INFANT GAZE, HEAD, FACE AND SELF-TOUCH AT FOUR MONTHS DIFFERENTIATE SECURE VS AVOIDANT ATTACHMENT AT ONE YEAR: A MICROANALYTIC APPROACH

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The study attempted to distinguish avoidant vs. secure infants at one year from 4-month infant behavior only, during a face-to-face play interaction with mother. Thirty-five 4-month-old infants were coded second-by-second for infant gaze, head orientation, facial expression and self-touch/mouthing behavior. Mother behavior was not coded. At one year, 27 of these infants were classified as Secure (B), and 8 as Avoidant (A) attachment in the Ainsworth Strange Situation. Compared to the B, the future A infant spent less time paying "focused" visual attention (a look of minimum 2 sec) to the mother's face. Only if the A infant engaged in self-touch/mouthing behavior did focused visual attention match that of the B. Markovian t to t+1 transition matricies then showed that for both future A and B infants, focused visual attention on mother constrained the movements of the head to within 60 degrees from center vis-a-vis, defining head/gaze coordination within an attentional-interpersonal space. However, infant maintenance of head/gaze coordination was associated with self-touch/mouthing behavior for the A infant but not the B. Positive affect was associated with a disruption of head/gaze coordination for the A but not the B. Whereas the B had more variable facial behavior, potentially providing more facial signaling for the mother, the A had more variable tactile/mouthing behavior, changing patterns of self-soothing more often. Thus, infants classified as A vs. B at 12 months showed different behavioral patterns in face-to face play with their mothers as early as four months.

INFANT GAZE, HEAD, FACE AND SELF-TOUCH AT FOUR MONTHS

DIFFERENTIATE SECURE VS AVOIDANT ATTACHMENT AT ONE YEAR:

A MICROANALYTIC APPROACH

Infant attachment security, measured by the Ainsworth Strange Situation (Ainsworth & Wittig, 1969; Ainsworth, Blehar, Waters & Wall, 1978), is an important predictor of developmental outcomes, such as peer relations, school performance (Arend, Gove & Sroufe, 1979; Erickson, Sroufe & Egeland, 1985; Lyons-Ruth, 1993), affect regulation (Kobak & Sceery, 1988), and psychopathology (Lewis, Feiring, McGuffog, & Jaskir, 1984; Sroufe, 1983; Sroufe, 1985; Lyons-Ruth, Repacholi, McLeod & Silva, 1991; Lyons-Ruth, Alpern, & Repacholi, 1993). Representations or "internal working models" of attachment security at one year are attributed to the history of infant-parent interactions (Main, Kaplan & Cassidy, 1985; Tarabulsy, Tessier & Kappas, 1996; Seifer & Schiller, 1995). Although many studies have identified behavioral predictors of later attachment, we still lack a full understanding of early attachment formation (Fox, 1994; Seifer & Schiller, 1995; Tarabulsy et al, 1996), giving equal status to the contribution of both partners. Indeed, several critics have noted relative neglect of the infant in studies of the origins of attachment (Pederson & Moran, 1995; Seifer & Schiller, 1995; Tarabulsy et al, 1996).

To remedy the relative neglect of the infant's contribution, a more comprehensive approach would compare what can be learned from studying the infant, the mother, and mother-infant dyadic patterns. As a first step in such a longterm project, we now report what can be learned from the infant alone. Therefore, 4-month infant gaze at mother, head orientation to mother, face and self-touch/mouthing behaviors were examined as precursors of one-year attachment categories.

Our focus in this paper is limited to a microanalytic approach to the study of specific infant behaviors from videotaped interactions, using units of one second (Tronick & Weinberg, 1990;

Cohn & Tronick, 1986, 1988, 1989). Over 60 studies using global assessments and clinical ratings, rather than microanalytic approaches, have converged on a picture of interactions in the early months of life that culminate in secure or insecure attachment outcomes at 12 to 18 months (see De Wolff & van IJzendoorn, 1997, for a review). The literature generally portrays mothers of secure (B) infants as more contingently responsive and "sensitive", more consistent and prompt in response to infant distress, more likely to hold their infants, less intrusive, and less tense and irritable. Compared to avoidant (A) infants, B infants are described as more responsive in face-to-face play, better able to elicit responsive caretaking, more positive, better able to express distress, crying less, more variable in their communication, and more readily quieted when picked up (see De Wolff & van Ijsendoorn, 1997).

Fewer than a dozen studies employ second-by-second microanalytic approaches. Although extremely labor-intensive, this approach explicates fine details of behavioral organization. While the research reported below exclusively concerns infant behavior, here we review what the microanalytic approach has yielded in understanding both infant and mother behavior. Langhorst & Fogel (1982) showed that the degree to which mother reserved her stimulation for periods of infant looking at her was inversely related to the infant's avoidance in the Stange Situation. The proportion of time infants spent in gaze "avert" and postural "avoid" was positively correlated with avoidance in the Strange Situation. Maternal tendency to increase stimulation in response to negative infant cues was positively correlated with infant avoidance, and negatively correlated with proximity seeking.

Using the "Still-Face" paradigm (Tronick, Als, Adamson,Wise, & Brazelton, 1978), Kiser, Bates, Maslin & Bayles (1986) found that mothers of B infants at 6 months promoted longer bouts of play than those of C infants in the baseline face-to-face play. B infants showed less distress than

C in the still-face segment, but B infants showed more fuss in the third segment (resumption of normal play) than C. A infants differed from B and C infants by displaying less positive mutuality and sustaining shorter bouts of play in the baseline segment, but more positive expressiveness in the third segment. Cohn, Campbell and Ross (1992) also used the Still-Face paradigm to show that at 6 months, future B, but not A, infants displayed positive eliciting behaviors while mother maintained a still face.

Lewis and Feiring (1989) predicted B attachment from midrange values of infant object/toy play, infant sociability, mother respond, and mother proximal stimulation at three months; insecures received scores either higher or lower than secures. In addition, A infants received the most stimulation, B infants a moderate level, and C infants the least. Malatesta, Culver, Tesman and Shepard (1989) analyzed maternal facial changes contingent (within one sec) on infant facial changes (but not vice-versa) in dyads at 2.5, 5, and 7.5 months. Mothers of B infants showed moderate, whereas those of A infants showed high, levels of contingency. Mothers of A infants were also more variable in their display of negative affect. Based on the Adult Attachment Interview (AAI) administered in the last trimester of the mother's pregnancy, Tobias (Tobias, 1995; Slade, Dermer, Gerber, Gibson, Graf, Siegel & Tobias, 1995) found that four month face-to-face engagement changes of C mothers and infants were coordinated with higher degrees of contingency than those of B mothers and infants. (Although the adult's attachment coded from the AAI is not completely consistent with the infant's attachment classification, there is a strong correlation between the two measures [Fonagy, Steele & Steele, 1991])**.** Jaffe, Beebe, Feldstein, Crown and Jasnow (2001) predicted 12 month attachment from degree of vocal rhythm coordination during face-to-face play at 4 months, in mother-infant and stranger-infant interactions. Based on the coordination of both infant and adult partners, insecure attachments clustered at the extremes of the

distribution of degree of contingency at 4 months, whereas B clustered in the midrange.

One conclusion emerging from the microanalytic as well as other studies is that, rather than conceptualizing "more" as "better", B attachment outcomes are associated with *midrange* intensities of mother and infant behavior. Maternal overstimulation, intrusiveness, inconsistency, and particularly high or low levels of maternal stimulation and/or infant and mother responsiveness are associated with insecure outcomes (Belsky, Ronnie & Taylor, 1984; Isabella & Belsky, 1991; Jaffe et al, 2001; Lewis & Feiring, 1989; Malatesta et al, 1988; Tobias, 1995). A second generalization from both microanalytic and other studies is that, in contrast to insecure infants, B infants are more positive, and are more likely to show the full range of both positive and negative expressiveness (see Cassidy, 1994).

Infant self regulation

There is considerable interest in infant self regulation, as an approach to emotion regulation (Fox, 1994; Thompson, 1994; Rothbart, Posner & Hershey, 1995) and self regulatory disturbances (Tronick, 1989; Gianino & Tronick, 1988). Kopp (1989) suggests that self regulation in infancy includes the capacity to maintain positive states as well as the management of distress, and is expressed through such behaviors as head aversion, non-nutritive sucking, and body rubbing. Thompson, Connell and Bridges (1988) distinguish among intensity, range, lability, and persistence as aspects of self regulation. However, as Fox (1994) and Thompson (1994) argue, although emotion regulation is of significant interest to the developmental and clinical communities, there is a dearth of empirical work and a lack of agreement as to methods of study.

Self and interactive regulation are concurrent and reciprocal processes, each affecting the success of the other (Sander, 1977, 1995; Tronick, 1989; Gianino & Tronick, 1988; Thomas & Martin, 1976). Any particular behavior may simultaneously serve both processes. On the one hand,

infants elicit responses from caregivers via a repertoire of affective (facial and vocal) and motoric engagement/disengagement signals. On the other, the infant regulates inner environment through these same behaviors, as well as self-soothing behaviors, which cue the mother as to the infant's state of arousal (Tronick, 1989; Gianino & Tronick, 1988).

Studies of self regulation have found that infants use more self-touch during the still-face experiment (Weinberg & Tronick, 1996); female infants restrict the range of facial expression toward neutral face as a coping strategy in the still-face experiment (Weinberg & Tronick, 1996); infants show more self-touch when mother leaves the room, or when a stranger enters (Trevarthen, 1977, 1979); and infants gaze away from mothers to regulate level of arousal (Stern, 1971, 1977), as measured by heart rate (Field, 1982). Infants of depressed mothers are more preoccupied with self-soothing behaviors (turning away, dull-looking eyes, loss of postural tonus, oral self-comfort, rocking, and self-clasping) than infants of control mothers (Tronick, 1989). Thus, infant self-regulation increases in various distress situations.

Interactive- and self regulation of distress are considered key mechanisms in attachment security (Cassidy, 1994; Kobak & Sceery, 1988; Sroufe, 1985). There are, however, only a few studies of the prediction of attachment from infant self regulation. Mikaye (1984/5) found that infants who were smooth criers at birth, and cried less in infancy, tended to be classified as B at one year; infants classified as Anxious-Resistant (C) showed more fear in infancy than did infants classified as B. Using regulation items on the Brazelton Neonatal Behavioral Assessment Scale, Waters, Vaughn & Egeland (1980) found that, when assessed at 7 (but not 10) days, infants classified as C scored lower than those classified either B or A. Lester and Seifer (1990) suggested that A infants may begin life with a different arousal regulation process than that of the B, finding that the future A infant at 2 and 30 days had higher vocal formant tension than the B, interpreted as

"holding in" distress. Spangler and Grossman (1993) showed that, following the Ainsworth Strange Situation, insecure infants at 12 months showed higher stress levels (measured by cortisol) than secure. Gunnar, Brodersen, Nachmias, Buss and Rigatuso (1996) have shown that lower cortisol baselines (but not cortisol reactivity) at two, four and six months predicted later attachment security.

Approach of this study

Tronick (1989) has proposed a view of the infant at risk which, although illustrated with maternal depression, is applicable to insecurity of attachment as well.   He suggested that if the infant cannot sufficiently affect the caregiver's behavior through affective signaling, the infant turns to other more self-directed regulation strategies, such as looking away for extended periods, orienting and arching away, self-soothing behaviors such as self-touch and oral behaviors, and losing postural control. This preoccupation with self-directed self regulation frequently occurs with chronic negative affect and failures to repair miscoordinations.

These self-directed infant behaviors can be described as a pattern of behavioral dampening. The infant at risk is presumably stressed, and has to work harder to reduce stress, through a pattern of behavioral dampening. The Gunnar et al (1996) findings that cortisol baselines are higher in insecure infants than secure provide a clear suggestion that Avoidant (as well as other types of insecure) infants are already struggling with a higher level of stress in the early months of life. Thus patterns of behavioral dampening are presumably efforts at regulating over-arousal or over-activation.

A microanalysis of infant behaviors in the face-to-face situation with mother at 4 months was thus undertaken to investigate the general proposal that infants later classified as Avoidant are already stressed at 4 months and show signs of behavioral dampening, such as decreased ability to sustain an attentional focus on the mother, more orienting away, and more self-comforting.

At 4 months, infant gaze, head movement, facial expression and "self-comfort" (self-touch/mouthing) are central behaviors regulating the moment-by-moment face-to-face exchange (Beebe & Stern, 1977; Beebe & Gerstman, 1980; Cohn & Tronick, 1988; Field, 1982; Stern, 1977, 1985; Tronick, 1989; Weinberg & Tronick, 1994). By three to four months, the visual system, along with head movement (and sucking), approach adult efficiency (Stern, 1977). The infant is physiologically capable of directly looking at, as well as peripherally monitoring, the mother's face from a variety of head positions, affecting attention management. Infant head orientation toward and away from mother is one central means of regulating proximity and attention. All infants look away and orient away at various points in the interaction (Stern, 1974), which facilitates self regulation through a dampening of arousal (Field, 1981). More extreme head aversions approach a 90 degree angle away from the vis-a-vis; they can escalate into arching and twisting the body completely away from the mother (Beebe & Stern, 1977; Stern, 1971, 1977; Beebe, 2000). The full range of display of infant facial expressions flowers by 4 months and has been shown to be a central feature of these early interactions (Cohn & Tronick, 1988; Beebe & Gerstman, 1980, 1984; Beebe, Jaffe, Feldstein, Mays & Alson, 1985). Infant self-touch and oral/mouthing behaviors are important means of self-comfort (Gianino & Tronick, 1988; Tronick, 1989; Murray & Trevarthen, 1985; Weinberg & Tronick, 1994; Weinberg, Tronick, Olson & Cohn, 1998).

Hypotheses

The general hypothesis is that Avoidant infants show various forms of behavioral dampening, consistent with a picture of greater distress than Secure infants.

(1) Compared to B infants, A infants look less, with less *stable* gaze, and are less able to maintain attentional focus (coordinating orienting and looking at mother). This hypothesis is based on the findings that B infants look more and orient away less (Langhorst & Fogel, 1982), as well as the

finding that infants look away to regulate over-stimulation (Field, 1981; Stern, 1971, 1977). The investigation of stability/lability of behavior (gaze, face, and self-comfort) is based on the suggestion of Thompson et al (1988), as well as the finding by Malatesta et al (1989) that mothers of avoidant infants show more labile behavior.

(2) Compared to B infants, A infants show less *stable* face and self-comfort behavior, as well as more neutral/negative face and more self-comfort behavior. This hypothesis is based on the findings that B infants are more positive (Bates et al, 1986; Cohn et al, 1992; Cassidy, 1994; De Wolff & Ijzendoorn, 1997), and findings that greater infant distress is associated with more infant self-comfort (Weinberg & Tronick, 1996; Trevarthen, 1977, 1979; Tronick, 1989), and restriction of face toward neutral (Weinberg & Tronick, 1996).

(3) In the presence of negative affect, looking at mother, as well as maintenance of attentional focus (coordinating orienting and looking at mother), is disrupted; more so for A infants than B. The documentation that A infants have more negative affect, less looking, and more orientational aversion (see above) is based on studies of each behavior separately. Here we hypothesize that these behaviors are organized together, as an approach-avoidance constellation.

(4) In the presence of self-comfort behaviors, looking at mother, as well as maintenance of attentional focus, is facilitated; more so for A infants than B. Because self-comfort increases under conditions of distress (Tronick, 1989) or novelty (Trevarthen, 1977, 1979), it is reasonable to hypothesize that it is a coping mechanism to dampen over-activation or over-arousal, and thus would, if successful, facilitate engagement.

METHOD

Participants Recruited postpartum from a large metropolitan hospital maternity ward, mothers were predominantly Caucasian, middle to upper class, college educated, average age 33, and the mean social status (Hollingshead Four Factor Index, 1975) was 57. Infants were firstborns, delivered vaginally or by Caesarian Section, without complication, within three weeks pre-term or two weeks post-term, weighing at least 2,500 grams, with a minimum five-minute Apgar score of 7. The 35 mother-infant pairs in this study were a subset of participants in a larger study (N=82) on mother-infant vocal interaction at 4 and 12 months (Jaffe et al, 2001). In the larger study, exclusively examining vocal rhythm, all subjects were audiotaped in the home, and a subset of 55 were videotaped and audiotaped in the lab, when the infant was 4 months. A second video microanalysis study was then designed to analyze the videotapes of the Jaffe et al sample, for behaviors other than vocal rhythm. This second study had a mini-longitudinal design, consisting of data available at 3 age points: a 4-month face-to-face interaction videotaped in the lab; a 1-year Strange Situation, and a two-year videotaped face-to-face interaction (see Sarro, Goldstein, Zicht, Anderson, & Beebe, 1993), yielding 41 infants. We now report on the 4-month data of the second video microanalysis study.

In the larger Jaffe et al study, the distribution of attachment classifications was A (Avoidant)=16, B (Secure)=55, C (Ambivalent)=4, and D (Disorganized)=7. In the current subset of 41, A=8, B=27, C=2, and D=4. Because C and D were too few to analyze, the study was conducted on the 35 B and A infants, of whom 17 were female (72% B's) and 18 were male (82% B's). There was no selection bias in this subset sample, since half of each attachment group from the original study (N=82) is represented in this subset.

Procedure At infant age 4 months, mother and infant were videotaped during face-to-face play for approximately 12 minutes, with infant in an infant seat and mother was seated directly across.

Mother was instructed to play with her baby just as she would at home. A split-screen generator

combined recordings from two cameras situated on opposite sides of the room into a single view,

yielding simultaneous frontal displays of the mother and infant. A digital timer display was

superimposed on the stream of video frames. At infant age 12 months, the mother and infant

returned to be videotaped in the Ainsworth and Wittig Strange Situation (1969). This procedure is a

series of separations and reunions between mother and infant, in the intermittent presence of a

stranger (Ainsworth et al., 1978).

Coding of Infant Behavior   The first two minutes of continuous face-to-face play (uninterrupted

for technical adjustments) in which both mother and infant were in full view was coded.

Approximately two minutes is a standard sample in second-by-second microanalysis studies (see

Cohn & Tronick, 1988; Field, Healy, Goldstein & Guthertz, 1990). The study was focused

exclusively on infant behavior. The scoring combined criteria from Beebe and Gerstman's (1980)

Infant Engagement Scale, which had finely elaborated face and orientation codes, and from Tronick

and Weinberg's (1990) Infant Regulatory Scoring System (IRSS), which had finely elaborated

tactile/mouthing behavior. Gaze, head orientation, facial behavior, and tactile/mouthing were coded

(see Table 1) second-by-second.

Gaze was coded as on or off the mother's face.

Face was coded as neutral; two degrees of positive (low, high); two degrees of negative (low, high).

For purposes of analysis, these distinctions were collapsed into neutral, positive and negative.

Neutral face was defined as forehead smooth, eyes open, mouth relaxed open/closed, or slightly

pursed; low positive face as forehead smooth, eyes open, mouth corners curved up, mouth open or

closed; high positive face as forehead smooth, cheeks raised, mouth corners drawn back and curved

up in full display, mouth fully open; low negative face as inner corners of eyebrows raised, eyes

open or squinting, mouth corners down (grimace), or lips squeezed tightly together ("line-mouth");

high negative as eyebrows drawn together (classical frown), eyes squinting, mouth open and

squarish (pre-cry or cry-face).

Head Orientation was coded in three horizontal positions: (1) "en face", (2) minor avert (30-60

degrees from enface), and (3) "major avert" (60-90 degrees). Three vertical head displacements

were coded as up, down, or level (see Beebe & Stern, 1977; Stern, 1977). Preliminary analyses of

gaze and head determined that the coded distinction between en face and minor avert could be

collapsed into one category, which was termed "en face/minor avert" (see below).

Tactile/Mouthing was coded as none, self-directed skin-to-skin; self-directed fingering fabric; and

other-directed (oral or tactile directed at mother). For purposes of analysis, the two self-directed

categories were collapsed.

Reliability of Coding For the microanalysis of face-to-face play at 4 months, two independent

raters were intensively trained in using the scheme over several months, culminating in reliability

obtained on samples of two minutes from eight pilot videotapes, 23% of the sample. Using the

distinction within codes noted above, mean Cohen's (1960) kappa coefficients were .97 for Gaze,

.93 for Head Orientation, .78 for Face and .93 for Tactile/Mouthing. Raters were blind to the later

infant attachment classification. Videotapes of the Strange Situation for the original full sample

were scored by a coder (blind to four month data) who was trained by Mary Jo Ward, Ph.D., whose

prior reliability was established in training with Alan Sroufe, Ph.D. Dr. May Jo Ward coded 20 of

the original 82 infants in the larger study. Intra-class correlation between Dr. Ward and the coder

was R=.73; Kappa coefficient k=.59 (see Jaffe et al, 2001).

Statistical Analysis

Markovian Transition Matrices were used to evaluate whether t to t+1 transitions (see footnote 1)

of infant head orientation were differentially constrained by three different infant "contexts": (1) gaze on vs. gaze off; (2) positive, negative and neutral face, and (3) self-directed, other-directed, or absence of tactile/mouthing. Data from all A infants were aggregated separately from all B infants. Each dyad's 120 sec sample of coded infant behavior yielded 119 behavioral transitions. These transitions were cast into a matrix that represented all possible pair-wise combinations of codes selected for examination. In the matrix, each cell represented the total number of transitions for each possible pair of coded states. Transition probabilities were calculated by dividing the frequency in any cell by the sum of all frequencies in that row. Each pair of seconds may entail behavioral constancy or behavioral change. Transitions from any state to itself were called "stable", contributing to a measure called "stable transition time." Transitions from one state to another were called "labile", contributing to "labile transition time" (see Figure 1).

Twelve-state matrix analyses of B vs. A attachment   For A vs. B infants examined separately, we used transition probabilities to investigate whether gaze-on (vs.-off) mother constrained head orientation, from t to t+1. Based on preliminary analyses, en face and minor avert were lumped into one state, "en face/minor avert"(see footnote 2). The 12 states of the matrix were 2 horizontal head positions, by 3 vertical head positions, by 2 gaze states. As shown in Figure 1, each 12-state matrix was partitioned into four 6-state submatrices, 1 and 4 representing stable gaze-on and -off, respectively, and 2 and 3 representing labile gaze. Two seconds of stable gaze was used as the criterion of "focus of attention" (see footnote 3). Corresponding rows of the stable submatrices were compared by the Neyman-Pearson likelihood ratio test (distributed like chi-square), predicting less head movement during stable gaze on than during stable gaze off. Significant chi-square values would indicate that the infant's head moves differently under the condition of 'stable gaze-on'

mother, as compared to 'stable gaze-off' mother. We translate this relationship into the phrase, "gaze constrains head orientation". The null hypothesis was that B and A infants would both have significant chi-square values in the same pair of corresponding rows. In the partition comparisons within the 12-state matrices, the crucial data were contained in the rows which contained information about the movement of the head away from the en face/minor avert orientation into major avert, during stable gaze on versus off mother.

The next analysis asked if B versus A infants differed in the ways that infant stable gaze-on mother might constrain infant head movement *in the context of* different facial and tactile/mouthing behaviors. This question was addressed in similar 12-state matrices. Now, 2-second transitions were scanned for stable gaze-on (or -off) mother, *co-occurring with stable* facial or tactile/ mouthing behaviors. Three facial behaviors, and 3 tactile/mouthing behaviors were each examined in separate transition matrices, examining how stable gaze/face, or stable gaze/tactile-mouthing behavior, constrained infant head movement across a 2-second sequence. The relative frequencies of the transitions within each context were treated statistically in the same way as the frequencies of head-gaze transitions in the previous gaze matrices.

<u>Percent time spent in gaze, face, and tactile behaviors</u> The 12-state transition matrices defined above were also employed to calculate percentages of time spent by A vs. B infants in gaze behavior. A series of Yates-corrected Pearson chi-square tests were used to compare time spent by B versus A infants in stable-gaze (sum of frequencies in Quadrants 1 and 4, Figure 1) and labile-gaze (sum of frequencies in Quadrants 2 and 3, Figure 1). Two additional 9-cell transition matrices were prepared for the three face, and three tactile codes, respectively, to arrive at stable and labile percentages in the same manner as calculated for gaze.

RESULTS

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The results were organized in the following way. First, we evaluated whether B versus A infants differed in percent time spent in gaze, face and tactile behaviors, and in the co-occurrences of these behaviors. Second, we addressed probabilities of transitions from one second to the next in these behaviors. We began analyzing these transition probabilities by developing the concept of a stable focus of attention, examining whether infant head orientation was constrained by 'stable' (minimum 2 sec) infant gaze on mother: that is, does looking at mother for 2 seconds or more tend to produce a more stable head orientation than not looking (for 2 seconds or more)? Then we evaluated whether this gaze/orientation constraint was maintained in the context of different face and tactile behaviors, as a function of B versus A attachment status. The data are presented in Table 2, on which rows and columns are numbered to facilitate reference.

Gaze

Do B versus A infants differ in proportion of time in which gaze (whether on or off mother's face) is stable ($\geq$ 2 seconds) or labile (1 second)? Table 2, Rows 1 and 2, and Columns 1 and 4 show that B and A infants spent relatively similar percentages of time in "stable" gaze (whether on or off mother), (91% and 89% for B and A, respectively) and labile gaze (on or off mother), (9% and 11%, respectively). Nevertheless, these rather small differences in both the stable and labile gaze percentages significantly differed as a function of attachment ($x^2 = 4.031$; p< .04), with B infants showing more stable gaze, and A infants more labile gaze, confirming hypothesis 1 that A infants look with less stable gaze. This difference widened when percent of total stable gaze time on mother's face was compared in the next analysis.

Do B versus A infants differ in proportion of time spent in stable gaze on, vs off, mother's face? Table 2, Row 1, Columns 2 and 5 show that B infants spent 57% of the time in stable gaze at mother's face, whereas A infants spent 50%, a significant difference ($x^2 = 14.116$; p<.0002),

confirming hypothesis 1.

Face, Face/Gaze

Do B vs. A infants differ in proportion of time spent in stable versus labile facial behaviors (neutral, positive and negative face)? Table 2, Rows 3 and 4, Columns 1 and 4 show that B infants exhibited somewhat less stable facial behavior (88%) than A (91%), a small but significant difference (x^2 =5.572; p<.018). Thus, the A infant's face was somewhat more likely to stay the same across a two second sequence, changing expression less frequently, while the B infant used somewhat more variable facial signaling. This finding of less stable (more variable) facial behavior in B infants is opposite hypothesis 2 which proposed that A infants use less stable face behavior.

Do B vs. A infants differ in proportion of time spent in each type of facial behavior (neutral, positive and negative face)? Table 2, Row 5, Columns 1 and 4 show that the most frequently used facial behavior in both groups was stable neutral face. However, total stable time in neutral face was higher in A (82%) than B infants (74%), x^2 =104.632, p<.0001, confirming hypothesis 2 that A infants show more neutral face. As seen in Rows 6 and 7, column 1 and 4 on Table 2, the next most frequently used stable facial behavior was positive face, and the least used was negative face. These latter two frequencies were too low to test for significant differences between groups.

Do B vs. A infants differ in the proportion of time that stable gaze is on versus off mother's face, during the three facial contexts (neutral, positive and negative face)? Table 2, Rows 5, 6, and 7, Columns 2 and 5 show that B vs. A infants differed in proportion of gaze on mother's face only in the context of neutral face (x^2 =22.752; p<.0001). Thus B infants tended to look at mother more, when face was neutral, than A infants. In positive and negative face (Rows 6 and 7), frequencies were too low to test, and therefore hypothesis 3, that negative affect disrupts looking at mother, was not testable. The frequencies suggest that while in positive face, both B and A infants spent an

overwhelming proportion of their time with gaze on mother's face. The finding that, for A infants, neutral face is associated with less stable gazing time on mother's face, was not hypothesized.

Tactile/mouthing, Tactile/mouthing/Gaze

Do B vs. A infants differ in stable versus labile time spent in all tactile/mouthing behaviors (total self-directed and other-directed)? Table 2, rows 8 and 9, columns 1 and 4 show that B infants exhibited somewhat less labile (6%) and more stable (94%) tactile/mouthing behavior than A (11% and 89%, respectively), a small but significant difference (x^2 =6.086; p<.01), confirming hypothesis 2. Thus, A infants changed their tactile/mouthing behaviors somewhat more often, exhibiting more short bursts of behavior, whereas B infants tended to have more sustained tactile/mouthing behavior.

Do B vs. A infants differ in their distribution of stable tactile/mouthing time in none, self-directed, and other-directed? Table 2, rows 10, 11 and 12, columns 1 and 4 show that the most frequently coded tactile/mouthing behavior by both attachment groups was self-directed tactile/mouthing (fingering or rubbing clothing, sucking own fingers). The next most frequent for both was "none", and least frequent was "other-directed" (playing with or sucking mother's fingers). Rows 10, 11, and 12 also show that B infants more frequently exhibited "none" (36%) than A (27%); B infants exhibited more other-directed tactile/mouthing (12%) than A (3%); and A infants exhibited more self-directed tactile/ mouthing behavior (59%) than B (46%) (x^2 = 25.407,p<.0001). The finding that B infants show "none" more than A confirms hypothesis 2 that A infants show more self-comfort behavior. The findings that B infants show more other-directed, and A infants more self-directed self-comfort behavior, was not hypothesized.

Do B vs. A infants differ in the proportion of stable time gaze is on versus off mother's face, during the three tactile/mouthing contexts (none, self-directed, other-directed)? Table 2, row 10,

columns 2 and 5 show that in the context of no tactile/mouthing ("none"), B infants spent 59% of the time in stable gaze on mother's face, whereas A infants spent 32% ($x^2 = 14.116$; p<.0001). The finding was in the same direction in the context of other-directed tactile/ mouthing behavior (Row 11, Columns 2 and 5), although the frequencies were too small to interpret. Table 2, row 12, Columns 2 and 5 shows that in the context of self-directed tactile/ mouthing behavior, B infants were similar to A, both spending approximately 60% of the time in stable gaze on mother's face. Thus, only in the context of self-directed tactile/ mouthing behavior were A infants as visually engaged as B. If A infants performed no tactile/mouthing behavior, their stable gaze on mother's face was half that of B infants. This finding partially confirms hypothesis 4 that, in the presence of self-comfort behaviors, looking at mother is facilitated, and moreso for A than B infants. The hypothesis is correct only for A infants. B infants maintain the same amount of time looking at mother's face irrespective of tactile/mouthing self-comfort behaviors.

Head/Gaze Coordination This section presents a sequence of analyses of transition probabilities that address the coordination of infant head and gaze so as to constitute a stable focusing of attention on the mother's face. These analyses asked whether this head/gaze coordination tends to be maintained or not, from one second to the next, across sequences of at least two seconds. The analyses then addressed whether this head/gaze coordination is maintained or not in the different facial and tactile contexts. A 12-state matrix contained 6 head orientations with gaze on mother's face, and 6 with gaze off mother's face (see method section). We used this matrix to evaluate the degree to which infant gaze on mother's face constrained infant head orientation within en face/minor avert, with head level, for B vs. A infants. We then evaluated the same question within the more differentiated facial (neutral, positive, negative) and tactile/ mouthing (none, other-directed, self-directed) contexts.

Does infant Head/Gaze Coordination differ as a function of B versus A attachment? Table

2, row 1, columns 3 and 6 show that, for both attachment groups, gaze on mother constrained head

similarly (to en face/minor avert), indicating that coordination of gaze and head operated similarly

for both. The 12-state matrix analysis showed that corresponding first rows for stable gaze-on and

stable gaze-off showed similar levels of significance for A and B infants (B: x^2 =91.639, p<.001; A:

x^2 = 37.519, p<.001).   Thus both A and B infants coordinated head and gaze so as to yield a stable

focus of attention on mother's face, disconfirming hypothesis 1 that A infants are less able to

maintain attentional focus, coordinating orienting and looking at mother, than B infants. However,

this generalization was modified once the specific contexts of face and self-touch were taken into

account, as documented below.

In the contexts of different facial behaviors, is head/gaze coordination different for B vs. A

infants? Table 2, rows 5, 6 and 7, columns 3 and 6 show that, among the 3 facial contexts, B vs. A

infants operated differently only in the context of positive face. In the context of neutral face (row

5), for both attachment groups, gaze on mother's face constrained head orientation within en

face/minor avert, sustaining head/gaze coordination (B: x^2 =53.866, p<.001; A: x^2 = 24.782,

p<.001). When the face was negative (row 7), neither attachment group showed a significant

finding (B:x^2 =3.791, not significant; A: x^2 =1.581, not significant); that is, gaze on mother's face

did not constrain the head within en face/minor avert for either group, when the face was negative.

However, when the face was positive (Table 2, row 6), A and B infants differed. When B infants

showed a positive face, gaze on mother's face did constrain head orientation within en face/minor

avert, sustaining head/gaze coordination into a stable focus of attention on mother's face (x^2

=20.654; p<.001). In contrast, when A infants showed a positive face (row 6), gaze on mother's

face did not constrain the head within en face/minor avert, (x^2 =10.288; n/s), so that stable focus of

attention was not present. This finding only partially confirms hypothesis 3, that in the presence of

negative affect, maintenance of attentional focus (coordinating orienting and looking at mother) is

disrupted, more so for A infants than B: attentional focus is equally disrupted for both groups in the

presence of negative affect. This analysis also yielded a totally unexpected finding; positive affect

disrupts attentional focus for A, but not B, infants.

In the contexts of different tactile/mouthing behaviors (none, self-directed, other-directed),

is head/gaze coordination different for B vs A infants? Table 2, rows 10, 11 and 12, columns 3 and

6 also show that in the 3 tactile/mouthing contexts, B and A infants operated differently only in the

context of no tactile mouthing ("none", row 10). In this context, B infants sustained head/gaze

coordination ($x^2 = 38.9109$, p<.001), while A infants did not ($x^2 = 9.917$, n.s). Thus, for the A

infant, without any tactile/mouthing behavior, gaze on mother's face did not constrain the head to

en face/minor avert; instead the A infant's head orientation was more likely to wander into major

avert, and displacement up or down. In contrast, B infants maintain head and gaze coordination

without tactile/mouthing. This finding only partially confirms hypothesis 4, that self-comfort

behaviors facilitate maintenance of attentional focus; the statement holds for A infants only.

In the context of other-directed tactile mouthing (Table 2, row 11, cols 3 and 6), both B and

A infants failed to maintain head/gaze coordination (B:$x^2 = 3.825$, n.s; A: $x^2 = 1.560$, n.s.). This

finding is likely to have been confounded by the postural changes that accompany other-directed

behavior (pulling and leaning forward to suck on the mother's fingers), thus moving the head

forward and down in space.

In the context of self-directed tactile/mouthing behavior (Table 2, row 12, cols 3 and 6), the

A infant was able to sustain head/gaze coordination similarly to that of the B infant (B: $x^2 = 31.770$,

p< .0001; A $x^2 = 13.823$, p<.001). Unlike the B, only in this context of self-directed tactile/

mouthing behavior did the A infant maintain a stable gaze/head coordination. As noted above, the A infant used self-directed tactile behavior more than the B infant. A "wandering head orientation", where head is unconstrained by gaze on mother's face, was thus more prevalent in the A infant, unless self-directed tactile/mouthing behavior was used. Thus for A infants, self-directed tactile/mouthing was necessary to sustain a stable focus of attention on mother's face, again partially confirming hypothesis 4, that self-comfort facilitates maintenance of attentional focus, but only for A infants.

<div align="center">DISCUSSION</div>

Future secure (B) infants at 4 months already negotiate the face-to-face interaction differently from those who will be classified as avoidant (A). The B infant looks at mother more, has a more variable facial signaling process, spends less time in neutral face, is more able to sustain gaze at mother when the face dampens toward neutral, is able to sustain a more stable pattern of tactile/mouthing self-comfort, sustains a similar level of gaze at mother irrespective of presence or absence of tactile/ mouthing; and is able to sustain gaze/head orientation, yielding a stable focus of attention to mother's face, regardless of the presence or absence of self-directed tactile/mouthing.

In contrast, the future A infant at four months looks at mother less; has a less variable facial process for the mother to track; spends more time in neutral face, which is associated with a disruption of gaze at mother; uses more tactile/mouthing behaviors; changes the pattern of tactile/mouthing more frequently; and maintains a level of stable gaze at mother equal to that of the B only if involved in self-directed tactile/mouthing. Without this form of self-comfort, the A infant looks at the mother half as much as the B. Additionally the A infant maintains gaze/head coordination, yielding a stable focus of attention to mother's face, only when engaged in self-directed tactile/mouthing. These findings confirm, as well as elaborate, the general hypothesis that

<div align="center">22</div>

Avoidant infants show various forms of behavioral dampening, consistent with a picture of greater distress.

An attention management process, coordinating gaze and head orientation

Similarities of gaze and head coordination in A and B infants suggest a common attention management process. For both A and B infants, looking at mother tends to constrain the head in a stable orientation comprising an angle from direct en face to minor avert. This constraint of head movement while gazing at mother defines a limited range of likely spatial head positions, and coordinates head and eye in a coherent way. In this process head position can become recognized by the mother as an important social cue, since head movement is strongly coordinated with direction of gaze. The angle from en face to minor avert (see footnote 3) gives the infant a considerable vector of space within which interpersonal focus of attention can be flexibly organized.

However, in certain face and tactile/mouthing contexts, this attentional management process breaks down for the A infant, confirming the hypothesis that the Avoidant infant has more difficulty in maintaining a clear attentional focus on mother. When affect is neutral, both A and B infants can maintain a stable gaze/head coordination. When affect is negative, both A and B infants exhibit a disruption of the attentional focus, so that gaze at mother no longer constrains the head to stay within the en face/minor avert orientation. However, positive affect is associated with a disruption in attentional focus in A infants, such that looking at mother no longer constrains the head to an en face/minor avert orientation. This finding was not hypothesized in advance, but in retrospect is consistent with Kopp's (1989) concept that self regulation in infancy includes affect tolerance of positive states. It is also consistent with the possibility that the mother of the Avoidant infant does something disruptive when the infant becomes positive, such as escalating her input to maximize a positive moment (a testable hypothesis for future analysis). In contrast, B infants show gaze/head

coordination in the context of positive affect, maintaining a stable focus of attention.

When tactile/mouthing is self-directed, both A and B infants can maintain gaze/head coordination. When tactile/mouthing is other-directed, neither A nor B exhibit this coordination. However, in the context of *no* tactile/mouthing, the B infant still maintains gaze/head coordination, whereas the A does not. Thus, when the A infant looks at mother in the context of no tactile/mouthing behavior, the head "wanders" from en face/minor avert into major avert, and upward or downward. But, in the context of self-directed tactile/mouthing, the A infant's maintenance of gaze/head coordination is "repaired", that is, equivalent to that of the B. Self-comfort thus seems to be an effective coping device for the Avoidant infant. Infant self-stimulation is a tactile mode that is developed prior to visual-acoustic channels, and in the A provides extra support for the visual-acoustic channels. The A infant seems to provide more of his own physical "holding environment" (see Winnicott, 1965). This finding is consistent with a picture of the A infant as learning that mother is uncomfortable with distress, and that the infant must learn to soothe herself/himself (Cassidy, 1999). This finding also confirms the position of Tronick (1989) and Weinberg et al (1998) that infant self-comfort is an important aspect of the regulation of the face-to-face exchange.

The adaptive style of the A infant biases her somewhat away from the mother's face. The somewhat greater tendency to look away, accompanied by a greater tendency to move the head out of the interpersonal space into major avert unless self-comforting, may interfere with attentional focus, a form of proximity-maintenance which is central to developing attachment. On the other hand, it is possible that the Avoidant infant's greater tendency to look away and orient away may be an adaptation to maternal intrusion or overstimulation, a hypothesis testable in future work. From the point of view of the mother, the A infant's head appears to wander while displaying positive

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affect, sending an unclear, ambivalent message about the infant's attention to the mother and potential next move. Paradoxically, infant difficulties with sustaining facial-visual-orientational engagement may increase the mother's level of stimulation, further escalating infant "escape" behaviors (Beebe & Stern, 1977; Stern, 1985, Tronick, 1989, Field, 1982), again a hypothesis testable in future work. Likewise from the point of view of the mother, the A infant's more variable pattern of tactile/ mouthing may be more distracting than the B's more stable pattern. This variability may relate to Thompson et al's (1988) concept of lability as an aspect of self regulation. In the findings of more overall self-comfort behavior, as well as a more variable pattern of self-comfort behavior, the Avoidant infant as relatively more "activated" than the secure, but in the service of dampening. The Avoidant infant seems to be working harder to find a mode of self comfort that is successful

The B infant's maintenance of head/gaze coordination in the context of positive affect, the flexibility to maintain head/gaze coordination with or without self-directed tactile/mouthing, as well as a greater tendency to vary facial signaling, are clearly an advantage for interpersonal engagement. Looking at mother more, with a steadier orientation, regardless of self-comforting behaviors, may give the mother of the B infant the feeling that her infant is "with" her: calmer, more engaged and accessible. The B infant also provides more positive and negative fluctuations which the mother can use to track the infant's state of engagement. The B infant's greater range of positive and negative facial signaling is consistent with Cassidy's (1994) argument that the freedom to express a range of emotions is central to the development of secure base behavior.

An arousal regulation process

These differences between A and B infants at four months can be interpreted as behavioral manifestations of differences in a more general arousal regulation process. We presume that this

arousal regulation process is an aspect of the dyadic exchange, as well as infant temperament. This

issue cannot, however, be addressed with this study. Most of the findings characteristic of the A

infants are consistent with a pattern of behavioral dampening to reduce stress or over-arousal. The

finding that A infants showed lower levels of gaze at mother's face can be interpreted in terms of

Field's (1981) demonstration that infant looking away lowers heart rate in the face-to-face play

situation and thus is a potent arousal-regulation move. The wandering head can be interpreted as

part of the system of looking away, in the range of orienting away documented in "chase and

dodge" patterns, in the context of maternal "looming" and spatial intrusion (Beebe & Stern, 1977).

Microanalytic data from experimental perturbations of the face-to-face situation are also

relevant to the concept of arousal regulation in the context of infant stress. Increased infant looking

away and decreased positive face have been documented in the maternal "blank face" condition

(identical to the "still-face") by Murray & Trevarthen (1985), and increased infant looking away

and neutral face have been documented during the "Still Face" experiment by Weinberg & Tronick

(1996). During the experiment of maternal "replay" condition (loss of contingency condition

simulated through a videotape replay of mother's response), Murray and Trevarthen (1985) found

that infant positive display and gaze at mother decreased. Thus, dampening the face toward neutral

may be a form of down-regulating arousal. The full display of positive facial expressiveness is

presumably associated with an increase in arousal, which may further stress the A infant. Cohn,

Campbell and Ross's (1992) finding that infants later classified as B exhibited more positive

eliciting behaviors in the still-face episode highlights the future B infant's ability to persist in

positive engagement even under duress. The finding that the A infant uses more neutral face at 4

months may presage the "minimization" of emotional expression in the Strange Situation at 12

months (see Cassidy, 1994). Our results on self-touch/mouthing are consistent with Murray and

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Trevarthen (1985), who found increased tactile ("fingering") behavior during the maternal "blank face" experiment, and with Tronick (1989), who found increased infant self-clasping and oral self-comfort behaviors in infants of depressed mothers.

We speculate that the A infant's modes of visual, orientational, and facial engagement in the face-to-face encounter are all adaptive self-regulatory efforts to cope with heightened, stressful arousal, quite possibly in the context of nonoptimal maternal behaviors. Behaviors such as fingering or rubbing the body, clothing or a strap, or mouthing, are a special regulatory requirement for the A, but highly adaptive since they enabled the infant to maintain visual contact with mother, and to maintain stable head/gaze coordination. Nevertheless, the A infant's more frequent and variable use of tactile behaviors, more looking away, and looking with a wandering head, suggest that regulatory difficulties persist. These regulatory efforts "cost" the infant, both in biasing behavior toward down-regulation, and compromising interpersonal engagement. Nevertheless, they may be adaptive in the face of particular maternal behaviors.

The B infant also used tactile/mouthing self-comforting behaviors, but was able to keep her gaze and head in focused attention to mother independently of these behaviors. The B infant used an "other-directed" mode of touching and mouthing the mother more frequently than the A, thus connecting with mother. The B's less frequent use of tactile/mouthing behavior may indicate less reactivity to interactive stress, or that changes of affective display are effective in regulating mother's intensity and the infant's own arousal level. The B infant's tactile/mouthing self-comforting behaviors, when used, were less variable. The future B infant's interactions must appear smoother and less tenuous to the mother.

Limitations of the study. Given our systems approach to the study of interaction, the major limitation of this study is the absence of mother data, which will be rectified in the future.

In summary, this study shows that in the face-to-face encounter at 4 months, head/gaze coordination, in the contexts of positive and negative affect, and various tactile/mouthing behaviors, presage the infant's later Secure vs. Avoidant style in the Strange Situation. Presumably, these infant behaviors are adaptive responses to the emerging interactive matrix. The infant categorizes, remembers and expects the structure of interactional events (Haith, Hazan & Goodman, 1988; Fagen, Morrongiello, Rovee-Collier & Gekoski, 1984). By 4 months infants have had ample opportunity to consolidate procedural memories of self- and interactive regulation patterns. Characteristic early interaction patterns are proposed to form one important basis for the infant's early presymbolic representations of how interactions proceed (Beebe & Stern, 1977; Beebe, Lachmann & Jaffe, 1997; Seifer & Schiller, 1995; Stern 1977, 1985; Tarabulsi et al, 1996). This argument is strengthened by our finding that, at one year of age, the infant's behavior in the Ainsworth Strange Situation reflects patterns of the preceding twelve months. This study contributes to the understanding of the origins of emerging internal working models of avoidant vs. secure attachment security by specifying details of the differences in the infant's regulation of gaze, head orientation, face and self-comforting behavior during face-to-face play at 4 months.

Although the complete story of the contributions of mother, infant, and dyadic patterns to the formation of infant attachment remains untold in this study, the fact that infant behavior alone is associated with the different attachment classifications is intriguing.

footnote 1 A finite state Markov chain is a sequence of mutually exclusive states in which the conditional (transition) probability of being in any state at time t+1 depends only upon the state occupied at time t. Coding advances by one second (secs one and two, secs two and three, etc), so that the state occupied at time t+1 becomes the state at time t for the next transition. Continuation of a state for more than 1 sec is counted as a transition from the state to itself.

footnote 2 The 12 state matrix was originally an 18-state matrix, with 3 horizontal head positions (en face, minor avert, major avert), by 3 vertical positions (up, level, down), by two gaze states (on/off). A preliminary analysis, comparing pairs of corresponding rows in the gaze on and gaze off partitions (Figure 1), found significant chi square values for both the enface gaze on and gaze off rows (x^2=133.02; p<.001), and in the minor avert gaze on and gaze off rows (x^2 =35.82; p<.001). When starting at time t in enface/level *or* minor avert/level, the infant's probability of staying in this same state at time t+1 was greater during gaze on, than gaze off, mother's face. Thus both enface and minor avert were similarly constrained by gaze on, justifying lumping the enface and minor avert states, yielding a 12-state matrix. Infants used enface and minor avert almost entirely at the "level" vertical displacement.

footnote 3 It is well known that shifts of visual attention begin by saccadic eye movement, but are completed only after a compensatory head movement which follows no more than one second later, in accordance with the parameters of an eye/head coordination system specified by Listings Law (Tweed, 1998). Our method makes use of a corollary of Listing's Law: Once a gaze target is achieved and held for two seconds or longer, the eye-head attentional system will have established an en face head orientation toward that target. Thus we use a criterion of two seconds of stable gaze at mother's face to define a focus of visual attention.

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TABLE 1
Behavioral Codes

Gaze	On	Off	
Head Horizontal	Enface*	Minor Avert*	Major Avert
Head Vertical	Level	Up	Down
Face	Positive	Neutral	Negative
Tactile/Mouthing	Self-Directed	Other-Directed	None

* these 2 states were ultimately lumped

Table 2.
Summary of Results

Infant Behavior			Secure "B" Infants			Insecure "A" Infants		
			1	2	3	4	5	6
			% time spent	% time Gaze On	Gaze/ Head Coord.	% time spent	% time Gaze On	Gaze/Head Coord.
Gaze	1	Total Stable	91% a	57% c	Present	89% b	50% d	Present
	2	Total Labile	9% a			11% b		
Face	3	Total Stable	88% a			91% b		
	4	Total Labile	12% a			9% b		
	5	Stable Face Neutral	74% a	55% c	Present	82% b	45% d	Present
	6	Stable Face Pos.	11%	96% c	Present	8%	93% c	n/s
	7	Stable Face Neg.	3%	37% c	n/s	1%	40% c	n/s
Tactile/ Mouthing	8	Total Stable	94% a			89% b		
	9	Total Labile	6% a			11% b		
	10	Stable T/M None	36% a	59% c	Present	27% b	32% d	n/s
	11	Stable T/M Other	12% a	63% c	n/s	3% b	35% d	n/s
	12	Stable T/M Self	46% a	57% c	Present	59% b	61% c	Present

Note: Percentages with different letters (a vs b; c vs d) differ significantly at p<.05 or less.
Gaze/head Coordination -Present indicates that head orientation deviations from enface are less likely
during gaze on mother than gaze off at p<.05 or less. T/M = Tactile/Mouthing behaviors