The International Psychoanalytic Association
Interim Report
February 28, 2009

"Mother-Infant vs. Stranger-Infant: Depression and Attachment"

Beatrice Beebe, Amy Margolis, Joseph Jaffe, Karen Buck, Henian Chen,
Patricia Cohen, Nidhi Parashar, Alla Chavarga and Alina Pavlakos

Summary of Report

1. Original Purpose: Specific Aims

(1) Differences: Describe differences in mother-infant (M-I) vs. stranger-infant (S-I) (a) behavioral qualities (eg degrees of positive/negative facial affect) and (b) self- and interactive contingency (by multi-level time-series models), across multiple communication modalities.

(2) Generalization: (a) Test assumption that M-I interaction serves as a template (inner working model) for new partners; infant "generalization" from M to S.

(3) Depression: Test whether maternal depression affects infant behaviors with mother, and with stranger; and whether maternal depression affects infant generalization from mother to stranger.

(4) Attachment: (a) Test whether 4-month "future" infant attachment insecurity affects infant generalization. (b) Test whether, in the context of secure 12-month attachment, 6-week maternal depression affects infant generalization from mother to stranger with the prediction that attachment security protects infants from the effects of maternal depression.

(5) Communication Modalities and Methods: Analyze sec-by-sec video coding (gaze on/off, facial and vocal quality, touch and self touch) and *automated* vocal rhythm coding, evaluating the redundancy vs. specificity of these communication modalities.

2. Progress

Using infant behavioral qualities, we tested Aim (1a), Differences in M-I vs. S-I communication, Aim (2), Generalization of infant communication patterns from M to S, and Aim (3) Effects of maternal depression on infant generalization, with measures of infant behavioral qualities in multiple modalities. We tested Aim (4a), effects of attachment insecurity on generalization. Using self- and interactive contingencies, we tested Aim (1b) differences in M-I and S-I self- and interactive contingencies.

3. Abstract of Findings

Aim (1a) Examining infant behavioral qualities with S and M, in approximately half the analyses infants showed differences with strangers, an adaptation to the novel partner. Infants showed robust differences in the ways that they adapted to the novel stranger, particularly in gaze, facial affect, engagement and touch. They looked more at the stranger's than mother's face, suggesting vigilance. They looked less at objects when playing with the stranger compared to the mother. But they were more likely to look at the stranger's face with a head orientation of "angled for escape," suggesting wariness. They were less facially positive with the stranger, and more facially negative. Infants used "self-regulatory" forms of touch (fingering object or own skin) more with stranger, but interpersonal forms of touch (touch partner) more with mother.

Aim (1b) Examining M-I vs. S-I self- and interactive contingencies, infants and strangers showed higher self-contingency of facial and vocal affect than infants and mothers. Strangers showed lower contingent facial affect contingent coordination with infant facial affect than mothers. Thus in facial affect, strangers tipped the balance toward higher self-contingency, and lower interactive contingency.

Aim (2) It is a widely held assumption of most theories of social development that children learn patterns in the family which they carry into interactions with novel partners ("generalization" from M-I to S-I). We found considerable evidence of infant generalization of behavioral qualities in the across-group analyses. Degrees of head orientation from en face to arch, progressive increments in head aversions from the vis-à-vis, was the lead modality in infant generalization. Infants more robustly generalize behaviors which are high-frequency or measures of central tendency: tendency to vocalize (or not), to look at partner's face (or not), to touch (or not); average levels of vocal affect, facial-visual engagement, head orientation and touch.

Aim (3) Maternal depression was associated with infant behavioral qualities with mother, and with stranger, but these findings were modest. Maternal depression did affect infant generalization of negative affect from mother to stranger, replicating Field. However, these findings were also modest.

Aim (4a) Degree of infant disorganized attachment insecurity (assessed at 12 months) was associated with 4-month infant difficulties with mother but not stranger. Moreover, there were no effects of "future" degree of infant disorganization on 4-month infant generalization. Instead, future disorganized attachment infants at 4 months "recalibrate" or "repair" with the stranger.

We identified (a) specifically relational difficulties in "future" disorganized infants at 4 months, who show difficulties with mother but not stranger. These infants "recalibrate" or "repair" with the stranger. We identified (b) specific infant adaptations to the novel partner in numerous differences in infant patterns of gaze, facial affect, engagement and touch; and in heightened infant self-contingency in facial and vocal affect. We identified (c) developmental difficulties in which infant difficulties with mother generalize to the stranger in infants of depressed mothers. Although these findings were few, they replicated findings of Field et al. (1988). Finally, we identified a "normative" process across the group in which infants learn styles of relating which they carry over to interactions with novel partners.

1. Obstacles - none
2. Manuscripts – none
3. Approved funding applications for this grant
    a. Kohler Foundation ($20,000)
    b. Self Psychology Foundation ($10,000)

OUTLINE OF REPORT

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This interim report is a continuation of that submitted to the *Fund for Psychoanalytic Research* of The American Psychoanalytic Association (APA), May 30, 2008. The Introduction has not changed. This Report to the Internal Psychoanalytic Association (IPA) advances the study over that submitted to the American Psychoanalytic Association (APA) in the following ways:

With extensive consultation from Drs. Patricia Cohen and Henian Chen, an important methodological decision was made in June, 2008, to change the method of modeling the lag weights used to construct the multi-level time-series estimates of contingency. This decision improves our ability to compare mother-infant and stranger-infant data. This change is described in the Method. Otherwise, the Method section has not changed.

This decision yielded somewhat different results in the contingency estimates of the communication modality pairings analyzed for the APA Report, adult facial affect – infant facial affect, and adult facial affect – infant vocal affect. Thus we present new results for these contingency estimates. We have added one modality pairing to the contingency analyses: adult gaze – infant gaze,

Consistent with the design of the grant and the APA Report, the questions posed by the grant are analyzed with two kinds of data, "process" and "content:" (a) "process" is represented by estimates of self- and interactive contingency, for example of adult and infant facial affect; (b) "content" is represented by "behavioral qualities," such as amount of time in specific levels of facial affect, from positive to negative.

In the prior APA Report, analyses of behavioral qualities were based on infant facial affect and vocal affect. In this IPA report we extend our analysis of infant behavioral qualities with mother and stranger to other modalities of communication (gaze at partner and at object, head orientation, touch, and a composite variable, facial-visual engagement).

I. INTRODUCTION

Despite its importance, the stranger-infant (S-I) interaction remains relatively uncharted. The 4-month S-I interaction generates social engagement rather than fearfulness and is a critical probe into early social development. Analogous to a still-face perturbation, or the stranger in the Ainsworth attachment paradigm, 4-month S-I interaction is an age-appropriate challenge, amplifying the system's organization.

In our SRCD monograph[55] which pioneered our "M-I, S-I" paradigm, *both M-I and S-I data were necessary to detect our key result, namely that midrange degrees of regulation were optimal for attachment.* Moreover, S-I interaction predicted 8 times the variance in infant cognition than M-I interaction. Our "M-I, S-I" paradigm thus tapped 4-month infant social-emotional-cognitive processes more powerfully than did M-I alone.

Overall, however, the explanatory potential of the S-I vs. M-I design has not been exploited.[73c] For example, as a function of distress in the mother (e.g., depression) or in the dyad (e.g., insecure infant attachment), the S-I interaction has the potential to address the question of whether infants of distressed mothers may generalize difficulties with mother to difficulties with stranger, thus constricting the infant's repertoire for engaging new social partners and constructing new experience. If so, we may identify micro-processes of distress transmission from M-I to S-I. Alternatively, generalization may be too simple a model. That is, in some contexts infants may show altered interaction patterns *only* with the stranger; if so, the S-I interaction may be an important additional means of identifying infant risk. As yet another possibility, infants who are distressed with mothers may in some contexts "repair" with the stranger; if so, we may be able to identify processes through which early infant resilience is achieved.

Specifically, as a function of distress (maternal depression and disorganized attachment), we may identify those effects in infants which are in evidence (a) only with M but not S, that is, specifically *relational* difficulties; (b) only with S but not M, that is, difficulties or forms of adaptation which are visible only with the challenge of the novel partner, that is *novelty effects*; or (c) with both M and S, that is, *developmental* difficulties in which the entire social system is thrown off, and infant difficulties with M generalize to S. Without a comparison of M-I and S-I interactions the field cannot address these issues.

Introduction to Data Analysis

We examine 122 infants interacting with stranger (S), as well as mother (M), a total of 244 interactions. The questions posed by the grant are analyzed with two kinds of data, "process" and "content:" (a) "process" is represented by estimates of self- and interactive contingency, for example of adult and infant facial affect; (b) "content" is represented by "behavioral qualities," such as amount of time in specific levels of facial affect, from positive to negative.

In this report we primarily address analyses of "content" (infant behavioral qualities such as degree of positive and negative facial affect). The previous APA report addressed infant behavioral qualities of infant facial affect and vocal affect. In this IPA report we extend our analysis of infant behavioral qualities with mother and stranger to other modalities of communication (attention, head orientation, touch, facial-visual engagement). We include the variables of maternal depression and infant degree of attachment disorganization in these analyses.

This report also includes a small section on "process," self- and interactive contingencies, and how they may differ in M-I vs. S-I interactions. In this section we report on an improvement in our method of calculating contingencies from multi-level time-series modeling.

Specific Aims

Infant Behavioral Qualities

(1) a description of the similarities and differences in infant patterns of behavior with mother vs. stranger, yielding basic knowledge on the ways infants relate to novel partners;

(2) a test of the widely held assumption of most theories of social development, that children learn patterns in the family which they carry into interactions with novel partners: "generalization" of infant patterns of behavior from mother to stranger;

(3) the ramifications of maternal depression for infants in the larger ecology of novel social partners, examining the effects of maternal depression on (i) infant behaviors with mother and with stranger; and (ii) infant generalization of behavior patterns from mother to stranger;

(4) the ramifications of attachment disorganization for infants in the larger ecology of novel social partners, examining the effects of degree of attachment disorganization on (i) infant behaviors with mother and with stranger; and (ii) infant generalization of behavior patterns from mother to stranger;

The above aims are examined in 7 infant scales of behavioral qualities coded to a 1s time base, which are presented in Table 1:

(a) gaze at partner
(b) gaze at object
(c) facial affect
(d) vocal affect
(e) facial-visual engagement (a constructed multi-modal variable),
(f) head orientation
(g) infant-initiated touch

Self- and Interactive Contingency

(1) an examination of whether self- and interactive contingency are significant across the group of mothers, and strangers, and infants with mothers, and infants with strangers;

(2) an evaluation of whether there are differences in levels of self- and interactive contingency in mother-infant and stranger-infant dyads;

The above aims are examined in 3 modality pairings:

(a) adult facial affect – infant facial affect
(b) adult facial affect – infant vocal affect
(c) adult gaze – infant gaze (gaze is coded on/off partner's face)

II. Method

We examined an urban university hospital community sample of 122 healthy first-borns and their mothers, with no obvious risk, for M-I and S-I self- and interactive contingency, and the effects of maternal depression and the origins of attachment in relation to M-I and S-I contingencies. Videotaped interactions were coded sec-by-sec for infant face and vocal quality, and adult face.

Participants

Mothers and infants 132 M-I (74 male infants, 58 female) and 122 S-I pairs were assessed when infants were 4 months. We report on the 122 M-I interactions in which S-I interactions were also recorded. The 10 dyads for which we recorded no S-I interaction did not differ from the 122 with S-I interactions in maternal ethnicity, education, infant gender, level of maternal depression, or likelihood of Anxious-Resistant (C) or Disorganized (D) infant attachment. However, these 10 dyads had infants who were significantly more distressed with mother than the 122 dyads with complete M-I, S-I data sets. By Fisher's exact test, these 10 infants with mother had a greater likelihood of spending 20% time or more in facial and/or vocal distress ($p=.05$) and of spending 20% time or more in negative facial affect (low + high negative) ($p=.007$). Thus we lost 10 dyads because the infants became too distressed during the M-I interaction to be able to participate in the S-I interaction. At 12 months, 84 M-I pairs returned for assessment of Attachment (by Ainsworth Strange Situation). The 84 with attachment classifications did not differ from the 48 without, in CES-D, age, ethnicity or infant gender. Of these 84 dyads, 81 had S-I as well as M-I interactions.

Strangers 13 "strangers," graduate students in clinical psychology, interacted with 122 infants at 4 months. Strangers were trained by the P.I. (through 2-3 pilot videotapings) to match infant facial and vocal patterns, to keep a relatively slow pace, to accept infant visual disengagement without pursuit, not to interfere with infant self touch, and to keep touch minimal except during infant distress.

Recruitment Within 24 hours of delivery, mothers were recruited from Columbia Presbyterian Medical Center according to established procedures for informed consent, with criteria: (a) primiparous birth; (b) mother at least 18 years old; (c) stable nuclear family; (d) home telephone; (e) no maternal gross psychopathology on initial contact; (f) no positive maternal prenatal urine drug screen; (f) no significant medical complications; (g) Caesarean acceptable if no fetal distress; (h) singleton birth; (i) one-minute Apgar less than 7 ok if 5-minute Apgar 7 or more; (j) birth weight greater than 2500 gs.; (k) infant not more than 3 weeks pre-term or 2-weeks post-term; (l) no positive infant urine toxicology screen; (m) abnormal infant blood gases acceptable if all other inclusion criteria met; (n) attending obstetrician confirmed suitability; (o) baby discharged with mother.

Demographic Description of Sample The sample is 49% White, 15% Black, 33% Hispanic, 2% Asian, 1% Native American; educated with 4% grade school, 8% high school, 27% some college, 32% college graduate, 34% post-college.

Sequence of Contacts Recruited in the hospital, mothers gave permission to be contacted at 6 weeks; a trained psychology PhD student gave the CES-D by telephone. 132 mothers and their 4-month infants came to the lab for face-to-face filming. Infants interacted first with mothers, then

strangers, following Field et al.,[44] who found no order effects. Mothers filled out the CES-D,[77a] and Carey[19a] Infant Temperament scales. At 12 months, 84 mothers and infants returned to the lab for Ainsworth Attachment.

Procedure

Face-to-face Play at 4 months Mothers were instructed to play with their infants as they would at home, but without toys. The session lasts 12 minutes (to obtain vocal rhythm data). The infant is in an infant seat, adult seated opposite. 2 videotape cameras generate a split-screen view of the interaction. Following the mother-infant interaction, the stranger and infant also play, again without toys. The mother settles the infant in the seat as the infant and stranger prepare to play.

Coding of 4-Month Interactive Behavior by Microanalysis of Videotape

Introduction to Coding of Videotapes The first 2-1/2 uninterrupted continuous play mins of videotaped M-I (S-I) interaction were coded (coders blind to maternal depression/ infant attachment status) in 1 sec intervals, using timing rules of Weinberg and Tronick.[97a] We report here on adult facial affect, and infant facial affect and vocal affect, organized in the two modality pairings noted below. These scales are ordinalized as required by time-series techniques.[7a,7b,97a,57a,91a] S*mall slices of behavior* generate highly reliable information when analyzed sec by sec[3a] Samples of f*ace-to-face interaction of 2-3 min are stable, with robust session-to- session reliability.* [101,23b ,72b ,98C]

Behaviors Coded are adult attention (on/off partner's face) and facial affect (ordinalized high positive to negative). For infants, the following behaviors were coded: attention (on/off partner's face; on/off object), vocal affect (ordinalized high positive to cry)[40a], head orientation (ordinalized from en face to arch), and touch (none, self, partner, object, 2 or more types per sec; ordinalized from none, any one type, 2+ types per sec). Higher scores indicate more positive/ engaged behavior. Coding schemes can be found in Appendix A. Mean kappas for infant with mother: gaze .80, facial affect .78, vocal affect .89, head orientation .71, touch .75; for infant with stranger: gaze .87, facial affect .90, vocal affect .89, head orientation .73, touch .90. Mean kappas for mother: gaze.83, facial affect .68; for stranger gaze .84, facial affect .73. The distribution of these behaviors for infants with mothers and strangers, and for mothers and strangers, can be found in Figure 1.

Mother and Infant Engagement Scales were constructed from the original codes (by an algorithm and therefore reliability was not relevant) (see Appendix B). The infant scale was ordinalized from infant "high positive engagement" to "cry." The adult engagement scale was ordinalized from "mock surprise" to "neutral/ negative off."

6-week Maternal Self-Report Depression The Center for Epidemiological Studies-Depression Scale (CES-D) [77a] is a 20 item self-report inventory, assessing current nonspecific distress in the general population, not clinically diagnosed depression. Items probe for depressive symptoms/attitudes within the week before administration. Extensively used to measure maternal depression, it has high internal consistency across age, sex and race subgroups[77a]. CES-D assessed with a 16+ cut-off yielded 25% depressed at 6 weeks (6-wk CES-D mean = 12.91 [SD 9.41], range 0-41); 19% depressed at 4 months (4-mo CES-D mean= 9.5 [SD 8.3, range 0-35]). 6-week and 4-

month CES-D are correlated r = .47. We use 6-week depression to see whether depressive symptoms at this early stage affect the dyad 2 ½ months later, consistent with our prior work.[8]

Ainsworth Strange Situation at 12 months For 84 infants who returned at one year, this laboratory test of infant attachment[2a] yielded secure (B: N = 47:56%), avoidant (A: N = 4: 4.8%), angry-resistant (C: N = 16:19%), disorganized (D: N = 17: 20.2%). Dr. Elizabeth Carlson coded the tapes; reliability Kappa =.55 (N=32), p<.001.

Infant Gender is uncorrelated with 6-week and 4-month CES-D. Disorganized attachment has more males (p<.01).

Evaluation of Strangers Prior to analyzing infant differences in behavioral qualities with mother vs. stranger, we investigated whether any of the strangers may have differed among themselves in the ways that they interacted with the infants. We grouped strangers by (a) 13 strangers who interacted with 1-5 infants, (b) 6 strangers who interacted with 6-10 infants, (c) 1 stranger who interacted with over 10 infants (N=14), and (d) 1 stranger who interacted with 25 infants. Using ANOVA we tested whether these 4 groups of strangers differed as a function of any of the infant mean values of the behavioral scales. We found only one subtle difference in infant mean face (F = 3.55, 3df, p=.017). Further examination revealed that this difference was due to very slight differences within the range of neutral/interest facial affect across the 4 groups of strangers. We considered this difference not to be clinically meaningful.

Prior to examining associations of maternal depression with infant behavior with stranger, we investigated whether different strangers may have played with different numbers of infants from the depressed vs. nondepressed subgroups. With one exception, in each grouping of strangers noted above [strangers who interacted with (a) 1-5 infants, (b) 6-10 infants, (c) over 10 infants, and (d) 25 infants] approximately 1/3 of the infants were from the depressed subgroup. In the one exception, one stranger interacted with only 8% of infants from the depressed subgroup. We conclude that no stranger interacted predominantly with infants from the depressed subgroup.

Prior to examining the role of secure vs. disorganized (B vs. D) attachment classification in infant behavior with stranger, we investigated whether different strangers may have played with different numbers of infants from B vs. D classifications. There was no significant association of B vs. D attachment with the groupings of strangers noted above [strangers who interacted with (a) 1-5 infants, (b) 6-10 infants, (c) over 10 infants, and (d) 25 infants].

Statistical Approach to Self- and Interactive Contingency: Multi-Level Models

In traditional repeated measures regression models, the model for the intercept and slope are the same across subjects, and only the error term varies from subject to subject. In multilevel modeling, intercept and slope vary as well, and the basic analyses focus on the entire set of scores for each individual as the basic "random" dependent variable. Thus, multi-level models include for example all 150 seconds coded from videotape for mother face and infant face. These methods may examine lagged effects, including auto-regression. For example, ratings of positive to negative quality of infant's face are predicted from the combined auto-regression of infant's face in the previous seconds (I-> I: self-contingency) and mother's face in the previous seconds (M->I:

interactive contingency). These Bayesian estimates incorporate information from the whole group and tend to bring in any outliers. They are not simply time-series regression equations run for each individual.

The number of seconds of history used in these analyses for the lagged effects was based on a weighted average of the 3 prior seconds for the behavior in question. For example, evaluating interactive contingency using AR3, a weighted average of the lagged behavior in question (lags at t_{-1}, t_{-2}, t_{-3}) was used to predict the behavior of the partner in the current moment (t_0). Prior analyses had identified 3 prior seconds as sufficient to account for the lagged effect. We modeled lags for stranger-infant separately from lags for mother-infant data. Figure 3 illustrates this analysis.

We ran the following model to calculate appropriate weights for Lags of I Face, illustrating with self-contingency of I face:

$$\textbf{I Face} = \textbf{Time} + \textbf{Intercept} + \beta_1\,\textbf{I Face Lag1} + \beta_2\,\textbf{I Face Lag2} + \beta_3\,\textbf{I Face Lag3}$$

Illustrating interactive contingency of I face coordinating with A (Adult) face, the following model calculates weights for I Face.

$$\textbf{I Face} = \textbf{Time} + \textbf{Intercept} + \beta_1\,\textbf{A Face Lag1} + \beta_2\,\textbf{A Face Lag2} + \beta_3\,\textbf{A Face Lag3}$$

Using multi-level modeling methods, a model was produced for each set of modality pairings (e.g. mother face, infant face). Estimated coefficients for effects of these lagged variables on current behavior over the subsequent 147 seconds of interaction indicates the level of self- or interactive contingency: the larger the coefficient, the stronger the contingency. Each analysis included lagged variables for both own and partner behaviour; thus estimated coefficients for self-contingency control for interactive contingency, and vice-versa. Individual estimates of self- and interactive contingency were outputted and stored for each multi-level model. We employ SAS PROC MIXED to fit the longitudinal multilevel models for video-coded variables (except gaze, for which we used ASA PROC GLIMMIX[63a,70a,86]).

In these analyses we modelled the lagged weights across the full data set of M-I and S-I (N=244 individuals (adult or infant) x 150 sec = 36,600 secs per variable, per individual), rather than modelling them within the M-I and within the S-I data sets separately, as we did in the May 2008 Report. These lagged weights were used to calculate weighted lag variables, thus putting M-I and S-I estimates in the same metric. These weighted lab variables were then used to assess self-contingency (acf) and interactive contingency (ccf).

We ran the multi-level time-series equations as 3-level models (rather than as 2-level models as we did in the prior May 2008 Report). In these 3-level models, the infant is the first level (N=122), the identity of the adult (mother or stranger) is the second level (N=244), and the seconds per infant is the third level (N=36, 600). In these 3-level models, all M-I and S-I data are in the same equation. Using this approach, differences in contingencies (M-I vs. S-I) can be tested at per sec level rather than at the per dyad level (as in the May 2008 Report), yielding a more comparable analysis of M-I and S-I data, and more statistical power.

This methodological advance allows us to analyze our data in ways that match our goal of comparing M-I vs. S-I interactions. In what follows we describe these changes in more detail. In the May 08 interim report, the lag weights for the S-I time-series analyses were calculated separately for the M-I, and for the S-I, dyads. This original procedure followed the approach we had used in our previous M-I analyses. Following the submission of the report, however, after extensive consultations among our statistical team (Patricia Cohen, Henian Chen, Karen Buck), we changed our method of calculating the lagged weights in order to make the findings from M-I and S-I more directly comparable.

We created a constant lag structure across all M-I and S-I data (N=244 individuals [adult or infant] x 150 sec = 36,600 secs per variable). This identical weighting process resulted in weighted labs that are on one scale. We began by running a 3-level multilevel model to identify the lagged weights. We used them to compute a single weighted lag variable for each video-coded behavioral scale. Thus, across all 244 dyads, we created weighted lags based on all the available data, using 2 or 3 secs of prior behavior to predict current behavior. Before running models testing self- and interactive contingency, we standardized all lagged variables as well as all dependent variables.

III. Results on Infant Behavioral Qualities

(1) Descriptive Information: Infant Behavioral Qualities

Table 1 presents descriptive information on infant behaviors with mother, and with stranger; Figure 1 illustrates the distributions of these behaviors. We examine the frequencies of behaviors in the 7 infant patterns, with mother, and with stranger. We identify "dominant" codes which describe where the infants spend most of their time, yielding the following observations:

(a) Gaze at partner: infants gaze away from the mother's face 73.2% of the time, and away from the stranger's face 58.4% of the time.

(b) Gaze at object: infants gaze at objects 18.9% of the time when interacting with mothers, and 5.5% when interacting with strangers.

(c) Facial affect: infants spend the most time in "neutral/interest:" 76.6% with mother, 72.1% with stranger; the next most frequent code is "low positive:" 10.0% with mother, 17.3% with stranger.

(d) Vocal affect: infants spend the most time in "no vocalization:" 79.0% with mother, 74.9% with stranger; the next most frequent codes are "neutral/ positive:" 9.3% with mother, 11.5% with stranger; and "fuss/whimper:" 9.7% with mother, 8.8% with stranger.

(e) Facial-visual engagement: the most frequent codes are "neutral off" (gaze off partner's face, and neutral/interest affect), 35.9% with mother and 32.2% with stranger; and "positive on" (gaze on partner's face, and positive affect), 22.2% with mother and 34.6% with stranger.

(f) Head orientation: infants spend the most time in "en face:" 67.4% with mother and 64.3% with stranger.

(g) Infant-initiated touch: infants spend the most time in "no touch:" 32.7% with mother, and 36.5% with stranger; the next most frequent codes are "touch object:" 21.8% with mother, and 29.3% with stranger; and touch partner: 29.4% with mother, and 5.3% with stranger.

(2) Infant Differences in Behavioral Qualities with Mother vs. Stranger

We now test whether any differences between frequencies of infant behavior with mother vs. stranger presented above may be significantly different. Table 2 presents differences in infant behavioral qualities with mother vs. stranger, analyzed by paired t-tests; Figure 3 illustrates them.

(a) Gaze at partner: infants gaze away from the mother's face 1.5 times more than from the stranger's face. Thus infants gaze at stranger's face more. Infants with strangers also show more variability in gaze patterns (SD).

(b) Gaze at object: infants gaze at objects approximately 3 times as much when interacting with mothers (vs. strangers), and show approximately twice the amount of variability (SD) in gaze patterns.

(c) Facial affect: when interacting with mothers (vs. strangers), infants spend slightly but significantly more time in the most frequent facial code of "neutral/interest," where infants spend approximately ¾ of their time. Thus infants with strangers are slightly more likely to be in codes either higher or lower than "neutral/interest," consistent with our hypothesis that infants are more facially "activated" with strangers. When moving in the positive facial affect direction, infants are more likely to show low positive with strangers, but high positive with mothers; when moving in the negative direction infants show the opposite pattern, more likely to show low negative with mother, but high negative with strangers.

(d) Vocal affect: when interacting with mothers (vs. strangers), infants spend slightly but significantly more time in the most frequent vocal code of "no vocalization," where infants spend approximately ¾ of their time. Thus infants vocalize more with strangers, and show a more variable vocalizing pattern with strangers, consistent with our hypothesis that infants are more "activated" with strangers. When moving in the positive vocal affect direction, there are no differences; when moving in the negative direction, infants are approximately 3 times more likely to show the most negative pattern of "cry" with strangers. Thus facial and vocal affect are organized similarly in the pattern of mother vs. stranger differences in infant use of the "midpoint" codes of neutral/interest facial affect, and "no vocalization;" and in the pattern of use of more severe negative affect, which is more likely shown with stranger.

(e) Facial-visual engagement: the most frequent code of "neutral off" shows no differences, but the similarly frequent code of "positive on" is more likely with stranger; this difference is likely driven by the fact that infants gaze more at the stranger. Infants are approximately 3 times more likely to look at the stranger from an "angled" head position, metaphorically "angled for escape;" and infants are more likely to show "positive off" with stranger, a pattern of looking away from the stranger's face, but with a positive facial or vocal affect. Both these patterns are "mixed messages" organized by intermodal discrepancies, indicating wariness or "ambivalence" toward the stranger.

Infants are more likely to show "negative off" with mother, a pattern of looking away from mother's face, with negative affect (and a head orientation of either enface or avert). Infants are approximately 2 times more likely to show engagement "distress" with the stranger, a code reflecting cry face, and/or angry protest, and/or cry vocalization (regardless of gaze at partner or head orientation).

(f) Head orientation: infants with the stranger (vs. mother) are approximately 2 times more likely to show the position of "head down," while remaining enface; infants with the mother (vs. stranger) are approximately 2 times more likely to show the orientation of "arch," a code that captures a whole body movement of arching away from the partner.

(g) Infant-initiated touch: infants with mother (vs. stranger) are approximately 5 times as likely to touch the partner (that is, mother); but infants with stranger (vs. mother) are more likely to touch an object (clothing, strap, chair), and approximately 1.5 times more likely to touch the self (skin). Thus infants are more likely to use "self-regulatory" forms of touch (fingering object or own skin) with stranger, and more interpersonal forms of touch (touch partner) with mother. When the touch codes are collapsed into "any one type of touch" per sec (touch self, object, partner), infants show greater likelihood with mother, but this result is likely driven by the 5 times greater time in touching partner with mother.

General Comment: Infant differences with mother vs. stranger

Infants are more gaze "activated" with strangers in the finding that infants look at the face of strangers about 1.5 times as much as at the face of mothers, and have more variable patterns of looking with stranger. This finding replicates Alfasi (1982). These results are consistent with our hypothesis that infants are more "activated" with the stranger.

But infants look at objects 3 times as much with mothers as with strangers. We infer that the infant has less need to monitor the mother's face, is likely at a lower level of arousal with the mother, and is thus more able to turn attention to an object. But with strangers, infants are likely at higher levels of arousal as they process a novel situation (novel partner, novel lab). They monitor the novel stranger's face more, and thus are less able to turn attention to an object.

Across the scales of facial affect, vocal affect, and facial-visual engagement, infants are more likely to show the most extreme negative affect with the stranger. These findings are consistent with our hypothesis that infants are more "activated" with the stranger. Although we had originally hypothesized greater activation in either positive or negative affect directions, infant greater activation with stranger is in the negative affect direction. In contrast, infants are more activated with mothers in the positive affect direction. Availability of negative affect in the context of novelty and challenge with the stranger may be species-adaptive. The finding of more infant negative affect with stranger than mother is consistent with the literature. These findings point to differences in the organization of positive and negative facial affect, also consistent with the literature. They also point to the subtlety of the organization of infant affect with M vs. S. Lumping positive codes, and negative codes, yielded no findings.

Infants with stranger (vs. mother) show more looking at partner's face, but also show more looking with head "angled for escape," an ambivalent, wary posture, organized through an intermodal attention/orientation discrepancy. Infants with stranger (vs. mother) also show more "head down," while remaining vis-à-vis (which could occur whether or not the infant is gazing at partner). This head posture indicates a slight "distancing" from the partner. However, it is with their mothers that infants show more "arch," a whole-body movement back and away (often accompanied by vocal or facial distress). Arch is different from negative affect: it is an active distancing move, and by clinical observation we conjecture that it is accompanied by anger. This movement is reserved for the mother.

Infants are more likely to use "self-regulatory" forms of touch (fingering object or own skin) with stranger, but more interpersonal forms of touch (touch partner) with mother.

The differences in infant behavior with mother vs. stranger were robust: 58% (28 of 48 analyses) were significant, most at $p<.01$ or better. This description of the similarities and differences in infant patterns of behavior with mother vs. stranger yields basic new knowledge on the ways infants relate to novel partners.

(3) Infant generalization from mother to stranger

Generalization, defined as "similar behavior toward discriminable entities,"[15] reflects a flexibility to apply capacities to new, but related situations, inherent in cognitive/ emotional flexibility.[2] Construed as social expectancies, generalization provides a powerful tool for investigating an organizing process within the infant, referred to as an "inner working model" of the relationship, formed through the outcomes of interactions.[17,64] Our data analysis addresses this inner organizing process within the context of a dyadic process. Whereas above we examined differences in infant behavior with M vs. S, we now examine *similarities* in infant behavior with M and S.

Table 3 presents infant generalization of behavioral qualities from mother to stranger, tested by Pearson Product Moment correlation. Of the 22 significant generalization findings, 9/22 also showed significant difference findings, presented above. Despite differences, nevertheless it is possible for infants to generalize. Of the 22 significant generalization findings, 5 were significant in the depressed subgroup only, as presented below. Figure 4 presents scatterplots of the significant findings of infant generalization from mother to stranger. Based on visual inspection of the scatterplots, for each finding we identify which quadrant of the graph may characterize the findings, upper right, upper left, lower right, lower left, as well as findings which spread from the lower left to upper right quadrant in a typical positive correlation pattern. Figure 5 summarizes these quadrant characterizations. Figure 5 also annotates findings for "dominant" codes (where infants spend 60%+ time in that scale) and measures of central tendency (mean, SD).

(a) Mean gaze at partner (% time gaze at partner): Although infants gaze at stranger's face more than at mother's face, nevertheless they also generalize their gaze pattern from mothers to strangers. This is a measure of central tendency. As seen in Figure 4A, this finding spreads across the scatterplot from lower left to upper right quadrants. Thus infants who are high gazers at mother are likely to be high gazers at stranger as well.

(b) Gaze at object: Infants do not generalize their likelihood of gazing at objects from mother to stranger.

(c) Facial affect: Infants generalize their facial affect pattern from mother to stranger in the dominant (and most frequent) code of "neutral/interest," where infants spend approximately ¾ of their time. Figure 4B shows that this finding is most evident in the upper right quadrant. Thus infants who tend to spend approximately 60% of their time or more in neutral/interest facial affect tend to do the same with strangers.

Infants also generalize negative facial affect: the relatively rare codes of low negative (5.8% time with M, 2.2% time with S), and of combined % time in both low and high negative (8.0% time with M, 9.5% time with S). Figures 4C and 4D show that these findings are characterized by the lower left quadrant. As we will see in the analysis below, generalization of low negative, and combined low and high % negative facial affect, were significant only in the depressed subgroup.

(d) Vocal affect: Infants generalize mean vocal affect from mother to stranger, despite the fact that they tend to vocalize less with mothers than strangers. Figure 4E shows that mean vocal affect clusters in the upper right quadrant, at the score of 4, which represents no vocalization. Thus infants tend to generalize their likelihood of not vocalizing. Infants also generalize the specific code of "no vocalization," a dominant code. Figure 4F shows a similar pattern clustering in the upper right quadrant.

Infants also generalize several negatives affect codes, "fuss-whimper," "cry," and "% negative vocal affect (high + low)," all of which are low frequency behaviors. These negative affect behaviors show patterns of generalization which cluster in the lower left quadrant, as seen in Figures 4G, 4H, and 4I. They generalize "fuss-whimper," a relatively rare code (9.7% time with M, 8.8% with S). Thus infants who have a modest amount of fuss/whimper with mother are likely to have a similar modest amount with stranger. Infants also generalize the likelihood of cry, a rare behavior, despite the fact that infants are 3 times more likely to cry with S (3.8% time) than M (1.3% time). Thus infants who cry even a small amount with mother also tend to cry a similar amount with the stranger. Infants also generalize the combined % time in "high or low" negative vocalization. Thus infants who have even a small amount of "high or low" negative vocal affect with mother tend to show a similar amount with the stranger. However, as we will see in the analysis below, generalization of mean vocal affect, and of cry, was significant only in the depressed subgroup.

(e) Facial-visual engagement: Infants generalize mean engagement and "positive on" from mother to stranger. Both these findings spread across the scatterplot from lower left to upper right, as seen in Figures 4J and 4K. Thus infants who tend to have higher mean engagement with M are likely to show similar higher values with S. Although the frequent code of "positive on" (25%-35% of time) is less likely with mother, nevertheless infants generalize their likelihood of being in "positive on" from mother to stranger.

Infants also generalize the likelihood of engagement discrepant affect from mother to stranger, a rare code (approximately 1% time). Our previous work in the mother-infant data set showed that

infants who will be classified Disorganized attachment at 12 months are more likely to show discrepant affect with mothers at 4 months. Infants also generalize engagement "distress" (cry-face, and/or angry-protest or cry), also a rare code (1.5 - 4.0% time). Figures 4L and 4M show patterns of generalization of engagement discrepant affect and engagement distress that cluster in the lower left quadrant. Thus infants who show even a small amount of discrepant affect or distress with mother are likely to have a small amount with stranger. However, these codes are very rare and it is likely that both these generalization findings are carried by a few infants who became upset. As we will see in the analysis below, generalization of distress was significant only in the depressed subgroup.

(f) Head orientation: Infants generalize from mother to stranger all the head orientation positions coded (with the exception of 60-90 degree avert), as well as the mean and SD of head orientation. Head orientation can be conceptualized as a central means by which infants regulate visual-spatial "distance" or "boundaries" in the face-to-face encounter (Stern, 1971; Beebe & Stern, 1977). Infants generalize the mean value of head orientation. Figure 4N shows that these values cluster in the upper right quadrant. Thus infants who tend to have higher mean head orientation with M are likely to show similar higher values with S. Infants generalize the SD of head orientation, and the "dominant" code of En Face, where infants spend approximately ⅔ of their time. Figures 4O and 4P show that these patterns spread from the lower left to the upper right quadrant. The remaining head orientation codes show patterns of generalization that cluster in the lower left quadrant. These are "minor" codes of Head Down (5-10% time), 30-60 Avert (11-14% time), 30-60 Avert + Head Down (7% time), and Arch (1-2% time), illustrated in Figures 4Q, 4R, 4S, and 4T, respectively.

(g) Infant-initiated touch: Infants generalize the mean frequency of touch (none, any one, or 2+ of the codes of touch self, partner, or object). Figure 4U shows that this pattern spreads from the lower left to the upper right quadrant, as well as shows a pattern of clustering in the lower right quadrant. Figure 4U suggests that for some infants, a higher touch mean with mother generalizes to similar values with stranger. However, for more infants, the Figure suggests that higher infant values of touch mean with mother are associated with modest values with stranger. This pattern is consistent with differences in infant touch patterns with mother vs. stranger: the infant is more likely to engage in any one type of touch (self, partner, object) with mother than with stranger (see Table 2). In addition infants generalize the code of "no touch," which represents about 1/3 of the time. Figure 4V shows that this pattern spreads from the lower left to the upper right quadrant. Thus likelihood of no touch generalizes from mother to stranger.

Discussion comment: Infant Generalization

Overall, there are a substantial number of generalization findings (22 of 48 analyses, or 46%). However, 5 of these effects are significant only in the depressed subgroup, as we will see below. Excluding these 5, across the group, 35% (17 of 48) of the analyses were significant. These correlations tend to be rather modest, in the range of .2, although they range to .6. Of the 22 findings, 9 appear in the "dominant codes" where infants spend 60%+ time in that behavioral scale.

Gaze at partner vs. object operated very differently: gaze at partner showed infant generalization, whereas gaze at object did not. Instead, infants show greater gaze at object with mother than stranger.

Generalization of facial and vocal affect operated similarly: infants generalized the "midpoint," (facial neutral/interest, and no vocalization), as well as negative affect. The generalization of negative affect was also evident in facial-visual engagement. However, generalization of most of the negative affect codes (with the exceptions of fuss/whimper and discrepant affect) was significant only in the depressed subgroup, as we will see below.

Head orientation showed the most generalization of any scale: a striking finding. More than any other scale with subcodes, infant head orientation indexes infant "styles" (of visual-spatial boundaries) that infants carry into their interactions with strangers.

Infants generalized the mean of all but 2 scales (gaze at object and facial affect), indicating that infants generalized their average use of codes across the scales. However, generalization of mean vocal affect was significant only in the depressed subgroup. Infants generalized mean gaze, an index of % time gazing at the partner, indicating that infants generalized the likelihood of gazing at (or away) from the partner. Infants also generalized the "neutral" or "midpoint" of the facial affect, vocal affect and touch scales. They generalized neutral/interest facial affect, (where infants spent approximately ¾ of the time); no vocalization (where infants spent approximately ¾ of the time), indicating that infants generalized the likelihood of vocalizing or not; and no touch (where infants spent approximately 1/3 of the time), indicating that infants generalized the likelihood of touching or not. These findings indicate that infant generalization occurred in "dominant" codes that captured major portions of infant time within each scale.

Infants also generalized some codes that captured very small percentages of time within scales, which we termed "minor" codes: for example, low negative facial affect (2-6% time, significant only in the depressed subgroup), vocal affect of cry (1-4%, significant only in the depressed subgroup), engagement discrepant affect (1%), engagement distress (1-4%, significant only in the depressed subgroup), and head orientations of arch (1-2%), and 30-60 degree avert + head down (7%). Note that these codes capture negative affect and more extreme orientational aversions. Thus generalization also occurred in "minor" codes that captured very small portions of time within scales, but which captured specific modes of negative affect and more extreme orientational aversions.

The correlation patterns are sensitive to the frequency of the codes. A careful examination of the scatterplot patterns of the correlations, summarized in Figure 5, revealed differences in the meaning of "generalization" in the different codes. Particularly negative affect and head aversions, which clustered in the lower left quadrant, revealed a different meaning of generalization than the patterns which spread from the lower left to the upper right quadrant, or which clustered in the upper right quadrant. These latter two patterns look like more typical correlations. They occurred in the "dominant" codes, that is measures of central tendency (mean and SD), or codes where infants spend substantial portions of their time (⅓ to ⅔).

Because the codes of negative affect or orientational aversion are rare ("minor" codes), generalization in these codes means that even a little of this behavior with the mother is likely to predict a little with the stranger. Here we draw on our principle of "heightened affective moments" (Beebe & Lachmann, 1994), where even a moment of a very intense behavior can be organizing out of proportion to mere duration or frequency. A small amount of negative affect or orientational aversion can be very important in the quality of the relatedness. However, because these codes of negative affect and orientation aversion tend to be rare, naturally they tend to be less robust. Although 2 correlations were .44 and .57, careful examination revealed that a handful of infants are most likely responsible for these findings. Because these behaviors are rare, this picture of generalization requires replication with a larger sample of distressed infants.

Conclusion: Infant Generalization from Mother to Stranger

These findings suggest that infants do learn styles of behaving with their mothers that they tend to carry over into interactions with strangers. However, these styles are different in low frequency behaviors ("minor codes") vs. "dominant" codes and measures of central tendency. The generalization findings in the low-frequency "minor" codes of negative affect and orientational aversions ("avoidance") are subtle and less robust. Nevertheless we consider these findings important because negative affect and orientational aversion affect the quality of the relatedness. Approach behaviors (orientation en face), "dominant" codes (such as neutral/interest facial affect), and central tendencies (mean and SD) characterize generalization more robustly.

"Styles" of behaving that infants generalize from M to S can be conceptualized as infant expectancies of their own behaviors. However, we infer that these expectancies are more robust for the more dominant codes, and more subtle for the minor codes of negative affect and orientational aversion. Speculatively, our findings may indicate the origins of "transference:" modes of relating in a primary relationship that are brought into an interaction with a novel partner.

In summary, we conclude that the widely held assumption of most theories of social development, that children learn patterns in the family which they carry into interactions with novel partners, holds weight. In about one third of the analyses, infants "generalized" patterns of behavior from mother to stranger. To our knowledge, ours is the first test of this assumption in infancy. However, this assumption is further refined by our data. The correlations indexing generalization were modest. More "dominant" patterns, where infants spend large portions of time (or measures of central tendency), were somewhat more robust, and are more likely to be carried forward into interactions with novel partners. Head orientation, which indexes the management of spatial-visual boundaries, was the most robust generalization pattern. "Minor" patterns, with low frequency, such as negative affect and orientational aversion, are also carried into interactions with novel partners, but because these were rare behaviors, these findings were subtle and require replication. Thus the dimensions of negative (vs. positive) affect and avoid (vs. approach) orientation patterns are salient in the organization of infant generalization of behavior from mother to stranger.

(4) Effects of maternal depression on infant behaviors with mother vs. stranger

We turn to the ramifications of maternal depression for infants in the larger ecology of novel social partners. We address the question of whether infants of distressed mothers may show difficulties with mother which are also evident with stranger, thus constricting the infant's repertoire for engaging new social partners and constructing new experience. If so, we may identify micro-processes of distress transmission from M-I to S-I.

Here we address associations of maternal depression with infant behaviors when interacting (i) with mothers, and (ii) with strangers. Below we address the question of whether maternal depression affects infant generalization from mother to stranger.

Table 4 presents associations of 6-week maternal depressive symptoms (CES-D) with the mean and SD of infant behaviors, when interacting with mother, and with strangers. Depression is measured at 6 weeks because of the implications for early intervention, and following our earlier work which found stronger associations with 4-month behavior than depression measured concurrently at 4 months (Beebe et al, 2008).

We found 28% (4 of 14) of analyses significant in tests of associations of maternal depression with infant behavior when interacting with mother. When interacting with their mothers, infants of depressed (vs. nondepressed) mothers show (a) higher mean gaze, that is, higher % time gazing at mother's face, interpreted as infant gaze "vigilance,"; (b) higher SD of gaze, a greater variability and instability in gaze patterns with mother; (c) lower % time gazing at objects, consistent with the greater time gazing at mother's face; (d) higher head orientation mean, accounted for by greater percent time in the enface orientation with mother. The latter finding is interpreted as less flexibility to orient away from mother, a form of "orientational vigilance." These findings (with the exception of higher gaze SD, and lower % time gazing at objects) have previously been reported in Beebe et al (2008).

In contrast, we found 14% (2 of 14) analyses significant in tests of associations of maternal depression with infant behavior when interacting with stranger, a very modest amount. When interacting with the stranger, infants of depressed (vs. nondepressed) mothers show (a) lower % time gazing at objects, and (b) lower variability (SD) in pattern of gazing at objects. These findings suggest a constriction in the infant's ability to visually engage with objects.

Because we found in our prior work on the association of maternal depression with mother-infant interaction in this data set (Beebe et al, 2008) that higher head orientation mean was accounted for by greater percent time in the enface orientation with mother (a form of "orientational vigilance"), we decided to test this specific behavioral code with infants interacting with strangers. Replicating our prior work (N=132) with the current mother-infant data set (N=122), we again found that infant of depressed mothers spent more time (77% time) enface than infants of nondepressed mothers (64%) (t=2.29, 75.14df, p=.009). Infants with strangers, however, showed no significant difference in % time enface in the subgroups of depressed (70.7%time) vs. nondepressed (61.9%) (t=1.49, 120df, p=.138).

In conclusion, we found a few significant associations of maternal depression with infant behaviors of gaze at mother, gaze at object, and head orientation. Associations of maternal depression were less evident in infant behavior with strangers, manifesting only in gaze at object. Overall, associations of maternal depression with infant behavioral qualities is modest.

(5) The effects of maternal depression on infant generalization of behavior patterns from mother to stranger

We now ask if the patterns of generalization of infant behavior from mother to stranger documented above may be affected by maternal depression, as argued by Field et al. (1988).

Infant generalization of behavior patterns from M to S would perpetuate effects of maternal depression: infants would carry these patterns into new social encounters. Field[44] found that infants of self-reported depressed mothers showed less positive behavior with both M and S and inferred that infants developed a "depressed style" of interacting, used with new partners. If maternal depression has specific effects on infant generalization, we infer a constriction of the infant's repertoire for engaging new social partners and constructing new experience. We attempt to replicate (a) Field's[44] finding of infant generalization of negative facial affect with depression, and (b) Phelan's[75,59] finding of infant gaze generalization with depression. More generally, we hypothesize infant generalization of negative facial and vocal affect with maternal depression.

Table 5 presents the effects of 6-week maternal depressive symptoms (CES-D) on infant generalization of behavior from mother to stranger, tested with stratified regression equations for depressed (CES-D 16+) vs. nondepressed groups. Depression is measured at 6 weeks because of the implications for early intervention, and following our earlier work which found stronger associations with 4-month behavior than depression measured concurrently at 4 months.

Although there were few significant effects (5 of 48 equations, approximately 10%), nevertheless they confirmed our hypothesis that maternal depression would increase the likelihood that infants would generalize negative affect from mother to stranger. Table 5 shows that maternal depression affected infant generalization of low negative facial affect, and a combined measure of low and high degree of negative facial affect; mean vocal affect, as well as the prevalence of the vocal affect code of cry; and engagement distress, a combination of the facial affect code of cry-face, and the vocal affect codes of angry-protest or cry.

Figure 6 shows scatterplots of the significant findings, contrasting depressed and nondepressed groups. We do have effects of maternal depression on infant generalization of distress from mother to stranger, replicating Field et al. (1988), but the associations characterize relatively few infants. These effects of depression on generalization occurred in more "minor," low-frequency negatives affect behaviors, and generated patterns which clustered in the lower left quadrant. We would need more depressed mothers, and more infants who were more upset, to be able to see if the associations here are strong or not. A few infants of the depressed mothers may be responsible for these associations. Those infants who were seriously upset with mother do tend to stay seriously upset with stranger, and these infants are in the maternal depression group.

Nevertheless it is intriguing that we did reproduce Field et al.'s (1988) finding. In the time intervening since the Field et al report, several studies have shown that negative infant affect shows more continuity in development than positive infant affect, and predicts infant developmental outcomes.[68]

These findings also shed light on the generalization findings reported in Table 3. As noted above, the generalization of infant negative affect is largely accounted for by maternal depression; infants in the nondepressed group do not show significant effects. It is interesting that other ways in which infants of depressed mothers differ when interacting with their mothers did not show generalization to the stranger. The greater percent time gazing at mother, and greater variability in gaze patterns, in infants of depressed mothers did not generalize to the stranger. Nor did the lower percent time gazing at objects, or higher head orientation mean, generalize to the stranger.

(6) An Integrated View of Infant Differences and Generalization with Mother and Stranger

Table 7 presents an integration of the significant findings of infant differences in behavioral qualities with M vs. S, and infant generalization of behavioral qualities from M to S. We excluded any generalization findings that were significant in the depressed subgroup only. We divided the findings into 4 mutual exclusive categories: (1) both differences and generalization, (2) differences, but no generalization, (3) no differences, but significant generalization, and (4) neither differences nor generalization.

We conceptualize the categories in the following ways: (1) captures both infant adaptations to novelty (novel partner) as well as infant expectancies, or internal working models, which are "carried" from mother to stranger; (2) captures "pure" adaptation to the novel partner, without generalization; (3) captures "pure" internal working models, without any evidence of adaptation to novelty; and (4) captures those behaviors which showed no evidence of either adaptation to novelty or generalization. However, to understand the full picture of the infant's adaptation to the novel partner, categories (1) and (2) are both necessary; and to understand the full picture of infant expectancies or internal working models, categories (3) and (3) are necessary.

Table 7 shows that category (2) "pure" adaptation to the novel partner (N=18) and category (3) "pure" internal working models (N=11), characterize the data more than the mixed category (1), both adaptation to the novel partner and internal working models (N= 6). Thus most of the findings of infant differences with S vs. M (18/24) are not generalized from M to S but rather are "pure" novelty adaptations. Likewise, 2/3 of the internal working model findings (11/17) are not about adaptation to novelty. Thus we seem to be tapping 2 rather different processes.

Of the 6 findings which represent both adaptations to the novel partner and internal working models, 3 are measures of central tendency or dominant codes (mean gaze, mean engagement, and neutral/interest facial affect). Two are rare head orientation codes (head down and arch).

Generalization (Internal Working Models)
In the findings which represent "pure" internal working models (generalization, without differences), the leading modalities are vocal affect and head orientation. These findings can be characterized by

(a) measures of central tendency, whether the infant vocalizes or not, and whether the infant touches or not;

(b) most head orientation codes, which concern the management of visual-spatial boundaries;

(c) negative affect: negative vocal affect codes (fuss/whimper, and combined negative affect), and the rare code of discrepant affect.

Infants thus generalize from mother to stranger the likelihood of vocalizing or not, negative vocal affect, and discrepant vocal/facial affect; head orientation patterns, indexing modes of managing visual-spatial boundaries; and the likelihood of touching or not.

Differences (Adaptation to the Novel Partner)
In the findings which represent "pure" adaptation to novelty, without generalization, the leading modalities are gaze, facial affect, engagement and touch. These findings of infant differences with stranger (vs. mother) can be characterized by:

(a) gaze: the infant with the stranger has a more variable pattern of gazing at the partner's face, and is more likely to look at the stranger "angled for escape;" and the infant with the stranger gazes less at an object, with a less variable pattern;

(b) facial affect: the infant with the stranger has a lower mean facial affect; less high positive but more low positive facial affect; and more high negative facial affect;

(c) facial-visual engagement: the infant with the stranger has less "negative on (negative affect while gazing at partner)" and "negative off" (negative affect while gazing away from partner), and less non-distressed gazing at object; he has more "positive off" (positive affect while gazing away from partner);

(d) touch: the infant with the stranger has a less variable touch pattern; touches the partner, the stranger, less than mother; and is less likely to use the combined touch code of "any one code" (partner, object, self); but is more likely to use the touch codes of object and self. Thus the infant uses more relational touch patterns with the mother (touch partner), and more self-directed touch patterns (self or object) with stranger. Whereas the infant generalizes from mother to stranger the likelihood of touching or not, the infant shows very different patterns of touch when interacting with mother vs. stranger.

(e) vocal affect: the infant with the stranger has a more variable pattern of vocal affect with the stranger.

In summary, there is little overlap between the findings of M-I vs. S-I differences and generalization, such that only a few of the findings characterize both processes. We seem to be tapping 2 rather different processes. Furthermore, the content of "pure" generalization vs. "pure" differences is distinct. Infants generalize from mother to stranger patterns of negative vocal affect, and head orientation; they also generalize the likelihood of vocalizing, or of touching. In contrast, infants show differences from mother to stranger in patterns of gazing (at partner and object), facial affect, facial-visual engagement, and touch.

(7) Associations of degree of attachment disorganization (at 12 months) with mean and SD of infant 4-month behaviors with mother vs. stranger

In these analyses we construe attachment as a "climate" that is already evident at 4 months, based on numerous studies showing associations of 4-month behavior with 12-month attachment (Jaffe et al, 2001). Table 8 presents associations of degree of attachment disorganization with means and SD of infant behavioral qualities from mother to stranger, tested by correlation. When infants interacted with mothers, we found 35% (5 of 14) of analyses significant in tests of associations of degree of attachment disorganization with infant behavior. Infants who were more likely to be disorganized at 12 months showed with mothers at 4 months (a) lower variability in patterns of gazing at objects, (b) higher variability in patterns of facial affect, (c) lower mean vocal affect, that is, toward negative vocal affect, (d) higher variability in vocal affect patterns, and (e) lower mean touch, indicating less % time touching (partner, object, self).

In striking contrast, when infants interacted with strangers, there were no significant findings. This finding is consistent with our hypothesis that "future" disorganized infants are able to "recalibrate" or "repair" with the stranger.

(8) Effects of degree of attachment disorganization on infant generalization of behavior patterns from mother to stranger

There were no significant effects. This finding is also consistent with our hypothesis that "future" disorganized infants are able to "recalibrate" or "repair" with the stranger. Put another way, future D infants do not tend to generalize their patterns of behavior from mother to stranger.

IV. Results on "Process" Measures: Self- and Interactive Contingency

We report here on self- and interactive contingencies which have been calculated with methodological advances over the multi-level models we used in the May 2008 APA Report (see Method). The purpose of the new models we report is to incorporate more direct comparisons of infant behavior with mother and with stranger. We ran these new models using the modality pairings of adult facial affect – infant facial affect, adult facial affect – infant vocal affect, and adult gaze (at partner's face) – infant gaze (at partner's face).

Findings of Self- and Interactive Contingency

Table 9 presents the main effects of M-I and S-I self- and interactive contingencies for the modality pairings of adult gaze – infant gaze, adult facial affect – infant facial affect, and adult facial affect – infant vocal affect. Table entries are standardized betas from 3-level multi-level time series models, conducted at the sec-by-sec level. Adult models predict adult behavior from prior adult and prior infant behavior; infant models predict infant behavior from prior infant and prior adult behavior. The r is the effect size, reported as a correlation coefficient. Figure 2 illustrates self- and interactive contingency when calculated for infants. All self- and interactive contingency estimates are significant. As in our prior work (Beebe et al, 2007), the effects for self-contingency are rather large, and the effects for interactive contingency small. Thus much more of the predictability of the system is carried through the individual's degree of self-contingency, interpreted as degree of stability from the prior 3 sec to the current sec.

Table 10 presents differences in M-I vs. S-I self- and interactive contingencies. Figure 7 illustrates these differences. We find no differences in the pairing of adult gaze – infant gaze. For the pairings of adult facial affect – infant facial affect, and adult facial affect – infant vocal affect, Table 10 shows that strangers, and infants with strangers, have higher self-contingency than mothers, and infants with mothers. This finding indicates that, with novelty, both stranger and infant self-stabilize: the current sec in more predictable from the prior 3 sec. Moreover, in the adult facial affect – infant facial affect pairing, strangers have lower interactive contingency than mothers. Thus compared to mothers, strangers tip the balance between self- and interactive contingency of facial affect toward greater self-stabilization, and lower coordination with infants.

Because we ran new models using the pairings of adult facial affect – infant facial affect, and adult facial affect – infant vocal affect, we are in a position to compare findings from the May 2008 Report with our current findings. Our new approach did not change the findings of the main effects of self- and interactive contingency. As before, for both M-I and S-I data, for both partners, main effects of self- and interactive contingency are significant across the group. But our new approach did change some of the findings for the comparison of M-I vs. S-I contingencies.

Adult Facial Affect – Infant Facial Affect

For adult facial affect – infant facial affect, both the May 2008 Report and our current methods concur in the finding that infant and stranger self-contingency are higher than that of mother and infant. Higher self-contingency indicates a stabilization, in which degree of positive to negative facial affect tends to stay more stable in infants and strangers than in infants and mothers. This stabilization can be considered a coping effort with novelty. It may a form of wariness or carefulness. Because we infer a coping effort, we consider higher self-contingency a form of activation.

However, the findings differ for interactive contingency in the modality pairing of adult facial affect – infant facial affect. In the May 2008 Report, both infant and stranger interactive contingency was higher that that of mother and infant. In our revised findings, there are no differences for infant interactive contingency. And the finding for stranger interactive contingency is in the opposite direction, decreased rather than increased. Here we see the definitive impact of changing the method.

Adult Facial Affect – Infant Vocal Affect

For adult facial affect – infant *vocal* affect, both the May 2008 Report and our current methods concur in the finding that stranger self-contingency is higher than that of mother. But, unlike the May 2008 Report, we also now find that infant self-contingency of vocal affect is higher with stranger than mother. The findings also differ for interactive contingency. In the May 2008 Report, stranger interactive contingency was higher that that of mother. In our current findings, there are no differences for M-I vs. S-I interactive contingency. Again we see the definitive impact of changing the method.

General comment on Contingency Findings

We found no differences in M-I vs. S-I self- and interactive contingency for gaze at or away from the partner's face. Gaze is often considered the infant's most advanced communicative capacity by 4 months, comparable to adult status. Infants gaze at the stranger's face more than at the mother's face, as noted above, but the infant's level of contingent gaze coordination with adult shifts of gaze (on and off infant's face) is comparable with mother and stranger. Thus the infant novelty effect in gaze is found not in the *process* measure of self- or interactive contingency, but in the *content* measure of amount of time gazing at the stranger.

Infants showed higher self-contingency of facial and vocal affect with strangers, compared to mothers. Strangers similarly showed higher facial self-contingency than mothers. Both strangers, and infants with strangers, are encountering a novel partner. Both strangers, and infants with strangers, adapt by self-stabilization. As noted above, infants also showed M-I vs. S-I differences in facial and vocal affect using our *content* measures of behavioral qualities. Thus, the infant novelty effect in facial and vocal affect is found in both process and content measures.

We identified only one significant effect of interactive contingency. In the modality pairing of infant facial affect – adult facial affect, strangers showed lower interactive coordination than mothers. Combining the stranger's higher self- but lower interactive contingency, the strangers tilt the balance toward self-stabilization, lowering their interactive coordination. Thus, despite their brief training to be facially responsive to infants, and to match the direction of infant affective change, strangers were less facially responsive than mothers. This finding may indicate a certain wariness, or "novelty effect," on the part of the strangers. From prior work on the mothers and infants of this data set, examining individuals on a per dyad basis we discovered that some mothers and infants showed the "style" of tilting the balance toward higher self-contingency and lower interactive contingency; and others showed the opposite style, tilting toward higher interactive contingency, and lower self-contingency. Here we discover, on an across-group basis, that strangers have the "style" of tilting the balance toward self-contingency. In future work we plan to examine the data from the point of view of individual styles. We are interested in whether mother or infant styles of tilting toward higher self- and lower interactive contingency (and vice-versa) generalize to infants with strangers.

V. DISCUSSION

To what degree are infant patterns of behavior with mother carried into a new social situation with the stranger? To what degree do infant patterns of interaction adjust and shift with a novel partner? Are there differences by modality, maternal depression, or attachment disorganization? Our documentation of the ways in which stranger-infant interactions are both similar to and different from mother-infant interactions has implications for our understanding of the development of infant expectancies of "how interactions go."[52,91c] This report addressed these issues primarily with "content" measures of infant behavioral qualities.

Our data indicate that behaviors in which infants show differences with mother vs. stranger, which we termed "adaptation to the novel partner," are largely separate from those behaviors which generalize from mother to stranger, which we termed "expectancies," or "internal working models." Both processes were robust in our data, significant in approximately half of the analyses run. We conclude that the stranger is salient in the infant's world, and that the infant is well aware of the stranger's difference. We also conclude that infants do learn styles of behaving with their mothers that they tend to carry over into interactions with strangers.

1. Differences in Infant Behavior with Stranger vs. Mother: Adaptation to the Novel Partner

Infants showed robust differences in the ways that they adapted to the novel stranger, particularly in gaze, facial affect, engagement and touch. They looked more at the stranger's than mother's face, suggesting vigilance. They looked less at objects when playing with the stranger compared to the mother. But they were more likely to look at the stranger's face with a head orientation of "angled for escape," suggesting wariness. They were less facially positive with the stranger, and more facially negative. Infants used "self-regulatory" forms of touch (fingering object or own skin) more with stranger, but interpersonal forms of touch (touch partner) more with mother.

2. Infant Generalization of Behavior from Mother to Stranger: Expectancies/Internal Working Models

We characterize our generalization findings as modest in strength, but nevertheless pervasive, evident in almost half the findings. We conclude that infants do develop "internal working models" or expectancies, that generalize from mother to stranger, but that these expectancies are more robust for our "dominant" codes (measures of central tendency, or codes characterizing 60%+ of a behavioral scale) than "minor" codes of low frequency behaviors.

Degrees of head orientation from en face to arch, indicating progressive increments in head aversions from the vis-à-vis, was the lead modality in infant generalization of behavior patterns from mother to stranger. These increments in head aversion index the management of visual-spatial boundaries. Infants also more robustly generalize those behaviors which are measures of central tendency or which characterize where infants spend 2/3 or more of their time: tendency to vocalize (or not), to look at partner's face (or not), to touch (or not); average levels of vocal affect, facial-visual engagement, head orientation and touch.

Infants also generalized the "minor" low-frequency codes of negative affect and orientational aversion. These findings require replication.

Thus the dimensions of negative (vs. positive) affect and avoid (vs. approach) orientation patterns are salient in the organization of infant generalization of behavior from mother to stranger.

Speculatively, our findings may indicate the origins of "transference:" modes of relating in a primary relationship that are brought into an interaction with a novel partner.

3. Effects of Depression on Infant Generalization of Behavior Patterns from Mother to Stranger

Although the findings were few (approximately 10% of analyses run), nevertheless they confirmed our hypothesis that maternal depression increases the likelihood that infants generalize negative affect from mother to stranger, replicating Field et al (1988). These findings occurred in the low frequency codes of negative affect, and would require replication.

4. Effects of Degree of Disorganization on Infant Behaviors with Mother vs. Stranger, and on Infant Generalization from Mother to Stranger

Consistent with our prior work, 4-month infants with higher (vs. lower) degrees of disorganization (at 12 months) showed differences with their mothers; in striking contrast, there were no significant findings with strangers. This finding is consistent with our hypothesis that "future" disorganized infants are able to "recalibrate" or "repair" with the stranger. There were no findings of effects of degree of disorganization on infant generalization, again indicating that infants with high degrees of disorganization do not generalize their difficulty to the stranger. On the basis of these findings, we propose that for "future" D infants at 4 months, attachment disorganization is a "relational problem," but not yet a "developmental" problem (although we plan to see what these infants look like with the stranger in face-to-face interaction at 12 months).

These analyses are consistent with the May, 2008 Report, in which we compared vocal affect and facial affect code by code in D vs. B infants, with M and with S. Future D and B were very different and distressed with their mothers, but indistinguishable with the S. This finding is also consistent with Jaffe et al. (2001).

5. Self and Interactive Contingency in Mother-Infant and Stranger-Infant Interactions

Compared to mothers and infants, both strangers and infants stabilized self-contingency in facial and vocal affect. This higher self-contingency is interpreted as coping, carefulness, and possibly wariness. This is an important new finding, that self-contingency is heightened in the context of novelty. In our prior work in this mother-infant data set, self-contingency of mothers and infants was robustly lowered (a destabilization) in the context of maternal distress (depression, anxiety, self-criticism). Thus, in different contexts, self-contingency is heightened (in the context of

novelty) and lowered (in the context of maternal distress), consistent with our optimum midrange model of contingency.

CONCLUSION

We began the study of stranger-infant vs. mother-infant interaction proposing that, as a function of distress (e.g., maternal depression or disorganized infant attachment), we might identify those effects in infants which are in evidence (a) only with M but not S, that is, specifically *relational* difficulties; (b) only with S but not M, that is, difficulties or forms of adaptation which are visible only with the challenge of the novel partner, that is *novelty effects*; or (c) with both M and S, that is, *developmental* difficulties in which the entire social system is thrown off, and infant difficulties with M generalize to S.

We identified (a) specifically relational difficulties in "future" disorganized infants at 4 months, who show difficulties with mother but not stranger. These infants "recalibrate" or "repair" with the stranger. We identified (b) specific infant adaptations to the novel partner in numerous differences in infant patterns of gaze, facial affect, engagement and touch; and in heightened infant self-contingency in facial and vocal affect. We identified (c) developmental difficulties in which infant difficulties with mother generalize to the stranger in infants of depressed mothers. Although these findings were few, they replicated findings of Field et al. (1988). Finally, we identified a "normative" process across the group in which infants learn styles of relating which they carry over to interactions with novel partners.

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Table 1

Infant Behavioral Qualities with Mother and Stranger: Descriptive Information

	Infant with Mother		Infant with Stranger		Total	
	Freq. sec	% sec	Freq. sec	% sec	Freq. sec	% sec
(A) Infant Gaze at Partner						
Gaze At	4848	26.8	7506	41.6	12354	34.2
Gaze Away	13227	73.2[†]	10537	58.4	23764	65.8
Total	18075	100.0	18043	100.0	36118	100.0
(B) Infant Gaze at Object						
Gaze at Object	3432	18.9	996	5.5	4428	12.3
Not Gaze at Object[a]	14715	81.1[†]	16994	94.5	31709	87.7
Total	18147	100.0	17990	100.0	36137	100.0
(C) Infant Facial Affect						
High Positive	963	5.5	209	1.2	1172	3.3
Low Positive	1752	10.0	3122	17.3	4874	13.7
Neutral/Interest	13484	76.6[†]	13011	72.1	26495	74.3
Low Negative	1023	5.8	3930	2.2	1416	4.0
High Negative	384	2.2	1313	7.3	1697	4.8
% Positive (High + Low)	2715	15.4	3331	18.5	6046	17.0
% Negative (High + Low)	1407	8.0	1706	9.5	3113	8.7
Total	17606	100.0	18048	100.0	35654	100.0
(D) Infant Vocal Affect						
High Positive	65	0.4	150	.9	215	0.6
Neutral/Positive	1578	9.3	1940	11.5	3518	10.4
No Voc	13378	79.0[†]	12661	74.9	26039	77.0
Fuss/Whimper	1650	9.7	1487	8.8	3137	9.3
Angry Protest	42	0.2	28	0.2	70	.2
Cry	225	1.3	634	3.8	859	2.5
% Pos (Hi Pos + Neut/Pos)	1643	9.7	2090	12.4	3733	11.0
% Neg (Fuss, Protest, Cry)	1917	11.3	2149	12.7	4066	12.0
Total	16938	100.0	16900	100.0	33838	100.0
(E) Infant Engagement[b]						
Positive On	3568	22.2	5522	34.6	9090	28.4
Negative On	371	2.3	182	1.1	553	1.7
Look-Angled Escape	245	1.5	981	6.1	1226	3.8
Positive Off	1598	10.0	2003	12.5	3601	11.2
Neutral Off	5758	35.9	5145	32.2	10903	34.1
Non-distressed Gaze at Obj	2953	18.4	780	2.4	3733	11.7
Neg Off (En Face/Avert)	1122	7.0	565	3.5	1687	5.3
Discrepant Affect	195	1.2	145	.9	340	1.0
Distress	241	1.5	644	4.0	885	2.8
Total	16051	100.0	15967	100.0	32018	100.0

	Infant with Mother		Infant with Stranger		Total	
	Freq.	% sec	Freq.	% sec	Freq.	% sec
(F) Infant Head Orientation						
En Face	12274	67.4†	11658	64.3	23932	65.9
Head down	1002	5.5	2161	11.9	3163	8.7
30-60 Avert	2567	14.1	2060	11.4	4627	12.7
30-60 Avert + Head Down	1239	6.8	1248	6.9	2487	6.8
61-90 Avert	789	4.3	814	4.5	1603	4.4
Arch	346	1.9	178	1.0	524	1.4
Total	18217	100.0	18119	100	36336	100.0
(G) Infant Touch (Ordinalized by Frequency)[c]						
2+ Codes	683	4.0	1192	6.8	1875	5.4
Any One Code	10743	63.2†	9607	55.2	20350	59.1
No Touch	5563	32.7	6620	38.0	12183	35.4
Total	16989	100.0	17419	100.0	34408	100.0
(H) Infant Touch						
2+ Codes	683	4.0	1192	6.8	1875	5.4
Object	3708	21.8	5316	30.5	9024	26.2
Partner	4992	29.4	959	5.5	5951	17.3
Self (Skin)	2043	12.0	3332	19.1	5375	15.6
No Touch	5563	32.7	6620	38.0	12183	35.4
Total	16989	100.0	17419	100.0	34408	100.0

Note. All behavioral scales are analyzed with N=122 dyads, with the exception of Infant Vocal Affect (N=110), Infant Engagement (N=110), and Infant Touch (N=120).

[a]Not Gaze at Object includes scan: < 1 sec. glance at object.

[b]Engagement refers to the collapsed 9-level engagement codes (see Appendix B).

[c]Infant touch ordinalized by frequency was used to create infant touch means and standard deviations in the following Tables 2, 3, and 8.

† "dominant" code (60% + time in that scale) or measure of central tendency.

Table 2

Differences in Infant Behavioral Qualities with Mother (M) vs. Stranger (S)

			Per Dyad Differences of Infant with Mother vs. Stranger					
Behavioral Qualities Scale	Mean Level with M	Mean Level with S	Mean Diff. (S-M)	SD	SE of Mean	t	*df*	*p*
(A) Infant Gaze at Partner								
Mean[a]	26.66	41.36	14.70	21.38	.02	-7.59	121	**<.001**[†]
SD	38.41	45.76	7.36	13.88	.01	-5.85	121	**<.001**[†]
(B) Infant Gaze at Object								
Mean[a]	18.91	5.55	-13.37	21.72	.02	6.80	121	**<.001**[†]
SD	28.68	11.87	-16.81	23.03	.02	8.06	121	**<.001**[†]
(C) Infant Facial Affect								
Mean	56.42	54.91	-1.51	8.39	.76	1.99	121	**.049**[†]
SD	7.92	8.59	.67	6.87	.62	-1.07	121	.287
% High Positive	5.40	1.14	-4.25	9.19	.83	5.11	121	**<.001**
% Low Positive	9.94	17.08	7.14	20.10	1.86	-3.83	121	**<.001**
% Neutral/Interest	76.45	71.87	-4.58	25.65	2.32	1.97	121	**.051**[†]
% Low Negative	5.95	2.39	-3.56	10.21	.92	3.86	121	**<.001**
% High Negative	2.27	7.53	5.26	15.14	1.37	-3.84	121	**<.001**
% Positive (High + Low)	15.34	18.22	2.89	24.18	2.19	-1.32	121	.190
% Negative (High + Low)	8.22	9.91	1.70	20.13	1.82	-.93	121	.354
(D) Infant Vocal Affect								
Mean	3.96	3.91	-.05	.42	.04	1.13	109	.262
SD	.43	.54	.11	.44	.04	-2.65	109	**.009**[†]
% High Positive	.39	.91	.52	3.68	.35	-1.47	109	.145
% Neutral/Positive	9.41	11.66	2.25	15.42	1.47	-1.53	109	.129
% No Vocalization	78.80	73.87	-4.93	25.08	2.39	2.06	109	**.041**[†]
% Fuss/Whimper	9.77	9.19	-.58	17.79	1.70	.34	109	.733
% Angry Protest	.26	.17	-.09	1.14	.11	.79	109	.432
% Cry	1.37	4.20	2.83	9.95	.95	-2.99	109	**.003**
% Positive (High + Low)	9.81	12.57	2.77	16.42	1.57	-1.77	109	.080
% Negative (High + Low)	11.39	13.56	2.17	21.09	2.01	-1.08	109	.283
(E) Infant Engagement								
Mean[b]	9.52	10.52	1.00	3.15	.30	-3.34	109	**<.001**
SD	3.67	3.66	.00	1.37	.13	.10	109	.921
% Positive On	21.92	32.44	10.52	22.90	2.18	-4.82	109	**<.001**
% Negative On	2.41	1.22	-1.20	5.41	.52	2.32	109	**.022**
% Look-Angled Escape	1.46	6.43	4.97	8.85	.84	-5.89	109	**<.001**
% Positive Off	9.80	12.36	2.56	11.87	1.13	-2.26	109	**.026**
% Neutral Off	35.59	32.39	-3.20	22.70	2.16	1.48	109	.143
% Non-distressed Gz Obj	18.47	4.95	-13.52	20.86	1.99	6.80	109	**<.001**
% Neg Off (En Face/Av)	7.41	4.32	-3.09	12.23	1.17	2.65	109	**.009**
% Discrepant Affect	1.25	1.24	-.01	5.11	.49	.98	109	.980

% Distress	1.70	4.65	2.95	10.71	1.02	-2.89	109	**.005**
(F) Infant Head Orientation								
Mean	5.10	5.22	.03	.88	.08	-.34	121	.736
SD	.99	.95	-.04	.51	.46	.94	121	.348
% En Face	67.30	64.18	-3.11	34.20	3.10	1.01	121	.317
% Head Down	5.52	12.10	6.58	1.58	-9.69	-4.18	121	**.001**
% 30-60 Avert	14.08	11.30	-2.78	18.96	1.72	1.62	121	.108
% 30-60 Avert + Hd Dwn	6.89	6.93	.05	15.30	1.39	-.03	121	.973
% 60-90	4.32	4.51	.18	11.77	1.07	-.17	121	.864
% Arch	1.90	.99	-.92	4.45	.40	2.30	121	**.024**
(G) Infant Touch								
Mean[c]	.71	.69	-.03	.41	.04	.70	119	.485
SD	.46	.41	-.06	.21	.02	3.01	119	**.003**[†]
% 2+ Codes	3.85	6.72	2.87	17.05	1.56	-1.85	119	.067
% Any One Code	63.40	55.01	-8.39	33.91	3.10	2.71	119	**.008**[†]
% Object	21.60	29.53	7.93	38.11	3.48	-2.28	119	**.024**
% Partner	29.78	5.67	-24.11	32.11	2.93	8.23	119	**<.001**
% Self	12.02	18.41	6.39	30.01	2.74	-2.33	119	**.021**
% No Touch	32.75	38.27	5.52	33.72	3.08	-1.79	119	.076

Note. Paired t-tests of individual differences of Infant with Stranger vs. Mother. All behavioral scales are analyzed with N=122 dyads, with the exception of Infant Vocal Affect (N=110), Infant Engagement (N=110), and Infant Touch (N=120). SD = Standard Deviation; Obj = Object; Hd Down = Head Down; Engagement Distress = Cry Face, Angry Protest, and Cry. [a]Gaze mean (partner, object) = % gaze on.

[b]Engagement mean, SD are based on the original scale of 18 levels; the Engagement Codes are taken from the 9-Level Engagement Scale (see Appendix B).

[c]Touch mean, SD are based on the 3-level ordinalized touch scale (0, 1, 2+).

[†] "dominant" code (60% + time in that scale) or measure of central tendency.

Table 3
Infant Generalization of Behavioral Qualities from Mother to Stranger

Infant	*r*	*p*
(A) Infant Gaze at Partner		
Mean[a]	**.274**	**.002**[†]
SD	.125	.171
(B) Infant Gaze at Object		
Mean	.128	.159
SD	.096	.294
(C) Infant Facial Affect		
Mean	.113	.216
SD	-.093	.310
% High Positive	-.008	.935
% Low Positive	.166	.068
% Neutral/Interest	**.252**	**.005**[†]
% Low Negative	**.441**	**<.001**[d]
% High Negative	.083	.364
% Pos (High + Low)	.157	.084
% Neg (High + Low)	**.244**	**.007**[d]
(D) Infant Vocal Affect		
Mean	**.392**	**<.001**[†d]
SD	.120	.212
% High Positive	-.044	.646
% Neutral/Positive	.082	.393
% None	**.266**	**.005**[†]
% Fuss/Whimper	**.204**	**.033**
% Angry/Protest	-.030	.755
% Cry	**.568**	**<.001**[d]
% Pos (Hi Pos, Neut/Pos)	.076	.431
% Neg (Fuss, Protest, Cry)	**.322**	**.001**
(E) Infant Engagement (rev 9)		
Mean[b]	**.272**	**.004**
SD	-.109	.258
% Positive On	**.256**	**.007**
% Negative On	.034	.727
% Look Angled Escape	.080	.404
% Positive Off	.098	.311
% Neutral Off	.092	.341
% Non-distressed Gaze at Object	.182	.057
% Negative Off (En Face/Avert)	.157	.100
% Discrepant Affect	**.224**	**.018**
% Distress	**.536**	**<.001**[d]

(F) Infant Head Orientation		
Mean	**.260**	**.004**[†]
SD	**.341**	**<.001**[†]
% En Face	**.652**	**<.001**[†]
% Head Down	**.242**	**.007**
% 30-60 Avert	**.216**	**.017**
% 30-60 Avert + Head Down	**.191**	**.035**
% 60-90	.042	.647
% Arch	**.262**	**.003**
(G) Infant Touch		
Mean[c]	**.201**	**.028**
SD	.167	.068
% 2+	.093	.310
% Any One Code	.140	.126
% Object	.067	.466
% Partner	-.076	.407
% Self (Skin)	.062	.500
% No Touch	**.194**	**.034**

Note. *r* = Pearson product moment correlation. All behavioral scales are analyzed with N=122 dyads, with the exception of Infant Vocal Affect (N=110), Infant Engagement (N=110), and Infant Touch (N=120).
[a]Gaze mean (partner, object) = % gaze on.
[b]Engagement mean, SD are based on the original scale of 18 levels; the Engagement Codes are taken from the 9-Level Engagement Scale (see Appendix B).
[c]Touch mean, SD are based on the 3-level ordinalized touch scale (0, 1, 2+).
[d]This finding occurred only in the depressed subgroup: see Table 5.
[†] "dominant" code (60% + time in that scale) or measure of central tendency.

Table 4
Associations of Maternal Depression with Mean and SD of Infant Behavioral Qualities

(A) Infant Means & SDs with Mother

	CESD					
Infant	0-15	16+	Mean Diff	t	df	*p*
Gaze at Partner Mean	24.55	32.62	-.08	-2.22	120.0	**.029**
SD	36.96	42.49	-.06	-2.28	65.8	**.026**
Gaze at Object Mean	21.31	12.19	.09	2.71	85.7	**.008**
SD	29.96	25.08	.05	1.35	120.0	.181
Facial Affect Mean	56.20	57.05	-.85	-.76	120.0	.451
SD	7.51	9.08	1.57	-1.77	120.0	.079
Vocal Affect Mean	3.97	3.92	.05	.61	34.6	.543
SD	.40	.50	-.10	-1.78	111.0	.078
Engagement Mean	9.35	10.00	-.66	-1.35	111.0	.179
SD	3.61	3.83	-.22	-1.19	111.0	.236
Head Orientation Mean	5.10	5.43	-.32	-2.44	75.2	**.017**
SD	1.02	.92	.10	1.11	120.0	.268
Touch Mean	.71	.71	.00	-.07	118.0	.942
SD	.46	.47	-.01	-.40	118.0	.689

(B) Infant Means & SDs with Stranger

	CESD					
Infant	0-15	16+	Mean Diff	t	df	*p*
Gaze at Partner Mean	40.43	43.98	-.04	-.99	120.0	.326
SD	45.31	47.03	-.02	-1.52	78.9	.132
Gaze at Object Mean	6.75	2.17	.05	2.99	117.2	**.003**
SD	13.48	7.37	.06	2.18	82.0	**.032**
Facial Affect Mean	55.55	53.13	2.41	1.31	38.5	.198
SD	8.47	8.90	-.43	-.42	120.0	.675
Vocal Affect Mean	3.96	3.80	.16	1.49	38.9	.144
SD	.52	.56	-.05	-.55	112.0	.578
Engagement Mean	10.72	10.32	.41	.59	44.1	.556
SD	3.64	3.63	.01	.06	112.0	.956
Head Orientation Mean	5.17	5.33	-.16	-1.13	120.0	.263
SD	.95	.95	.01	.06	120.0	.956
Touch Mean	.64	.78	-.14	-1.80	120.0	.074
SD	.39	.44	.05	-1.13	120.0	.259

Note. Depression Mean Diff = Depressed Mothers (6-week CES-D 16+) – Non-Depressed Mothers (6-week CES-D 0-15).

Table 5
Effects of Maternal Depression on Infant Generalization

(5A) *Low Negative Facial Affect*

Model	*B*	*SE B*	β	*df*	*t*	*p*
Intercept	1.399	.798		121	1.754	.082
I (M)	.010	.074	.011	121	.129	.898
cesd6w	-2.900	1.540	-.144	121	-1.883	.062
I (M) • cesd6wdx	.903	.117	.735	121	7.700	.000

Note. Dependent Variable: Infant Facial Affect with Stranger: % Low Negative. The *B* for the intercept represents infant mean % low negative mean facial affect with stranger for infants of nondepressed mothers who showed no low negative facial affect with mother; the *B* for I (M) represents the strength of infant generalization from mother to stranger in infants of nondepressed mothers; the *B* for cesd6w represents the difference in % low negative facial affect with stranger, comparing infants whose mothers were depressed vs. nondepressed; and the *B* for I (M)→I (S) • cesd6wdx represents the effects of depression on infant generalization of low negative facial affect from mother to stranger. I (S) = β I (M) + β CES-D + β I (M) x CES-D. Cesd6w (0 = CES-D 0-15; 1 = CES-D 16+).

(5B) *% Negative Facial Affect (Low + High)*

Model	*B*	*SE B*	β	*df*	*t*	*p*
Intercept	6.905	1.982		121	3.485	.001
I (M)	.077	.124	.064	121	.622	.535
cesd6w	3.156	3.896	.078	121	.810	.420
I (M) • cesd6wdx	.625	.217	.330	121	2.888	.005

Note. Dependent Variable: Infant Facial Affect with Stranger: % Negative (Low + High).

(5C) *% Vocal Mean*

Model	*B*	*SE B*	β	*df*	*t*	*p*
Intercept	3.216	.754		109	4.268	.000
I (M)	.188	.189	.131	109	.991	.324
cesd6w	-2.595	.988	-2.709	109	-2.626	.010
I (M) • cesd6wdx	.619	.249	2.554	109	2.484	.015

Note. Dependent Variable: Infant Vocal Affect with Stranger: Mean.

(5D) *% Vocal Cry*

Model	*B*	*SE B*	β	*df*	*t*	*p*
Intercept	2.771	1.103		109	2.512	.014
I (M)	.209	.385	.089	109	.543	.588
cesd6w	.258	2.125	.010	109	.121	.904
I (M) • cesd6wdx	1.414	.437	.541	109	3.239	.002

Note. Dependent Variable: Infant Vocal Affect with Stranger: Cry.

(5E) *% Engagement Distress*

Model	*B*	*SE B*	β	*df*	*t*	*p*
Intercept	3.098	1.203		109	2.576	.011
I (M)	.220	.338	.095	109	.652	.516
cesd6w	-.036	2.311	-.001	109	-.016	.988
I (M) • cesd6wdx	1.393	.400	.523	109	3.478	.001

Note. Dependent Variable: Infant Engagement with Stranger: Distress. Engagement distress is taken from the 9-Level Engagement Scale (See Appendix B).

All analyses are at the dyad level. All behavioral scales are analyzed with N=122 dyads, with the exception of Infant Vocal Affect (N=110), Infant Engagement (N=110), and Infant Touch (N=120).

Table 6
Summary of Infant Differences and Generalization of Behavioral Qualities with Mother and Stranger

	Difference M vs. S	Generalization	Depression x Generalization
(A) Infant Gaze at Partner			
Mean	S	✓	
SD	S		
(B) Infant Gaze at Object			
Mean[a]	M		
SD	M		
(C) Infant Facial Affect			
Mean	M		
SD			
% High Positive	M		
% Low Positive	S		
% Neutral/Interest	M	✓	
% Low Negative	M	✓	✓
% High Negative	S		
% Pos. (High +Low)			
% Neg. (High + Low)		✓	✓
(D) Infant Vocal Affect			
Mean		✓	✓
SD	S		
% High Positive			
% Neutral/Positive			
% No Vocalization		✓	
% Fuss/Whimper		✓	
% Angry Protest			
% Cry	S	✓	✓
% Pos (Hi Pos + Neut/Pos)			
% Neg (Fuss, Protest, Cry)		✓	
(E) Infant Engagement[b]			
Mean	S	✓	
SD			
% Positive On	S	✓	
% Negative On	M		
% Look-Angled Escape	S		
% Positive Off	S		
% Neutral Off			
% Non-distress Look at Obj	M		
% Neg Off (En Face/Avert)	M		
% Discrepant Affect		✓	
% Distress	S	✓	✓

	Difference M vs. S	Generalization	Depression x Generalization
(F) Infant Head Orientation			
Mean		✓	
SD		✓	
% En Face		✓	
% Head Down	S	✓	
% 30-60 Avert		✓	
% 30-60 Avert + Hd Down		✓	
% 61-90 Avert			
% Arch	M	✓	
(G) Infant Touch			
Mean		✓	
SD	M		
% 2+ Codes			
% Any One Code	M		
% Object	S		
% Partner	M		
% Self (Skin)	S		
% No Touch		✓	

Note. Depression x Generalization = conditional effects of depression (6-week CES-D 16+) on generalization. Dness x Generalization = conditional effects of degree of attachment disorganization on generalization. All behavioral scales are analyzed with N=122 dyads, with the exception of Infant Vocal Affect (N=110), Infant Engagement (N=110), and Infant Touch (N=120). Entries of S (or M) indicate significant differences in which the behavioral quality is higher with S (or M) (see Table 2). Entries of ✓ indicate the presence of significant generalization (see Table 4), or significant effects of depression on generalization (see Table 5) (see text).

[a]Mean Gaze at Object indicates percent time gazing at object.

[b]Engagement mean and standard deviation are based on the original scale of 18 levels; the Engagement Codes are taken from the 9-Level Engagement Scale (see Appendix B).

Table 7

An Integration of Infant Differences and Generalization of Behavioral Qualities with Mother and Stranger

<table>
<tr><td></td><td></td><td colspan="3">Generalization</td></tr>
<tr><td rowspan="4">Differences</td><td rowspan="2"></td><td>Yes</td><td colspan="2">No</td></tr>
<tr><td>1) Internal Working Models With Adaptation To Novelty (N=6)</td><td colspan="2">2)“Pure” Adaptation to Novelty without Generalization (N=18)</td></tr>
<tr><td rowspan="2">Yes</td><td></td><td>S↑ (N=8)</td><td>S↓ (N=10)</td></tr>
<tr><td>Gaze $\bar{x}$
Face % Neutral/Positive
Engagement $\bar{x}$
% Positive On
Head Orien. % Head Down
% Arch</td><td>Gaze Partner SD
Face % Low Positive
% High Negative
Vocal SD
Engagement % Angled Escape
% Positive Off
Touch % Object
% Self</td><td>Gaze Object $\bar{x}$
SD
Face $\bar{x}$
% High Positive
Engagement % Neg On
% Non-distr Gz Obj
% Negative Off
Touch SD
% Any one code
% Partner</td></tr>
<tr><td rowspan="2">No</td><td>3) “Pure” Internal Working Model without Adaptation to Novelty (N=11)</td><td colspan="2">4) No Adaptation to Novelty and No Internal Working Model (N=10)</td></tr>
<tr><td>Vocal Affect % None
% Fuss/Whimper
% Neg(Fuss, Protest, Cry)
Engagement % Discrepant Affect
Head Orien. $\bar{x}$ % En face
SD % 30-60 Avert
% 30-60 Avert + Hd Dn
Touch $\bar{x}$ % No Touch</td><td>Facial Affect SD
% High & Low Positive
Vocal Affect % High Positive
% Neutral/Positive
% Angry Protest
% Positive (High, Neutral/Positive)
Engagement SD
% Neutral Off
Head Orien. % 60-90 Avert
Touch % 2+ Codes</td></tr>
</table>

Note. S↑ = code more frequent with Stranger than Mother; S↓ = code less frequent with stranger than Mother. Any findings of generalization associated with maternal depression are not included in the current table.

Table 8
Associations of Degree of Attachment Disorganization with Mean and SD of Infant Behavioral Qualities

	With Mother			With Stranger		
Infant	N	*r*	*p*	N	*r*	*p*
Gaze at Partner Mean	81	.17	.137	81	.00	.990
SD	81	.11	.310	81	.02	.847
Gaze at Object Mean	81	-.20	.076	81	-.76	.148
SD	81	-.27	**.014**	81	-.04	.729
Facial Affect Mean	81	.01	.958	81	.11	.347
SD	81	.31	**.005**	81	.02	.854
Vocal Affect Mean	76	-.32	**.004**	74	.08	.501
SD	76	.29	**.010**	74	.01	.921
Engagement Mean	76	.03	.791	74	.05	.657
SD	76	.13	.261	74	.00	.976
Head Orient Mean	81	.09	.409	81	-.07	.564
SD	81	.01	.907	81	.04	.751
Touch Mean	80	-.28	**.012**	81	-.18	.100
SD	80	.11	.328	81	-.04	.711

Note. *r* = Pearson product moment correlation. Of the 84 dyads with attachment classifications at 12 months, 81 had complete data sets of M–I and S–I interactions. N < 81 for vocal affect, engagement, and touch was due to missing data. Engagement mean and SD are calculated from the 18-level code (see Appendix B).

Table 9
Main Effects of Mother-Infant and Stranger-Infant Self- and Interactive Contingencies

	β	*SE*	*Df*	*t*	*r*	*P*
Intercept	2.611	0.087	120	29.85		<.001
M vs. S	0.817	0.113	33966	7.23		<.001
Lag MGz→MGz	0.533	0.017	33966	30.54	0.163	**<.001**
Lag SGz→SGz	0.528	0.029	33966	18.36	0.099	**<.001**
Lag IGz→MGz	0.239	0.037	33966	6.53	0.035	**<.001**
Lag IGz→SGz	0.258	0.044	33966	5.94	0.032	**<.001**

(A) *Predicting Adult Gaze (Adult Gaze – Infant Gaze)*
Number of sec of data in model = 34,214; number of adults = 122.

(B) *Predicting Infant Gaze (Adult Gaze – Infant Gaze)*

	β	*SE*	*df*	*t*	*r*	*P*
Intercept	-1.608	0.059	120	-27.43		<.001
M vs. S	0.424	0.059	34014	7.15		<.001
Lag IGz→IGz (M)	1.588	0.025	34014	62.51	0.321	**<.001**
Lag IGz→IGz (S)	1.569	0.022	34014	69.85	0.354	**<.001**
Lag MGz→IGz	0.116	0.025	34014	4.70	0.025	**<.001**
Lag SGz→IGz	0.077	0.033	34014	2.29	0.012	**.022**

Number of sec of data in model = 34,262; number of infants = 122.

(C) *Predicting Adult Facial Affect (Adult Facial Affect – Infant Facial Affect)*

	β	*SE*	*df*	*t*	*r*	*P*
Intercept	-0.003	0.016	121	-0.20		.843
M vs. S	0.088	0.020	33000	4.46		<.001
Lag MFc→MFc	0.532	0.007	33000	76.46	0.388	**<.001**
Lag SFc→SFc	0.644	0.006	33000	108.66	0.513	**<.001**
Lag IFc→ MFc	0.150	0.007	33000	20.06	0.110	**<.001**
Lag IFc→ SFc	0.116	0.006	33000	18.28	0.100	**<.001**

Number of sec of data in model = 33,569; number of adults = 122.

(D) *Predicting Infant Facial Affect (Adult Facial Affect – Infant Facial Affect)*

	β	*SE*	*df*	*t*	*R*	*P*
Intercept	0.056	0.013	121	4.35		<.001
M vs. S	-0.041	0.016	33000	-2.59		.010
Lag IFc→IFc (M)	0.659	0.006	33000	112.39	0.526	**<.001**
Lag IFc→IFc (S)	0.800	0.005	33000	154.96	0.649	**<.001**
Lag MFc→ IFc	0.043	0.006	33000	7.25	0.023	**<.001**
Lag SFc→ IFc	0.031	0.005	33000	6.34	0.033	**<.001**

Number of sec of data in model = 33,675; number of infants = 122.

(E) *Predicting Adult Facial Affect (Adult Facial Affect – Infant Vocal Affect)*

	β	*SE*	*df*	*t*	*R*	*P*
Intercept	0.004	0.015	116	0.29		.775
M vs.S	0.072	0.018	32000	3.96		<.001
Lag MFc→MFc	0.594	0.007	32000	89.80	0.449	**<.001**
Lag SFc→SFc	0.671	0.006	32000	115.28	0.542	**<.001**
Lag IVc→MFc	0.081	0.008	32000	10.38	0.058	**<.001**
Lag IVc→SFc	0.092	0.006	32000	16.04	0.089	**<.001**

Number of sec of data in model = 32,096; number of adults = 117; 5 dyads no infant audio channel.

(F) *Predicting Infant Vocal Affect (Adult Facial Affect – Infant Vocal Affect)*

	β	*SE*	*df*	*t*	*R*	*P*
Intercept	0.039	0.013	116	3.00		.003
M vs. S	-0.022	0.013	32000	-1.63		.104
Lag IVc→IVc (M)	0.665	0.007	32000	98.18	0.481	**<.001**
Lag IVc→IVc (S)	0.761	0.005	32000	149.39	0.641	**<.001**
Lag MFc→IVc	0.025	0.006	32000	4.07	0.023	**<.001**
Lag SFc→IVc	0.031	0.005	32000	5.83	0.033	**<.001**

Number of sec of data in model = 32,213; number of infants = 117; 5 infants no audio channel.

Note. Entries are standardized betas from 3-level multi-level time series models. These models are conducted at the second-by-second level. All parameter entries are maximum likelihood estimates fitted using PROC GLIMMIX(gaze) or SAS PROC MIXED (all other modalities). Intercept: estimated *β* represents the average value of the dependent variable. "M vs. S" indicates the difference in dependent variable with Stranger relative to with Mother (M=0, S=1). Adult models predict adult behavior from prior adult and prior infant behavior; infant models predict infant behavior from prior infant and prior adult behavior. For example in model (A), "Lag MGz→MGz" (mother self-contingency): estimated *β* represents the prediction of current maternal gaze from the weighted lag of maternal gaze. "Lag SGz→SGz" (stranger self-contingency): estimated *β* represents the prediction of current stranger gaze from the weighted lag of stranger gaze. "Lag IGz→MGz" (mother interactive-contingency): estimated *β* represents the prediction of current mother gaze from the weighted lag of infant gaze. "Lag IGz→SGz" (stranger interactive-contingency): estimated *β* represents the prediction of current stranger gaze from the weighted lag of infant gaze. r = correlation (effect size) calculated as the square root of $t/(t^2+df)$. Significant lagged main effects are bolded.

Table 10
Differences in Mother-Infant vs. Stranger-Infant Self- and Interactive Contingencies

	β	*SE*	*df*	*t*	*p*
Intercept	2.611	0.087	120	29.85	<.001
M vs. S	0.817	0.113	33966	7.23	<.001
Lag AGz→AGz	0.533	0.017	33966	30.54	<.001
Lag IGz →AGz	0.239	0.037	33966	6.53	<.001
Lag AGz→AGz x M vs. S	-0.005	0.034	33966	-0.15	.879
Lag IGz→AGz x M vs. S	0.020	0.056	33966	0.35	.727

(A) *Predicting Adult Gaze (Adult Gaze – Infant Gaze)*

(B) *Predicting Infant Gaze (Adult Gaze – Infant Gaze)*

	β	*SE*	*df*	*t*	*p*
Intercept	-1.608	0.059	120	-27.43	<.001
M vs. S	0.424	0.059	34014	7.15	<.001
Lag IGz→IGz	1.588	0.025	34014	62.51	<.001
Lag AGz→IGz	0.116	0.025	34014	4.70	<.001
Lag IGz→IGz x M vs. S	-0.019	0.034	34014	-0.57	.571
Lag AGz→IGz x M vs. S	-0.040	0.042	34014	-0.95	.341

(C) *Predicting Adult Facial Affect (Adult Facial Affect – Infant Facial Affect)*

	β	*SE*	*df*	*t*	*p*
Intercept	-0.003	0.016	121	-0.20	.843
M vs. S	0.088	0.020	33000	4.46	<.001
Lag AFc→AFc	0.532	0.007	33000	76.46	<.001
Lag IFc→AFc	0.150	0.007	33000	20.06	<.001
Lag AFc→AFc x M vs. S	0.113	0.009	33000	12.36	**<.001**
Lag IFc→Afc x M vs. S	-0.034	0.010	33000	-3.44	**<.001**

(D) *Predicting Infant Facial Affect (Adult Facial Affect – Infant Facial Affect)*

	β	*SE*	*df*	*t*	*p*
Intercept	0.056	0.013	121	4.35	<.001
M vs. S	-0.041	0.016	33000	-2.59	.010
Lag IFc→IFc	0.659	0.006	33000	112.39	<.001
Lag AFc→IFc	0.043	0.006	33000	7.25	<.001
Lag IFc→IFc x M vs. S	0.141	0.008	33000	18.05	**<.001**
Lag AFc→IFc x M vs. S	-0.012	0.008	33000	-1.53	.126

(E) *Predicting Adult Facial Affect (Adult Facial Affect – Infant Vocal Affect)*

	β	*SE*	*df*	*t*	*p*
Intercept	0.004	0.015	116	0.29	.775
M vs. S	0.072	0.018	32000	3.96	<.001
Lag AFc→AFc	0.594	0.007	32000	89.80	<.001
Lag IVc→AFc	0.081	0.008	32000	10.38	<.001
Lag IFc→AFc x M vs. S	0.077	0.009	32000	8.76	**<.001**
Lag IVc→AFc x M vs. S	0.012	0.010	32000	1.19	.235

(F) *Predicting Infant Vocal Affect (Adult Facial Affect – Infant Vocal Affect)*

	β	*SE*	*df*	*t*	*p*
Intercept	0.039	0.013	116	3.00	.003
M vs. S	-0.022	0.013	32000	-1.63	.104
Lag IVc→IVc	0.665	0.007	32000	98.18	<.001
Lag AFc→IVc	0.025	0.006	32000	4.07	<.001
Lag IVc→IVc x M vs. S	0.096	0.008	32000	11.40	**<.001**
Lag AFc→IVc x M vs. S	0.006	0.008	32000	0.71	.480

Note. Entries are standardized betas from 3-level multi-level time series models. These models are conducted at the second-by-second level. All parameter entries are maximum likelihood estimates fitted using PROC GLIMMIX (gaze) or SAS PROC MIXED (all other modalities). Intercept: estimated *β* represents the average value of the dependent variable. "M vs. S" indicates the difference in dependent variable with Stranger relative to with Mother (M=0, S=1). Adult models predict adult behavior from prior adult and prior infant behavior; infant models predict infant behavior from prior infant and prior adult behavior. r = correlation (effect size) calculated as the square root of $t/(t^2+df)$. "Lag AGz→AGz" (adult self-contingency): estimated *β* represents the prediction of current adult gaze from the weighted lag of adult gaze. "Lag IGz→AGz" (adult interactive-contingency): estimated *β* represents the prediction of current adult gaze from the weighted lag of infant gaze. "Lag AGz→AGz x M vs S:" estimated β represents the conditional effect of MvS on adult self- contingency. "Lag IGz→AGz x M vs S:" estimated β represents the conditional effect of MvS on adult interactive contingency. Significant conditional effects of MvS on contingency estimates are bolded.

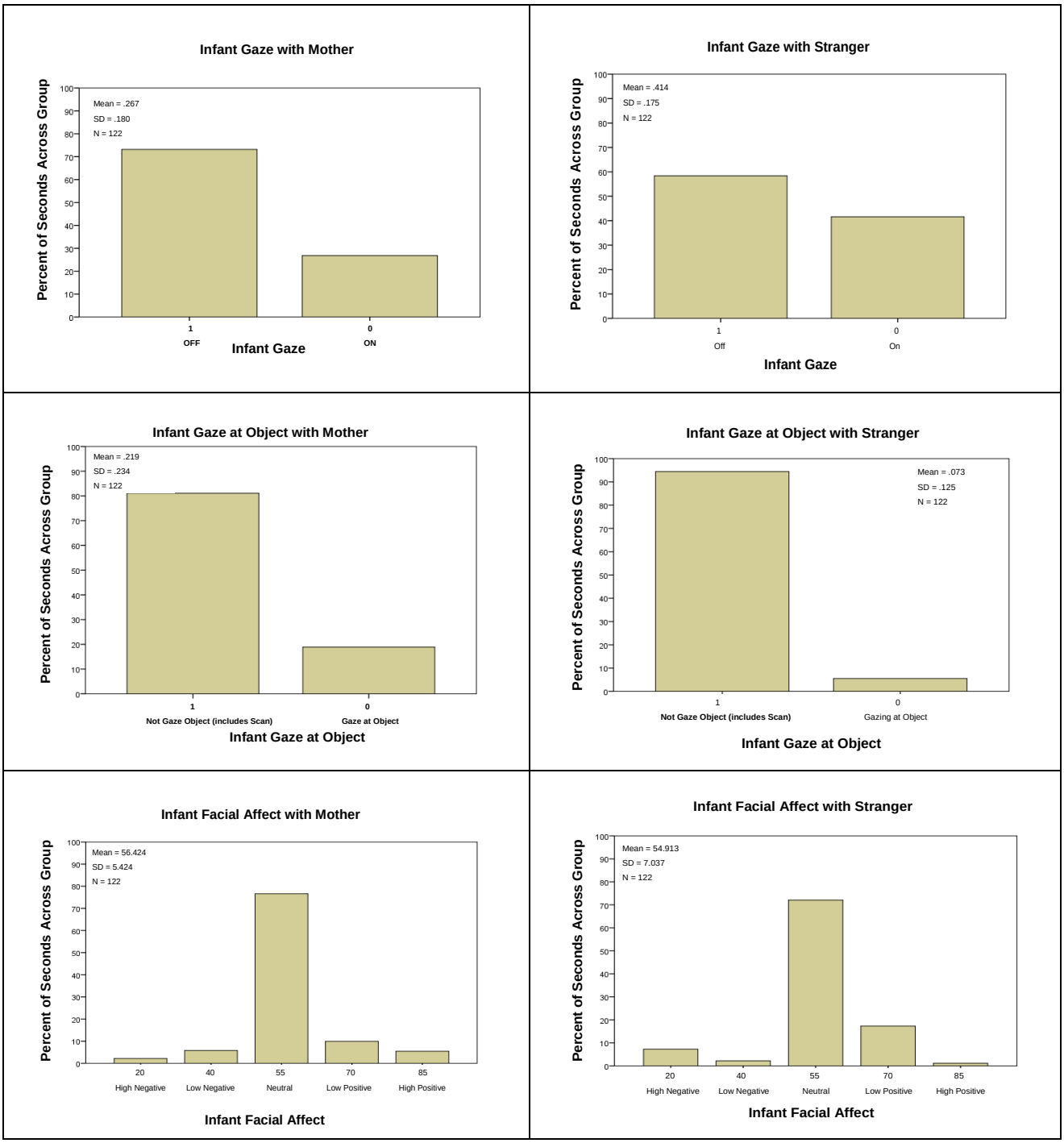


Figure 1. Distributions of Behavioral Scales of Infant with Mother/ Infant with Stranger

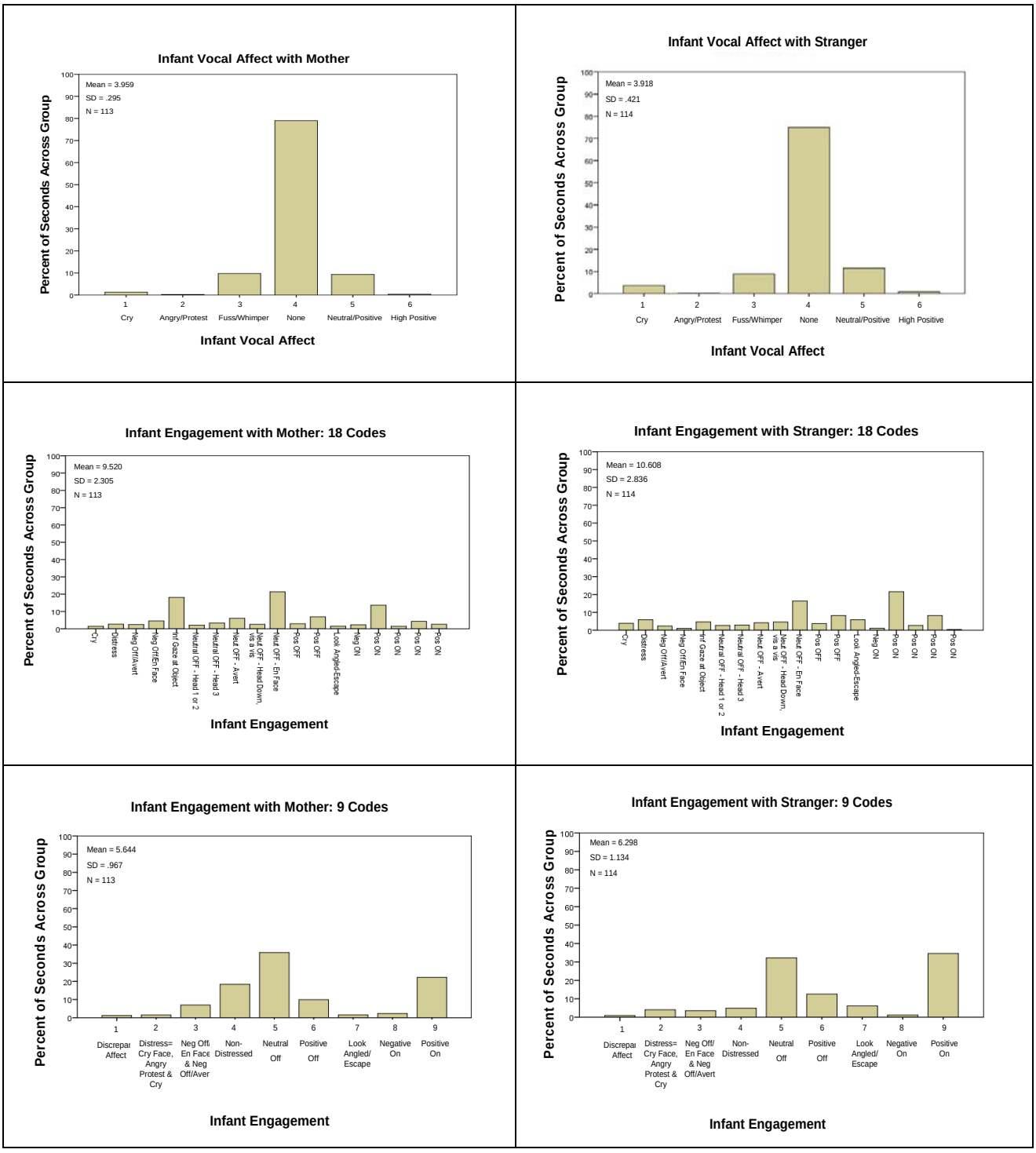


Figure 1. Continued

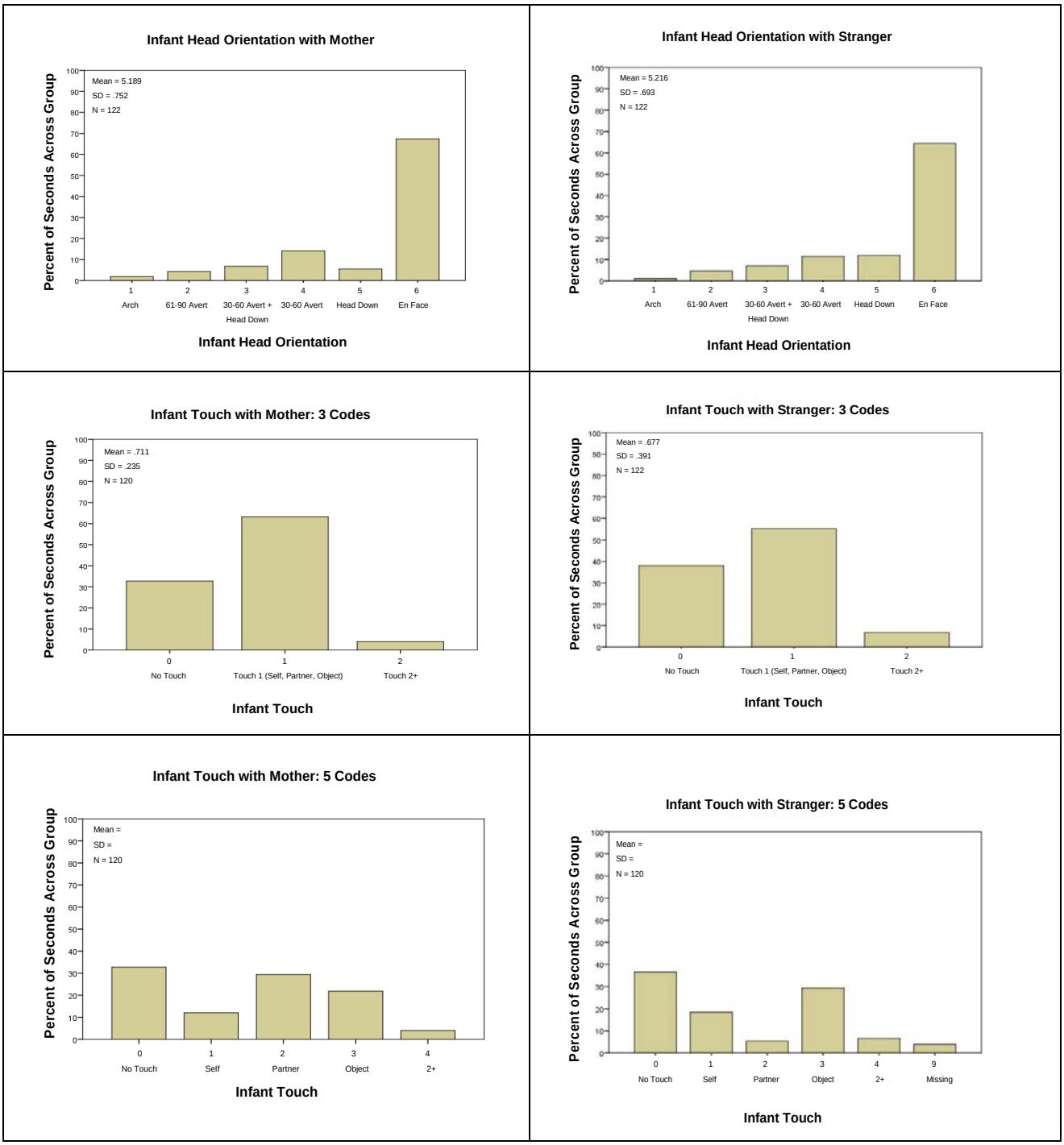


Figure 1. Continued

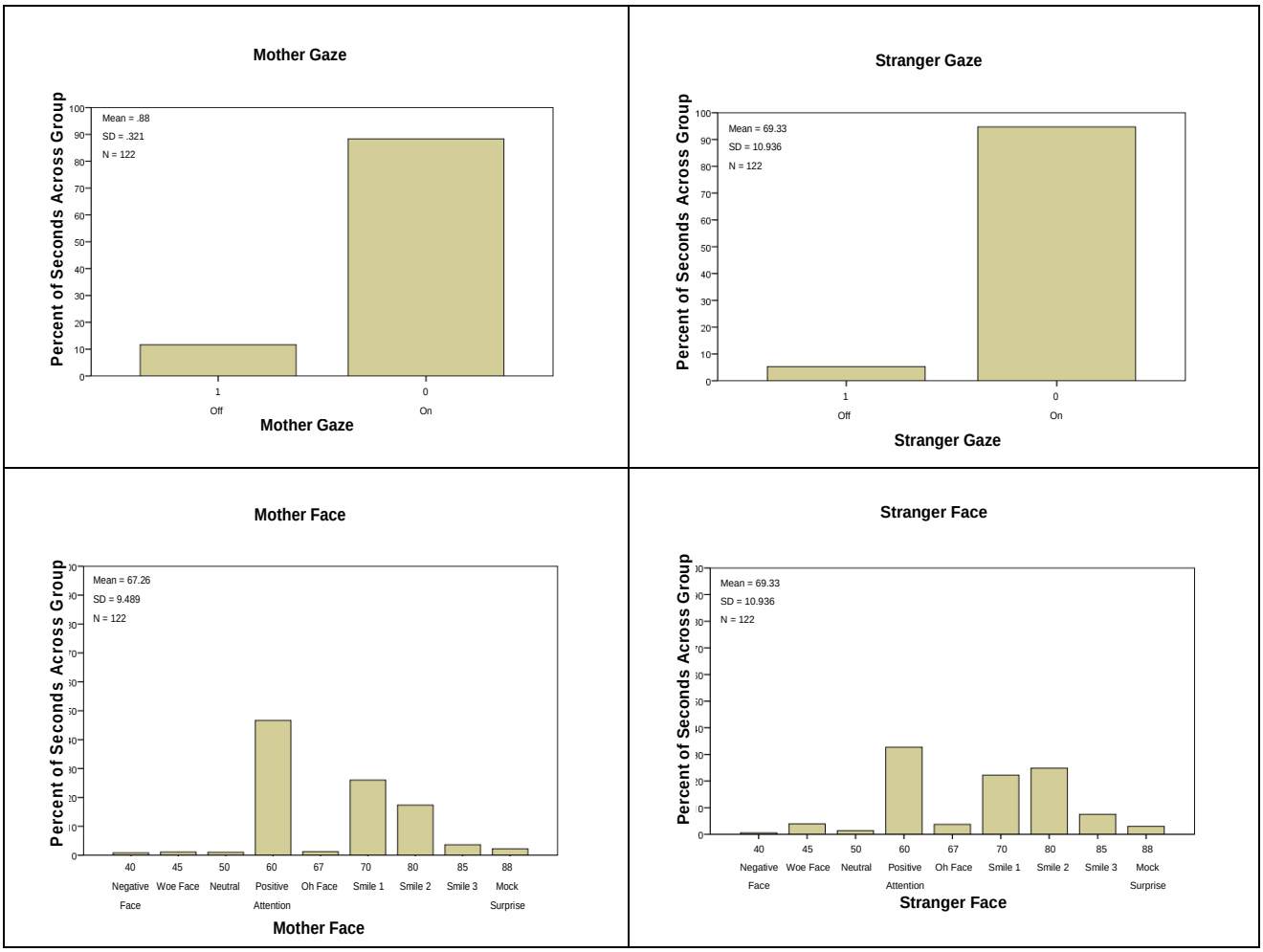


Figure 1. Continued

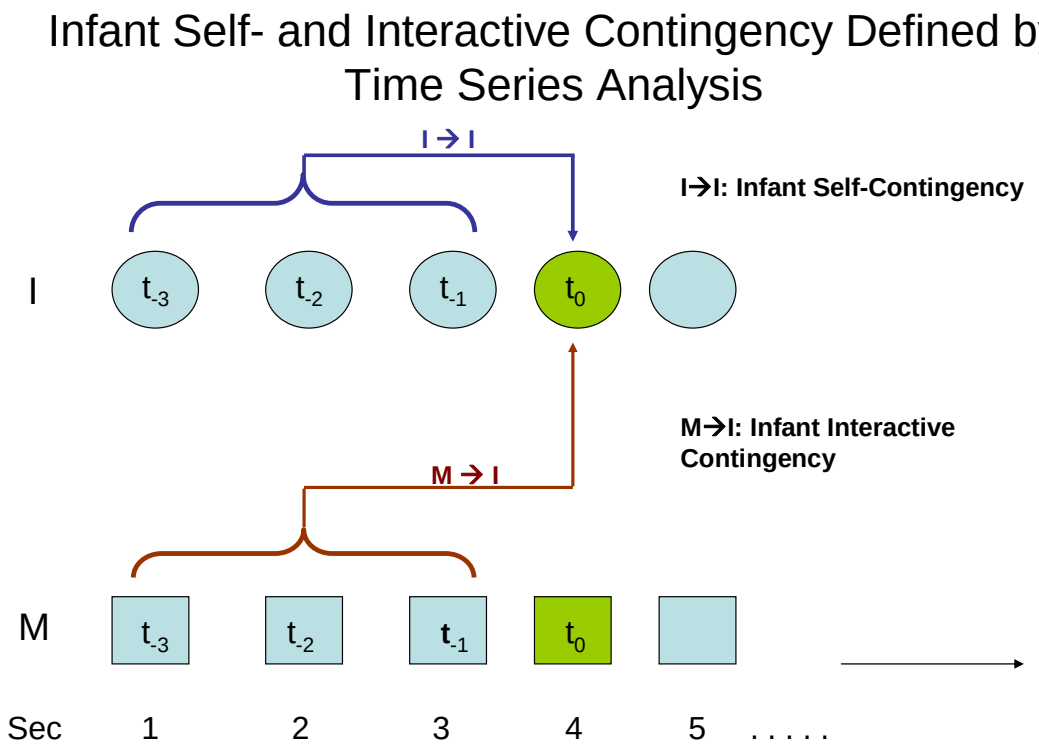


Figure 2. Illustrations of Infant Self- and Interactive Contingencies Defined by Time-Series Analysis.

Note. To calculate infant self-contingency, second 4 in the infant's stream of behavior identifies t_0, the predicted second. A weighted average of seconds t_{-1}, t_{-2}, and t_{-3} in the infant's behavioral stream identify the "weighted lag," which is used to predict t_0. To calculate infant interactive contingency, a weighted average of seconds t_{-1}, t_{-2}, and t_{-3} in the mother's behavioral stream is used to predict t_0 in the infant's behavioral stream. For both self- and interactive contingency, this is an iterative process in which second 5 will then identify the new t_0, and seconds 2, 3, and 4 will identify the new "weighted lag." A parallel diagram would depict mother self- and interactive contingency.

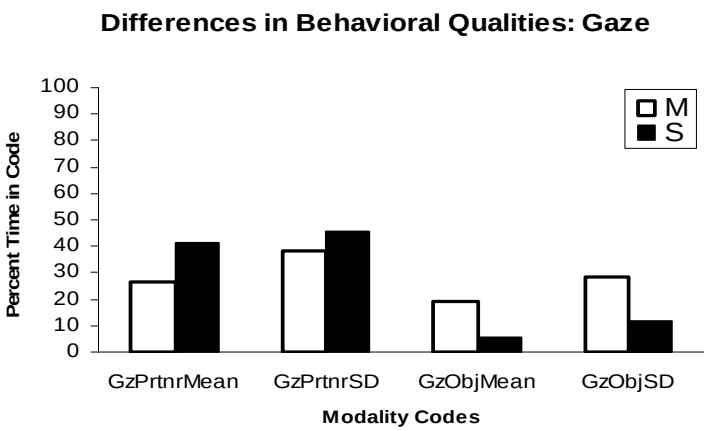


Figure 3A. Mean and standard deviations of percent time infants spent gazing at partner or at object, with mother versus with stranger.

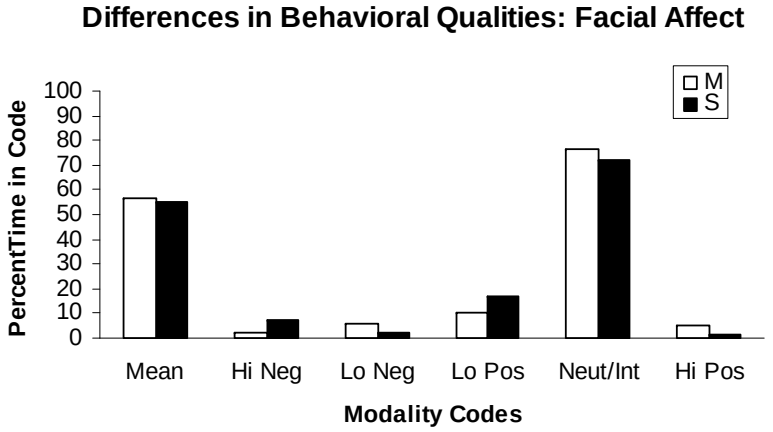


Figure 3B. Mean and standard deviations of percent time infants spent in different engagement codes, with mother versus with stranger.

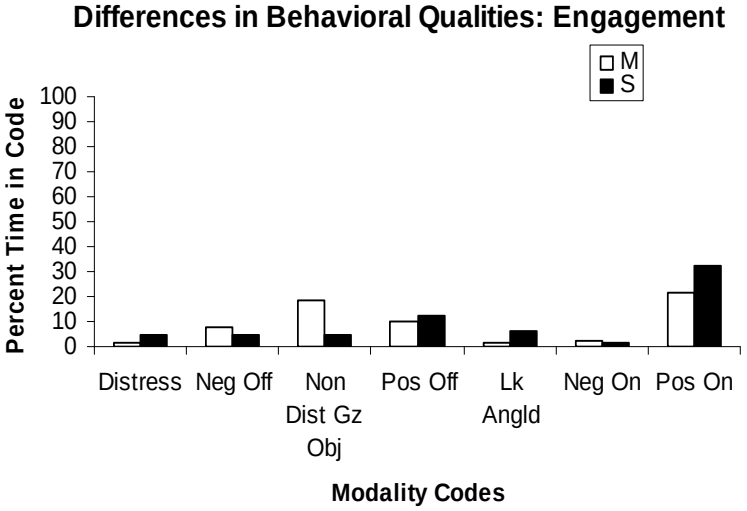


Figure 3C. Mean and standard deviations of percent time infants spent in different engagement codes, with mother versus with stranger.

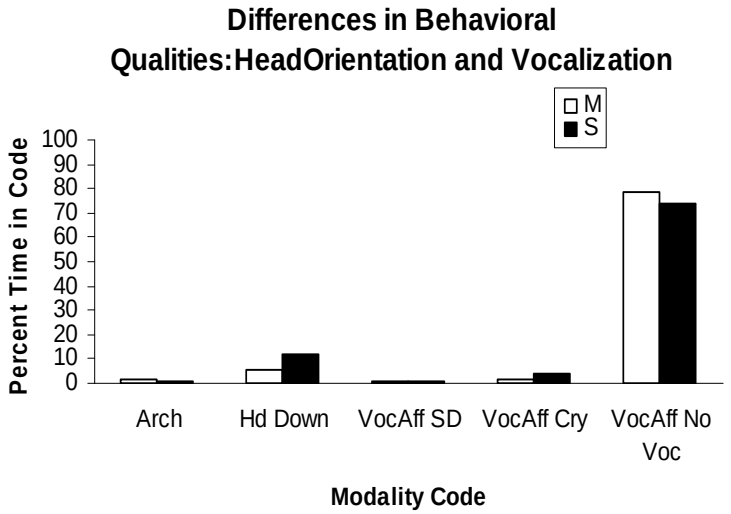


Figure 3D. Mean and standard deviations of percent time infants spent in different head orientation and vocal affect codes, with mother versus with stranger.

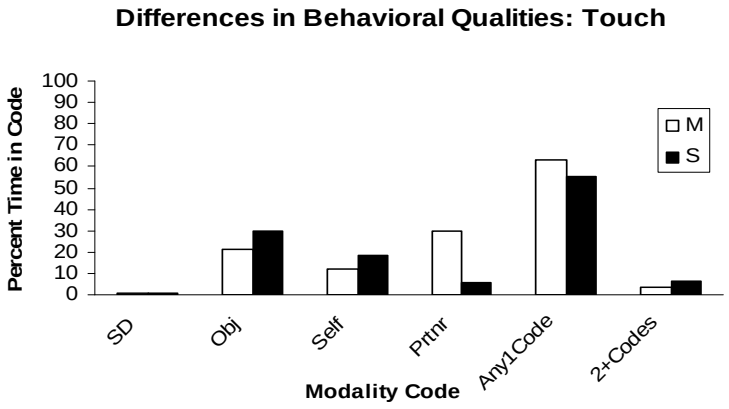
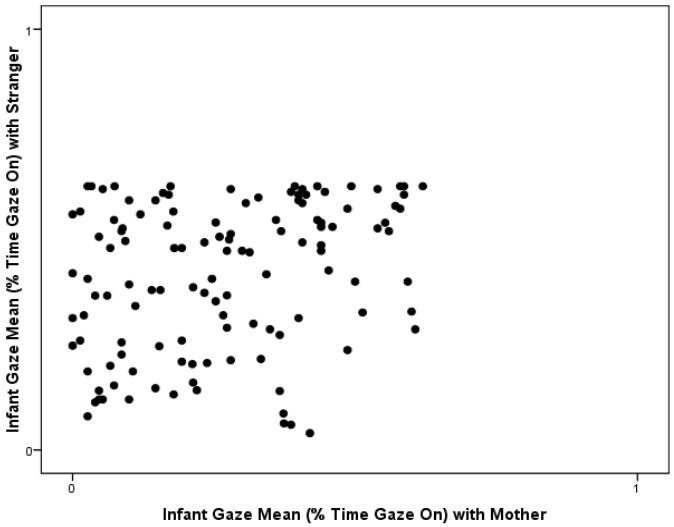
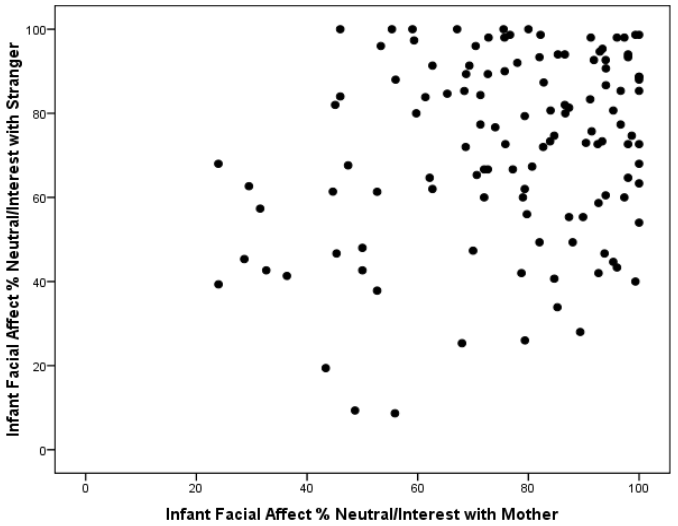


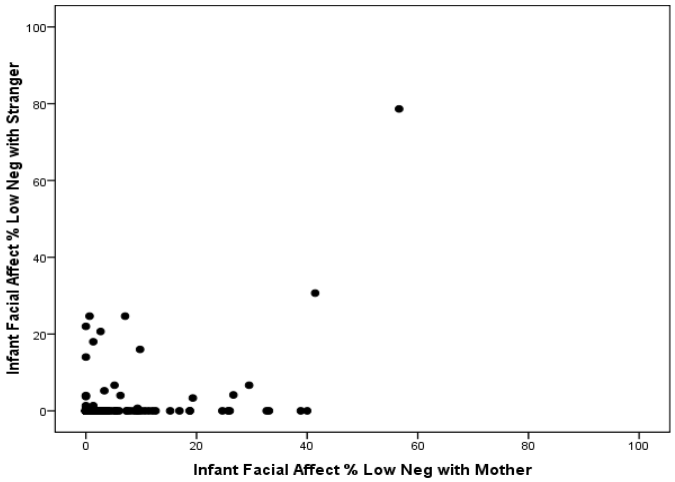
Figure 3E. Mean and standard deviations of percent time infants spent in different touch codes, with mother versus with stranger.



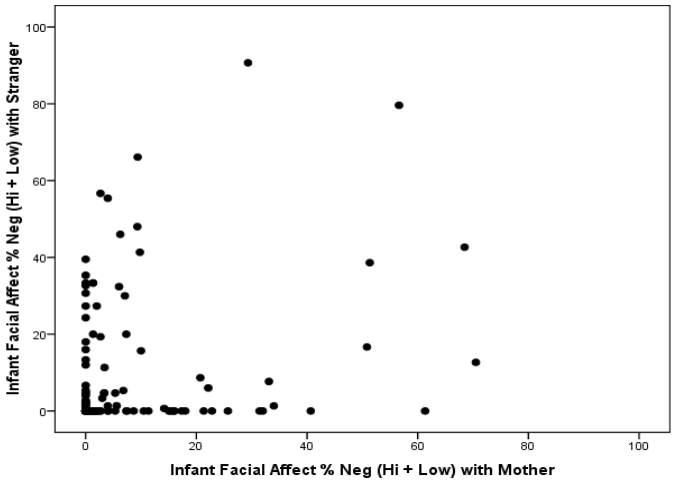
4A. Gaze: r= .274, p= .002



4B. Facial Affect - % Neutral/Interest: r= .252, p= .050

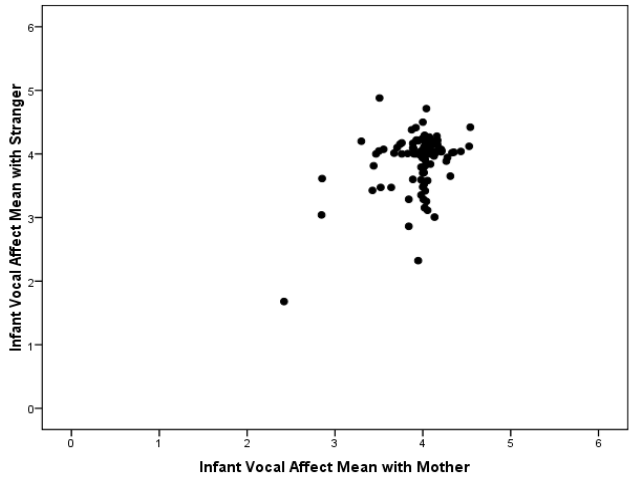


4C. Facial Affect - % Low Neg: r= .441, p= <.001

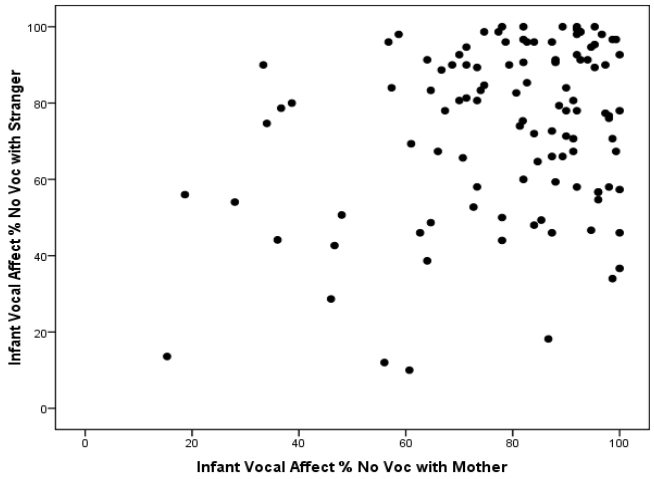


4D. Facial Affect % Neg (Hi + Low): r= .244, p= .007

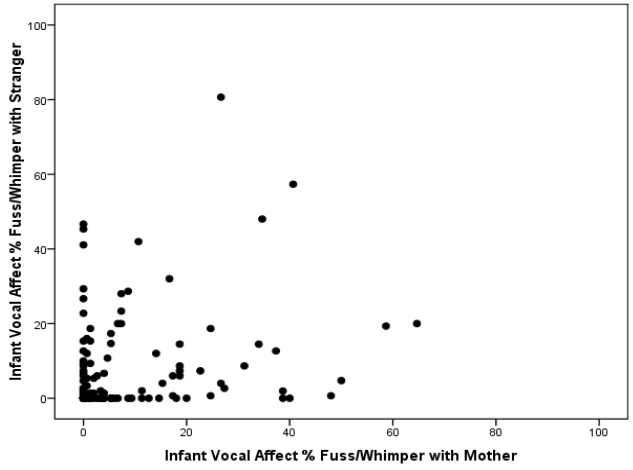
Figure 4. Scatterplots of Infant Generalization of Behavioral Qualities from Mother to Stranger



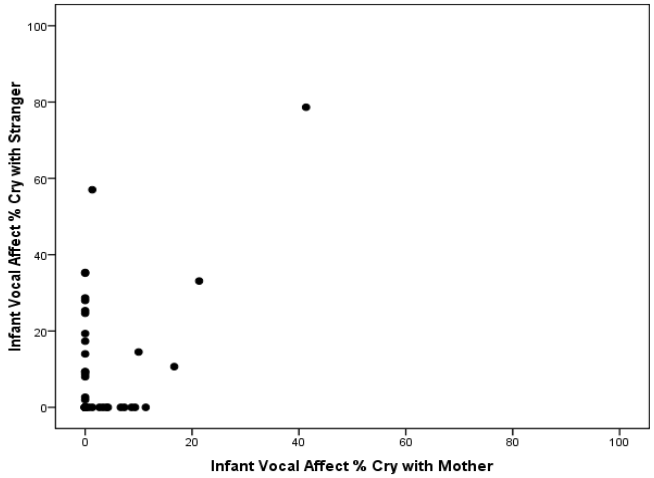
4E. Vocal Affect Mean: r= .392, p= <.001



4F. Vocal Affect - % No Voc: r= .266, p= .005

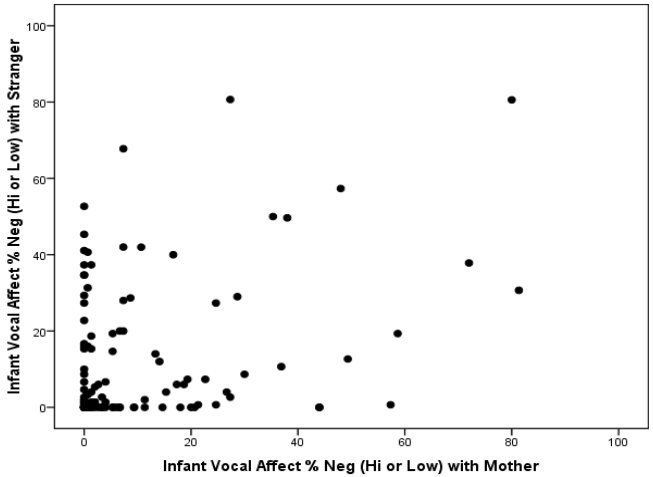


4G. Vocal Affect - % Fuss/Whimper: r= .204, p= .033

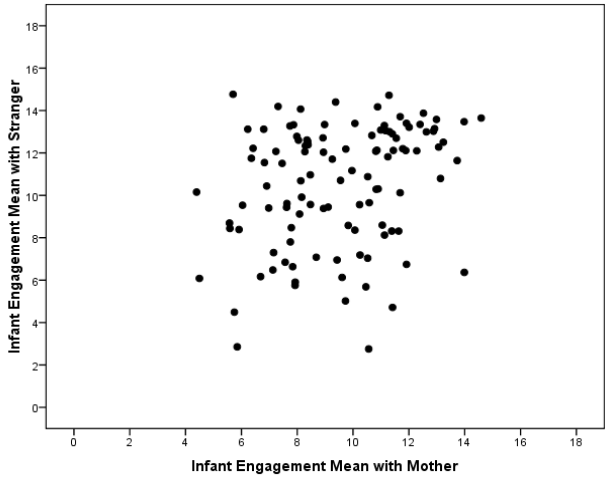


4H. Vocal Affect - % Cry: r= .568, p= .001

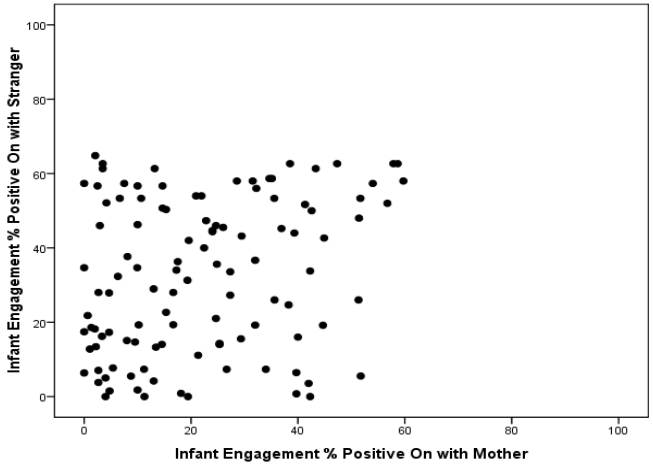
Figure 4. Continued



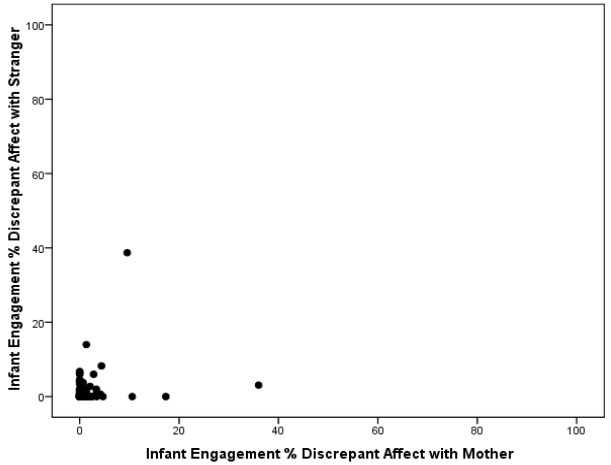
4I. Vocal Affect % Neg (Hi + Low): r= .322, p= .001



4J. Engagement Mean: r= .287, p= .002

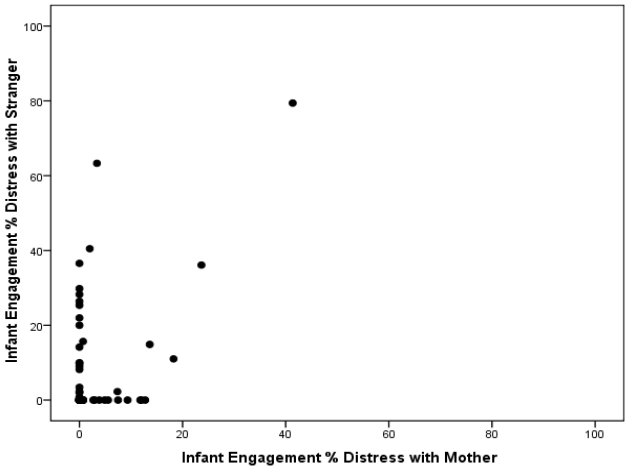


4K. Engagement % Positive On: r= .256, p= .007

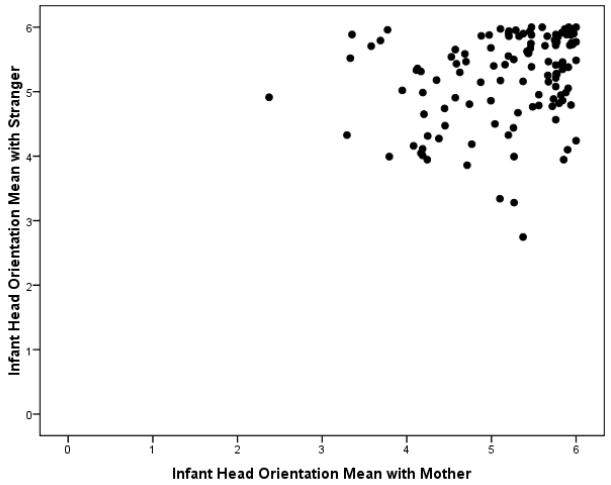


4L. Engagement % Discrepant Affect: r= .224, p= .018

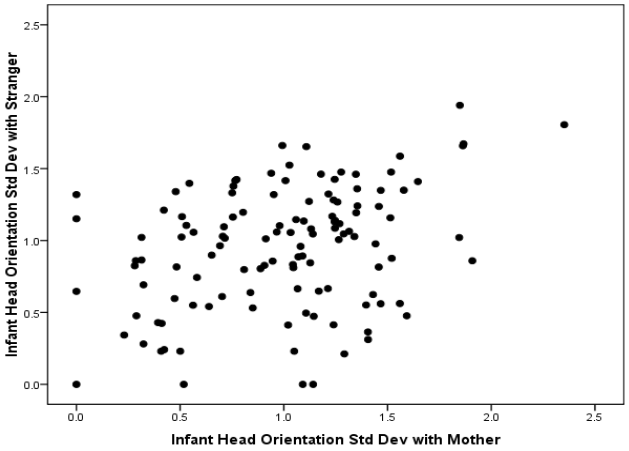
Figure 4. Continued



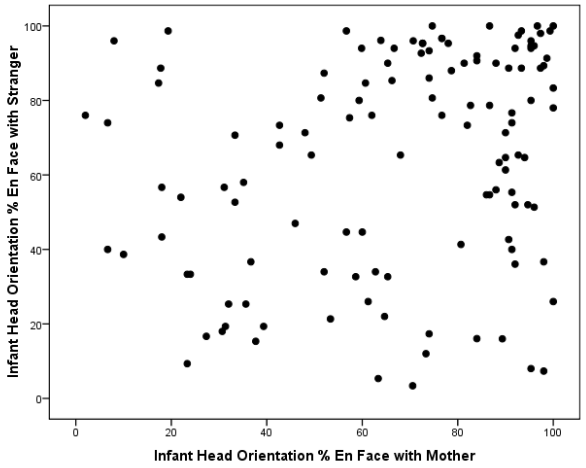
4M. Engagement - % Distress: r= .536, p= .001



4N. Head Orientation Mean: r= .260, p= .004

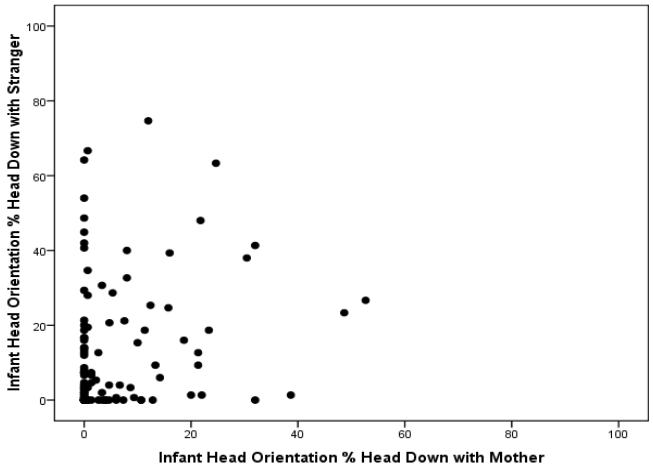


4O. Head Orientation SD: r= .341, p= .001

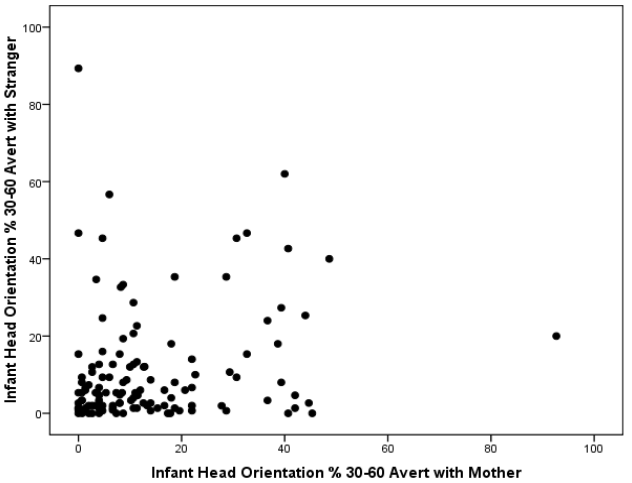


4P. Head Orientation – % En Face: r= .652, p= .001

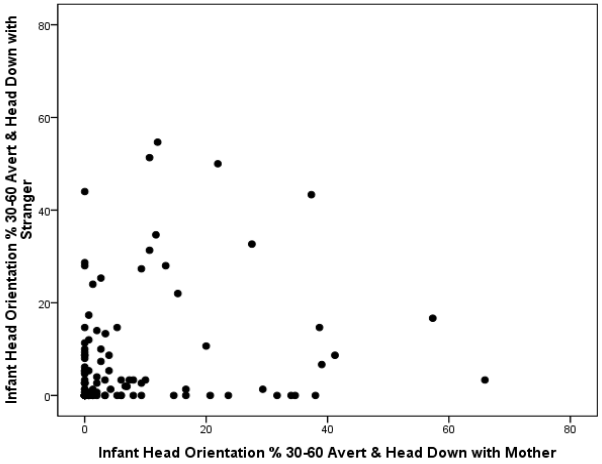
Figure 4. Continued



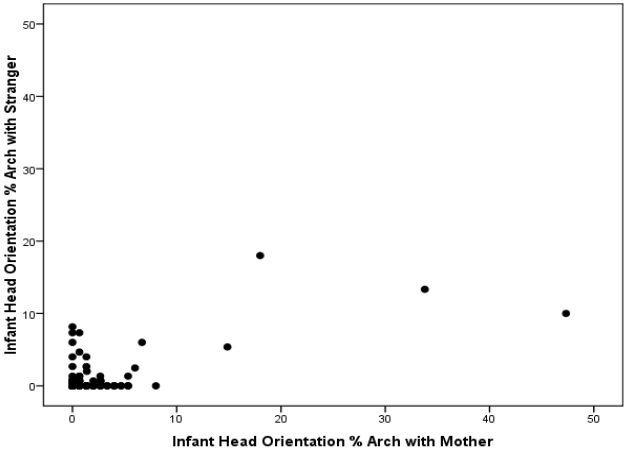
4Q. Head Orientation – Head Down: r=.242, p=. 007



4R. Head Orientation - % 30-60 Avert: r= .216, p= .017

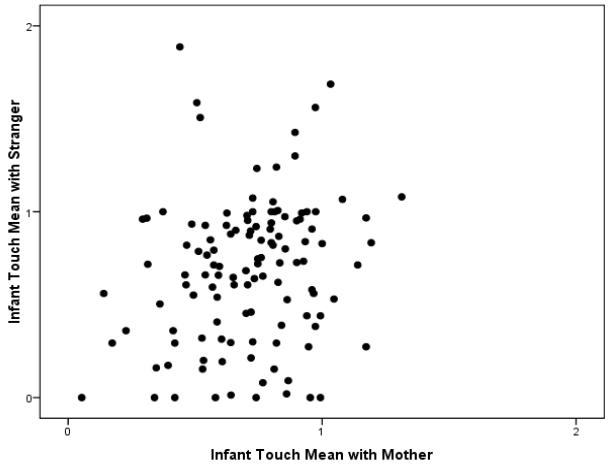


4S. Head Orientation - % 30-60 Avert & Hd Dn: r=.242, p=.007



4T. Head Orientation - % Arch: r= .262, p= .003

Figure 4. Continued



4U. Touch Mean: r=.201 p= .028
Figure 4. Continued

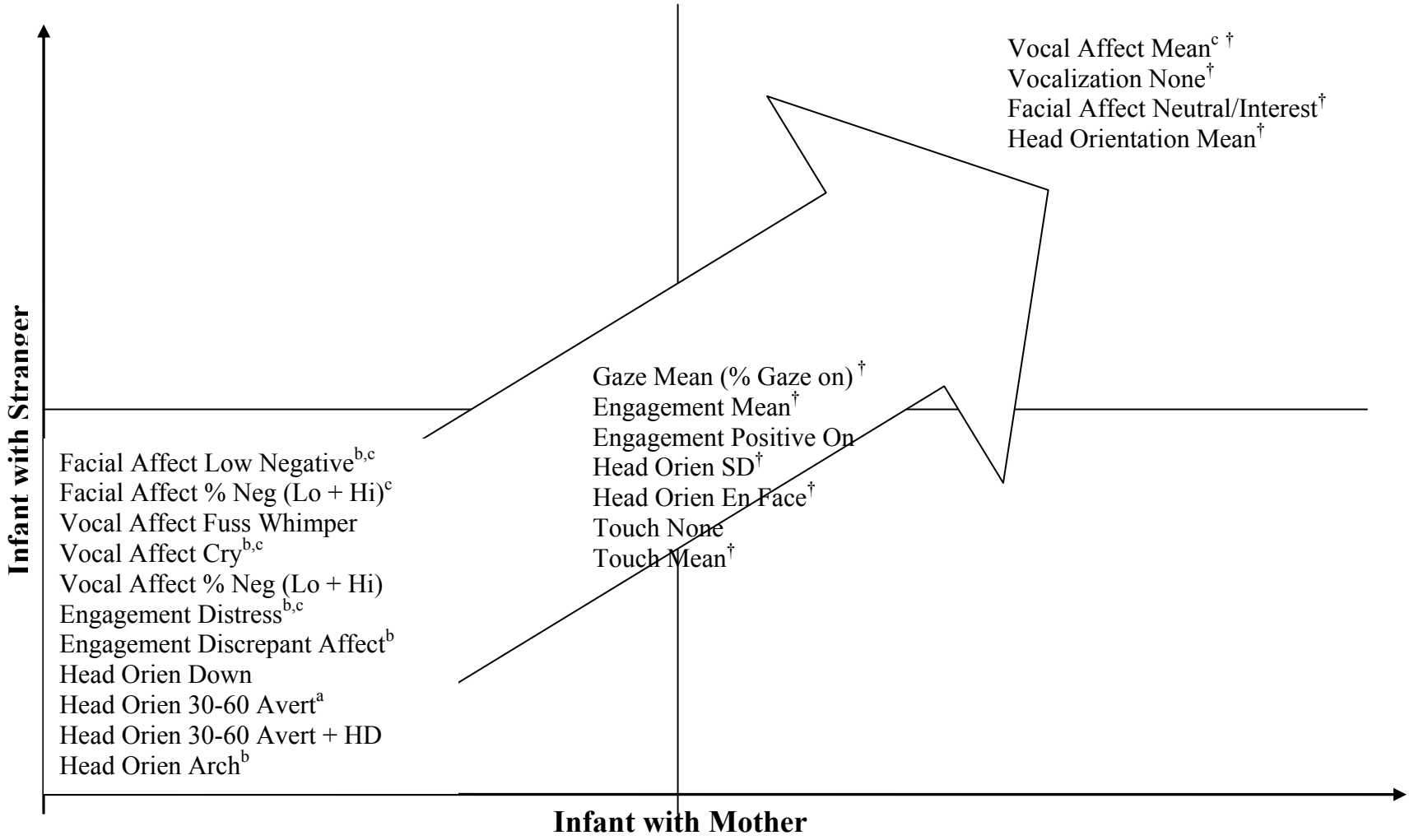


Figure 5. Summary of Across-Group Generalization Scatterplots

Note. Based on visual inspection of the scatterplots, for each finding we identify which quadrant of the graph may characterize the findings, upper right, upper left, lower right, lower left, as well as findings which spread from the lower left to upper right quadrant in a typical positive correlation pattern.

[a] Head Orien 30-60 Avert appears in upper left quadrant as well.

[b] Although significant, these correlations may reflect the pattern of relatively few infants.

[c] This finding is significant in the depressed subgroup only (see Tables 5,6).

[†] = measure of central tendency (mean, SD) or "dominant" code (60%+ time in scale).

(A) Facial Affect % Negative (Hi + Low)

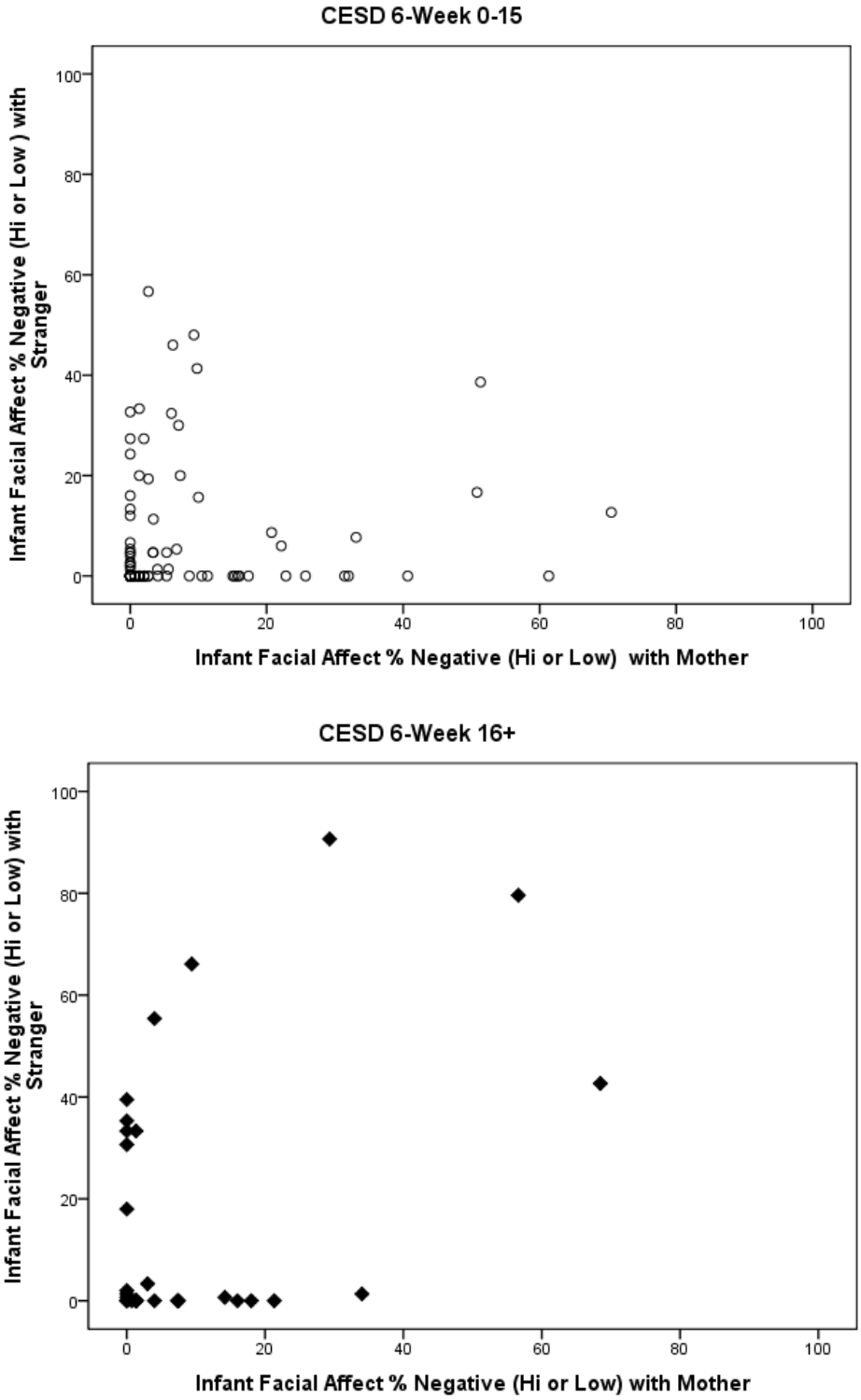
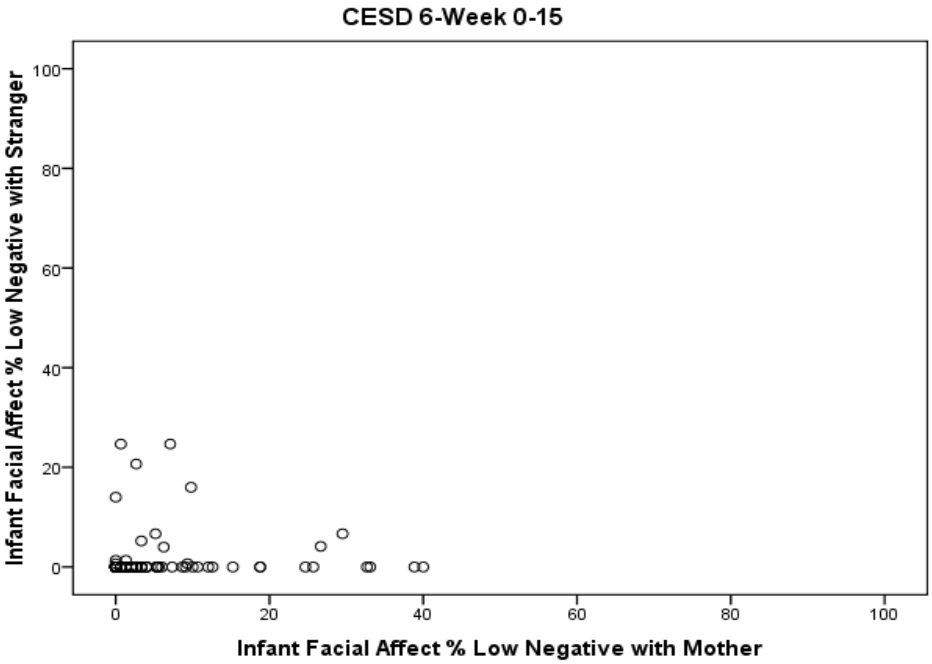


Figure 6. Effect of Maternal Depression (CES-D) on Infant Generalization of Behavioral Qualities from Mother to Stranger

(B) Facial Affect % Low Negative



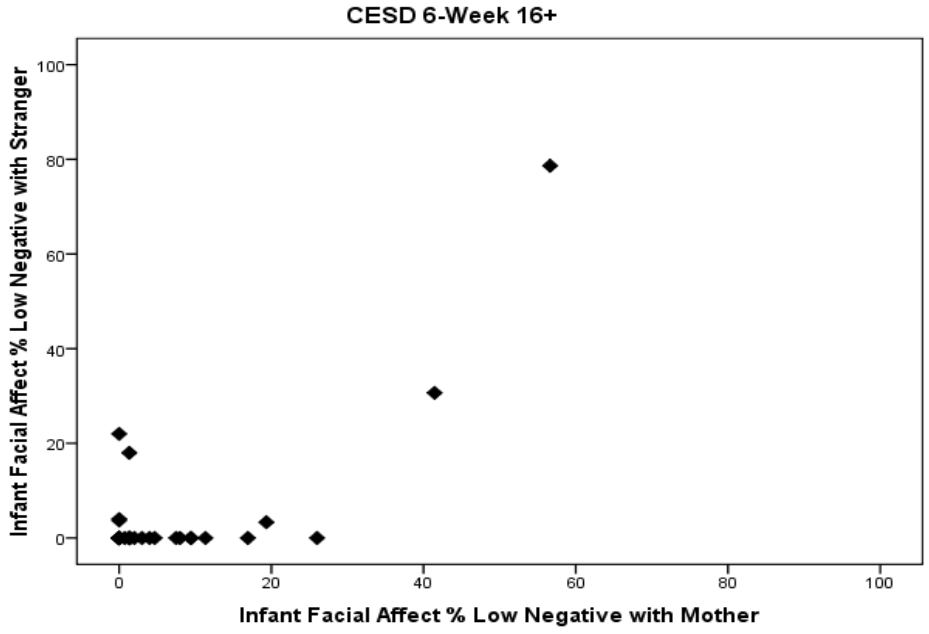
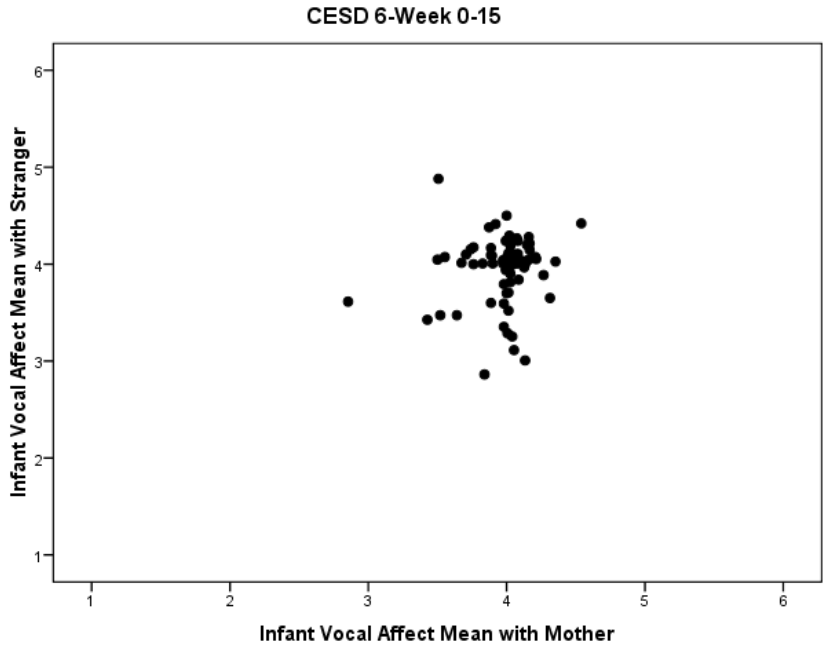


Figure 6. Continued

(C) Vocal Affect Mean



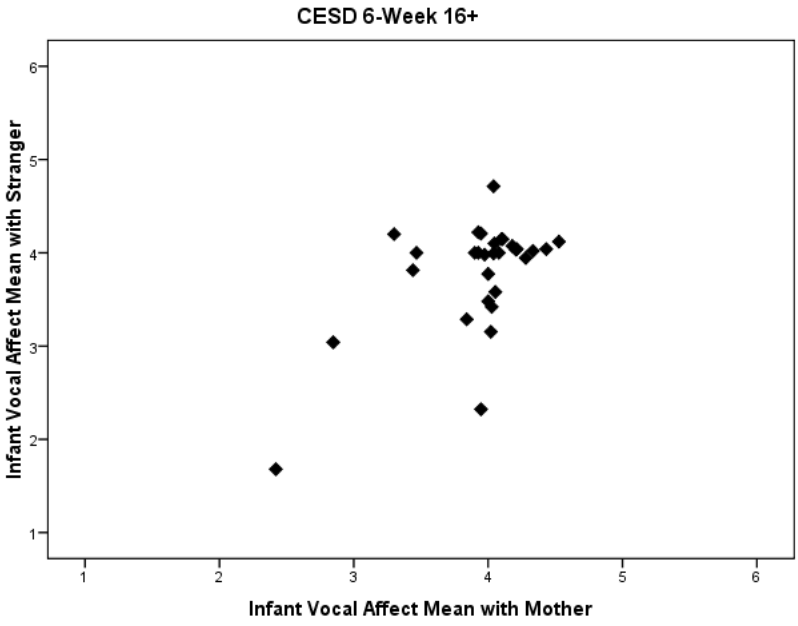


Figure 6. Continued

(D) Vocal Affect % Vocal Cry

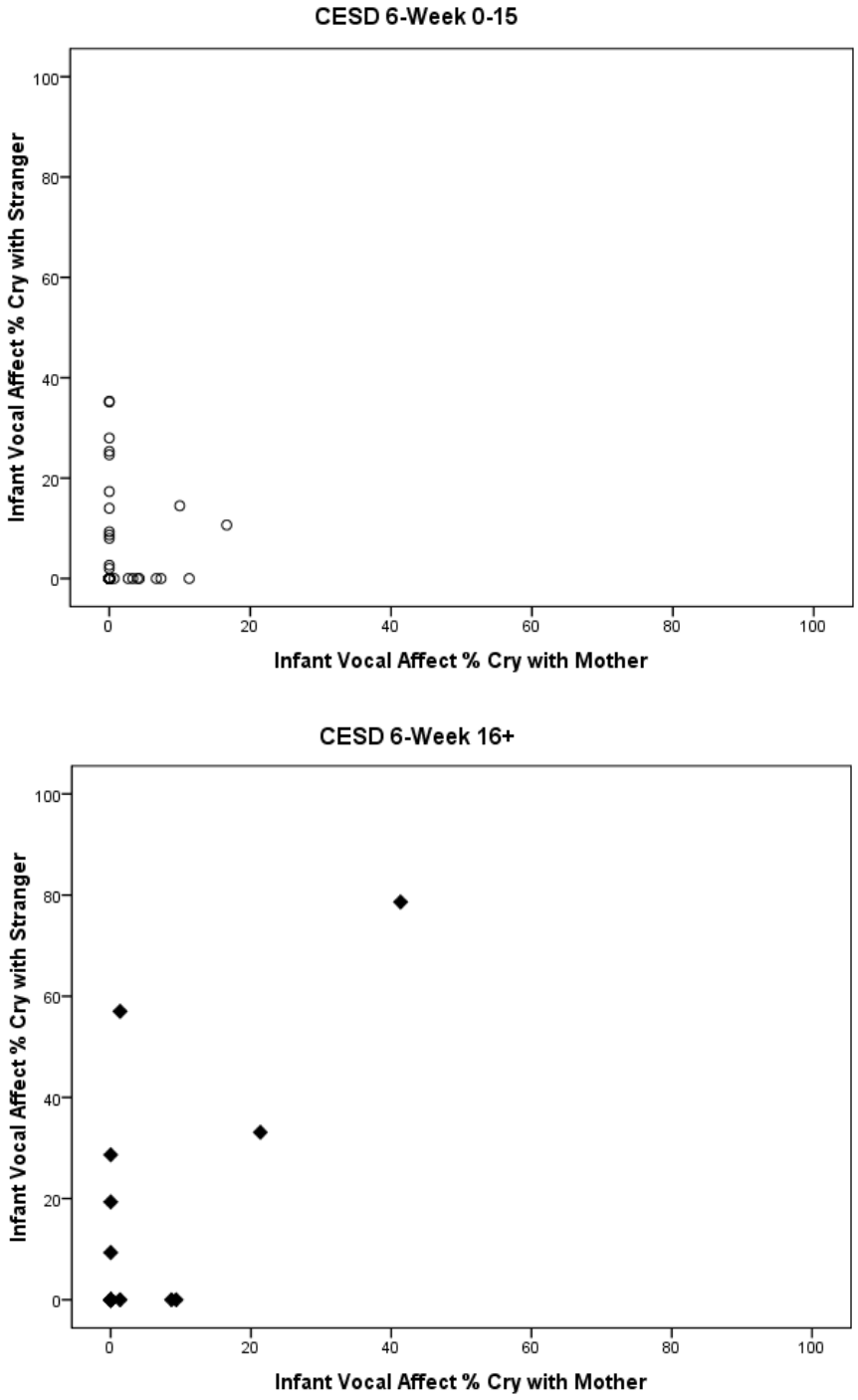
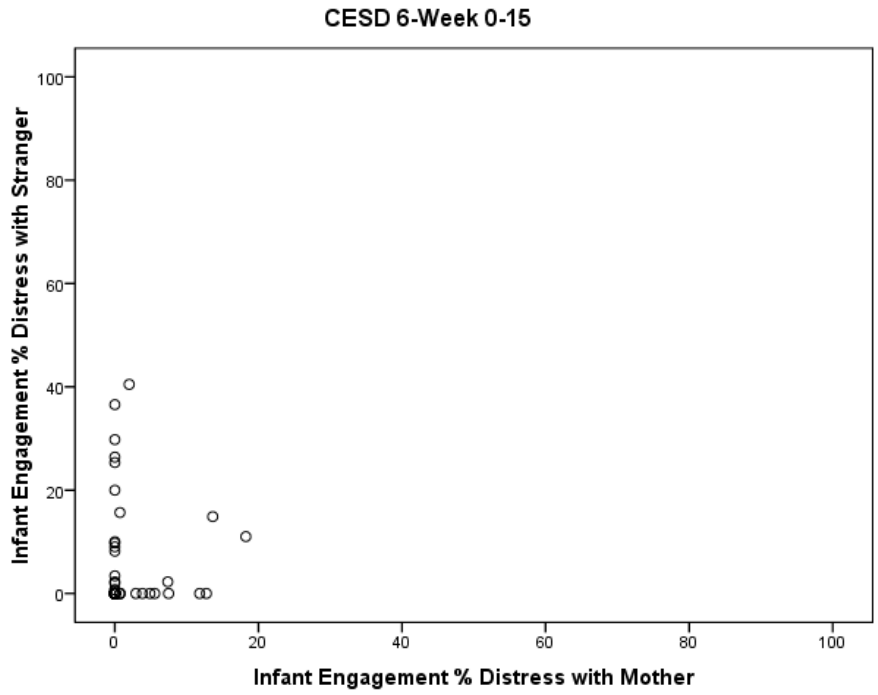


Figure 6. Continued

(E) Engagement % Distress



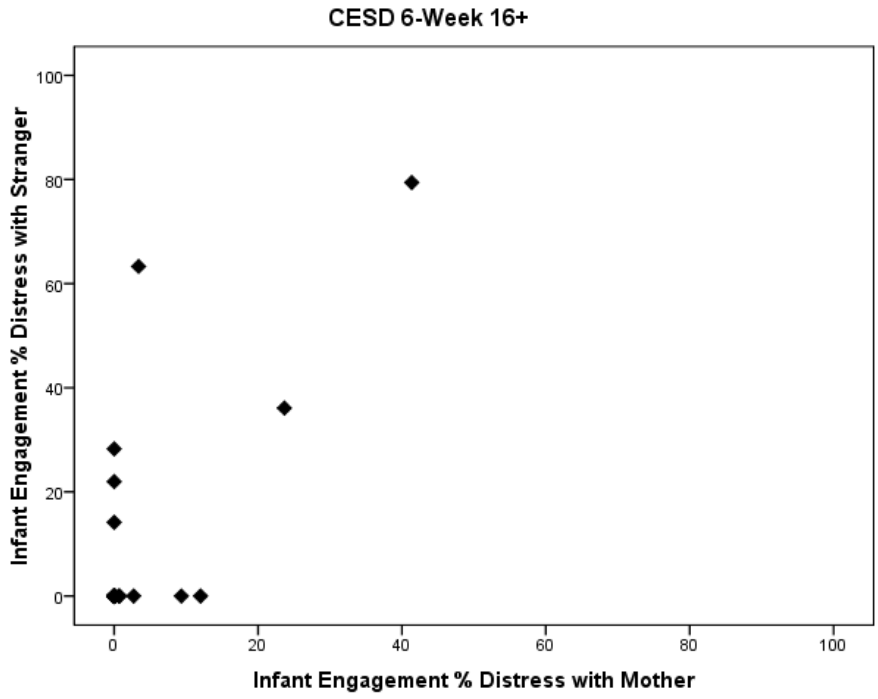
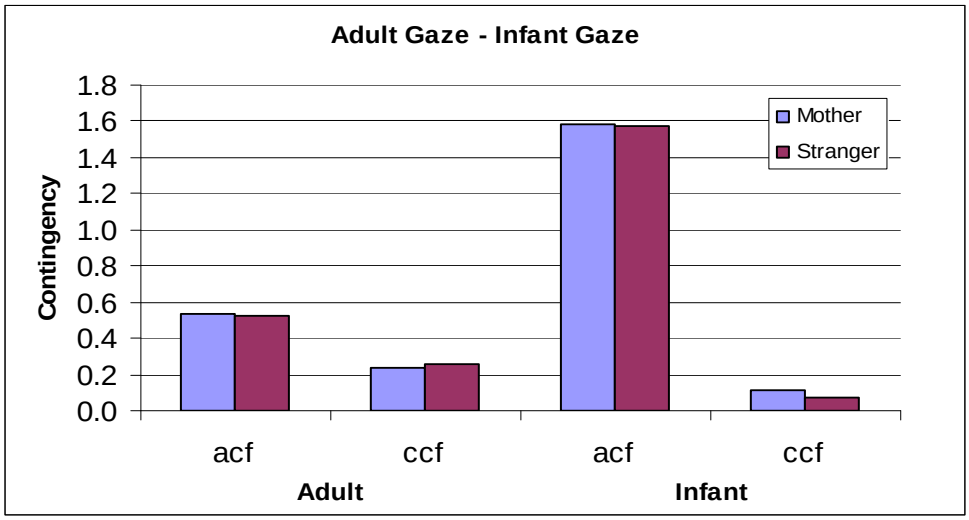
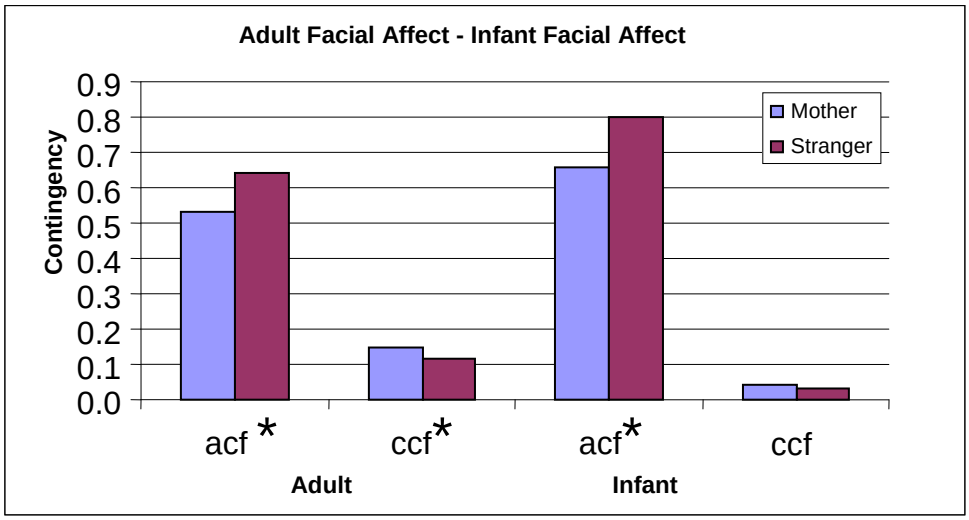


Figure 6. Continued





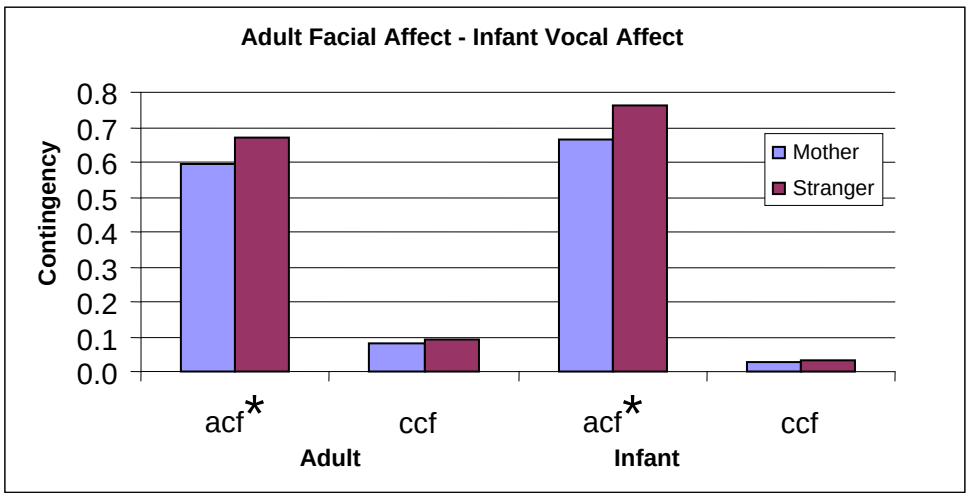


Figure 7. Differences in Mother-Infant vs. Stranger-Infant Self- and Interactive Contingencies
Note. acf = self-contingency; ccf = interactive contingency; * = significant difference (see Table 9). Entries are effect sizes of main effects (see Table 8).

Appendix A

Coding of Ordinalized Behavioral Scales

		Modality	Definition	
Adult Facial Affect[a]		***Mouth widen (MW)***	***Mouth open (MO)***	***Other***
90	mock surprise	MW 0(1)	MO 3(4)	eye brows raised
85	smile 3	MW 2	MO 3(4)	
80	smile 2	MW 2	MO 2	
70	smile 1	MW 1	MO1(2)	
67	oh face	MW 0	MO 1(2)	
60	positive Interest	MW 0	MO 1(0)	[kiss/ purse]
	attention	MW 1	MO 0	
50	Neutral	MW 0	MO 0	
45	2 = woe face			empathic pout
40	1 = negative face	grimace and/or compressed lips		and/or frown
Infant Facial Affect[b]		***MW***	***MO***	***Other***
5	medium high/ high positive	2	3 (4)	
4	low/medium positive	1	1 (2)	
3	interest/neutral	0 (1)	0	
2	mild negative	Grimace	0 (1)	[and/or frown]
1	negative	squared anger mouth/pre-cry/cry-face (partial/full display)	2 (3)	[and/or frown]

Adult/Infant Gaze

1 = on partner's face

0 = off partner's face

Appendix A. continued

Infant Vocal Affect[c]

6	high positive	rising intonations, peals, laughter
5	neutral/positive	includes gurgles, coos, neutral sounds
4	None	
3	fuss/whimper	
2	angry protest	distinct angry quality
1	Cry	full-blown cry

Infant Head Orientation[d]

6	en face
5	enface/head down
4	30-60 degree minor avert
3	30-60 avert + head down
2	60-90 degree major avert
1	Arch

Infant Touch[e]

0	None
1	Self: touch/suck own skin
2	Object: touch/suck own clothing, strap, chair
3	Partner: touch/suck adult's skin, clothing

For data analysis, codes were ordinalized:

3	more than one code within one sec
2	any one code
1	None

Note. Codes within each modality coding scheme are mutually exclusive. Coding rules for multiple codes within the same sec follow Tronick and Weinberg (1990). If two codes occur in the same sec, the code occurring in the first half of the sec is attached to that sec; the code occurring in the second half of the sec is attached to the following sec. For vocalization, this coding rule was adapted as follows: if two vocalizations occur in the same sec, code the most intense one; if they are of equal intensity, code the second one. Vocalizations are scored in the sec they occur even if they occur in the second half of the sec (consistent with Weinberg & Tronick, 1990).

[a]Mother Facial Affect coding follows Beebe and Gerstman (1980). Two degrees of mouth widen (MW) were distinguished: MW1 = sideways lip stretch (without zygomaticus retraction); MW2 = lip-corner raise (zygomaticus retraction). Four degrees of mouth open (MO) were distinguished, from lips slightly parted to maximal display of mouth open ("gape"). Reliability was evaluated based on configurations (levels 40 - 90).

[b]Infant Facial Affect coding follows Koulomzin et al. (2002) and Marquette (1999). Two degrees of mouth widen and four degrees of mouth open were distinguished, definitions identical to that of *mother facial affect.* Reliability was evaluated based on configurations (levels 1 - 5).

[c]Infant Vocal Quality coding follows Demetri-Friedman (2005), adapted from Tronick and Weinberg (1990).

[d]Infant Head orientation coding follows Koulomzin et al. (2002) and Marquette (1999).

[e]Infant Touch coding follows Koulomzin et al. (2002); see also Hentel et al., (2000); Marquette (1999).

Appendix B

Mother and Infant Engagement Scales

Note:

Beebe and Gerstman (1980) developed an ordinal scale of degree of infant and mother facial-visual engagement. By three to four months, an extensive range of interpersonal affective play is present in the infant. Observations of infants sustaining or disrupting the face-to-face play encounter led to the development of an infant engagement scale describing the various ways that infants combine their orientation to the mother, their visual attention to her, and subtle variations in their facial expressiveness (Beebe and Stern, 1977, Beebe and Gerstman, 1980). This scale was influenced by the concept that nuances of affective quality occur on a continuum of gradations, rather than only as discrete on-or-off categories.

Although our previous versions of mother and infant engagement scales used mother and infant gaze, face and head orientation, in this study, we also integrated infant vocal quality into the ordinalization of infant gaze, head, and face in the creation of a multimodal infant engagement scale. Thus the construction of the infant engagement scale underwent extensive revision. The entire data set was run through a series of successive versions of the engagement scale, and frequency analyses were performed to see what percentage of the total seconds of data was accounted for by the engagement categories in each of the versions of the scale. Any engagement levels that accounted for less than 2% of the data were regrouped with other similar levels. Any large proportion of seconds unaccounted for by the existing categories led to the creation of new levels, until 92% (infant) and 94% (mother) of the data set was included in each engagement scale, and no single level of engagement represented less than 2% of the entire data set (with the exception of two levels of infant distress). These percentages can be found in the final column of the engagement scales.

INFANT ENGAGEMENT SCALE (18-Level)						
ENG	**GAZE (On/Off)**	**HEAD ORIENTATION**	**FACE**	**VOCALIZATION**	**DESCRIPTION**	**%**
	POSITIVE ON					
18	ON (1)	En Face (6)	Hi Positive (85)	Hi(6) / Neut (5) / No Voc(4)	Hi Positive Engagement	3.7
17	ON (1)	En Face (6)	Mild Positive (70)	Hi(6) / Neut (5) / No Voc(4)	Mild Positive Engagement	6.2
16	ON (1)	En Face (6)	Neutral (55)	Hi(6) / Neut (5)	Positive/Neutral Engagement	2.1
15	ON (1)	En Face (6)	Neutral (55)	No Voc (4)	Neutral / Interest	19.9
	NEGATIVE ON					
14	ON (1)	En Face (6)	Neutral (55)	Fuss (3)	Negative Engagement (Voc)	3.4
14	ON (1)	En Face (6)	Negative (40)	Neut(5)/No Voc(4)/ Fuss(3)	Negative Engagement	
	LOOK ANGLED-ESCAPE					
13	ON (1)	Any except En Face (1-5)	Any except Cry (40-85)	Any except Protest or Cry (3-6)	Look Angled for Escape	2.2
	POSITIVE OFF					
12	OFF(0)	Any	Hi Pos (85)/ Mld Pos(70)	Hi(6) / Neut (5) / No Voc(4)	Neutral Face / No Voc	2.2
11	OFF (0)	Any	Neutral (55)	Hi Pos (6) / Neut Pos (5)	Neutral Face / Pos Voc	3.2
	NEUTRAL OFF					
10	OFF (0)	En Face (6)	Neutral (55)	No Voc (4)	En Face	16.5
9	OFF (0)	Head Down, vis a vis (5)	Neutral (55)	No Voc (4)	Head Down, vis a vis	3.5
8	OFF (0)	30-60 Avert (4)	Neutral (55)	No Voc (4)	30-60 Avert	7.8
7	OFF (0)	30-60 + Head Down (3)	Neutral (55)	No Voc (4)	30-60 + Head Down	4.6
6	OFF (0)	60-90 (1) / Hd Up & Back (2)	Neutral (55)	No Voc (4)	60-90/Head Up & Back	3.0
	INF GAZE AT OBJECT (Non-distressed)					
5	Look at Object	Any	Any	Any	Object Engagement	6.2
	NEG OFF/ EN FACE					
4	OFF (0)	En Face (6)	Neutral (55)	Fuss (3)	Off En Face - Negative	2.9
4	OFF (0)	En Face (6)	Negative (40)	No Voc (4) / Fuss (3)	Off En Face - Negative	
	NEG OFF/ AVERT					
3	OFF (0)	Any (except En Face) (1-5)	Neutral (55)	Fuss (3)	Gaze Avert	2.2
3	OFF (0)	Any (except En Face) (1-5)	Negative (40)	No Voc (4) / Fuss (3)	Gaze Avert	
	DISTRESS					
	CRY FACE					
2	ON/OFF	Any	Cry Face (20)	No Voc (4) / Fuss (3)	Cry Face	
	ANGRY PROTEST					
2	ON/OFF	Any	Neutral (55) Neg (40) Cry Face (20)	Angry Protest (2)	Angry Protest	
	DISCREPANT AFFECT					1.6
2	ON/OFF	Any	Negative (40)	Neutral Positive (5)	Low Discrepancy	
2	ON/OFF	Any	Mild Positive (70)	Fuss (3)		
2	ON/OFF	Any	Negative (40)	Hi Positive (6)	Medium Discrepancy	
2	ON/OFF	Any	Hi Positive (85)	Fuss (3)		
2	ON/OFF	Any	Cry Face (20)	Hi Positive(6) / Neut Pos (5)	High Discrepancy	
2	ON/OFF	Any	Hi Pos(85)/ Mild Pos(70)	Angry Protest (2)		
2	ON/OFF	Any	Hi Pos(85)/ Mild Pos(70)	Cry (1)		
	CRY		Neutral (55) Neg (40)			
1	ON/OFF	Any	Cry Face (20)	Cry (1)	Cry	1.0

COLLAPSED INFANT ENGAGEMENT SCALE (9-Level)					
ENG	**GAZE (On/Off)**	**HEAD ORIENTATION**	**FACE**	**VOCALIZATION**	**DESCRIPTION**
9	**POSITIVE ON**				
	ON (1)	En Face (6)	Hi Positive (85)	Hi(6) / Neut (5) / No Voc(4)	Hi Positive Engagement
	ON (1)	En Face (6)	Mild Positive (70)	Hi(6) / Neut (5) / No Voc(4)	Mild Positive Engagement
	ON (1)	En Face (6)	Neutral (55)	Hi(6) / Neut (5)	Positive/Neutral Engagement
	ON (1)	En Face (6)	Neutral (55)	No Voc (4)	Neutral / Interest
8	**NEGATIVE ON**				
	ON (1)	En Face (6)	Neutral (55)	Fuss (3)	Negative Engagement (Voc)
	ON (1)	En Face (6)	Negative (40)	Neut(5)/NoVc(4)/Fuss3	Negative Engagement
7	**LOOK ANGLED-ESCAPE**				
	ON (1)	Any except En Face (1-5)	Any except Cry (40-85)	Any except Protest or Cry (3-6)	Look Angled for Escape
6	**POSITIVE OFF**				
	OFF(0)	Any	Hi Pos (85)/ Mld Pos(70)	Hi(6)/Neut(5)/NoVoc(4)	Neutral Face / No Voc
	OFF (0)	Any	Neutral (55)	Hi Pos (6)/Neut Pos (5)	Neutral Face / Pos Voc
5	**NEUTRAL OFF**				
	OFF (0)	En Face (6)	Neutral (55)	No Voc (4)	En Face
	OFF (0)	Head Down, vis a vis (5)	Neutral (55)	No Voc (4)	Head Down, vis a vis
	OFF (0)	30-60 Avert (4)	Neutral (55)	No Voc (4)	30-60 Avert
	OFF (0)	30-60 + Head Down (3)	Neutral (55)	No Voc (4)	30-60 + Head Down
	OFF (0)	60-90 (1) / Hd Up & Back (2)	Neutral (55)	No Voc (4)	60-90/Head Up & Back
4	**INF GAZE AT OBJECT (Non-distressed)**				
	Look at Object	Any	Any	Any	Object Engagement
3	**NEG OFF/ EN FACE**				
	OFF (0)	En Face (6)	Neutral (55)	Fuss (3)	Off En Face - Negative
	OFF (0)	En Face (6)	Negative (40)	No Voc (4) / Fuss (3)	Off En Face - Negative
3	**NEG OFF/ AVERT**				
	OFF (0)	Any (except En Face) (1-5)	Neutral (55)	Fuss (3)	Gaze Avert
	OFF (0)	Any (except En Face) (1-5)	Negative (40)	No Voc (4) / Fuss (3)	Gaze Avert
2	**DISCREPANT AFFECT**				
	ON/OFF	Any	Negative (40)	Neutral Positive (5)	Low Discrepancy
	ON/OFF	Any	Mild Positive (70)	Fuss (3)	
	ON/OFF	Any	Negative (40)	Hi Positive (6)	Medium Discrepancy
	ON/OFF	Any	Hi Positive (85)	Fuss (3)	
	ON/OFF	Any	Cry Face (20)	Hi Pos(6)/Neut Pos (5)	High Discrepancy
	ON/OFF	Any	Hi Pos(85)/ Mild Pos(70)	Angry Protest (2)	
	ON/OFF	Any	Hi Pos(85) /Mild Pos(70)	Cry (1)	
1	**DISTRESS**				
	CRY FACE				
	ON/OFF	Any	Cry Face (20)	No Voc (4) / Fuss (3)	Cry Face
	ANGRY PROTEST				
	ON/OFF	Any	Neut(55)Neg(40)CryFce	Angry Protest (2)	Angry Protest
	CRY				
	ON/OFF	Any	Neut (55)Neg(40)Cry(20)	Cry(1)/Angry Protest (2)	Cry/ Angry Protest

ADULT (Mother/Stranger) ENGAGEMENT SCALE

	GAZE (On/Off)	FACE	%
	GAZE AT INFANT		
9	ON	Mock Surprise (90)	2.0
8	ON	Smile 3 (hi) (85)	3.2
7	ON	Smile 2 (med) (80)	15.5
6	ON	Smile 1 (lo) (70)	22.7
5	ON	Oh Face (67)	1.1
4	ON	Positive Attention (60)	38.0
3	ON	Neutral (50) / Woe(45) / Negative Attention (40)	2.2
	GAZE OFF INFANT		
	Positive Off		
2	OFF	Oh(67)/Sm1(70)/Sm 2(80)/Sm3(85)/Mock(90)	3.8
	Neutral / Negative Off		
1	OFF	Neg Attn(40)/Woe(45)/Neut(50)/Pos Attn (60)	6.9

Note. For details of Mother face coding and ordinalization, see Appendix A. "Oh Face" = Mouth open midway, no smile; "Positive Attention" = Gaze on with slight mouth widening and / or opening without smile; "Woe Face" = Slight down-turned corners of mouth with pursed out lips; "Negative Attention" = Gaze on, with mouth corners turned down in grimace and / or frown and / or mouth drawn in tightly in "compressed lips."