that other forms of maternal psychopathology such as borderline personality disorder are related to infant responses in the SFP (Hobson et al., 2005; Crandell et al., 2003). As borderline personality disorder is one of the often-found comorbid diagnoses in depressed individuals (Shea, Widiger, & Klein, 1992) this may be an important avenue for further research. The studies in Table 6 mostly used a self-report questionnaire as a measure of depression, and did not examine clinical diagnoses of depression or other comorbid disorders. Other potential moderators that may explain the inconsistent findings on depression in relation to infant response to the SFP need to be tested further, including duration of maternal depression, infant age, gender and temperament, but also maternal demographic risk status in terms of SES, marital status, and age.

The developmental significance of infant responses to the SFP

Individual differences in infant responses to the SFP have not only been studied as outcomes of external influences, but also as predictors of future adaptation. A first test of the predictive value of the SFP is the stability of infant responses during this paradigm across time. The narrative review revealed little longitudinal stability in infant behaviors across the SFP (e.g., Cossette et al., 1996; Moore et al., 2001). Unfortunately, these studies all examined stability of infant responses within episodes rather than the stability of infant changes in affect from one episode to the next. It may be that the rank order of infant responses within episodes changes across time, but that individual differences in the strength of the still-face effect in terms of within-infant changes in responses are more stable. It also has to be noted that none of these studies provide a good measure of the test-retest reliability of the SFP, as the longitudinal time intervals were all too long for this purpose (between 2 and 4 months). Other studies have looked at the relation between infant responses to the SFP and their behavior in other contexts, reporting interesting links with future compliance (Hill & Braungart-Rieker, 2002), internalizing problems (Moore et al., 2001), and attention following (Yazbek & D'Entremont, 2006). However, these and other studies examining similar issues all used different indicators of infant response to the SFP, including crying, attentional regulation, the strength of the still-face effect, attempts to reengage the adult, and neutral affect. It is therefore unclear which aspects of the infant's response to the SFP are the most salient in terms of their predictive validity regarding different outcomes. Studies investigating multiple measures of infant responses to the SFP in relation to multiple outcomes in other contexts could shed light on this issue. Further, it is unclear whether the still-face variables examined in relation to child outcomes are specific to the unique features of the SFP, or whether they represent an assessment of infant behavior and affect that could just as easily have been obtained in a different setting. It would be very informative to compare the predictive validity of the SFP to the predictive value of infant behavior measured in other settings. As an alternative explanation, the reported findings may be due to a common third variable, such as maternal interactive behavior. As maternal sensitivity is known to be related to both infant response to the SFP (see above) and child outcomes such as compliance (e.g., Feldman & Klein, 2003) and internalizing problems (e.g., Warren & Simmens, 2005), this variable may explain the link between the SFP and other infant behaviors.

An interesting line of research is that of infant SFP responses in relation to the quality of future mother–infant attachment as measured in the SSP. The SFP is similar to the SSP in the sense that both include episodes of manipulated maternal unresponsiveness and subsequent reunion episodes in which normal interaction is resumed. In a way, the SFP can be seen as an age-appropriate version of the SSP, and therefore infant responses to the SFP as a potential predictor of infant behavior during the SSP. The narrative review and meta-analyses both show that infant responses to the SFP are related to the quality of future attachment. Infants that respond less negatively and more positively to the still-face are more likely to be securely attached at age 12 months than other infants. In the literature there is some inconsistency as to the age at which infant responses to the SFP become predictive of attachment. Some studies suggest that the prediction is only found for age 6 months and not in younger or older infants (Cohn et al., 1991; Tronick et al., 1982), whereas others also find effects for younger infants (Braungart-Rieker et al., 2001; Fuertes et al., 2006; Kogan & Carter, 1996). Age could not be tested as a moderator in our meta-analyses because of the small number of studies. The explanation of the link between infant responses in the SFP and future attachment is likely to reside in differences in maternal sensitivity, as this variable has been found to predict infant response in the SFP (see earlier) and attachment security as measured in the SSP (De Wolff & Van IJzendoorn, 1997). Indeed, Braungart-Rieker et al. (2001) found evidence for a mediating model in which maternal sensitivity predicted infant regulation (gazing away, self-comforting) in the still-face which in turn predicted attachment security. Since this finding may be an artifact of stable maternal sensitivity, future studies in this area should include maternal sensitivity at both times of assessment (at SFP and at SSP) to find out whether the early infant and maternal variables during the SFP remain significant predictors of attachment after current sensitivity has been accounted for. As was also noted for the link between maternal depression and infant responses to the SFP, infant temperament may play a moderating role in the associations between infant response to the SFP and maternal sensitivity and attachment as well.

Studies focused only on levels of infant affect within episodes rather than within-subject changes in affect across episodes, precluding definite conclusions about the role of the still-face *effect* and the recovery in the prediction of attachment.

Theoretical implications

What can the narrative review and meta-analyses contribute to the theoretical foundations of the still-face effect? First, the still-face effect appears to be very robust, in that it occurs independently of sample and procedural variations, and from a very early age onwards. This suggests that the negative effects of a sudden loss of responsiveness of the interaction partner touches upon deep-seeded characteristics of human social interaction. Interestingly, Tronick (2005) reports similar effects even in toddlers and also using a role-play paradigm in adults, even though their attempts to cope with the break in interaction are more sophisticated than those of infants. The original hypothesis by Tronick et al. (1978) was that the still-face effect is due to a violation of infant expectations of reciprocity in social interaction. Consistent with this idea, early experimental studies from the field of ethnomethodology tried to uncover the expectations that adults have of commonplace social interactions by 'making trouble' (Garfinkel, 1967). In these experiments, students would break the rules of social interaction by going against these expectations (for instance by asking for clarifications of statements with implicitly clear meanings in everyday conversations). These experiments had quite severe disrupting effects on social interactions, making people angry, confused, or upset. The perceived necessity for following the ground rules of social interactions is likely to stem from the evolutionary roots of human social life (e.g., Goffman, 1983).

Tronick (2003) seems to reject the original hypothesis that the still-face effect is caused by a violation of infants' expectations of the rules of social interaction as still-face effect. His reasons for rejecting the idea are twofold. First, because it would be unlikely that infants have previously encountered a situation like the SFP, he reasons that this would preclude the formation of expectations about the situation. Second, Tronick (2003) states that he no longer thinks that face-to-face interactions are rule governed, as they have been found to be predominantly asynchronous and full of mismatches between the interaction partners. We agree that infants may not have encountered this specific situation often before, but this fact may only strengthen the infants' reliance on previous experiences with normal face-to-face interactions during which adults rarely freeze and stop responding for a few minutes. And although face-to-face interactions may tend to be asynchronous from time to time, the overall pattern of such interactions does show a two-way street in which both partners contribute in predictable ways to the interaction (Cohn & Tronick, 1988). This suggests that while synchrony may not always be the rule, reciprocity certainly is expected, and the still-face breaks that expectation. Thus, the role of infants' expectations of the nature of social interactions should not be ruled out entirely (see also Frick & Adamson, 2003).

Tronick's Dyadic States of Consciousness Model (DSCM, Tronick, 2005) explains the negative effect of a perturbation in social interaction on infant affective organization by positing that infants need the adult partner to create meaning in order to maintain a coherent state of consciousness. Failing that (as in the still-face), infants are left to their own devices and employ different coping strategies to maintain coherence, such as gaze aversion and attempts to reengage the adult by exhibiting distress. To explain the carry-over effect we found in our meta-analyses, the DSCM would also need to include hypotheses about what is needed to repair the loss of a dyadic state of consciousness. The fact that infants remain upset after normal interaction has been resumed suggests that it is not easy to recover from such a state. In fact, toddlers also appear to show the carry-over effect found in infants (Tronick, personal communication, December 9, 2007). Within the DSCM one may hypothesize that a sudden resumption of interaction is almost as puzzling as a sudden cessation of interaction. In that case, the meaning-making required for a coherent dyadic state of consciousness is still hampered because the infant (or toddler) does not know what to make of this sudden change. As suggested earlier, the duration of most reunion episodes may simply be too short for infants to resume normal interaction even if the adult is now available again for the co-creation of meaning.

To evaluate the hypotheses put forward in the DSCM, it is important to know more about the relationship-specificity of the still-face effect. Is the need to co-create dyadic meaning universal to all human interactions, or does the nature and felt importance of dyadic meaning vary according to the identity of the interaction partner? The occurrence of the still-face effect may be robust, but our meta-analytic findings also suggest that the identity of the adult may have some impact on the *strength* of that effect. Infants interacting with mothers showed a larger decrease in positive affect from baseline to reunion than infants with strangers. As mentioned earlier, the lack of studies examining infant negative affect in interaction with strangers precludes conclusions about such differences in possibly the most salient infant response to the still-face, especially in terms of the carry-over effect that was found to be strongest for negative affect.

From the perspective of attachment theory and research, some differentiation in infant responses to a stranger and its mother would be expected. For instance, mothers' unresponsiveness in the still-face episode may be characterized as maternal frightening behavior. According to Hesse and Main (2006) maternal frightening behavior may include '*direct indices of entrance into a dissociative state*: for example, parent suddenly completely "freezes" with eyes unmoving, half-lidded, despite nearby movement' (Hesse & Main, 2006, p. 320). This description of frightening behavior is very similar to the mother's experimentally manipulated behavior during the still-face episode. Maternal frightening behavior has been found to predict infant disorganized attachment, as characterized by the display of contradictory behaviors, undirected or misdirected expressions, or direct indices of apprehension in the Strange Situation Procedure (Madigan, Moran, & Pederson, 2006; Main & Solomon, 1990). These infant behaviors are very similar to those found in the still-face literature, such as the combination of gazing away and bids for attention (i.e., contradictory and misdirected) or attempts to increase the physical distance from the mother combined with crying (i.e., indices of apprehension). The link between maternal frightening behavior and infant disorganized attachment is generally explained through the concept of the irresolvable approach-flight paradox for the infant (Hesse & Main, 2006). The mother is the attachment figure and therefore represents the infant's haven of safety when he is frightened or distressed. However, in the case of maternal frightening behavior, the infant is confronted with a paradox, because its haven of safety is also the source of fright and distress. The infant can not decide whether to flee from the source of distress or to approach its haven of safety, which leads to a breakdown in emotion and behavioral regulation as evidenced by disorganized behaviors. This explanation is clearly relationship-specific, as only an attachment figure can provoke this paradox, whereas the DSCM is relationship-independent because it assumes the need for co-created meaning in all human interactions.

To test the two hypotheses, more studies are needed to examine potential differences in infant responses to the still-face with a parent or a stranger. As it stands now, the results of this comparison are equivocal, as we lack information on the parent–stranger comparison with respect to infant negative affect. Further the confounding effect of using touch during normal interaction (mothers are more often allowed to use touch than strangers) needs to be taken into consideration by using standardized procedures. Under these conditions, the extent to which the still-face effect and the carry-over effect are relationship-specific can be tested, providing crucial information for the development of theories that explain the still-face effect.

Implications for future research

Our review and meta-analyses show that procedural variations and even most sample variations do not have a very profound impact on the classic still-face effect. This means that investigators can be relatively free to choose specific procedures without having to worry too much about the potential influence on the infant's responses. Some issues still need to be resolved however. As there is still uncertainty about differences between mothers and strangers, this issue needs to be tested empirically before concluding that there are relatively few differences between the nature and meaning of infant responses to mothers and strangers in the SFP. The same is true for the distinction between infants with mothers and infants with fathers. Also, the combination of allowing touch and using a global gaze measures may result in hiding the still-face effect, so researchers need to carefully consider the type of gaze measures they use in relation to the specific SFP procedures. Further, a closer examination of infant affect in the first and second halves of the still-face and reunion episodes and reunions longer than 180 s may inform researchers about the optimal duration of these episodes in terms of affective recovery. This may influence which duration is chosen for a particular research question. The issue of the timing of the still-face episode in terms of the infant's arousal level also deserves further attention. If timing in terms of the interaction cycle indeed plays a major role in the still-face effect and possibly the recovery, researchers may need to include a measure of this timing into their assessments and analyses, or even adapt their procedures to synchronize the timing of the still-face episode across all participants. Another issue that deserves further research attention is the coding procedures used for the SFP. Almost all studies used microanalytic coding. However, two studies used global scores for infant behavior (Kogan & Carter, 1996; Rosenblum et al., 2002) and both found the classic still-face effect. Indeed, there does not seem to be an inherent reason to use microcoding for infant behavior in the SFP, and because microanalysis is a very time-consuming procedure, furtherer exploration of the usefulness of the global coding system is worthwhile.

The SFP was originally developed to test the hypothesis that infants are active contributors to social interaction (Tronick et al., 1978). In a related vein, a large part of subsequent SFP research focused on normative issues in infant responses to a perturbation in social interaction. Now that the use of the SFP has been extended to the investigation of antecedents and outcomes of infant responses to the still-face, it is important to pay attention to the issues that studies in this area would need to consider. Research examining infant responses to the SFP in relation to external variables often focuses only on the effects on or of between-subject differences within SFP episodes, rather than within-subject differences between episodes. Unfortunately, the unique properties of the SFP are partially lost if one does not take the within-subject changes into account. Not taking these changes into account makes it unclear whether the findings are specific to the still-face perturbation or mainly reflect general differences in response style between infants.

One reason for the scarce use of changes in infant responses in the SFP as a variable may be the universality of the still-face effect. Because the occurrence and even the strength of the still-face effect in terms of changes between episodes seem to be very robust, this variable may just not provide enough variations between individuals to be a useful predictor or outcome variable. Since the *level* of specific infant responses within episodes does seem to vary substantially, this variable may be easier to use in research. The question does arise whether the level of specific infant responses within episodes reflects general temperament-like traits or specifically interpersonal traits. The two studies investigating temperament in relation to infant behavior in the SFP have shown inconsistent results (Braungart-Rieker et al., 1998; Tarabulsy et al., 2003). Because the infant variables derived from the SFP are often interpreted on an interpersonal level, it is important to investigate whether this interpretation is correct or whether a temperament-approach would be more to the point. Further, the use of this type of variable derived from the SFP is far from standardized. Many different measures of infant responses to the SFP are reported in the various studies. It would help if studies would always report on the standard variables of gaze, positive and negative affect in relation to future adaptation. Other variables could also be included, but this way some standardization would be attained and may facilitate the interpretation of the results in terms of their comparability to other findings.

Finally, maternal sensitivity may be a crucial explaining factor for various associations found between infant response to the SFP and other variables such as maternal depression, attachment security, and infant behavioral outcomes. The inclusion of maternal behavior at multiple time points in studies using the SFP in relation to external variables would help answer some questions regarding underlying processes.

Conclusion

With the introduction of the SFP, Tronick et al. (1978) have provided scientists with a valuable instrument to test a wide variety of hypotheses about normative and individual infant social and emotional development. The classic still-face effect is robust and found regardless of variations in samples and procedures. Interpretations of the classic still-face effect remain tentative however, as long as differences in infant responses to the SFP with parents versus strangers have not been fully explored. The investigation of individual differences in the strength of the still-face effect would benefit from taking interactional history (e.g., maternal sensitivity), and infant temperament into account. When examining the SFP in relation to other variables, a focus on within-subjects changes in behavior and affect across the three episodes would do more justice to the specificity of the SFP as an assessment tool for infant behavior and affect. In sum, although there are indeed ''still things to be done on the still-face effect'' (Tronick, 2003, p. 475), these future directions for SFP research hold the promise of providing us with a deeper understanding of infant social-emotional development.

References

Abelkop, B. S., & Frick, J. E. (2003). Cross-task stability in infant attention: New perspectives using the still-face procedure. *Infancy, 4*, 567–588.
Adamson, L. B., & Frick, J. E. (2003). The still face: A history of a shared experimental paradigm. *Infancy, 4*, 451–473.
Agnetta, B.T. (2001). *Emerging detection and understanding of imitation in infancy*. Unpublished Doctoral thesis, Emory University.
Ainsworth, M. D. S., Blehar, M., Waters, E., & Wall, S. (1978). *Patterns of attachment*. Hillsdale, NJ: Erlbaum.
Bakermans-Kranenburg, M. J., Van IJzendoorn, M. H., & Juffer, F. (2003). Less is more: Meta-analyses of sensitivity and attachment interventions in early childhood. *Psychological Bulletin, 129*, 195–215.

Bazhenova, O. V., Plonskaia, O., & Porges, S. W. (2001). Vagal reactivity and affective adjustment in infants during interaction challenges. *Child Development, 72*, 1314–1326.

Belsky, J. (1997). Variation in susceptibility to environmental influence: An evolutionary argument. *Psychological Inquiry, 8*, 182–186.

Bendersky, M., & Lewis, M. (1998). Arousal modulation in cocaine-exposed infants. *Developmental Psychology, 34*, 555–564.

Bertin, E., & Striano, T. (2006). The still-face response in newborn, 1.5-, and 3-month-old infants. *Infant Behavior & Development, 29*, 294–297.

Bigelow, A. E., & Rochat, P. (2006). Two-month-old infants' sensitivity to social contingency in mother–infant and stranger–infant interaction. *Infancy, 9*(3), 313–325.

Bingen, K. (2001). Individual differences in infant response to the still-face paradigm and prediction of later attachment. Unpublished Doctoral dissertation.

Bornstein, M. H., Arterberry, M. E., & Mash, C. (2004). Long-term memory for an emotional interpersonal interaction occurring at 5 months of age. *Infancy, 6*, 407–416.

Borenstein, M., Rothstein, D., & Cohen, J. (2005). *Comprehensive meta-analysis: A computer program for research synthesis [Computer software]*. Englewood, NJ: Biostat.

Braungart-Rieker, J., Courtney, S., & Garwood, M. M. (1999). Mother- and father-infant attachment: Families in context. *Journal of Family Psychology, 13*, 535–553.

Braungart-Rieker, J., Garwood, M. M., Powers, B. P., & Notaro, P. C. (1998). Infant affect and affect regulation during the still-face paradigm with mothers and fathers: The role of infant characteristics and parental sensitivity. *Developmental Psychology, 34*, 1428–1437.

Braungart-Rieker, J. M., Garwood, M. M., Powers, B. P., & Wang, X. Y. (2001). Parental sensitivity, infant affect, and affect regulation: Predictors of later attachment. *Child Development, 72*, 252–270.

Brazelton, T. B., Koslowski, B., Main, M., Lewis, M., & Rosenblum, L. A. (1974). The origins of reciprocity: The early mother–infant interaction. In *The effect of the infant on its caregiver* (pp. 49–76). NY and London: John Wiley & Sons.

Bridges, L., & Grolnick, W. (1995). The development of emotional self-regulation in infancy and early childhood. In N. Eisenberg (Ed.), *Social development: Review of child development research* (pp. 185–211). Thousand Lakes, CA: Sage.

Brown, T. A., Campbell, L. A., Lehman, C. L., Grisham, J. R., & Mancill, R. B. (2001). Current and lifetime comorbidity of the *DSM-IV* anxiety and mood disorders in a large clinical sample. *Journal of Abnormal Psychology, 110*, 585–599.

Carter, A. S., Garrity-Rokous, F. E., Chazen-Cohen, R., Little, C., & Briggs-Gowan, M. J. (2001). Maternal depression and comorbidity: Predicting early parenting, attachment security, and toddler social-emotional problems and competencies. *Journal of the American Academy Child and Adolescent Psychiatry, 40*, 18–26.

Carter, A. S., Mayes, L. C., & Pajer, K. A. (1990). The role of dyadic affect in play and infant sex in predicting infant response to the still-face situation. *Child Development, 61*, 764–773.

Carvajal, F., & Iglesias, J. (1997). Mother and infant smiling exchanges during face-to-face interaction in infants with and without Down syndrome. *Developmental Psychobiology, 31*, 277–286.

Cassel, T. D., Messinger, D. S., Ibanez, L. V., Haltigan, J. D., Acosta, S. I., & Buchman, A. C. (2007). Early social and emotional communication in the infant siblings of children with autism spectrum disorders: An examination of the broad phenotype. *Journal of Autism and Developmental Disorders, 37*, 122–132.

Cleveland, A., Kobiella, A., & Striano, T. (2006). Intention or expression? Four-month-olds' reactions to a sudden still-face. *Infant Behavior & Development, 29*, 299–307.

Cohn, J. F. (2003). Additional components of the still-face effect: Commentary on Adamson and Frick. *Infancy, 4*, 493–497.

Cohn, J. F., Campbell, S. B., & Ross, S. (1991). Infant response in the still-face paradigm at 6 months predicts avoidant and secure attachment at 12 months. *Development and Psychopathology, 3*, 367–376.

Cohn, J. F., & Elmore, M. (1988). Effect of contingent changes in mothers' affective expression on the organization of behavior in 3-month-old infants. *Infant Behavior & Development, 11*, 493–505.

Cohn, J. F., & Tronick, E. Z. (1988). Mother–infant face-to-face interaction: Influence is bidirectional and unrelated to periodic cycles in either partner's behavior. *Developmental Psychology, 24*, 386–392.

Cossette, L., Pomerleau, A., Malcuit, G., & Kaczorowski, J. (1996). Emotional expressions of female and male infants in a social and a nonsocial context. *Sex Roles, 35*, 693–709.

Crandell, L. E., Patrick, M. P. H., & Hobson, R. P. (2003). 'Still-face' interactions between mothers with borderline personality disorder and their 2-month-old infants. *British Journal of Psychiatry, 183*, 239–247.

De Haan, M., Johnson, M. H., & Halit, H. (2003). Development of face-sensitive event-related potentials during infancy: A review. *International Journal of Psychophysiology, 51*, 45–58.

Delgado, C. E. F., Messinger, D. S., & Yale, W. (2002). Infant responses to direction of parental gaze: A comparison of two still-face conditions. *Infant Behavior & Development, 25*, 311–318.

D'Entremont, B., & Muir, D. W. (1997). Five-month-olds' attention and affective responses to still-faced emotional expressions. *Infant Behavior & Development, 20*, 563–568.

De Wolff, M. S., & Van IJzendoorn, M. H. (1997). Sensitivity and attachment: A meta-analysis on parental antecedents of infant attachment. *Child Development, 68*(4), 571–591.

Duval, S., & Tweedie, R. (2000a). A nonparametric trim and fill method for accounting for publication bias in meta-analysis. *Journal of the American Statistical Association, 95*, 89–98.

Duval, S., & Tweedie, R. (2000b). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics, 56*, 455–463.

Ellsworth, C. P., Muir, D. W., & Hains, S. M. J. (1993). Social competence and person-object differentiation – An analysis of the still-face effect. *Developmental Psychology, 29*, 63–73.

Escalona, A., Field, T., Nadel, J., & Lundy, B. (2002). Brief report: Imitation effects on children with autism. *Journal of Autism and Developmental Disorders, 32*, 141–144.

Feldman, R., & Klein, P. S. (2003). Toddlers' self-regulated compliance to mothers, caregivers, and fathers: Implications for theories of socialization. *Developmental Psychology, 39*, 680–692.

Field, T. (1994). The effects of mother's physical and emotional unavailability on emotion regulation. *Monographs of the Society for Research in Child Development, 59*, 208–227.
Field, T. (1995). Infants of depressed mothers. *Infant Behavior & Development, 18*, 1–13.
Field, T., Hernandez-Reif, M., Diego, M., Feijo, L., Vera, Y., Gil, K., et al (2007). Still-face and separation effects on depressed mother–infant interactions. *Infant Mental Health Journal, 28*, 314–323.
Field, T., Stoller, S., Vega-Lahr, N., Scafidi, F., & Goldstein, S. (1986). Maternal unavailability effects on very young infants in homecare verses daycare. *Infant Mental Health Journal, 7*, 274–280.
Field, T., Vega-Lahr, N., Scafidi, F., & Goldstein, S. (1986). Effects of maternal unavailability on mother–infant interactions. *Infant Behavior & Development, 9*, 473–478.
Fivaz-Depeursinge, E., Favez, N., Lavanchy, S., de Noni, S., & Frascarolo, F. (2005). Four-month-olds make triangular bids to father and mother during trilogue play with still-face. *Social Development, 14*, 361–378.
Fogel, A. (1982). Affect dynamics in early infancy: Affective tolerance. In T. Field & A. Fogel (Eds.), *Emotion and early interaction* (pp. 25–56). Hillsdale, NJ: Erlbaum.
Fogel, A., Diamond, G. R., Langhorst, B. H., & Demos, V. (1982). Affective and cognitive aspects of the 2-month-old's participation in face-to-face interaction with the mother. In E. Tronick (Ed.), *Social interchange in infancy: Affect, cognition, and communication* (pp. 35–57). Baltimore: University Park Press.
Forbes, E. E., Cohn, J. F., Allen, N. B., & Lewinsohn, P. M. (2004). Infant affect during parent-infant interaction at 3 and 6 months: Differences between mothers and fathers and influence of parent history of depression. *Infancy, 5*, 61–84.
Forman, D. R., O'Hara, M. W., Larsen, K., Coy, K. C., Gorman, L. L., & Stuart, S. (2003). Infant emotionality: Observational methods and the validity of maternal reports. *Infancy, 4*, 541–565.
Forman, D. R., O'Hara, M. W., Stuart, S., Gorman, L. L., Larsen, K. E., & Coy, K. C. (2007). Effective treatment for postpartum depression is not sufficient to improve the developing mother–child relationship. *Development and Psychopathology, 19*, 585–602.
Fuertes, M., Lopes dos Santos, P. L., Beeghly, M., & Tronick, E. (2006). More than maternal sensitivity shapes attachment – Infant coping and temperament. *Resilience in Children, 1094*, 292–296.
Frick, J. E., & Adamson, L. (2003). One still face, many visions. *Infancy, 4*(4), 499–501.
Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs: Prentice-Hall.
Garrity-Rokous, F. E. (1999). Regulation of negative arousal in infants of depressed mothers. Unpublished Doctoral dissertation.
Gianino, A., & Tronick, E. Z. (1988). The mutual regulation model: The infant's self and interactive regulation, coping, and defensive capacities. In T. Field, P. McCabe, & N. Schneiderman (Eds.), *Stress and coping across development* (pp. 47–68). Hillsdale, NJ: Erlbaum.
Goffman, E. (1983). The interaction order. *American Sociological Review, 48*, 1–17.
Grossmann, T., Striano, T., & Friederici, A. D. (2006). Crossmodal integration of emotional information from face and voice in the infant brain. *Developmental Science, 9*, 309–315.
Grossmann, K. E., Grossmann, K., & Waters, E. (2005). *Attachment from infancy to adulthood. The major longitudinal studies*. New York: The Guilford Press.
Gunnar, M., Mangelsdorf, S., Kestenbaum, R., Lang, S., Larson, M., & Andreas, D. (1989). *Stress and coping in early development*. In D. Cicchetti (Ed.), *Rochester symposium on developmental psychopathology. The emergence of a discipline* (Vol. 1, pp. 119–138). Hillsdale, NJ: Erlbaum.
Gusella, J. L., Muir, D., & Tronick, E. Z. (1988). The effect of manipulating maternal behavior during an interaction on three- and six-month-olds' affect and attention. *Child Development, 59*, 1111–1124.
Haley, W. D. (2001). Infant self-regulation and parent responsiveness. Unpublished Doctoral dissertation.
Haley, D. W., Handmaker, N. S., & Lowe, J. (2006). Infant stress reactivity and prenatal alcohol exposure. *Alcoholism-Clinical and Experimental Research, 30*, 2055–2064.
Haley, D. W., & Stansbury, K. (2003). Infant stress and parent responsiveness: Regulation of physiology and behavior during still-face and reunion. *Child Development, 74*, 1534–1546.
Ham, J., & Tronick, E. (2006). Infant resilience to the stress of the still-face: Infant and maternal psychophysiology are related. *Resilience in Children, 1094*, 297–302.
Hampel, E. R., Ronchetti, E. M., Rousseeuw, P. J., & Stahel, W. H. (1986). *Robust statistics: The approach based on influence functions*. New York: Wiley.
Hart, S. L., Carrington, H. A., Tronick, E. Z., & Carroll, S. R. (2004). When infants lose exclusive maternal attention: Is it jealousy? *Infancy, 6*, 57–78.
Heimann, M., Laberg, K. E., & Nordoen, B. (2006). Imitative interaction increases social interest and elicited imitation in non-verbal children with autism. *Infant and Child Development, 15*, 297–309.
Hesse, E., & Main, M. (2006). Frightened, threatening, and dissociative parental behavior in low-risk samples: Description, discussion, and interpretation. *Development and Psychopathology, 18*, 309–343.
Hill, A. L., & Braungart-Rieker, J. (2002). Four-month attentional regulation and its prediction of three-year compliance. *Infancy, 3*(2), 261–273.
Hobson, R. P., Patrick, M., Crandell, L., Garcia-Perez, R., & Lee, A. (2005). Personal relatedness and attachment in infants of mothers with borderline personality disorder. *Development and Psychopathology, 17*, 329–347.
Jamieson, S. (2004). Identifying precursors of attachment in the Still-Face paradigm. Unpublished Doctoral dissertation.
Jung, V., Short, R., Letourneau, N., & Andrews, D. (2007). Interventions with depressed mothers and their infants: Modifying interactive behaviours. *Journal of Affective Disorders, 98*, 199–205.
Kamman, T. (2001). Infant learning in the context of early social interaction: Contrast effects in infant eye gaze duration as an indicator of maternal availability and contingency. Unpublished Doctoral dissertation.
Kiser, L. J., Bates, J. E., Maslin, C. A., & Bayles, K. (1986). Mother–infant play at six months as a predictor of attachment security at thirteen months. *Journal of the American Academy of Child and Adolescent Psychiatry, 25*, 68–75.
Kisilevsky, B. S., Hains, S. M. J., Lee, K., Muir, D. W., Xu, F., Fu, G. Y., et al (1998). The still-face effect in Chinese and Canadian 3- to 6-month-old infants. *Developmental Psychology, 34*, 629–639.

Koester, L. S. (1995). Face-to-face interactions between hearing mothers and their deaf or hearing infants. *Infant Behavior & Development, 18*, 145–153.
Koester, L. S., & Meadow-Orlans, K. P. (1999). Responses to interactive stress: Infants who are deaf or hearing. *American Annals of the Deaf, 144*, 395–403.
Kogan, N., & Carter, A. S. (1996). Mother–infant reengagement following the still-face: The role of maternal emotional availability in infant affect regulation. *Infant Behavior & Development, 19*, 359–370.
Lamb, M. E., Morrison, D. C., & Malkin, C. M. (1987). The development of infant social expectations in face-to-face interaction – A longitudinal-study. *Merrill-Palmer Quarterly-Journal of Developmental Psychology, 33*, 241–254.
Legerstee, M., & Bowman, T. G. (1989). The development of responses to people and a toy in infants with Down syndrome. *Infant Behavior & Development, 12*, 465–477.
Legerstee, M., Corter, C., & Kienapple, K. (1990). Hand, arm, and facial actions of young infants to a social and nonsocial stimulus. *Child Development, 61*, 774–784.
Legerstee, M., & Markova, G. (2007). Intentions make a difference: Infant responses to still-face and modified still-face conditions. *Infant Behavior & Development, 30*, 232–250.
Legerstee, M., Pomerleau, A., Malcuit, G., & Feider, H. (1987). The development of infants responses to people and a doll – Implications for research in communication. *Infant Behavior & Development, 10*, 81–95.
Lewis, M., & Ramsay, D. (2005). Infant emotional and cortisol responses to goal blockage. *Child Development, 76*, 518–530.
Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis. Applied social research methods series* (Vol. 49). Thousand Oaks, CA: Sage Publications.
Lowe, J., Handmaker, N., & Aragón, C. (2006). Impact of mother interactive style on infant affect among babies exposed to alcohol in utero. *Infant Mental Health Journal, 27*, 371–382.
Madigan, S., Moran, G., & Pederson, D. R. (2006). Unresolved states of mind, disorganized attachment relationships, and disrupted interactions of adolescent mothers and their infants. *Developmental Psychology, 42*, 293–304.
Main, M., & Solomon, J. (1990). Procedures for identifying infants as disorganized/disoriented during the Ainsworth Strange Situation. In M. Greenberg, D. Cicchetti, & E. M. Cummings (Eds.), *Attachment in the preschool years: Theory, research and intervention* (pp. 121–160). Chicago: University of Chicago Press.
Matias, R., & Cohn, J. F. (1993). Are MAX-specified infant facial expressions during face-to-face interaction consistent with differential emotions theory. *Developmental Psychology, 29*, 524–531.
Mayes, L. C., & Carter, A. S. (1990). Emerging social regulatory capacities as seen in the still-face situation. *Child Development, 61*, 754–763.
Mayes, L. C., Carter, A. S., Egger, H. L., & Pajer, K. A. (1991). Reflections on stillness – Mothers reactions to the still-face situation. *Journal of the American Academy of Child and Adolescent Psychiatry, 30*, 22–28.
Merin, N., Young, G. S., Ozonoff, S., & Rogers, S. J. (2007). Visual fixation patterns during reciprocal social interaction distinguish a subgroup of 6-month-old infants at-risk for autism from comparison infants. *Journal of Autism and Developmental Disorders, 37*, 108–121.
Miller, A., McDonough, S., Rosenblum, K. L., & Sameroff, A. (2002). Emotion regulation in context: Situational effects on infant and caregiver behavior. *Infancy, 3*, 403–433.
Moore, G. A., & Calkins, S. D. (2004). Infants' vagal regulation in the still-face paradigm is related to dyadic coordination of mother–infant interaction. *Developmental Psychology, 40*, 1068–1080.
Moore, G. A., Cohn, J. F., & Campbell, S. B. (2001). Infant affective responses to mother's still face at 6 months differentially predict externalizing and internalizing behaviors at 18 months. *Developmental Psychology, 37*, 706–714.
Moszkowski, R. J., & Stack, D. M. (2007). Infant touching behaviour during mother–infant face-to-face interactions. *Infant and Child Development, 16*, 307–319.
Murray, L., & Trevarthen, C. (1985). Emotional regulation of interactions between two-month-olds and their mothers. In T. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 177–197). Norwood, NJ: Ablex Publishing.
Nadel, J., Croue, S., Mattlinger, M.-J., Canet, P., Hudelot, C., Lecuyer, C., et al (2000). Do children with autism have expectancies about the social behaviour of unfamiliar people? A pilot study using the still face paradigm. *Autism, 4*, 133–145.
Nelson, C. A., & de Haan, M. (1996). Neural correlates of visual responsiveness to facial expressions of emotion. *Developmental Psychobiology, 29*, 1–18.
Papoušek, M. (2007). Communication in early infancy: An arena of intersubjective learning. *Infant Behavior & Development, 30*, 258–266.
Peláez-Nogueras, M., Field, T. M., Hossain, Z., & Pickens, J. (1996). Depressed mothers' touching increases infants' positive affect and attention in still-face interactions. *Child Development, 67*, 1780–1792.
Rochat, P., & Striano, T. (2002). Who's in the mirror? Self-other discrimination in specular images by four- and nine-month-old infants. *Child Development, 73*, 35–46.
Rochat, P., Striano, T., & Blatt, L. (2002). Differential effects of happy, neutral, and sad still-faces on 2-, 4- and 6-month-old infants. *Infant and Child Development, 11*, 289–303.
Rosenblum, K. L., McDonough, S., Muzik, M., Miller, A., & Sameroff, A. (2002). Maternal representations of the infant: Associations with infant response to the Still Face. *Child Development, 73*, 999–1015.
Rosenthal, R. (1995). Writing meta-analytic reviews. *Psychological Bulletin, 118*, 183–192.
Sutton, A. J., Duval, S. J., Tweedie, R. L., Abrams, K. R., & Jones, D. R. (2000). Empirical assessment of effect of publication bias on meta-analyses. *British Medical Journal, 320*, 1574–1577.
Rossi, A., Marinangeli, M. G., Butti, G., Scinto, A., Di Cicco, L., Kalyvoka, A., et al (2001). Personality disorders in bipolar and depressive disorders. *Journal of Affective Disorders, 65*, 3–8.
Segal, L. B., Oster, H., Cohen, M., Caspi, B., Myers, M., & Brown, D. (1995). Smiling and fussing in seven-month-old preterm and full-term black infants in the still-face situation. *Child Development, 66*, 1829–1843.
Shapiro, B., Fagen, J., Prigot, J., Carroll, M., & Shalan, J. (1998). Infants' emotional and regulatory behaviors in response to violations of expectancies. *Infant Behavior & Development, 21*, 299–313.
Shea, M. T., Widiger, T. A., & Klein, M. H. (1992). Comorbidity of personality disorders and depression: Implications for treatment. *Journal of Consulting and Clinical Psychology, 60*, 857–868.

Solomon, R. (1980). The opponent-process theory of acquired motivation. The costs of pleasure and the benefits of pain. *American Psychologist, 35*, 691–712.
Spitzer, S. (2000). Maternal distress regulation and dyadic repair: Contributions to infant socio-emotional functioning. Unpublished Doctoral dissertation.
Sroufe, L. A., & Waters, E. (1976). The ontogenesis of smiling and laughter: A perspective on the organization of development in infancy. *Psychological Review, 83*, 173–189.
Stack, D. M., & Arnold, S. L. (1998). Changes in mothers' touch and hand gestures influence infant behavior during face-to-face interchanges. *Infant Behavior & Development, 21*, 451–468.
Stack, D. M., & Lepage, D. E. (1996). Infants' sensitivity to manipulations of maternal touch during face-to-face interactions. *Social Development, 5*, 41–55.
Stack, D. M., & Muir, D. W. (1990). Tactile stimulation as a component of social interchange – New interpretations for the still-face effect. *British Journal of Developmental Psychology, 8*, 131–145.
Stanley, C., Murray, L., & Stein, A. (2004). The effect of postnatal depression on mother–infant interaction, infant response to the still-face perturbation, and performance on an instrumental learning task. *Development and Psychopathology, 16*, 1–18.
Stoller, S., & Field, T. (1982). Alteration of mother and infant behavior and heart rate during a still-face perturbation of face-to-face interaction. In T. Field & A. Fogel (Eds.), *Emotion and early interaction* (pp. 57–82). Lawrence Erlbaum.
Striano, T. (2004). Direction of regard and the still-face effect in the first year: Does intention matter? *Child Development, 75*, 468–479.
Striano, T., & Bertin, E. (2004). Contribution of facial and vocal cues in the still-face response of 4-month-old infants. *Infant Behavior & Development, 27*, 499–508.
Striano, T., & Liszkowski, U. (2005). Sensitivity to the context of facial expression in the still face at 3-, 6-, and 9-months of age. *Infant Behavior & Development, 28*, 10–19.
Striano, T., & Rochat, P. (1999). Developmental link between dyadic and triadic social competence in infancy. *British Journal of Developmental Psychology, 17*, 551–562.
Tabachnick, B. G., & Fidell, L. S. (2001). *Using multivariate statistics*. New York: Harper & Row.
Tarabulsy, G. M., Provost, M. A., Deslandes, J., St-Laurent, D., Moss, E., Lemelin, J. P., et al (2003). Individual differences in infant still-face response at 6 months. *Infant Behavior & Development, 26*, 421–438.
Thomas, L. (2002). Comparisons of maternal eye-gaze deprivation: Responses of 3-month-old infants to three episodes of maternal unavailability. Unpublished Doctoral dissertation.
Toda, S., & Fogel, A. (1993). Infant response to the still-face situation at 3 and 6 months. *Developmental Psychology, 29*, 532–538.
Trevarthen, C. (1977). Descriptive analyses of infant communicative behaviour. In R. Schaffer (Ed.), *Studies in mother–infant interaction* (pp. 227–269). London: Academic Press.
Tronick, E. (2003). Things still to be done on the still-face effect. *Infancy, 4*, 475–482.
Tronick, E. Z. (2005). Why is connection with others so critical? The formation of dyadic states of consciousness and the expansion of individuals' states of consciousness: Coherence governed selection and the co-creation of meaning out of messy meaning making. In J. Nadel & D. Muir (Eds.), *Emotional development: Recent research advances* (pp. 293–315). Oxford: Oxford University Press.
Tronick, E., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). Infants response to entrapment between contradictory messages in face-to-face interaction. *Journal of the American Academy of Child and Adolescent Psychiatry, 17*, 1–13.
Tronick, E. Z., Brushweller-Stern, N., Harrison, A. M., Lyons-Ruth, K., Morgan, A. C., Nahum, J. P., et al (1998). Dyadically expanded states of consciousness and the process of therapeutic change. *Infant Mental Health Journal, 19*, 290–299.
Tronick, E. Z., & Cohn, J. F. (1989). Infant–mother face-to-face interaction: Age and gender differences in coordination and the occurence of miscoordination. *Child Development, 60*, 85–92.
Tronick, E. Z., & Gianino, A. (1986). Interactive mismatch and repair: Challenges to the coping infant. *Zero-to-Three, 6*, 1–6.
Tronick, E. Z., Messinger, D. S., Weinberg, M. K., Lester, B. A., LaGasse, L., Seifer, R., et al (2005). Cocaine exposure is associated with subtle compromises of infants' and mothers' social-emotional behavior and dyadic features of their interaction in the face-to-face still-face paradigm. *Developmental Psychology, 41*, 711–722.
Tronick, E., Ricks, M., & Cohn, J. F. (1982). Maternal and infant affective exchange: Patterns of adaptation. In T. Field & A. Fogel (Eds.), *Emotion and early interaction* (pp. 83–100). Hillsdale, NJ: Lawrence Erlbaum.
Tronick, E. Z., & Weinberg, M. K. (1997). Depressed mothers and infants: Failure to form dyadic states of consciousness. In L. Murray & P. J. Cooper (Eds.), *Postpartum depression and child development* (pp. 54–84). New York: Guilford Press.
Van Zeijl, J., Mesman, J., Stolk, M. N., Alink, L. R. A., Van IJzendoorn, M. H., Juffer, F., et al (2007). Differential susceptibility to discipline: The moderating effect of child temperament on the association between maternal discipline and early externalizing problems. *Journal of Family Psychology, 21*, 626–636.
Warren, S. L., & Simmens, S. J. (2005). Predicting toddler anxiety/depressive symptoms: Effects of caregiver sensitivity on temperamentally vulnerable children. *Infant Mental Health Journal, 26*, 40–55.
Weinberg, M. K., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry, 47*, 670–683.
Weinberg, M. K., & Tronick, E. Z. (1994). Beyond the face – An empirical-study of infant affective configurations of facial, vocal, gestural, and regulatory behaviors. *Child Development, 65*, 1503–1515.
Weinberg, M. K., & Tronick, E. Z. (1996). Infant affective reactions to the resumption of maternal interaction after the still-face. *Child Development, 67*, 905–914.
Weinberg, M. K., Tronick, E. Z., Cohn, J. F., & Olson, K. L. (1999). Gender differences in emotional expressivity and self-regulation during early infancy. *Developmental Psychology, 35*, 175–188.
Yazbek, A., & D'Entremont, B. (2006). A longitudinal investigation of the still-face effect at 6 months and joint attention at 12 months. *British Journal of Developmental Psychology, 24*, 589–601.
Yirmiya, N., Gamliel, I., Pilowsky, T., Feldman, R., Baron-Cohen, S., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement, communication, and cognition. *Journal of Child Psychology and Psychiatry, 47*, 511–523.

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