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Behavioural Indices Of Emerging Social Competence Of Infants: A Microanalysis Of Early Mother-infant Face-to-face Interactions

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BEHAVIOURAL INDICES OF EMERGING SOCIAL COMPETENCE OF INFANTS: A MICROANALYSIS OF EARLY MOTHER-INFANT FACE-TO-FACE INTERACTIONS

by

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ABSTRACT

The temporal relations of expressive behaviours in early mother-infant interactions were investigated for evidence of infant social competence. Competence was operationalized as an overall increase in expressive behaviour with age, selective display of expressive behaviour while attending to mothers, and onset of expressive behaviours contingent upon those of mothers. Parallel analyses were conducted of maternal behaviours to investigate the behaviour of the senior and presumably "competent" partner. 25 mother-infant dyads were studied longitudinally when the infants were 8, 12, 16, and 20 weeks of age and 32 dyads cross-sectionally at the latter 3 ages (N's= 10, 12, and 10, respectively). All dyads were videotaped while engaged in face-to-face play interactions. Elements of expressive behaviour were independently coded for each interactant. Multi- and univariate analyses were conducted on proportional durations of behaviours as functions of infant sex, age, and attention to mother. Sequential analyses were conducted of the conditional onsets of smiles and a constellation of expressive behaviours selectively directed at the partner.

There were only minor differences in the proportional durations of expressive behaviours of longitudinal and cross-sectional groups, suggesting that changes across ages in the longitudinal group were due to developmental differences rather than repeated visits to the university. Infants displayed more positive behaviours (smiles, eyebrow raises) with increasing age and when attending, relative to not attending, to their mothers (smiles, vocalizations). Mothers displayed more positive behaviours (smiles, eyebrow raises, vocalizations) to their attentive than innattentive infants. There were no effects of infant age on maternal behaviours nor infant sex on either partner's behaviours.

Infant expression onsets were associated with preceding expression onsets of mothers and vice-versa. These results were found when expressions were defined as smiles and a constellation of positive behaviours including smiles. This evidence of infant and maternal contingent behaviours was further explored with measures of responsiveness and dependency. Infant smiles were dependent upon and not responsive to maternal smiles and maternal smiles were responsive to and not dependent upon infant smiles. Infant expressions were responsive to and mother expressions were dependent upon those of their partners and both indices increased across ages. These patterns suggested that the two behavioural assays had very different functions. Infants were responsive to general rather than specific like-expressions and mothers showed the opposite pattern. Inferences were drawn as to how the consequences of this behavioural patterning may be perceived by each interactant and contribute to early cognitive and social development.

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CHAPTER 1 - INTRODUCTION

Infants develop communication skills between birth and 6 months of age (Kaye, 1982; Schaffer, 1984; Stern, 1985). The emergence of expressive and communicative behaviour in infancy is directed by a complex system that includes elements of infant physiology, behaviour, and social environment (Fogel and Thelen, 1987; Trevarthen, 1977). Early interactions with caregivers are the primary source of experience and form the initial impressions infants have of their environment. They have been widely described as the foundation of almost all later abilities: communication and language (Kaye, 1982; Miller & Byrne, 1984), attachment and socialization (Ainsworth & Bell, 1974; Blehar, Lieberman, & Ainsworth, 1977; Field, 1982; Hinde & Stevenson-Hinde, 1987; Watson, 1979), and cognition (Lewis & Goldberg, 1969; Papousek & Papousek, 1977; Schaffer, 1984). The purpose of the present thesis is to provide detailed descriptions of infant social competence in the early social environment. Three behavioural definitions of increasing social competence will be employed using microanalyses of expressive behaviours.

Theoretical Approaches to Social Competence

Proprioceptive Stimulation

Stern (1985) has suggested that infants learn the difference between actions upon the self and those upon others because of different schedules of reinforcement. He suggested that when an infant acts upon itself there is always a felt consequence reflecting 100% reinforcement and when an infant acts on someone else there is a consequence only some of the time, reflecting partial reinforcement. For example, when an infant gazes at its mother, it is certain that she will come into view, but the odds are only high, not certain, that she will look back (Messer & Vietz, 1984; Stern, 1974). There is certainty in the consequence of intrapersonal processes but relatively less certainty in the consequence of interpersonal processes.

Lewis and Brooks-Gunn (1979) have suggested that the earliest stages of self-perception are based on experiencing the perfect contingency between proprioceptive and visual feedback from a body motion. For example, infants can see and feel their arm moving in their visual field and ultimately learn that their arm is under their control. Similarly, conjugate reinforcement paradigms (e.g. Rovee & Rovee, 1969; Watson & Ramey, 1972) have been used to show that infants learn to control environmental events that are made contingent on a body motion. Bahrick and Watson (1985) suggested that the transition from self to social perception occurs between 3 and 5 months. They drew this conclusion from a demonstration that infants exposed to live (contingent) and delayed (noncontingent) video displays of their own leg movements showed a selective preference for non-contingent controls at 5 months but did not display a preference at 3 months.

Watson (1985) suggested that once infants have developed social perception, their perception of contingency would be a direct monotonic function of the level of contingency but behavioural arousal and attention to that contingency would be inverted U-shaped function of contingency. Behavioural arousal would be minimal when either no contingency existed or when contingency was perceived as approaching perfection. That is, it is presumably an uninteresting and unproductive investment to attend to social events that either cannot be controlled or can be controlled completely. Moderate degrees of contingency then are presumed to be maximally arousing. Similar to the thoughts of Stern (1985), Watson (1985) described imperfect contingencies as a way that infants may learn to attend to and become interpersonal beings. This supports the investigation of social interactions between infants and caregivers where the interdependency of behaviours is a stochastic rather than a determined process. Infants can learn whether their caregiver's behaviour is under their control and vice-versa.

Framing, Sensitivity, and Attachment

As most researchers have investigated relationships between mothers and their infants, the word "mother" will be used instead of "caregiver". This is not to say that caregivers other than mothers, e.g., fathers, are unimportant factors in infant development. Brazelton, Koslowski, and Main (1974) suggested that a rule governing early interactions is that mothers use interactions to "model the baby into becoming more and more complex" (p. 74). Fogel and Thelen (1987) have pointed out that mothers' social interactions can enhance a child's performance beyond the level at which the child is capable of functioning alone. An infant engages in incomplete behaviour patterns that a mother organizes their own behaviour around. The mother therefore accomodates into a social interaction the infant's temporal patterns of behaviour as well as current skill levels. This phenomenon has been described as framing (Fogel, 1977), apprenticeship (Fogel & Thelen, 1987; Kaye, 1982), scaffolding (Brunner, 1983), and zone of proximal development (Vygotsky, 1978). The goal of early social interaction is for mothers to provide the scaffolds by which infants can build relatively more mature interactions (Fogel & Thelen, 1987). Development is facilitated by mothers behaving just above the infant's current ability level.

Maternal behaviour changes to accommodate infant age and ability level. Three examples will be given of how mothers alter their behaviour toward their infants throughout the first year of life in consideration of the abilities at a given age. An initial task is that a neonate must try to calm itself when distressed, and mothers assist by holding, rocking, or giving the infant something to suck. Neonatal behaviour subsequently becomes more organized when external cues can be used to modulate internal state. Second, a 3-month-old is ready to engage in face-to-face interactions when alert, so a mother must monitor infant state as well as be ready to respond to vocalizations or smiles as invitations to interact. Infant behaviour is subsequently more complex when infants can initiate interchanges. Third, a 6-month-old is becoming interested in objects in the environment, and a mother can begin to incorporate toys into play with their infant. Developing interest in objects in the environment is encouraged by mothers. In each of these examples, a mother frames the skills of the infant to enhance competence, and provides an environment for the infant to develop further skills.

Each of these examples are at the "macroanalytic" level where behaviours are of a relatively large scale and the time frame of contingencies is minutes or fractions of minutes. The fine details of behaviour, however, also can be investigated for evidence of framing at a "microanalytic" level where behaviours are of a relatively small scale and the time frame of contingencies is seconds or fractions of seconds. As an example of the latter, a mother may smile at her infant and provide an affective frame that the infant can join by smiling. The infant's behaviour appears more complex when considered in conjunction with maternal behaviour than when considered alone. This supports the concept of a mother-infant system where the whole is greater than the sum of its parts (Kaye, 1982).

Two skills are involved in the type of parental sensitivity suggested by framing: responding at the appropriate time and in the appropriate fashion. Sensitivity is therefore different from contingency as the latter is a function of only the timing and the former is a function of timing and the qualitative aspects of the response. For example, a mother who fails to respond to a neonate's cry or responds by overstimulating the infant is in both cases responding in an insensitive manner at a molar level. A mother who fails to respond to an infant's smile or responds by frowning is insensitive at a microanalytic level.

Bowlby (1969), and later Ainsworth (Ainsworth, Blehar, Waters, & Wall, 1978), both defined maternal sensitivity in terms of the mother's ability to read and respond appropriately to infant signals. Ainsworth's generally accepted proposition is that the variability in early interactions and maternal sensitivity contributes to later attachment status of the infant (most recently, see Lewis & Feiring, 1989; Malatesta, Culver, Tesman, and Shepard, 1989; Smith & Pederson, 1988). In the above example, less than optimal attachment can result from a mother who ignores her infant's signals or is overly intrusive. The most extreme forms are therefore neglectful or abusive parenting, respectively, which are known to be associated with attachment difficulties. Interdependency of appropriate behaviours is at the root of infant attachments as well as communication (Brazelton et al., 1974). Malatesta et al. (1989) have provided an excellent review of the important interdependency of emotional experience, cognition, temperament, and contingency experience in early infancy. They described complex interactions between the emergence of these four factors and individual difference measures in order to help explain the development of attachment and personality.

<u>Expectations</u>

Assessments of maternal sensitivity beg the question of whether the infant expects that its mother will respond in a sensitive or insensitive fashion. The relationship between maternal sensitivity and attachment is most likely mediated by social expectations an infant has of its mother's behaviour. For example, Lamb and Malkin (1986) found early anticipatory soothing in 1-month-old infants in anticipation of being picked up. Only infants older than 3 months of age, however, changed their behaviour when mothers were instructed to <u>not</u> pick up their infants, that is, when the expectation was violated. They argued that anticipatory soothing was reflected by conditional associations at 1 month of age and cognitively complex expectations at and beyond 3 months of age (see also Lamb, 1981). Kopp (1989) suggested that the ability to regulate negative arousal develops from social interactions with caregivers. She described how infants by 5 months of age show behaviours that indicate communicative competence in that their actions suggest expectations that their cries will be responded to by a caregiver. This is consistant with Piagetian theory where infant expectations are predicted to emerge after 4 months of age (Piaget, 1952).

Expectations of maternal responsiveness also have been investigated by experimentally manipulating maternal behaviours in face-to-face interactions. The face-to-face paradigm is a widely used method for investigating parent-infant interactions thought to occur typically in the home (e.g. a mother or father has their infant in an infant seat on the kithchen table and stops to play with the infant while cooking dinner). Tronick, Als, Adamson, Wise, & Brazelton (1978), among others (Cohn & Tronick, 1983; Field, 1977; Stack & Muir, 1988; Symons & Moran, 1987), have reduced or enhanced maternal responsiveness in face-to-face play by asking mothers to behave in certain ways. The assumption here is that an infant's reaction to an unresponsive adult might reflect infant expectations of their interactant's behaviour. These studies have had varied success at capturing changes in infant behaviour as a function of changes in maternal behaviour. The classic example is where an infant becomes distressed when their mother assumes an unresponsive "stone-face". Lamb, Morrison, & Malkin (1987), however, have pointed out that infant distress may be due to a change in stimulus characteristics. They suggested that the unresponsive display may reflect either boredom or discomfort, and only the latter indicates the violation of expectancy. The former is a simple function of how unstimulating the mother is when unresponsive. The role of other non-facial behaviours such as tactile stimulation also affect an infant's experience of an unresponsive mother (Stack & Muir, 1988). Despite the importance of infant expectancy, there is still no acceptable method for studying expectations due to some of the inherent difficulties in working with very young infants.

Contingency, Expectations, and Intentional Behaviour

Lewis and Goldberg (1969) have proposed a socio-cognitive model of the development of intentional behaviour in infants. They have built upon Moss' (1967) proposal that a mother acquires reinforcement value if she has previously behaved contingently toward her infant. Lewis and Goldberg (1969; see also Hopkins, 1983; Papousek & Papousek, 1977) have theorized that infants develop intentional behaviour when they begin to believe that their own actions can affect their environments. Mothers reliably respond to their infant's social signals during early interactions, enabling the infant to learn the fundamental rule that his or her behaviour does have consequences. Initial expectations regarding the behaviour of the mother generalize to expectations about other aspects of the infant's environment.

Based upon previous experience, infants behave with intentionality because they are able to make predictions that their behaviour will have an effect upon their environment. The expectation may be about influencing the behaviour of either objects or someone other than mother.

The role of a mother in this model is twofold. First, she behaves responsively so that an infant experiences contingency and develops expectations about the consequences of his or her own behaviour. Second, a mother provides an enriched environment where an infant's expectancies have the opportunity to be realized. Parallel to this, an infant develops a repertoire of behaviours creatively designed to affect persons as well as objects in his or her environment (Lewis and Goldberg, 1969). Papousek and Papousek (1977) have provided an excellant summary of the model of generalized expectancy and early socio-emotional development:

> The effective circumstance eliciting an infant's pleasure during a social interaction is related to the fulfilment of the infant's prediction that ... his own activity will elicit a relevant event. Thus smiles or other signs of pleasure in the infant may first appear as responses caused by confirmations of predictions, fulfilment of expectations or correct outcome of movements. From the very beginning, however, they act as stimuli eliciting changes in the mother's behaviour, and the infant may soon discover that through this kind of activity he can manipulate behaviour in his mother. The role of emotional signs may thus soon become very complex and can be hardly be understood if we do not have sufficient insight into their earliest post-natal development. (p. 75)

They have introduced the new concept that not only do infants develop expectations about their environment, but they display positive emotional behaviours when these expectations have been met. They have suggested a link between affect and contingency experience.

The emergence of social competence, in this framework, is dependent upon the early contingency environments provided by social interactions, many of which involve mothers. Contingency between the behaviour of mothers and infants ensures an expectation of control and feelings of efficacy for both interactants. Goldberg (1978) has argued that an infant who is readable, predictive, and responsive can engage an adult in cycles of mutually rewarding and effective interactions. Conversely, when an infant is unreadable, unpredictable, and unresponsive, learned helplessness (see Seligman, 1975) can result from a combination of poorly organized infant behaviour and/or poorly developed parenting skills. This has implications for infants with difficult temperaments and disorganized states (e.g. those with cholic or chronic illness) as they may be perceived as less responsive by their caregivers. Also, this has implications for parents whose expectancies are unrealistic (e.g. teenage mothers) or interest level is low (e.g. depressed mothers) as they are less likely to be effective at interacting with their infants. Each of these examples has been investigated with various degrees of success at demonstrating less-than-optimal mother-infant interactions in these populations (see for example Bettes, 1989; Field, 1982, 1984; Field et al., 1985; Goldberg, 1978).

Behavioural Indices of Social Competence

There are many ways that an infant can show emerging social competence in a microanalysis of expressive behaviour in early face-to-face interactions. Three hypotheses were developed in the current investigation. First, an infant should become more expressive with age. Second, an infant should increasingly display social discrimination and reserve its expressive behaviours for times when attending to its mother. Third, an infant should increasingly behave contingently and organize its behaviour in temporal proximity to its mother's behaviour. The moment-to-moment contingency environment was assessed by looking at the antecedents and consequences of each interactant's signalling behaviour.

Infants Become More Expressive With Age

It is widely known that infant behaviour changes dramatically in the first five months of life. Expressive behaviours such as smiles and vocalizations increase as infants emerge from the neonatal period. The current presentation will restrict itself to three studies presenting longitudinal data reflecting the emergence of expressiveness in the face-to-face situation. Lamb et al. (1987) videotaped the face-to-face interactions of 30 mothers (as well as strangers) and their first-born infants at 1 month intervals between the ages of 1-7 months. Many of the infant behaviours displayed inverted U-shaped developmental trends with the behaviour peaking between 3-5 months before stabilizing or decreasing in frequency (e.g. knit brow, look at mother, hand to mouth). The failure to demonstrate clear developmental trends was attributed to the variable nature of interactions within this paradigm across this age range. Unfortunately, these authors did not reanalyze their data excluding the 6 and 7 month age-levels. Their coding technique was also imprecise in assessing each behaviour by its presence or absence in 10-sec intervals of interaction. Coding precision increases as interval width decreases, and 10 seconds is a long period of time for infant behaviours, many of which have much smaller durations. Regardless, there was successful demonstration of increases in expressive behaviours (smiles, vocalizations, looking at mother) over the first 5 months of age.

Malatesta et al. (1989) presented data on mother-infant face-to-face interactions when infants were 2 1/2, 5, and 7 1/2 months of age. Elements of behaviour were coded to construct emotional behaviours. These authors did not assess main effects across ages for these behaviours as their study was one of individual differences where early emotional behaviour was used to predict attachment at 2 years as well as a number of other individual difference measures. However, inspection of the means suggested that across ages there were increases in an infant's display of positive emotions (joy and interest) and decreases in the display of negative expressions (knit brow, sadness, anger). Mother emotional behaviour appeared fairly stable across these ages.

Kaye and Fogel (1980) videotaped 4-7 minute face-to-face interactions of 37 mothers and their infants at 6, 13, and 26 weeks of age. They found that infant expressiveness (smile, wide mouth, vocalization, laugh) increased and maternal expressiveness remained the same across the ages of the study. These authors, however, argued that it was much more informative to investigate the behaviour of an interactant as some function of what the interactive partner was doing. Infant expressiveness could be examined as a function of conditions under which infants were expected to be expressive if they were performing in a competent fashion: specifically, when they were attending to their mothers and when their mothers were expressive.

Infants Display Social Discrimination

Kaye and Fogel (1980) looked at mother facial expressiveness as a function of infant age and attention. As infants' ages increased, they continued to attend to their mothers' facial expressions but decreased their attention when mothers were not expressive, resulting in an overall decrease of attention to mothers by infants (see also Papousek & Papousek, 1977). The infants became more selective in their attention. Kaye and Fogel (1980) subsequently analyzed infant facial expressiveness as a function of infant age and attention. Overall, infant expressiveness increased with age. Infants were more expressive when attending to their mothers than when not attending at 13 and 26 weeks, but they failed to make this discrimination at 6 weeks. This suggests that infant expressiveness was not initially used in a mature and competent fashion, as it was not selectively directed at the mother.

Other research has focused exclusively on infant vocalizations as functions of infant age and attention. Keller and Scholmerich (1987) videotaped 5 minute interactions of 20 infants with both their mothers and fathers when infants were 2, 6, 10, and 14 weeks of age. Across this age span (collapsed across parents), the proportion of total infant vocalizations coded as "positive" increased from 3 to 35% and those coded as "negative" decreased from 43 to 24%. By 14 weeks of age, a higher proportion of infant vocalizations were positive than negative. This was largely because during mutual attention, infants increased the amount of positive vocalizations (from 3 to 50%) while the amount of negative vocalizations remained the same (range of 8-18%). Although statistical comparisons were not conducted, the data suggested that only infants of 10 and 14 weeks discriminated mutual attention from non-attending as indicated by more positive than negative vocalizations during the former instances than the latter. Thus, there is evidence that infants become more socially competent as they begin to reserve their facial expressions (Kaye & Fogel, 1980) and positive vocalizations (Keller & Scholmerich, 1987) for their mothers.

Infants Behave Contingently

Kaye and Fogel (1980) used a number of different analyses to show that infants can discriminate a mother's expressive face from an unexpressive one. The simplest demonstration of this was that infants of all study ages were more expressive than non-expressive when their mothers were expressive. This has been replicated by Fogel et al. (in press) who found that infant smiling and maternal expressiveness (smile, exagerated expressions, raised brows, wide mouth, kiss infant) co-occurred greater than expected by chance in their American cross-sectional sample of 3-month-old infants. In this kind of analysis, however, it is difficult to attribute which partner is responsible for this co-occurrence of social signaling (see Moran, Krupka, Tutton, & Symons, 1987). In an attempt to attribute this phenomenon to infants, specific sequences of behaviour have been studied within the play interactions for evidence of infant's ability to discriminate maternal expressiveness from non-expressiveness. The sequences chosen by Kaye and Fogel (1980) to illustrate infant contingent responsiveness were those in which the mother was looking at the infant with either an expressive or unexpressive face and the infant turned its head to look at the mother. The infant could then display either an expressive (referred to as a greeting) or an unexpressive face, and its choice could be compared to that of the mother. At 6 weeks, infants greeted their expressive mothers at a low rate (35% over an 8 sec lag) that was significantly higher than the rate at which they greeted unexpressive faces (0%). Very young infants were able to discriminate their mother's expressive from her unexpressive face. An infant was expressive only in response to their mother's expression, and even then, the chance was relatively small. If mothers, however, want their 6-week-old infants to greet them, then they must act expressively.

At 13 weeks, infants demonstrated discrimination by greeting their unexpressive mothers at a low (slightly greater than 35% over an 8 sec lag) rate and greeting their expressive mothers at a significantly higher rate (65% over an 8-sec lag). An infant was still more likely to greet her expressive than unexpressive face, but the infant also greeted her unexpressive face on some occasions. Fogel et al. (in press) found in their 12-week-old sample that onset of maternal expressiveness was actually inhibited subsequent to an infant smile and gaze onset towards mother. This result seems counter-intuitive until the functions of discrete behaviours are considered. Given that these mother and infant behaviours are likely to co-occur, infants must join their mothers in expressive behaviour as in Kaye and Fogel's (1980) greeting response or Kaye's (1982) description of framing. A mother is not responsively expressive in this case because she is already engaged in expressive behaviour when her infant smiles. These patterns, however, may be some function of the aggregates of expressive behaviour chosen. For example, when smiles are considered alone, it has been found that mothers are responsive to and frame infant smile onsets of 16-week-old infants (Moran et al., 1987).

Kaye and Fogel's 26-week-old infants displayed similar rates of greeting to their expressive and unexpressive mothers (approximately 50% over an 8 sec lag). It is clearly unlikely that infants were no longer capable of discriminating maternal expressive from unexpressive faces. It appears more likely that infants of 6 months of age were more socially competent and their role in interactions was no longer to simply discriminate and react to the face displayed by the mother. An infant was equally likely to greet her expressive as unexpressive face and therefore initiated as many expressive interchanges as the mother did. The infant was performing as an "equal partner" in interactions using this behavioural assay.

Cohn and Tronick (1987) also have demonstrated that infant positive expressions become increasingly independent of maternal expressions with age. They videotaped the interactions of 18 different mother-infant dyads at each of three infant ages: 3, 6, and 9 months. Mother and infant behaviour was coded and collapsed into phases that included positive (smile, animated, or face play) and neutral states for both interactants. Log-linear models and transitional probabilities of the event sequence of dyadic states were used to investigate the hypothesis that maternal positive expression preceded the onset of infant positive expression. At 3 and 6 months, the mother almost always became positive before the infant. At 9 months, maternal positive expression was still effective at eliciting infant positive expression, but infants were increasingly positive prior to the mother. Infant expression became less dependent on maternal behaviour with age. The role of the infant in face-to-face interactions over the first year has been described as shifting from one of "mere responsiveness to spontaneous, reciprocal communication" (Kaye & Fogel, 1980, p. 463).

Individual Differences

Kaye and Fogel (1980) found no important significant effects of individual differences in any of their analyses and other studies (Keller & Scholmerich, 1987; Lamb et al., 1987) did not test for these effects. Malatesta et al. (1989), however, found a large number of significant correlations between the amounts of emotional behaviour displayed by mothers and infants. They also found that behaviour displayed by a partner at different ages was highly related. Although there may not be qualitative differences in the development of a final level of communicative competence, Schaffer (1984) has suggested that there may be individual differences in the rate at which infants develop this competence. For example, the infant of a more sensitive parent may develop social competence at an earlier age. If differences in rate are subtle, then testing this hypothesis would require more frequent repeated measurements than those employed by Kaye and Fogel (1980). These authors also focused on a very specific sequence of behaviour- infant greeting upon return of gaze towards the mother. More general, less restricted measures of maternal reponsiveness may be equally important and developmentally relevant as indicators of the infant's perception of interactive contingencies. The Kaye and Fogel (1980) study also featured a methodological weakness. Dyadic interactions were videotaped for coding using one camera at a side angle. Facial expressions, and in particular, gaze direction are much more difficult to code from profiles than full-face records.

What is a Contingency?

Applications of contingency analyses to mother-infant interactions in previous research emerged from anologue studies of infants experiencing contingencies in learning paradigms. Evidence from both anologue study and earlier learning research indicates that contingency must be specified according to two independent dimensions. These can be assessed in play interactions to permit further descriptions of social competence and perception of control over an evironmental event or an interactant's behaviour.

Infant Reactions to Response-contingent Stimulation

Infants have been placed in conditions where their behaviour has had the potential to control some aspect of the environment. Watson (Watson & Ramey, 1972; Watson, 1972) used an experimental paradigm where an infant was placed in a crib with its head resting on a pressure-sensitive pillow. The pillow was connected to an overhanging mobile such that each head turn by an infant caused the mobile to rotate for a few seconds. Watson and Ramey (1972) found that 8-week-old infants placed in these conditions for 10 minutes per day for 2 weeks learned to increase their frequency of head movements. Other infants did not increase their head movements when their mobile either did not rotate or rotated in a yoked non-contingent pattern. They concluded that infants could distinguish between response-dependent and response-independent stimulation because they learned to control their environments when given the opportunity (see also Rovee & Rovee, 1969). An unexpected result was that Watson (1972; Watso & Ramey, 1972) also found that the mothers of infants whose mobiles turned contingently reported the emergence of vigorous smiling and cooing to the mobile from the third or fourth day of exposure to the end of the 2 week period. This result was unexpected and only true of infants receiving contingent stimulation. Socio-emotional responses accompanied the contingent mobile turns even though they were not required as part of the instrumental response.

Other researchers have investigated more systematically when infants begin to emit socio-emotional responses to contingent stimulation. Lewis, Sullivan, & Brooks-Gunn (1985; see also Sullivan & Lewis, 1988) investigated the effect of contingent stimulation on fussiness and smiling of infants throughout the first half year of life. Ten infants each of 10, 16, and 24 weeks of age received visual and auditory stimulation contingent upon an arm tug. Ten other infants of each age received yoked non-contingent stimulation. Only 10-week-old infants showed the same rate of arm pulling in the contingent and non-contingent conditions. Infants of 16 and 24 weeks demonstrated learning by having greater rates of arm pulls in the presence of contingent stimulation. Contingency experience also had other effects on behaviour. Infants receiving contingent stimulation fussed less at all ages and smiled more at the latter two ages than yoked controls.

Lewis et al. (1985), like Watson & Ramey (1972), found relatively high levels of positive affect associated with contingent stimulation. These effects were found in Lewis' 16- and 24-week-old infants but not the 10-week-old infants. It should be kept in mind, however, that infants in this study received only one 10 minute exposure to contingency experience. It is possible that Lewis' 10-week-old infants would have shown effects with more exposure to the contingency. For example, it takes 8- (Watson and Ramey, 1972) and 12- (Sullivan, Rovee-Collier, & Tynes, 1979) week-old infants 3-4 days of this type of exposure to develop the ability to discriminate contingent from non-contingent stimulation. It also is difficult to assess how other methodological differences (e.g. home vs laboratory observation; characteristics of the contingent stimulation) may have affected the outcomes of the two studies. They are consistent, however, in that they both point to the relationship between learning a contingency and changes in affective behaviour.

Dimensions of Contingency: Responsiveness and Dependency

The results of these experimental studies can be interpreted as analogues to infants interacting with mothers. There are at least two relevant characteristics, however, which differentiate mobiles and mothers. First, the two stimuli clearly are qualitatively very different and may have very different unconditional effects on the child on this basis alone. Second, the experimental studies utilized a situation where every operant of the infant was followed by a mobile turn, and no mobile turns occurred unless they had been preceded by an infant operant, i.e. the contingency was perfectly 100%. It is highly unlikely, however, that infant signalling behaviour and maternal responses would ever be so highly organized. In any form of play paradigm, it is more likely that infants will sometimes signal and mothers will ignore or fail to perceive the infant signal. Infants would in this case be on a partial schedule of reinforcement where some signals are not followed by a maternal response, that is, maternal responsiveness is less than perfect. A mother can be said to be responsive when the percentage of infant acts followed by mother acts is greater than expected by chance. It is also likely that mothers will sometimes act independent of infant signalling. Infants would in this case be experiencing some degree of response-independent stimulation, that is, maternal dependency is less than perfect. A mother can be said to be dependent when the percentage of mother acts preceded by infant acts is greater than expected by chance. Maternal dependency can also be described as the tendency for a mother to restrict her actions to periods subsequent to infant actions. A free play situation between a mother and infant is characterized to a greater or lesser degree by both maternal responsiveness and dependency. Watson (1979) outlined precisely how these two effects have different impacts on the contingencies experienced by both interactants.

Responsiveness and dependency will be further elaborated in three different ways: as components of a contingency table, as phenomenon whose elements are analogous to those of classical conditioning, and as some function of discrepent base-rates of behaviour. First, responsiveness and dependency can be understood algebraically as different components of a contingency table. For example, Symons and Moran (1987) constructed 2X2 contingency tables from a series of 1-sec interval codes of the change or no change in mother and infant behaviours. Tables cf mother contingent behaviours consisted of the change/ no change of expressive behaviour for infants at time t and mothers at time t+1 (see below).

		Mother t+1	
		1	0
Infant t	1	A	B
	0	C	D

Their calculation of a z score allowed the assessment of the association between infant and subsequent maternal expression. However, also readily available were assessments of maternal responsiveness and dependency. Maternal responsiveness was the percentage of infant acts followed by mother acts, that is, A/A+B (controlled for chance level of occurrences). Maternal dependency was the percentage of mother acts preceded by infant acts, that is, A/A+C (controlled for chance level of occurrences). The conventional chi-square (Symons & Moran, 1987) or log-linear (Cohn & Tronick, 1987) analysis of a 2X2 contingency table assesses the association of behaviour and assessments of responsiveness and dependency require further analyses. At least 3 analyses are required to understand fully the sequential patterns in any one contingency table.

Second, a description of responsiveness and dependency as elements of contingency is consistent with that of Rescorla's (1967) account of the conditions necessary for classical conditioning to occur. In this description, infant signals are analogous to conditioned stimuli (CS) and maternal responses to unconditioned stimuli (US). Schwartz (1978; see also Rovee-Collier, 1986) described how animals in a classical conditioning paradigm do not evaluate CS and US pairings in a vacuum as in laboratory studies but rather against a background of other unpaired presentations of the CS and US. Conditioning occurs when a contingency is perceived- the occurrence of the CS predicts the occurrence of the US with a greater likelihood than the unconditional occurrence of the US. This is analogous to the US being "responsive" to the CS. Infant signals and maternal signals can be described in the same way- an infant may perceive a contingency between its own and its mother's behaviour when its own signals predict maternal signals with a greater likelihood than the unconditional probability of maternal signals. A contingency can be perceived when it is less than 100%, but Watson (1985) has suggested that an individual only perceives contingent control over an event when it is both responsive to <u>and</u> dependent upon an action of the interactant. This is analogous to the US being "dependent" upon the CS. In cases where there are many unpaired US presentations, contingency perception is decreased as dependency decreases.

Third, the unconditional base rates of both maternal and infant signals also are important to their contingent relations. Contingency decreases as a function of an increase in the discrepency between these base rates (Watson, 1979). This can be illustrated in analyses of contingencies in early interactions. Infants must be on some partial schedule of reinforcement when rates of maternal signals are lower than those of infant signals as there are not enough maternal signals to follow each infant signal. For example, there is evidence that mothers suffering from post-partum depression have low positive activity levels (see Cohn, Campbell, Matias, & Hopkins, in press; Field, 1984; Field, Sandberg, Garcia, Vega-Lahr, Goldstein, & Guy, 1985; Grubler-Gochman, 1985) and their infants may be on lean schedules of partial reinforcement. Second, infants must experience some degree of response-independent stimulation when rates of maternal signals are higher than those of infant signals as there are not enough infant signals to precede each maternal signal. For example, there is evidence that mothers of preterm infants have high activity levels (see Brown & Bakeman, 1980; Field, 1977) and their infants may experience unusually high levels of response-independent stimulation. In both of these examples, there would be a decrease in contingent behaviours if activity levels become unusually discrepant (Bettes, 1989; but see Cohn et al., in press). It has been suggested that this should impair interactions and communication in dyads where the infant is immature or the mother is depressed. This provides a model by which contingency analyses can be used to understand the mechanisms of social interactions within various clinical populations.

Empirical Data of Responsiveness and Dependency

Watson (1979, 1985) has reported the results of three studies where he introduced a degree of uncertainty into experimentally controlled contingency environments of infants. Partial schedules of reinforcement were a function of what percentage of infant operants resulted in an environmental event (similar to responsiveness) and response-independent stimulation was a function of how many environmental events per minute were introduced independent of infant operants (opposite to dependency). In this research, the operants were infant leg movements and the environmental events were either a brief presentations of lights and sounds (Watson, 1979) or 2 seconds of action by the video image of a mother's face (Watson, 1985). Contingency learning was defined as a significant increase over baseline of leg movements after exposure to the contingency environment.

The results of Watson's three studies (1979, 1985) were remarkably consistant. Not suprisingly, he found that infants did not display contingency learning when the contingency environment was weakened by low rates of partial reinforcement (eg. only 1 in 10 leg movements was followed by an environmental event) and high rates of response-independent stimulation (eg. 8 environmental events per minute occurred independent of infant leg movements). Other results, however, were not as expected. Infants displayed weak contingency learning when the contingency environment was perfect, that is, every operant was followed by an event and and no events occurred independently. The strongest contingency learning, however, occurred when the contingency environment was less than perfect due to both partial reinforcement (eg. 3 of 4 leg movements were followed by an environmental event) and response-independent stimulation (eg. 6 environmental events per minute occurred independent of infant leg movements). Watson (1985) concluded that 16-week-old infants are less aroused (as displayed by contingency learning) by perfect contingencies than by moderate levels of imperfect contingency. He suggested that imperfect contingencies are a closer approximation of the interpersonal environment of the infant at this age.

Given the limitations of Watson's analogue studies, conclusions can be made concerning only what infants do under certain experimental conditions and not what actually happens in normal play interactions with their mothers. Equally important developmentally to an infant are t his or her ability to learn a contingency at different ages and the contingency environment an infant is exposed to on a day to day basis in interactions with its primary caregiver. Watson (see also Stern, 1985) has therefore made two integral contributuions to the current investigation. First, he has provided a theoretical impetus to the investigation of second-to-second maternal responsiveness as a stochastic process (see for example Cohn & Tronick, 1987; Moran et al., 1987; Symons & Moran, 1987) rather than an absolute one. Secondly, he has suggested contingency experience for the infant is composed of maternal responsiveness as well as maternal dependency.

Only two investigations to date have described responsiveness and dependency as two distinct elements of the contingency environment within early face-to-face play interactions. Symons and Moran (1988) coded "social signals" as an onset of any exagerated positive socioemotional expression (primarily smiles) for mothers and their 14-week-old infants during laboratory-based interactions. Ewy's (1985) coding system included smiles of mothers and their 8-and 12-week-old infants during home-based observations. Sequential analyses of smiling onsets revealed significant levels of both mother and infant responsiveness and dependency in both of these studies. More importantly, however, was the relative strength of measures of responsiveness and dependency. In all three age groups, a mother's smiling onsets were relatively more responsive to than dependent upon infant smiling onsets, and infant smiling onsets were more dependent upon than responsive to mother smiling onsets. That is to say, infant smiles were significantly followed by mother smiles and rarely occurred. There did not appear to be appreciable differences across ages within Ewy's (1985) study, although he did not provide these statistical comparisons. Regardless, these studies have supported the notion that the mother is the "leader" and the infant the "follower" in these early interactions. Measures of responsiveness and dependency can be used to infer respective roles and describe competence within early interactions.

The Present Study

Rationale

Our current understanding of social processes supports the following model of the emergence of the infant as a communicative, interpersonal, social being. Initially, infants must be able to perceive contingency. Lewis and Goldberg (1969), among others, suggested that infants develop the ability to perceive contingencies through the repeated pairing of their own actions and some response of their mother. Infants learn to expect that their actions produce consequences from both their mother and the environment. The fulfillment of their expectencies elicits smiles and may be intrinsically reinforcing. Mothers may initially respond to a high proportion of their infants' actions, but as an infant matures, a mother's responsiveness becomes increasingly imperfect so as to maintain her infant's attention and arousal. Social competence of the infant also may be reflected by changes in their own patterns of contingent behaviour. That is, an infant's increasing social competence may be suggested by a pattern of behaviour that is relatively more responsive to and less dependent upon maternal actions. The first step in the assessment of the validity of this developmental scenario is to provide a detailed description of the contingency environment experienced by infants in early interactions with their mothers.

Three behavioural indices of social competence were used to investigate this model of early social interaction and its role in the development of intentional behaviour. First, unconditional displays of social expressions were examined for evidence of infants becoming more expressive with age. Second, discriminative display of expressions as a function of mutual attention were examined. The assumption here was that interactants who send messages only when those messages can be received are more competent communicators than those who do not make this discrimination. It was expected that both mothers and older infants would selectively reserve their positive expressions for periods of mutual attention. This was operationalized by comparing proportional durations of various expressive behaviours as functions of infant sex, age, and attention across ages with the following expectations: (1) infants would become more expressive (vocalize, smile, and raise their eyebrows) with age; (2) unconditional rates of maternal behaviour would not change across infant ages; (3) mothers would selectively direct positive expressive behaviours towards their attentive infants; and (4) with increasing age infants would selectively direct positive behaviours towards their mothers when attending to them.

Third, moment-to-moment sequencing of behaviours was examined for indices of social competence. The level of behavioural category that was socially meaningful and important to contingency perception was not known. Accordingly, a general and specific type of behaviour was chosen for sequential analyses because they were two possible functional units of behaviour. General expressions were investigated because mothers and infants may behave contingently to a broad class of positive expressions. A specific behaviour, smiling, was investigated because contingent behaviour may have occurred to the single most positive facial expression. It was expected that infant expressive behaviour would be associated with preceding maternal behaviour and vice-versa. Assessments of responsiveness and dependency also were planned to provide more details of the contingencies experienced by each interactant. Mothers were expected to be highly responsive to their infants' expressive behaviours at 8 weeks of age and levels of responsiveness were expected to decrease across age. Mothers were expected to be the leader in the interaction, which would have been reflected by lower levels of dependency relative to responsiveness. Infants were expected to be highly dependent upon the expressive behaviour of their mothers at 8 weeks of age. Across ages, infants were expected to become decreasingly dependent, that is, increasingly independent, as well as increasingly responsive. Infants were expected to be the followers in the interaction, which would have been reflected by higher levels of dependency than responsiveness. Differential predictions were not made for the two different categories of behaviour.

Methodological Considerations

Mother-infant face-to-face play interactions were videotaped when infants were 8, 12, 16, and 20 weeks of age. Research has suggested that this age range spans the period when the face-to-face situation is a useful indicator of mother-infant interactions (e.g., Field, 1977; Fogel, 1977; Kaye and Fogel, 1980; Lamb et al., 1987). Infants younger than 8 weeks of age are probably accustomed to more proximal forms of contact and may fuss or cry before a reasonable session length has been obtained.

Infants older than 20 weeks of age may have become too interested in objects in their environments and more tactile forms of play than the face-to-face situation permits.

Repeated measures were included to increase statistical power and to permit an assessment of individual differences in the interactive development of mother-infant dyads. Individual differences were not expected given past research. Random variability from sources such as states, moods, and levels of preparedness was expected to mask systematic individual differences. Detailed analyses of individual differences within the data were therefore to be reserved for future research and not included in the current presentation.

A limiting factor in any study of this nature is the selection of coded behaviours. Those behaviours that seemed most socially relevant, widely utilized, and representative of expressive behaviours were gaze direction, vocalizations, smiling, and eyebrow movements. The first 3 of these behaviours have been widely used in mother-infant interaction studies and the last of these behaviours has yielded important results in studies of imitation (see Moran et al., 1987) and emotion (particularly "interest" and "surprise" expressions; see Malatesta & Haviland, 1982; Malatesta et al., 1986). Facial behaviours offer the advantages of having the same operational definition for both mothers and infants and being more central to a "face-to-face" interaction than peripheral behaviours such as finger and leg movements.

The time interval between the onsets of interactants' behaviours contributes to whether an action is defined as "contingent". This interval is commonly called the "lag" (see Sackett, 1979). It has been suggested that reinforcement within 1-second maximizes infant learning (Watson & Ramey, 1972) and such a brief interval is required for contingency perception (Bettes, 1989; Bloom, 1979; Malatesta et al., 1989). It has also been shown that a large proportion of contingent behaviour in face-to-face interactions occurs in the first second subsequent to an action by the interactant (e.g. Symons & Moran, 1987). Contingent behaviour decreases across intervals that are longer than 1-second. Contingency analyses in the present study therefore focussed on a 1-second lag and longer intervals were included where indicated.

CHAPTER 2 - METHOD

Subjects

Subjects were 57 mother-infant pairs drawn randomly from the subject pool of the Child Development Centre, University of Western Ontario. This pool consists of mothers approached in the hospital shortly after their infants' births and asked to consent to be contacted at some future date for possible participation in a study. The longitudinal study group consisted of 25 dyads videotaped during each of four university visits when infants were 8, 12, 16, and 20 weeks of age. An additional five dyads initially consented to be in the longitudinal study group, but one dropped out after the first visit due to transportation difficulties, two dropped out after the third visit due to scheduling problems, and two could not be videotaped on one or more of their visits due to infant fussiness. The cross-sectional study groups consisted of 32 dyads videotaped only once when infants were either 12 weeks of age (N=10), 16 weeks of age (N=12), or 20 weeks of age (N=10). An additional two dyads initially consented to be in the cross-sectional study groups, but one at each of the latter two ages could not be videotaped due to infant fussiness. A cross-sectional study group of dyads with infants 8 weeks of age was not necessary to compare for the effects of repeated university visits.

The mean ages and ranges of infants on the day of their university visits within each age group are contained in Table 1. All visits occurred within 11 days of the target ages, with the

Table 1

Descriptive Statistics of Longitudinal (L) and Cross-Sectional (C) Study Groups at Time of University Visit

	8 weeks	12 weeks		16 weeks		20 weeks	
	L	L	C	L	C	L	C
N	25	25	10	25	12	25	10
Age (weeks.days):							
Mean	8.2	12.0	12.2	16.1	16.1	20.0	20.0
Range	7.1- 9.4	11.2- 13.0	11.0- 13.0	15.3- 17.4	15.6- 16.4	19.1- 20.5	19.6- 20.1
Number of Subjects With Episodes of:							
<4 min.	2	1	2	1	2	3	1
4 min.	23	24	8	24	10	22	9
Number of Infants Fed by:							
Breast	23	21	8	20	8	15	8
Formula	7	12	4	16	9	18	4
Pablum	1	4	3	9	5	21	6

Note. The numbers in Feeding are greater than N because some infants are fed in more than one way.

majority of the visits ocurring within three days. Table 1 also contains the distribution of infants that were breast-, formula-, and pablum-fed within each age group. Other descriptive statistics of the samples are contained in Table 2. Sex was balanced as much as possible within each group. Birthweights were all in the normal range and 40% of the mothers were primiparous. All births were full-term by medical definition, that is, greater than 36 weeks gestation. Nine mothers had either scheduled or emergency Caesarian births and seven mothers reported "difficult" vaginal births where the infant was either in distress or required special treatment(s) shortly after birth (e.g. phototreatment for jaundice). No infants, however, required long-term medical intervention or were reported to be in ill-health.

Socioeconomic status of subjects was assessed using the Blishen Scale (Blishen, Carroll, & Moore, 1987). In this scale a number between 17 and 103 is assigned to every occupation title based on an aggregate of income, education level, and a rating of social status. Scores were obtained for both husbands and wives with occupations outside the home, and the higher of these two scores was assigned to a dyad. This scale revealed that subjects in the present study were primarily middle and upper class. Examples of occupations that rate near the mean score of 53 are in nursing, public school teaching, and management. Only nine of 57 families possessed Blishen scores lower than 40 (an arbitrary cutoff for "low SES"), with occupations such as farmhands, musicians, labourers, and cashiers, and these were evenly distributed across groups. Seventy-two percent of the mothers

Table 2

Descriptive Statistics of Study Groups

	Longi-tudinal	Cross Sectional 12 weeks	16 weeks	20 weeks	Total
N	25	10	12	10	57
Sex:					
Male	14	5	7	5	31
Female	11	5	5	5	26
Birthweight (pounds):					
Mean	7.9	7.7	7.9	7.8	7.9
Range	(5.3-10.0)	(5.6-8.9)	(6.3-8.9)	(6.9-9.1)	(5.3-10.0)
Number of Siblings:					
0	7	4	7	5	23
1	15	6	3	3	27
>1	3	0	2	2	7
Birth His'ory:					
Vaginal	16	8	8	8	40
Caesarian	5	1	3	0	9
"Difficult"	4	1	1	1	7
Unknown	0	0	0	1	1
S.E.S.:					
Mean	58	50	47	58	53
Range	(27-101)	(30-78)	(35-67)	(37-101)	(27-101)
Women Work	19	6	9	7	41

Note. S.E.S. is the rounded off Blishen Scale regression score; *Women work* is the number of women who worked outside of the home.

were working outside of the home prior to the birth of their infant. Six mothers in the longitudinal study group had returned to full-time work by the time their infants were 20 weeks of age.

Subject recruitment occurred approximately three weeks prior to the appropriate time for a university visit. A female assistant contacted mothers from the subject pool by telephone and explained the purpose and general procedures of the study. Approximately 65% of those contacted were willing to participate. Participants were sent an information package (see Appendix A) containing a letter of introduction, a reminder of the date of the first appointment, a description of the study, and a map for finding the university. Subsequent university visits of longitudinal subjects were scheduled at the close of the preceding visit. Seven dyads attended university visits but were not included in the study groups for reasons already detailed. Numbers did not permit a statistical comparison of dropouts and the remaining subjects. However, the former relative to the latter tended to have lower Blishen scores and be less likely to have breastfed their babies.

Procedure

Two colour video cameras (Panasonic WV-3060), split screen (Viscount 1107 Programmer) and videotime (Video-Products 436) generators, and a video-recorder (Panasonic NV-8350 VHS) were used to obtain full-face video and auditory records. Sessions took place in a living room-like setting. Cameras were obscured by black curtains, placed in the room corners, and operated by two researchers.

Upon arrival at the University, the procedure was reviewed with the mother and informed consent for participation was obtained (see Appendix B). Mothers were asked to make themselves and their infants comfortable (e.g. feed or diaper as necessary). When infants seemed alert, they were placed on a table-top either in an infant seat or on a change pad directly in front of their mother in a face-to-face position. Mothers were asked to play with their infants in the same manner as they typically would at home for four minutes (precise instructions given to mothers can be found in Appendix A), although they were encouraged to interrupt the session any time their infant became sufficiently distressed. They were also asked not to use infant toys during their interactions. The lengths of videotape segments obtained within each group are contained in Table 1. Infant fussiness and/or drowsiness resulted in play sessions that lasted between 1 1/2 and 4 minutes on 12 occasions. The other 120 visits yielded four minutes of face-to-face play.

Mothers received gifts of infant T-shirts, food coupons, and/or certificates of appreciation. A video-copy of their interactions was also offered upon completion of their involvement in the study. A majority of mothers accepted this offer.

<u>Coding</u>

Mouth movements, eyebrow movements, gaze direction, and sounds were coded independently for each partner of each dyad (see Table 3). Behaviours coded within each of these categories are summarized in Table 4 and the coding instructions can be found in Appendix C. The same codes were used for mothers and

Table 3

Initials of Coders and Behavioural Passes Assigned to Each Coder for Coding and Interobserver Reliability Coding

	Coder		Reliability Coder	
Pass	Mother	Infant	Mother	Infant
Mouth Positions	S.L.	E.S	E.S.	S.L.
Eyebrow Positions	E.S.	D.S.	D.S.	E.S.
Gaze Directions	D.S.	H.A.	H.A.	D.S.
Sounds	H.A.	S.L.	S.L.	H.A.

infants, with the exception of four subcategories of behaviour applicable to infants only (gaze on partner/dull, gaze off partner/dull, non-distress vocalizations, and crying). The coding procedure was designed to minimize the possibility of anything but conservative coding errors. First, eight separate passes were required to code each episode (see Table 3). Passes were conducted by four trained observers such that each observer was responsible for two passes consisting of one maternal behaviour and a different infant behaviour (e.g. the present author was responsible for coding maternal gaze directions and infant eyebrow movements). Second, an observer also coded all of the episodes contained on a videotape (approximately 10) for one of the behaviours before coding the other behaviour on that videotape. Third, the image of one interactant was obscured when coding the behaviour of the other interactant and the audio channel was turned off during all but the vocalization pass. Observers were trained on their respective behaviours for at least 20 hours each on videotaped interactions from earlier studies (e.g. Moran et al., 1987).

Observers viewed a Video Cassette Recorder monitor while sitting at the keyboard of a Zenith Portable Personal Computer. Coding was conducted in real-time using a compiled computer program originally written in IBM-BASIC (see REALTIME; Symons, Acton, & Moran, 1989) that functioned by accessing time in milliseconds from the computer's internal clock whenever a key from the number pad was depressed. The program produced a matrix with one observation per line consisting of: (1) running time since the start of the episode; (2) elapsed time since the last key press; (3) the interactant being coded; (4) the pass number or category of behaviour being coded; and, (5) the sub-category of behaviour. After all passes had been completed an IBM-BASIC program was used to merge the eight matrices into a single data set for each episode ordered sequentially by running time for each episode (TMERGE; Symons et al., 1989).

Reliability

Seventeen four-minute episodes were randomly selected for the assessment of interobserver reliability. These episodes were recoded by the observer who had coded that particular behaviour for the other interactant (see Table 3; for example, the present author was responsible for recoding infant gaze direction and maternal eyebrow movements). A FORTRAN program (RELIABLE; Symons et al., 1989) was used to construct two-by-two tables that contained the time spent agreeing/ disagreeing on each subcategory of behaviour (+/- one-half second). Table cells were summed across subjects, and Kappa statistics (see Cohen, 1968) were calculated to correct for chance levels of agreement.

A listing of behaviours coded and their corresponding Kappa statistics for each interactant are contained in Table 4. Infant wide mouth, mother frown, infant eyes closed, and infant gazing at partner/dull had relatively low kappa values (kappa<.40). These actions were difficult to code, in part because they occurred less than 1% of the time and were not discrete, salient behaviours. Infant eyebrow positions had moderate kappa values (kappa<.60), suggesting there were some difficulties coding these behaviours, likely due to infants' subtle forehead musculature

Table 4

Behaviours Coded and Kappa Interobserver Reliability Estimates of Agreement/ Disagreement With a One-Half Second Window

Pass	Behaviour	Mother	Infant
Mouth Positions:	Smile	.79	.86
	Wide mouth	.88	.26 a
	Frown	.25 a	.72
	Neutral	.77	.73
	Uncodeable	.79	.85
Eyebrow Positions:	Raised	.81	.60
	Lowered	.93	.59
	Neutral	.77	.57
	Uncodeable	.51	.48
Gaze Directions:	On partner/alert	.79	.80
	Off partner/alert	.79	.80
	Closed	.92	.26 a
	On partner/dull	*	.10 a
	Off partner/dull	*	.98
	Uncodeable	*	.97
Sounds:	Non-vocal sounds	.97	*
	Non-distress vocs	.88	.97
	No sounds	.86	.97
	Distress vocs	*	.96
	Crying	*	.91
	Uncodeable	*	*

Note. Asterisks (*) mark low frequency behaviours that were either not coded or recoded in the sample of 4-min interactions. Subscript (a) denotes behaviours with low reliability (kappa<.4).

and the fair-hair colour of the eyebrows. Coding errors contributing to unreliability were unlikely to be biased in such a way as to threaten the validity of the data. Therefore, it was unnecessary to exclude behaviours with low reliability from analyses because this was a conservative error. In other words, it was possible to assess factor effects of behaviours despite low reliability given that the unreliability was random due to the strength of the coding procedures.

Statistical Analyses

The present study contained two types of data and analytic techniques. First, the unconditional occurrence of each act was investigated by submitting measures of the proportional durations to traditional multivariate and univariate techniques. The following questions were addressed: How much expressive behaviour occurs? Does the amount change with age, sex, or attention to the interactive partner? Second, the moment-to-moment relationship of the onsets of behaviours was used to investigate the sequential structure of the interaction. Using log-linear modeling and sequential analytic techniques, the following questions were addressed: Is there an association between the interactant's behaviour? Are mothers responsive to and/or dependert upon their infants' actions and vice-versa? Do these sequential relationships change with age?

Analyses excluded neutral and uncodeable categories of behaviour for both infants and mothers. Infant expressive behaviours for multi- and univariate analyses included smiling, wide mouth, frowning, eyebrow raising, eyebrow lowering, alert gaze on (where indicated), non-vocal sounds, vocal sounds, distress vocalizations, and crying. Mother expressive behaviours for similar analyses were the same except that distress vocalizations and crying were omitted.

Comparing the behaviour of longitudinal and cross-sectional subjects. One intent of the present study was to assess developmental trends in expressive facial behaviours of mothers and their infants during face-to-face interactions. Evidence of changes across visits could alternatively be attributed to effects of repeated university visits themselves. For example, a mother's expressive behaviours may have changed across an infant's age as she became more relaxed interacting in the laboratory-living room setting. This rival hypothesis was addressed by comparing the expressive behaviours of interactants in the longitudinal group to those in the same-age cross-sectional group. Proportional durations were calculated for each expressive behaviour as the total time engaged in that behaviour divided by the total episode length. These were entered into six multivariate analyses of variance (MANOVAs): one at each of the latter three infant ages for both mother and infant expressive behaviours. Each MANOVA had two between-subjects factors of Sex and Group. Significant factor effects were followed by univariate analyses of variance (ANOVA's) for each behaviour for which significant effects were found.

Distribution of infant gaze. Changes in infants' looking behaviour was considered as a function of age. Mean proportional durations for each of the six infant gaze behaviour codes were entered into six repeated measure ANOVA's in the longitudinal group. In the next set of analyses, the infant was defined as attentive to the mother when he/she was alert and his/her gaze was directed at the mother's face (first code of Infant Gaze Direction, Table 4). If the infant's gaze was directed away from the mother's face or if s/he was judged to be in a dull state, the infant was described as "not attentive" (all but the first code of Infant Gaze Direction, Table 4).

Proportional durations of infant expressive behaviours. Variations in infant expressive behaviour as a function of attention to mother, age, and sex were investigated in the longitudinal study group. The proportional durations for the nine expressive behaviours were calculated for each episode both when the infant was attentive and not attentive to the mother. Specifically, the proportional duration of a given behaviour was calculated as the time that an infant engaged in behaviour while attentive to the mother (or not attentive to the mother) divided by the total time the infant was attentive (or not attentive). These measures were entered into a MANOVA with sex as a between-subjects factor and age and attention as within-subjects factors. Significant factor effects were followed by ANOVAs for each behaviour for which significant effects were found. Behaviours on which significant effects were obtained were followed by Tukey's honestly significant difference (HSD) tests of means. The Type I error rate of MANOVAs and ANOVAs were set at $p<.10$ and $p<.05$, respectively.

Proportional durations of maternal expressive behaviours. A set of analyses was undertaken to examine variations in the eight maternal expressive behaviours as a function of infant attention to mother, sex, and age. These analyses were identical to those described in the previous section.

Behaviours selected for sequential analyses. Two behaviour categories were chosen for sequential analysis. The first was a general level of expressive change. General expressions were defined as those expressions selectively directed at the interactive partner during mutual attention. This was based upon other research that has successfully demonstrated responsiveness when behaviour can be any one of a number of mother and infant expressions (Cohn & Tronick, 1987; Kaye & Fogel, 1980; Symons & Moran, 1987). The second set of sequential analyses was conducted between mother and infant smiles as the simplest and most fundamental component of any definition of positive facial display. It was anticipated that smiles would be included in both behavioural definitions for sequential analyses. This would permit direct comparison of the contingencies of broadly and narrowly defined behavioural classifications of positive affect expressions.

Sequential analyses were undertaken for both categories of behaviour where maternal onsets of behaviour followed infant onsets of behaviour and vice-versa. The three types of sequential analyses were used to examine whether one interactant's behaviour was associated to, responsive to, and/or dependent upon the other interactant's behaviour. Each type is detailed below.

Measures of association using log-linear analyses. Log-linear analyses were used to conduct the initial sequential analyses. A description of the techniques of log-linear analyses is therefore in order (for a more detailed discussion, see Allison & Liker, 1982; Bakeman, Adamson, & Strisik, in press; Cohn & Tronick, 1987). Two-by-two contingency tables between an interactant's action at time _t_ (lag 0) behaviour and the subsequent behaviour of the partner at time _t_+1 second (lag 1) can be analyzed by traditional chi-square analyses. The chi-square statistic can be used to assess the interaction between lag 0 and lag 1 behaviours, that is, the association between the two behaviours (e.g. onset/ no onset behaviour of the mother followed by onset/ no onset behaviour of the infant). It is therefore more appropriate to refer to a significant chi-square as an association of behaviour than as responsiveness as has been inferred in prior research (see Symons & Moran, 1987).

In the 2X2 table described above, expected cell values are computed from the row and column totals. A chi-square analysis assumes that cell frequencies reflect the marginal distribution of lag 0 and lag 1 responses only, and thus a significant degree of association leads to a significant chi-square value. In a log-linear analysis, the model is specified to approximate expected cell frequencies. The analogous log-linear analysis would therefore be one where two terms are specified in the design statement: lag 0 and lag 1, and this would yield the same chi-square value. The log-linear design, however, can also be expanded to include three terms: lag 0, lag 1, and a lag 0 by lag 1 interaction. This is called the saturated model as all possible effects are included. In this case, the chi-square value would no longer be significant. To interpret a log-linear analysis, a significant chi-square value means that there are more effects contributing to the approximation of cell values than are included in a design statement. A non-significant chi-square means that a design includes sufficient effects to approximate cell values. In the latter case, effects not incorporated in the design can be assumed to be non-significant.

The advantage of log-linear analyses is for more complex models that include other effects such as autocorrelation, dyadic differences, or age effects (see Allison & Liker, 1982; Bakeman et al., in press). These analyses can be used to test for age effects between time 1 and time 2 by constructing 2X2 tables for data at each age and then entering age and age interaction effects into the log-linear model. When using the logit input format of SPSS-X, the standardized residuals of the saturated model are equal to $\underline{z}$ scores. This allows the direct assessment of the significance of the contribution of each component of the design to the approximation of expected values. The positive or negative value of the $\underline{z}$ score was a function of the input format. Therefore significant effects were either $\underline{z}>1.96$ or $\underline{z}<-1.96$ ($\underline{p}<.05$, two tailed test). Interpretation of the direction and meaning of significant effects are therefore reiterated throughout the text.

Data preparation for log-linear analyses in the present study required the conversion of behaviour streams to sequences of one second time blocks for each interactant noting onset or no onset of an expression. Two-by-two contingency tables were constructed of the onset/ no onset of an interactant's behaviour and the subsequent onset/ no onset of a partner's behaviour in the next one second time block. The initial log-linear analysis included a 2X2 contingency table for each of four ages. This was an unsaturated model with three terms: lag 1, lag 1 by age, and lag 1 by lag 0. The Type I error rate of these analyses was $p<.10$. If the chi-square test was not significant, then the lag 1 by lag 0 by age interaction term was not required to best approximate cell values and no further log-linear analyses were conducted. If the chi-square was significant, then the 3-way interaction term was important. In this latter case, six saturated model log-linear analyses were conducted, one for each of the possible pair-wise comparisons across age. The Type I error rate of these analyses was $p<.05$.

Dyad effects were not included in these analyses because it was felt that there was insufficient data for each dyad at each age to provide stable 2X2 contingency tables (see Sackett, 1979). Collapsing across dyads is always a concern (see Bakeman et al., in press; Moran & Symons, 1988), but seems acceptable as the current investigation is of developmental trends between dyads of different ages rather than a study of individual differences. Autocorrelation effects were not included for two reasons. First, it is likely that autocorrelation is not "factored out" when a person perceives the contingencies between their own behaviour and some other event. Superstitious behaviour is a good example of the coincidental pairing of a person's own behaviour and a spuriously "contingent" event. Second, analyses of similar data (e.g. Cohn & Tronick, 1987; Moran & Symons, 1988; Symons & Moran, 1987) have suggested that the contribution of autocorrelation is small (approximately 5% of the effect).

Measures of responsiveness. Watson (1979, 1985; see also Symons & Moran, 1988) has presented responsiveness as an important component of the contingency environment experienced by each interactant. Maternal responsiveness was assessed as the likelihood that an infant action was followed by a maternal action, which was calculated as the percentage of infant actions followed by maternal actions in time *t*, p(M/It). This observed conditional probability was compared to the expected unconditional probability of a mother acting alone, that is, the probability that a maternal action occurred within time *t* of any randomly selected point in time. Watson (1979) suggested that this parameter be estimated by the negative exponential of the rate of maternal actions, r(M), X the duration of the contingency interval, *t*, where $p(M) = 1 - e^{(-r(M)t)}$ (see also Cox, 1962; McGill, 1963). Contingency Magnitude 1, an assessment of maternal responsiveness is simply the difference between observed and expected probabilities:

$$CM1_t = p(M/It) - (1 - e^{(-r(M)t)})$$

Watson (1979) has argued that CM1 is the most important statistic to characterize responsiveness. However, CM1 can be assessed for statistical significance by dividing CM1 by the standard error of its distribution to produce a *z* score. This can be done according to the formula:

$$Zlt = \frac{p(M/It)-p(M)}{SE}$$

where the standard error of the distribution is calculated according to Allison & Liker (1982):

$$SE = \frac{p(M)\ (1-p(M))\ (1-p(I))}{n(I)}$$

where: $p(M)$ is defined as before;

$p(I)$ is the unconditional probability of an infant action with time _t_ where $p(I) = 1 - e^{(-r(I)t)}$;

$n(I)$ is the total number of infant acts.

In the current study, this assessment of maternal responsiveness was conducted where action was defined as smiles and general expression. Each was calculated at 5 contingency intervals: 0-1, 0-2, 0-3, 0-4, 0-5 seconds, for each of the four ages .

Infant responsiveness was assessed in a parallel set of analyses. The definitions and formula are identical to those above where infant actions replace maternal actions (and _vice-versa_) and I replace M (and _vice-versa_) in all of the above descriptions and formulas.

Measures of dependency. Watson (1979; 1985) has presented dependency as the second important component of the contingency environment experienced by both interactants. He (1979; 1985) has argued that behavioural dependency is an independent measure from behavioural responsiveness. Maternal dependency was assessed as the likelihood that a maternal action was preceded by an infant action, calculated as the percentage of maternal actions preceded by infant actions within time _t_, p(I/tM). This observed conditional probability then was compared to the expected unconditional probability of an infant acting alone, $p(I) = 1 - e^{(-r(I)t)}$ as described previously. Contingency magnitude 2 as an assessment of maternal dependency is merely the difference between observed and expected probabilities:

$$CM2_t = p(I/tM) - (1 - e^{(-r(I)t)})$$

Watson (1979) has argued that CM2 is the important statistic to characterize dependency. However, CM2 can be tested for statistical significance by dividing by the standard error of the distribution according to the formula:

$$Z2t = \frac{p(I/tM) - p(I)}{SE}$$

Where the standard error of the distribution is calculated according to:

$$SE = \frac{p(I)\ (1-p(I))\ (1-p(M))}{n(M)}$$

where: p(M) and p(I) are defined as before; and,
n(M) is the total number of maternal actions.

This assessment of maternal dependency was conducted where action was defined as smiles and general expression. Each was calculated at the same 5 contiguity intervals as materal responsiveness for each of the four ages.

Infant dependency was assessed in a parallel set of analyses. The definitions and formula are identical to those above where infant actions replace maternal actions (and *vice-versa*) and I replace M (and *vice-versa*) in all the above descriptions and formulas.

CHAPTER 3 - RESULTS

Comparing the Behaviours of Longitudinal and Cross-sectional Subjects

Expressive behaviours of longitudinal and cross-sectional dyads were compared to assess the effects of repeated visits to the university. The proportional durations of each of ten infant expressive behaviours including alert gaze on were entered into three MANOVAs, one at each of 12, 16, and 20 weeks of age, with two between-subjects factors, both of two levels: Sex (male vs. female) and Group (longitudinal vs. cross-sectional). The results using Pillai's Trace Criterion (Marascuilo & Levin, 1983) showed that at these ages there were no significant effects of either Sex ($F(10,22)=.991$, n.s.; $F(10,24)=.484$, n.s.; $F(10,22)=.784$, n.s.) or Group ($F(10,22)=.474$, n.s.; $F(10,24)=1.268$, n.s.; $F(10,22)=.544$, n.s.). Repeated university visits had no significant impact on the proportions of total duration of infant expressive behaviours.

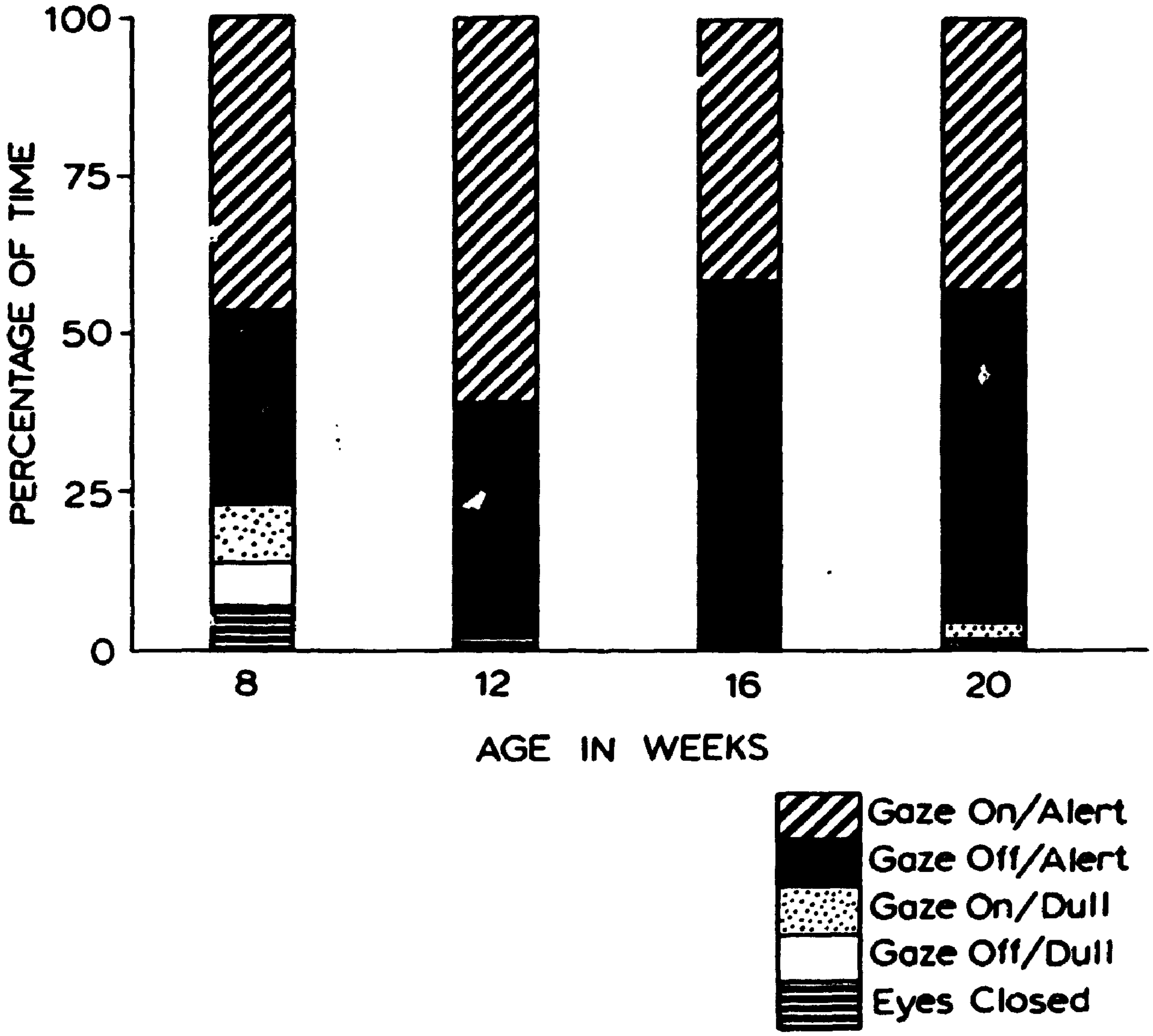
MANOVAs across Sex and Group also were conducted with the proportional durations of eight maternal expressive behaviours. These results showed that at 12, 16, and 20 weeks of age there were no respective effects of Sex ($F(8,24)=1.042$, n.s.; $F(8,26)=.741$, n.s.; $F(8,24)=1.801$, n.s.) and at 12 and 16 weeks of age there were no significant effects of Group ($F(8,24)=.651$, n.s.; $F(8,26)=2.007$, n.s.). At 20 weeks of age, however, there were significant effects of Group ($F(8,24)=3.216$, $p<.05$). Subsequent ANOVAs of each behaviour across group revealed that this effect was attributable to wide mouth ($F(1,31)=5.026$, $p<.05$) and vocalizations ($F(1,31)=4.398$, $p<.05$). Mothers of 20-week-old infants in the cross-sectional group used more wide mouth and non-vocal sounds than those in the longitudinal group. These results were consistant with the impression of coders who felt that mothers of the oldest infants were more animated in the cross-sectional than longitudinal group. Mothers in the latter group may have been relatively less susceptible to perceived experimenter demand (e.g. "performing") by their fourth visit. For the most part, however, the effects of repeated university visits were negligible.

<u>Distribution of Infant Gaze</u>

Repeated measure ANOVAs were conducted for the proportional durations of each of the different infant gaze states (see Table 4) within the longitudinal group. These analyses suggested that age had no effect on any category of gaze (all p's>.05). The mean proportional duration for each gaze state at each age are contained in Figure 1. The percentages of time that infants alertly gazed at their mothers at 8, 12, 16, and 20 weeks of age were 46.1, 60.5, 41.2, and 43.9%, respectively. The time infants were drowsy (eyes closed, gaze off/dull, or gaze on/dull) was nearly 25% at 8 weeks of age and nearly 0% at the latter three ages. This occurred despite the requirement that infants be alert to begin a play session. Conversely, infants showed a non-significant trend to spend more time gazing away from their mothers while alert as their age increased. This was consistant with the impression that infants became relatively less drowsy and more interested in scanning their environments as their age

Figure 1

Histogram of the proportions of total duration longitudinal infants spent in gaze categories at each of the four ages.



100
75
50
25
0
PERCENTAGE OF TIME
8
12
16
20
AGE IN WEEKS
Gaze On/Alert
Gaze Off/Alert
Gaze On/Dull
Gaze Off/Dull
Eyes Closed

increased.

__Proportional Durations of Infant Expressive Behaviours__

The effects of infant sex, age, and attention to mothers on infant expressive behaviours were examined next. Dependent measures were entered as a repeated dimension of the 25 longitudinal dyads into a MANOVA with a between-subjects factor of two levels: Sex (male vs. female); a within-subjects factor of four levels: Age (8, 12, 16, and 20 weeks); and, a within-subjects factor of two levels: Attention (attentive vs. non-attentive). The results of the MANOVA using Pillai's trace criterion (Marascuilo & Levin, 1983) revealed significant effects of Age ($F(27,189)=4.265$, $p<.001$) and Attention ($F(9,15)=9.150$, $p<.001$). There were no significant effects of Sex ($F(9,15)=.805$, n.s.) or interaction effects involving Sex. This factor then was dropped from subsequent analyses.

There were significant within-subject block effects for the repeated dimension of many behaviours: smiling ($F(1,24)=60.32$, $p<.0001$), frowning ($F(1,24)=13.91$, $p<.001$), eyebrow raising ($F(1,24)=26.64$, $p<.0001$), eyebrow lowering ($F(1,24)=18.86$, $p<.001$), vocalizations ($F(1,24)=37.58$, $p<.0001$), and distress vocalizations ($F(1,24)=8.62$, $p<.01$). Thus, there were powerful individual differences in the amount of expressive behaviour exhibited in this paradigm by infants across ages.

ANOVAs were conducted to find which infant expressive behaviours varied systematically across age and attention. The results of these analyses and the mean proportional durations for each condition are given in Table 5. Results of behaviours for which significant main effects were found are illustrated in

Table 5

<u>Proportional Durations of Infant Behaviours as Functions of Age and Infant Attentiveness to Mother</u>

Infant Behaviours	Age in Weeks 8	12	16	20	Significant Main Effects of Age and Atten and the Age X Atten (AXB) Interaction Term
Smiling					Age: $F(2,53) = 3.33$, $p < .05$
Attentive	6.8	12.3	17.1	18.6	Atten: $F(1,24) = 26.03$, $p < .001$
Not Attentive	1.8	6.7	2.3	7.1	AXB: $F(3,64) = 2.18$, n.s.
Wide Mouth $_a$					Age: $F(2,42) = .35$, n.s.
Attentive	.1	.3	.4	.4	Atten: $F(1,24) = 3.99$, n.s.
Not Attentive	.3	.1	.4	.1	AXB: $F(1,34) = .62$, n.s.
Frown					Age: $F(2,51) = .69$, n.s.
Attentive	2.1	1.7	.8	2.5	Atten: $F(1,24) = 15.64$, $p < .001$
Not Attentive	8.2	5.2	1.5	5.9	AXB: $F(1,34) = .62$, n.s.
Eyebrows Raised					Age: $F(2,50) = 6.18$, $p < .005$
Attentive	.3	2.7	3.9	2.1	Atten: $F(1,24) = .92$, n.s.
Not Attentive	.8	1.9	3.1	1.6	AXB: $F(2,52) = .59$, n.s.
Eyebrows Lowered					Age: $F(2,55) = 2.28$, n.s.
Attentive	12.3	6.8	6.2	2.7	Atten: $F(1,24) = 9.64$, $p < .005$
Not Attentive	19.3	9.6	4.9	11.1	AXB: $F(2,54) = 1.72$, n.s.
Non-vocal Sound					Age: $F(1,25) = 1.69$, n.s.
Attentive	0.0	0.1	0.9	0.2	Atten: $F(1,24) = 4.12$, n.s.
Not Attentive	0.0	0.1	0.5	0.0	AXB: $F(2,40) = 1.21$, n.s.
Vocalizations					Age: $F(2,51) = .97$, n.s.
Attentive	5.3	11.5	10.2	5.7	Atten: $F(1,24) = 4.77$, $p < .05$
Not Attentive	4.8	6.7	6.6	5.0	AXB: $F(2,51) = .96$, n.s.
Distress Vocalizations					Age: $F(2,38) = 1.28$, n.s.
Attentive	2.5	0.0	.7	1.0	Atten: $F(1,24) = 8.07$, $p < .01$
Not Attentive	4.8	1.1	.4	3.8	AXB: $F(2,51) = 1.53$, n.s.
Crying					Age: $F(1,28) = .71$, n.s.
Attentive	0.0	0.0	.3	0.0	Atten: $F(1,24) = 2.46$, n.s.
Not Attentive	.7	.3	.1	2.1	AXB: $F(1,28) = .73$, n.s.

<u>Notes</u>. Proportional durations were calculated when infants were alert and looking at their mothers (Attentive) and not alert and/or not looking at them (Not Attentive). Degrees of freedom against which randomized block ANOVAs were tested have been adjusted for possible violations of sphereicity in the variance-covariance matrix and rounded to the nearest whole number. Subscript (a) denotes behaviour with low reliability.

Figure 2. There were significant main effects of Age for infant smiling and eyebrow raising. Visual inspection of the cell means suggested that these effects were due to general increases in these positive expressive behaviours as age increased. However, Tukey's HSD tests of means did not reveal significant differences.

Table 5 also shows significant main effects of Attention for infant smiling, frowning, lowering eyebrows, vocalizing and distress vocalizing. Inspection of the cell means suggested that these effects were due to selectively directing positive behaviours (smiling, vocalizing) towards their mothers and negative behaviours (frowns, lowering eyebrows, distress vocalizing) away from their mothers. Tukey's HSD tests of means did not reveal any significant differences between means across attention.

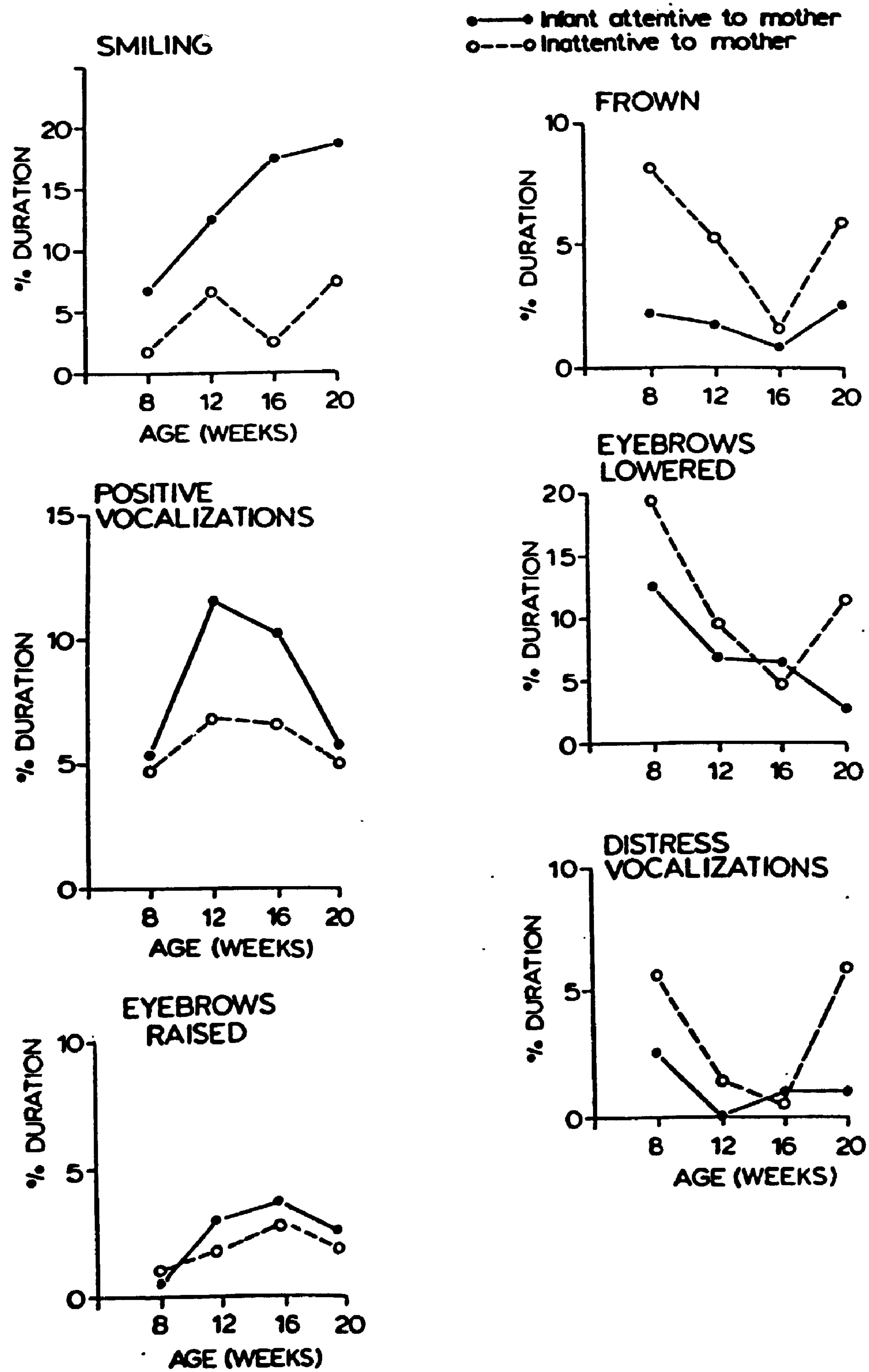
It was hypothesized that as infants socially matured they would increasingly direct their expressive behaviours towards their mothers. For example, it was hypothesized that infants would not selectively reserve their smiling behaviour to periods when they were looking at their mothers at 8 weeks of age, but would do so by 20 weeks of age as they became relatively more socially competent. Statistically, the emergence of infant discriminative abilities would have been represented as an age X attention interaction in relevent behaviours. Table 5 shows that none of these interaction terms were significant.

Proportional Durations of Maternal Expressive Behaviours

The effects on maternal expressive behaviour of infant sex, age, and attention to mothers was investigated in a set of

Figure 2

Mean proportional durations of infant expressive behaviours as a function of infant age and attention. Behaviours shown are those which displayed significant main effects on either or both factor(s). Analyses were of dyads in the longitudinal group.


●——● Infant attentive to mother
o---o Inattentive to mother
SMILING
% DURATION
0
5
10
15
20
8
12
16
20
AGE (WEEKS)
FROWN
% DURATION
0
5
10
8
12
16
20
POSITIVE VOCALIZATIONS
% DURATION
0
5
10
15
8
12
16
20
AGE (WEEKS)
EYEBROWS LOWERED
% DURATION
0
5
10
15
20
8
12
16
20
EYEBROWS RAISED
% DURATION
0
5
10
8
12
16
20
AGE (WEEKS)
DISTRESS VOCALIZATIONS
% DURATION
0
5
10
8
12
16
20
AGE (WEEKS)

analyses parallel to that performed on infant behaviours. Dependent measures consisted of the proportional durations of each of eight maternal expressive behaviours when the infant was attentive and not attentive to the mother. These were entered into a repeated dimension MANOVA of the 25 longitudinal dyads with Sex as a between-subjects factor and Age and Attention as two within-subjects factors. The results of the MANOVA using Pillai's trace criterion (Marascuilo & Levin, 1983) revealed significant effects of Age ($F(24,192)=9.525$, $p<.001$) and Attention ($F(8,16)= 141.806$, $p<.001$). As there was no significant effects of Sex ($F(8,16)=.839$, n.s.) or interactions involving Sex, this factor was dropped from subsequent analyses.

There were significant within-subject block effects for the repeated dimension of all but one maternal behaviour: smiling ($F(1,24)=60.32$, $p<.0001$), wide mouth ($F(1,24)=13.08$, $p<.01$), eyebrow raising ($F(1,24)=30.37$, $p<.0001$), eyebrow lowering ($F(1,24)=12.56$, $p<.01$), gaze on infant ($F(1,24)=97977.91$, $p<.0001$), non-vocal sounds ($F(1,24)=14.88$, $p.001$, and vocalizations ($F(1,24)=1620.70$, $p<.0001$). There was thus powerful individual differences in the amount of expressive behaviours exhibited by mothers across ages.

ANOVAs were conducted to find out which maternal expressive behaviours varied systematically across age and attention. The results of these analyses and the mean proportional durations obtained for each condition are contained in Table 6. Results of behaviours for which significant main effects are found are illustrated in Figure 3. There were significant main effects of Age for maternal vocalizations. The cell means do not suggest

Table 6

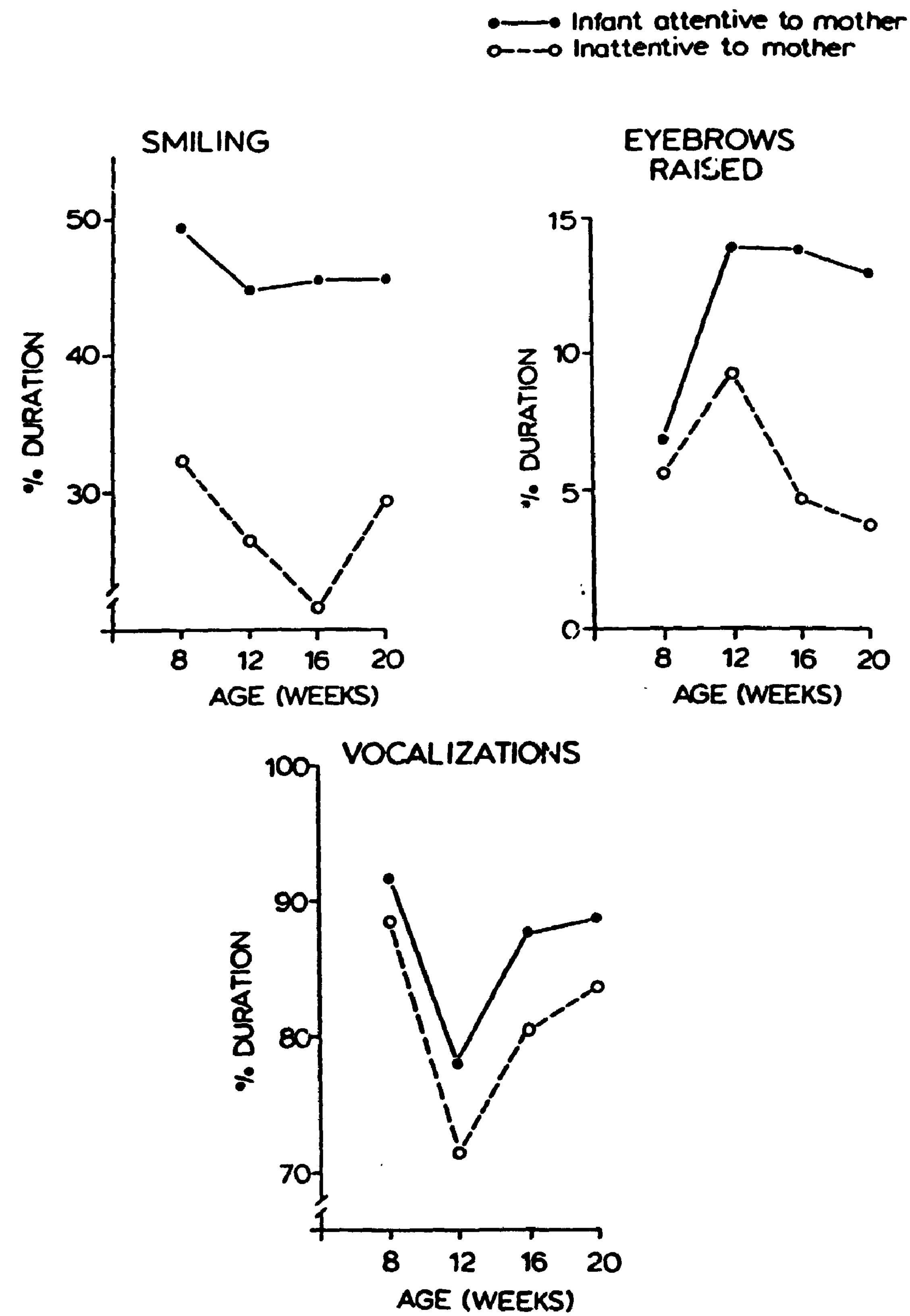
<u>Proportional Durations of Mother Behaviours as Functions of Age (Age) and Infant Attentiveness (Atten) to Mother</u> .

Mother Behaviours	Age in Weeks 8	12	16	20	Significant Main Effects of Age and Atten and the Age X Atten (AXB) Interaction Term
Smiling					Age: F(3,63)= 1.67, n.s.
Attentive	49.2	44.7	45.4	45.4	Atten: F(1,24)=58.39, p<.001
Not Attentive	32.1	26.5	21.8	29.2	AXB: F(3,67)= .88, n.s.
Wide Mouth					Age: F(2,45)= 1.70, n.s.
Attentive	.5	1.9	2.1	2.1	Atten: F(1,24)= 2.91, n.s.
Not Attentive	.3	.4	2.1	.8	AXB: F(2,49)= .78, n.s.
Frown [a]					Age: F(1,33)= 1.43, n.s.
Attentive	0.0	0.0	0.0	0.0	Atten: F(1,24)= 1.18, n.s.
Not Attentive	.1	.1	0.0	.2	AXB: F(1,34)= .28, n.s.
Eyebrows Raised					Age: F(2,48)= 2.40, n.s.
Attentive	6.9	13.9	13.9	13.0	Atten: F(1,24)=17.76, p<.001
Not Attentive	5.6	9.3	4.8	3.8	AXB: F(2,52)= 2.18, n.s.
Eyebrows Lowered					Age: F(2,46)= .25, n.s.
Attentive	.7	1.1	.6	.8	Atten: F(1,24)= .23, n.s.
Not Attentive	.7	.6	.9	.3	AXB: F(2,43)= 1.23, n.s.
Gaze On					Age: F(2,52)= 2.77, n.s.
Attentive	97.9	98.5	96.7	97.7	Atten: F(1,24)= 3.17, n.s.
Not Attentive	97.6	97.8	95.9	96.2	AXB: F(2,60)= .61, n.s.
Non-Vocal Sound					Age: F(2,51)= 1.26, n.s.
Attentive	1.1	2.0	2.4	2.3	Atten: F(1,24)= .10, n.s.
Not Attentive	.7	1.8	2.0	2.9	AXB: F(2,59)= .37, n.s.
Vocalizations					Age: F(1,28)= 4.01, p<.05
Attentive	91.7	78.0	87.8	88.8	Atten: F(1,24)=17.28, p<.001
Not Attentive	88.7	71.6	80.4	83.8	AXB: F(2,41)= .55, n.s.

<u>Notes</u>. Proportional durations were calculated when infants were either alert and looking at the mothers (Attentive) and not alert and/or not looking at them (Not Attentive). Degrees of freedom against which randomized block ANOVAs were tested have been adjusted for possible violations of sphereicity in the variance-covariance matrix rounded to the nearest whole number. Subscript (a) denotes behaviour with low reliability.

Figure 3

Mean proportional durations of mother expressive behaviours as a function of infant age and attention. Behaviours shown are those which displayed significant main effects of attention. Analyses were of dyads in the longitudinal group.



Infant attentive to mother
Inattentive to mother
SMILING
50
40
30
% DURATION
8
12
16
20
AGE (WEEKS)
EYEBROWS RAISED
15
10
5
0
% DURATION
8
12
16
20
AGE (WEEKS)
VOCALIZATIONS
100
90
80
70
% DURATION
8
12
16
20
AGE (WEEKS)

any clear developmental trend, however, as mothers vocalized most when their infants were 8 weeks of age and least when their infants were 12 weeks of age. Tukey's HSD tests of means indicated that these means were not significantly different.

Significant main effects of Attention were found for maternal smiling, raising eyebrows, and vocalizing. The cell means in Table 6 suggested that these effects were due to selectively directing these positive expressive behaviours to an infant that was attentive rather than not attentive. However, Tukey's HSD tests did not reveal any significant differences between means across attention. There were also no significant Age X Attention interactions.

Sequential Analyses of Infant Expressions Following Maternal Expressions

The first set of sequential analyses was designed to investigate whether a broad definition of infant expressions was associated with prior maternal expressions as a function of age. Infant expressions were defined as those selectively directed towards the mothers, that is, infant smiles, alert gaze at mothers, and non-distress vocalizations. Maternal expressions were defined as the onsets of those behaviours directed at an attentive infant, that is, maternal smiles and eyebrow raises. For the respective partners, an expression onset was defined as an onset of any one of their respective behaviours. The log-linear approach was used to address two central questions: Is there significant association between infant expressions and prior maternal expressions? And is the degree of association different for infants of different ages?

The first step in these analyses was to construct 2X2 contingency tables for maternal expression/ no expression in 1-sec intervals followed by infant expression/ no expression in the next interval. This data was summed across longitudinal and cross-sectional subjects within each age group and can be found in Table 7.

The first design statement in the log-linear analysis across all four levels of age contained three terms: BABY1, BABY1 by AGE, and BABY1 by MOMO. This design produced a significant Pearson Chi-square ($X^2(3)=11.055$, $p<.01$), indicating that the BABY1 by MOMO by AGE interaction term was required to best approximate the observed probabilities of contingency table cell values. To assess at what ages there was a significant difference in the degree of association between maternal and subsequent infant expressive behaviour, saturated model log-linear analyses were conducted at each of six possible age pairings. The standardized residuals from each of these analyses are contained in Table 8. In all analyses the BABY1 effects showed that an infant was far less likely to be expressive than not expressive and the BABY1 by MOMO effects showed infants were responsive at a general level of expressive behaviour. The BABY1 by AGE effects suggested that the probability of infant expressive behaviour onsets significantly increased over the first three ages in the following pattern: 8 weeks < 12 weeks < 16 weeks = 20 weeks. The BABY1 by MOMO by AGE effects suggested that infant responsiveness was significantly greater at 20 weeks than 12 weeks of age.

Table 7

Contingency Tables at Four Ages of Maternal Expression Onsets and Subsequent Infant Expression Onsets 1-sec Later

Mother Lag 0	Infant Lag 1: Expression	Infant Lag 1: No Expression	Totals
8 Weeks			
Expression	62	437	499
No Expression	460	4803	5263
Totals	522	5240	5762
12 Weeks			
Expression	100	655	755
No Expression	817	6371	7188
Totals	917	7026	7943
16 Weeks			
Expression	146	672	818
No Expression	936	6818	7750
Totals	1082	7486	8568
20 Weeks			
Expression	137	593	730
No Expression	769	6551	7320
Totals	906	7144	8050

Note. Contingency tables of 1-sec intervals are summed across longitudinal and cross-sectional subjects within each age group. Maternal expression consists of any onset of smile or eyebrow raise. Infant expression consists of any onset of smile, gaze at mother, or non-distress vocalization.

Table 8

Z Scores to Assess Age Differences in the Association Between Maternal Expressive Behaviour and Infant Expressive Behaviour 1-sec Later

Comparison Age (weeks)		12	16	20
8	BABY1	-44.89***	-44.89***	-44.79***
	BABY1 by MOMO	3.15***	4.95***	6.12***
	BABY1 by AGE	-1.98**	-4.50***	-3.89***
	BABY1 by MOMO by AGE	1 20	-.36	-1.59
12	BABY1		-49.71***	-49.38***
	BABY1 by MOMO		4.27***	5.62***
	BABY1 by AGE		-2.80***	-2.13**
	BABY1 by MOMO by AGE		-1.89	-3.29***
16	BABY1			-50.38***
	BABY1 by MOMO			8.08***
	BABY1 by AGE			.67
	BABY1 by MOMO by AGE			-1.54

Note. BABY1 is the infant lag 1 expressive behaviour, MOMO is mother lag 0 expressive behaviour, and AGE is the infant's age group. Numbers represent adjusted residuals, or z scores, from saturated model log-linear analyses across the two designated ages. Significance levels of z are designated by asterisks: *** p<.001, ** p<.05.

Infant responsiveness and dependency were calculated at a one second window at each age and are contained in Figure 4. Measures of infant responsiveness at all ages and dependency at the 8- and 20-week-ages were significantly above chance (z's>1.96). There was a trend for infant responsiveness measures to be higher than infant dependency measures and increase across the four ages. This may indicate that infants became more responsive in this broad definition of expressiveness as they got older. Increasing the lag had the general effect of reducing contingency magnitude measures. In summary, infant expression onsets were responsive to maternal smiling onsets at all ages and dependent at 8 and 20 weeks of age.

Sequential Analyses of Infant Smiles Following Maternal Smiles

The second set of sequential analyses was designed to investigate whether infant smiling was associated with prior maternal smiling. The log-linear approach was used to address two central questions: Is there significant association between infant smiling and prior infant smiling? And is the degree of association different for infants of different ages? Data preparation for these analyses involved the construction of 2X2 contingency tables for either the presence or absence of onsets of maternal smiling in a 1-sec intervals and infant smiling in the subsequent interval. Data was summed across longitudinal and cross-sectional subjects within each age group and is contained in Table 9.

Terms used in the log-linear analyses and their interpretations were as follows. BABY1 referred to the main effect of baby smiling vs. not smiling. BABY1 by AGE referred to

Figure 4

Contingency magnitude measures of infant responsiveness and dependency of expression onset behaviour at a 1-second interval across four ages. Measures not significantly different from chance ($p > .05$) according to Allison and Liker's (1982) z score formula are marked n.s..

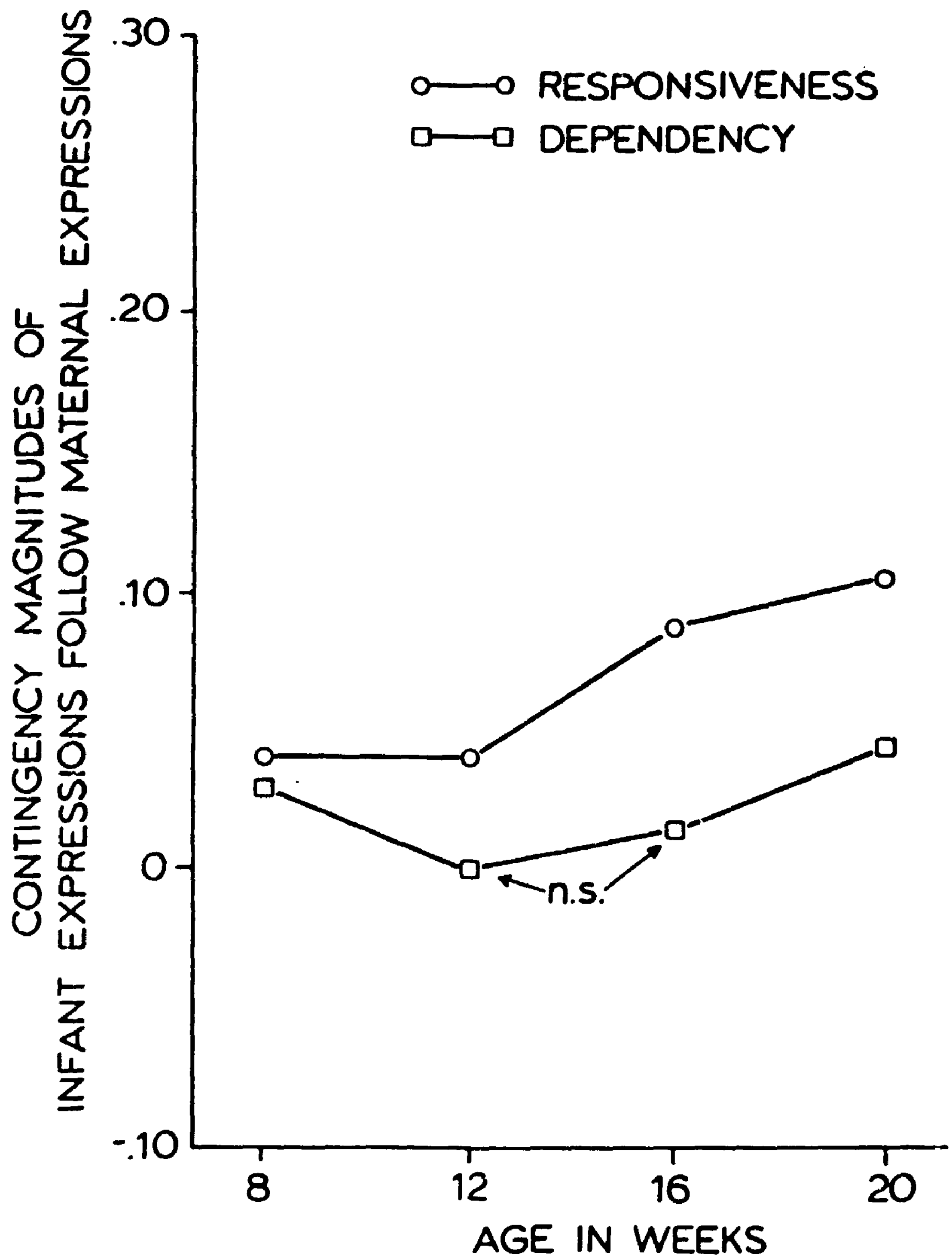

CONTINGENCY MAGNITUDES OF
INFANT EXPRESSIONS FOLLOW MATERNAL EXPRESSIONS
.30
.20
.10
0
-.10
RESPONSIVENESS
DEPENDENCY
n.s.
8
12
16
20
AGE IN WEEKS

Table 9

Contingency Tables at Four Ages of Mother Smile Onsets and Subsequent Infant Smile Onsets 1-sec Later

Mother Lag 0	Infant Lag 1: Smile	Infant Lag 1: No smile	Totals
8 Weeks			
Smile	16	337	353
No Smile	79	5330	5409
Totals	95	5667	5762
12 Weeks			
Smile	33	503	536
No Smile	138	7269	7407
Totals	171	7772	7943
16 Weeks			
Smile	39	564	603
No Smile	126	7839	7965
Totals	165	8403	8568
20 Weeks			
Smile	38	510	548
No Smile	140	7362	7504
Totals	178	7872	8050

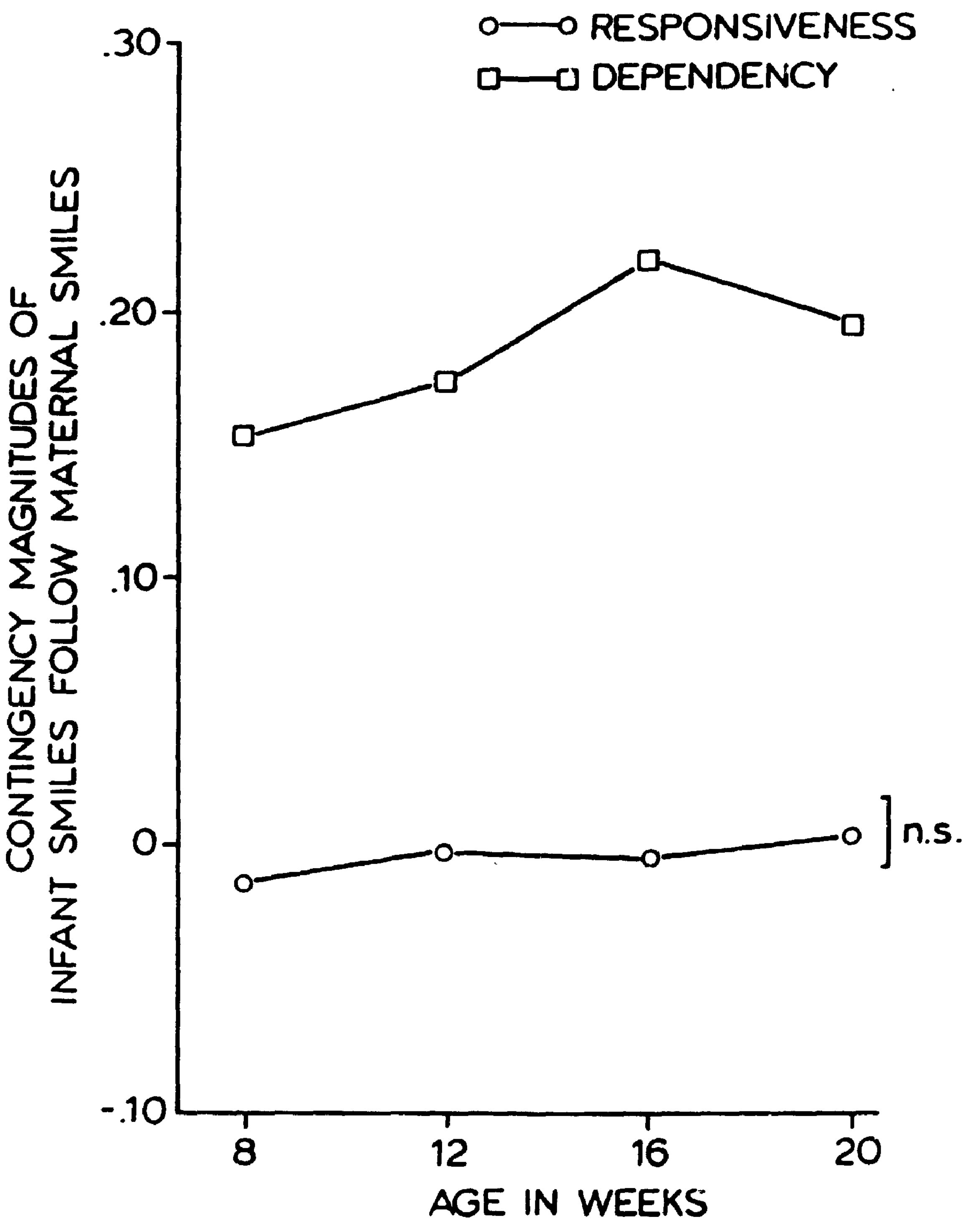
Note. Contingency tables of 1-sec intervals are summed across longitudinal and cross-sectional subjects within each age group.

an effect of infant age on the probability of infant smiling onset. BABY1 by MOMO referred to infant responsiveness, that is, the interaction of maternal smiling behaviour with subsequent infant smiling behaviour. BABY1 by MOMO by AGE refers to the three way interaction of mother smiling behaviour, subsequent infant behaviour, and infant age, thus addressing the impact of age on this assay of infant responsiveness. Two design statements were included in the log-linear analyses across all four levels of age, the first unsaturated design with three terms BABY1, BABY1 by AGE, and BABY1 by MOMO, and the second saturated design with these three terms and the 3-way interaction term. The first design revealed a non-significant Pearson Chi-square (X^2 (3)=4.319, p=.224), suggesting that the 3-way interaction term was not necessary to approximate the expected probabilities of the cells of the 2X2 contingency tables. Investigation of the standardized residuals of design suggested that there were significant effects of BABY1 (z=-63.987, p<.001), indicating that baby smiling onsets were less likely to occur than no smiling onset. A significant BABY1 by MOMO term (z=12.016, p<.001) indicated an association between maternal smile onsets and subsequent infant smile onsets. A significant BABY1 by AGE term (z=-2.752, p<.001) suggested that the probability of infant smiling onsets increased with age. The absence of a 3-way interaction term meant that pairwise comparisons between age groups was unnecessary.

Infant responsiveness and dependency were assessed. Figure 5 contains measures of infant responsiveness and dependency at a 1 second window for each of 4 ages. All measures

Figure 5

Contingency magnitude measures of infant responsiveness and dependency of smile onset behaviour at a 1-second interval across four ages. Measures not significantly different from chance ($p > .05$) according to Allison and Liker's (1982) z score formula are marked n.s..


RESPONSIVENESS
DEPENDENCY
CONTINGENCY MAGNITUDES OF INFANT SMILES FOLLOW MATERNAL SMILES
.30
.20
.10
0
-.10
n.s.
8
12
16
20
AGE IN WEEKS

were assessed for significance by dividing by the appropriate standard error to obtain a z statistic. Only measures of infant dependency were significant (all z's>1.96). Infant dependency measures were greater than infant responsiveness and there were tendencies for measures of the latter to increase across lags and ages. In summary, infant smiling onsets were dependent upon rather than responsive to maternal smiling onsets.

Sequential Analyses of Mother Expressions Follow g Infant Expressions

The third set of sequential analyses was designed to investigate whether broadly defined maternal expressions were associated with prior infant expressions and whether this association changed with infant age. Expressions were defined as in the first set of sequential analyses. The log-linear approach was used to address two central questions: Is there significant association between maternal expressions and prior infant expressions? And is the degree of association a function of infant age?

The first step was to construct 2X2 contingency tables for infant expression/ no expression in 1-sec intervals followed by maternal expression/ no expression in the next interval. This data was summed across longitudinal and cross-sectional subjects within each age group and can be found in Table 10.

The first design statement in the log-linear analysis across all four levels of age contained three terms: MOM1, MOM1 by AGE, and MOM1 by BABY0. This design produced a significant Pearson Chi-square ($X^2(3)=6.368$, $p<.10$), indicating that the BABY1 by MOM0 by AGE interaction term was required to best approximate the

Table 10

Contingency Tables at Four Ages of Infant Expression Onsets and Subsequent Maternal Expression Onsets 1-sec Later

Infant Lag 0	Mother Lag 1: Expression	Mother Lag 1: No Expression	Totals
8 Weeks			
Expression	64	458	522
No Expression	435	4805	5240
Totals	499	5263	5762
12 Weeks			
Expression	132	820	917
No Expression	658	6368	7026
Totals	755	7188	7943
16 Weeks			
Expression	160	922	1082
No Expression	658	6828	7486
Totals	818	7750	8568
20 Weeks			
Expression	146	760	906
No Expression	584	6560	7144
Totals	730	7320	8050

Note. Contingency tables of 1-sec intervals are summed across longitudinal and cross-sectional subjects within each age group. Maternal expression consists of any onset of smile or eyebrow raise. Infant expression consists of any onset of smile, gaze at mother, or non-distress vocalization.

observed probabilities of contingency table cell values. To assess at what ages there were significant differences in this assay of maternal responsiveness, saturated model log-linear analyses were conducted at each of six possible age pairings. The standardized residuals, or z scores, from each of these analyses are contained in Table 11. In all analyses the MOM1 effects showed that a mother was far less likely to be expressive than not expressive and the MOM1 by BABYO effects showed that infant expressive onsets and subsequent maternal expressive onsets were highly associated. The MOM1 by AGE effects were not significant suggesting that the rate of onset of maternal expressions did not vary with infant age. The MOM1 by BABYO by AGE effects suggested that the association between infant and subsequent maternal expressive behaviour was significantly greater at 20 weeks than 12 weeks of age. There was therefore a tendency for infant expressions and subsequent maternal expressions to become more associated across the four ages.

Maternal responsiveness and dependency were calculated according to Watson's CM1 and CM2 measures. These two measures are depicted in Figure 6 at a 1 second window for each of the four ages. In this assay, all measures of maternal dependency and responsiveness were significantly above chance (all z's >1.96). There were trends for maternal dependency to exceed responsiveness and increase across age. There was also a trend for maternal responsiveness to increase between 16 and 20 weeks of age. Increasing the lag had the general effect of reducing contingency magnitude measures. In summary, mother expression onsets were stochastically both dependent upon and responsive to

Table 11

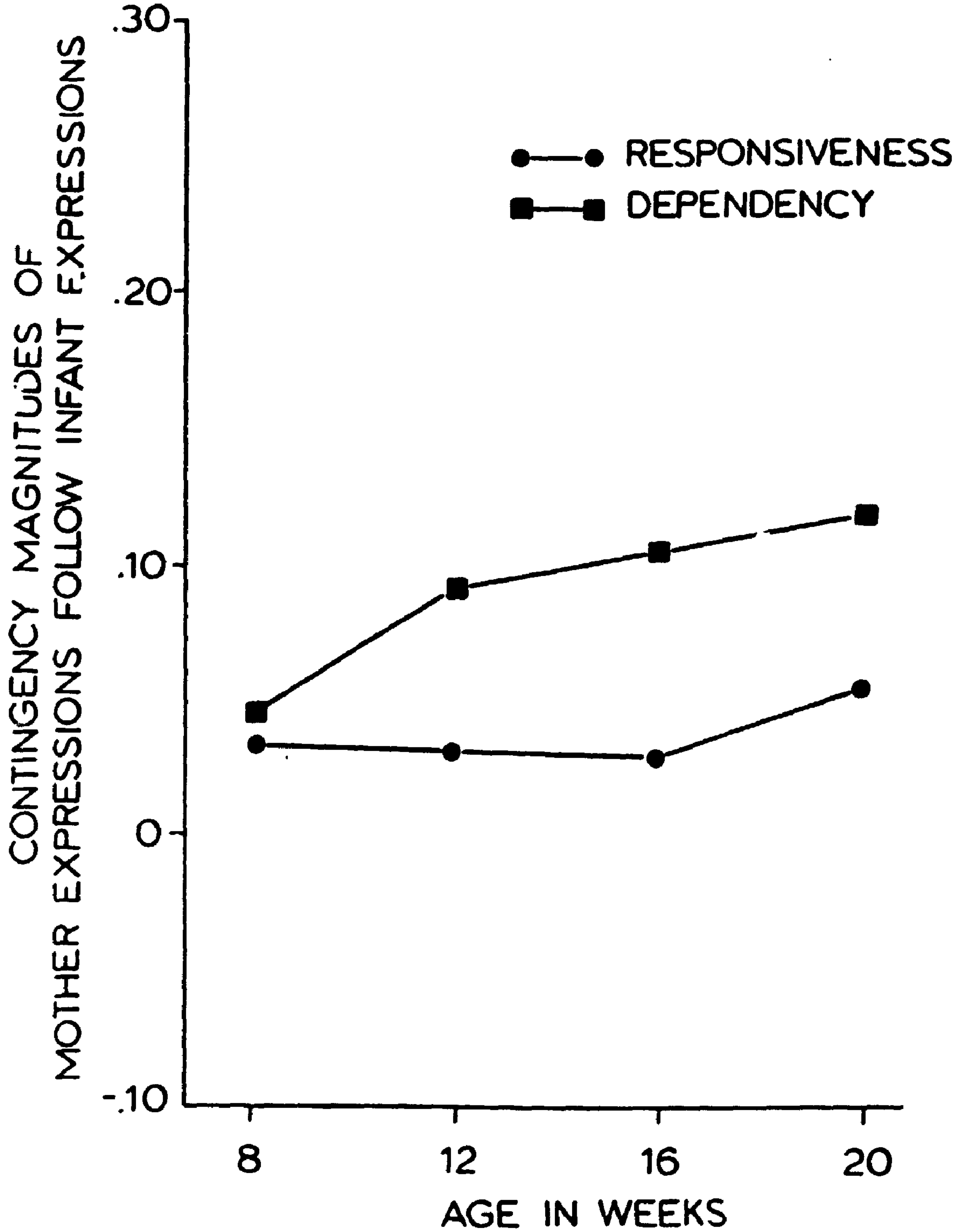
Z Scores to Assess Age Differences in the Association Between Infant Expressive Behaviour and Maternal Expressive Behaviour 1-sec Later

Comparison Age (weeks)		12	16	20
8	MOM1	-48.30***	-49.48***	-48.50***
	MOM1 by BABY0	5.06***	6.03***	6.97***
	MOM1 by AGE	-1.54	-1.61	-1.71
	MOM1 by BABY0 by AGE	-.03	-.88	-1.91
12	MOM1		-58.70***	-57.05***
	MOM1 by BABY0		7.43***	8.51***
	MOM1 by AGE		-.03	-.19
	MOM1 by BABY0 by AGE		-1.04	-2.27**
16	MOM1			-59.17***
	MOM1 by BABY0			9.88***
	MOM1 by AGE			-.16
	MOM1 by BABY0 by AGE			-1.31

Note. MOM1 is mother lag 1 expressive behaviour, BABY0 is infant lag 0 expressive behaviour, and AGE is the infant's age group. Numbers represent adjusted residuals, or z scores, from saturated model log-linear analyses across the two designated ages. Significance levels of z are designated by asterisks: *** $p<.001$, ** $p<.05$.

Figure 6

Contingency magnitude measures of maternal responsiveness and dependency of expression onset behaviour at a 1-second interval across four ages. All measures were significantly different from chance ($p > .05$) according to Allison and Liker's (1982) z score formula.


.30
.20
.10
0
-.10
CONTINGENCY MAGNITUDES OF
MOTHER EXPRESSIONS FOLLOW INFANT EXPRESSIONS
RESPONSIVENESS
DEPENDENCY
8
12
16
20
AGE IN WEEKS

infant expression onsets, with the former being higher than the latter.

Sequential Analyses of Mother Smiles Following Infant Smiles

The fourth set of sequential analyses was designed to investigate whether maternal smiling was associated with prior infant smiling. The log-linear approach was used to address two central questions: Is there a significant association between maternal smiling and prior infant smiling? And is the degree of association different for mothers of infants of different ages? Data preparation for these analyses involved the construction of 2X2 contingency tables for either the presence or absence of onsets of infant smiling in 1-sec intervals and maternal smiling in the subsequent intervals. Data was summed across longitudinal and cross-sectional subjects within each age group and is contained in Table 12.

Terms used in the log-linear analyses and their interpretation were as follows. MOM1 referred to the main effect of maternal smiling onset vs. no smiling onset. MOM1 by AGE referred to an effect of infant age on the probability of maternal smiling onset. MOM1 by BABYO referred to maternal responsiveness, that is, the interaction of infant smiling behaviour with subsequent maternal smiling behaviour. MOM1 by BABYO by AGE refers to the three way interaction of infant smiling behaviour, subsequent maternal behaviour, and infant age, thus addressing the impact of age on this assay of sequential relation. Two design statements were included in the log-linear analyses across all four levels of age. The first design was an unsaturated model with three terms MOM1, MOM1 by AGE, and MOM1 by

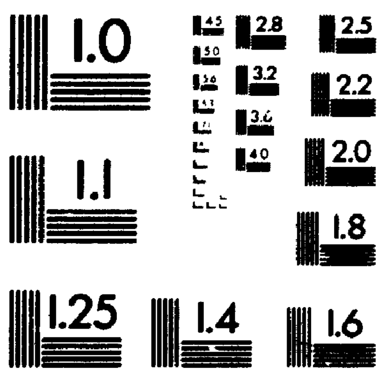
Table 12

Contingency Tables at Four Ages of Infant Smile Onsets and Subsequent Maternal Smile Onsets 1-sec Later

Infant Lag 0	Mother Lag 1: Smile	Mother Lag 1: No smile	Totals
8 Weeks			
Smile	12	83	95
No Smile	341	5326	5667
Totals	353	5409	5762
12 Weeks			
Smile	33	138	171
No Smile	503	7269	7772
Totals	536	7407	7943
16 Weeks			
Smile	37	128	165
No Smile	566	7837	8403
Totals	603	7965	8568
20 Weeks			
Smile	43	135	178
No Smile	505	7367	7872
Totals	548	7502	8050

Note. Contingency tables of 1-sec intervals are summed across longitudinal and cross-sectional subjects within each age group.

2 of/de 2



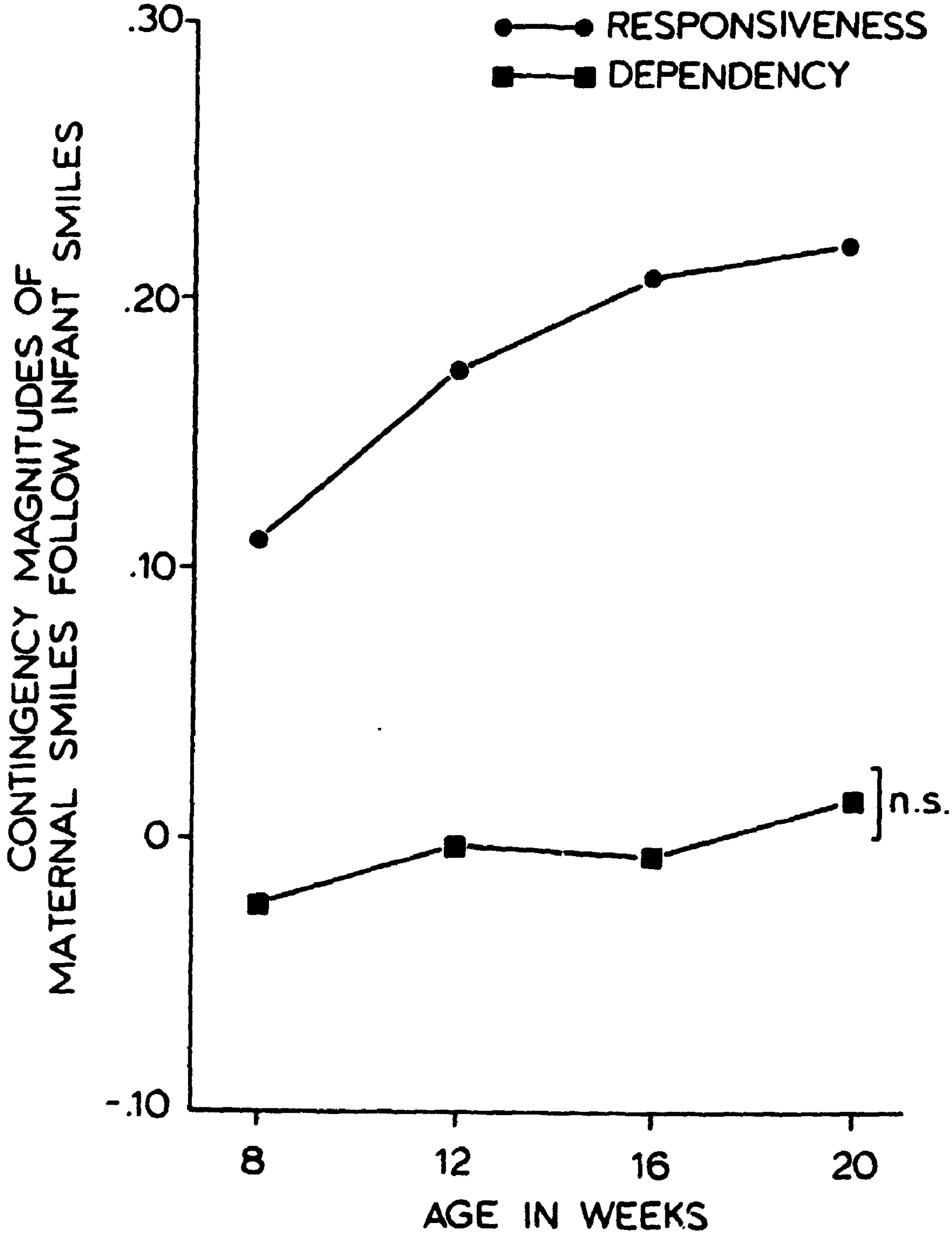
BABY0. The second design was a saturated model including all possible effects with these three terms and the 3-way interaction term.

The first design revealed a non-significant Pearson Chi-square ($X^2(3)=4.361$, $p=.225$), suggesting that the 3-way interaction term was not necessary to approximate the expected probabilities of the cells of the 2X2 contingency tables. Investigation of the standardized residuals of the design suggested that there were significant effects of MOM1 ($z=-39.055$, $p<.001$), indicating that mother smiling onsets were less likely to occur than no smiling onset. A significant MOM1 by BABY0 term ($z=12.792$, $p<.001$) indicated an association between infant smile onsets and subsequent maternal smile onsets. The MOM1 by AGE term ($z=-1.848$, n.s.) suggested that there were no effects of age on the probability of maternal smiling onsets. The absence of a 3-way interaction term meant that pairwise comparisons between age groups was unnecessary.

Maternal responsiveness and dependency were calculated according to Watson (1979, 1985). Figure 7 contains contingency magnitude measures of maternal responsiveness and dependency at a 1 second window for each of four ages. All measures were assessed for significance against chance levels by dividing by the appropriate standard error term to obtain a *z* score. Measures of maternal responsiveness were significantly above chance (all *z*'s>1.96). The measures of maternal dependency were non-significant at all ages. Maternal responsiveness measures were greater than maternal dependency, and both measures displayed trends to increase across age. Increasing the time

Figure 7

Contingency magnitude measures of maternal responsiveness and dependency of smiling onset behaviour at a 1-second interval across four ages. Measures not significantly different from chance ($p > .05$) according to Allison and Liker's (1982) z score formula are marked n.s..


RESPONSIVENESS
DEPENDENCY
CONTINGENCY MAGNITUDES OF MATERNAL SMILES FOLLOW INFANT SMILES
.30
.20
.10
0
-.10
n.s.
8
12
16
20
AGE IN WEEKS

window that defined a contingent act also had a tendency to increase measures of responsiveness and decrease measures of dependency. In summary, mother smiling onsets were responsive to rather than dependent upon infant smiling onsets.

CHAPTER 4 - DISCUSSION

The present study demonstrated emerging infant social competence by investigating the fine details of expressive behaviours in early mother-infant interactions. Social competence was defined as infants becoming more expressive, demonstrating social discrimination, and behaving contingently to their mother's behaviours. The present study also explored what is meant by the term "contingency". A common way to define contingency is the association of two coded behaviours in a contingency table. Responsiveness and dependency were described as two independent components of the contingency environment experienced by each interactant. Multiple measures of contingency provided further information of early behavioural dynamics and infant social competence, and conditions necessary for the perception of control over a partner's behaviours.

Infants Become More Competent in Early Interactions

It was hypothesized that infants would display more positive expressions with age as a result of developing communication skills. Consistent with this hypothesis, the infants' growing social competence was reflected by increased proportions of total durations of smiles and eyebrow raises from 8 to 20 weeks of age. Both of these behaviours have been associated with expressions of positive affect (Malatesta & Haviland, 1982; Malatesta et al., 1986). This supports Lamb et al.'s (1987) contention that this period is optimal for face-to-face interaction. Interactions are very likely to take on different forms after 5 months of age.

Mothers of 5-month-old infants reported they rarely interacted in this way anymore and preferred more tactile forms of play or play involving objects. It is difficult to know if behavioural change within the face-to-face paradigm across a wide age range (e.g. 3 to 9 months of age in Cohn & Tronick, 1987) reflects developmental differences or a change in interactive context.

It was also expected that an infant would display expressions selectively as a function of attention to the mother with increasing age. This hypothesis built upon Kaye's (1982; Kaye & Fogel, 1980) suggestion that an effective communicator reserves its signals for periods of mutual attention. Mutual attention in interactions of the present study resulted from infant attentive gaze towards their mothers, as mothers were almost always attentive to their infants. Consistent with this social discrimination hypothesis, infants displayed more positive expressions when attending than when not attending to their mothers. Specifically, they selectively directed smiles and positive vocalizations towards their mothers, which replicated the results of Kaye and Fogel (1980). However, there was no age effect in social discrimination ability in the present study.

Social discrimination was not displayed by the 6-week-old infants in Kaye and Fogel's (1980) study but was displayed by infants of all ages in the current study. A possible explanation for this finding is that this type of social competence may emerge between 6 and 8 weeks of age. Alternatively, this discrepency may reflect methodological differences between the two studies. Kaye and Fogel (1980) coded facial behaviour from a single side-view camera angle compared to the full-face angle for each partner in the present study. The latter technique may permit finer coding decisions than the former, which in turn may have been reflected in a more accurate assessment of infant attentiveness (see also Symons & Moran, 1987). Finally, this difference may reflect a floor effect in that there is so little expressive behaviour at 6 weeks of age it is difficult to find a statistically significant difference, even though the direction of the effects is the same (see Kaye & Fogel, 1980). This final explanation supports the possibility that positive expressions are used in the proper social context when they first emerge. This descriptive finding, however, does not mean that infants alone are responsible for this phenomenon. Mothers may be equally responsible for the appearance of this infant social competence by framing infant gaze and expressive behaviour with expressive behaviour of their own (Cohn & Tronick, 1987; Fogel & Thelen, 1987).

Additional evidence that infants displayed social discrimination was that they displayed more negative expressive behaviours when not attending than attending to their mothers. At all ages, infants selectively directed frowns, distress vocalizations, and crying away from their mothers. This was consistent with Keller and Scholmerich's (1987) finding that negative vocalizations were directed away from mothers at 10 but not at 6 weeks of age. This suggested that the emergence of social discrimination of negative behaviour may occur just prior to 8 weeks of age. The function of distress behaviour must also be considered. Infants may have directed negative vocalizations away from their mothers because head turns were associated with infant fussing, gaze aversion, or arousal during distress. Kopp (1989) has described how infants can use gaze aversion to modulate arousal (see also Brazelton et al., 1974), and this assumes motor development sufficient to permit voluntary activation and modulation of head rotation. An alternative explanation is that crying and distress usually occurred at the end of the four minute episode and may have represented habituation to the mother's behaviours or attempts to get out of the infant seat. Regardless of cause, however, this is further evidence of infant discrimination within the social environment.

The third definition of infant social competence was an infant's display of expressive behaviours contingent upon those of the mother. The expressive behaviour of infants was associated to preceding mother behaviour at all ages. This result was true for both a broad-based and narrow definitions of infant and mother expressions. There was little evidence of systematic developmental change in this type of social competence with the exception of infants behaving more contingently to broadly defined expressions at 20 than 12 weeks of age. This finding was consistent with the hypothesis of increasing infant contingent behaviour across age.

The findings of infant contingent behaviour were certainly not new to the literature (e.g. Cohn & Tronick, 1987; Cohn & Elmore, 1988; Kaye & Fogel, 1980; Malatesta & Haviland, 1982; Moran et al., 1987; Symons & Moran, 1987), but impressive in being the first demonstration of infant responsiveness in 8-week-old infants. As before, however, this ability cannot be attributed to either partner in a descriptive study of this nature. Infant responsiveness can be enhanced when mothers organize their behaviours around infant behaviours. Infant contingent behaviour can be explained by a mother who is sensitive, anticipates her infant's expressions, and acts before they occur. For example, if a mother anticipates that her infant is about to smile based upon subtle cues of attention and motor activity, she could smile prior to her infant and therefore structure an infant contingent response. This would only be possible for infants whose behaviours were readable and predictable by the mother (Goldberg, 1978). Otherwise, an infant's expressions would arise suddenly and spontaneously and a mother could not have begun appropriate behaviour prior to their display. Infant responsiveness can also be enhanced by an infant that can respond to his or her mother. This is similar to asking whether mother expressions are effective at eliciting infant expressions. However, whether such responses reflect conditional associations and reflexive behaviour or are accompanied by communicative intent is a completely different research question (Lamb et al., 1987; Lamb & Malkin, 1986). In other words, it is unknown whether an infant's smile in response to a mother smile is intended by the infant to mean anything to her. To further complicate this issue, mothers often respond to infant signals as though they had communicative intent. For example, a mother will respond to truely random infant behaviours such as burps and sneezes as though infants are sending them a message or "telling them a story". Mothers are one step ahead of infants in putting meaning into early interactions.

Mother Behaviours

Similar analyses of maternal behaviours were conducted to describe how the senior, and presumably expert, partner of the interaction behaved. Mothers displayed similar amounts of expressive behaviours to infants of all ages and did not engage in many negative expressions (see also Lamb et al., 1987; Malatesta & Haviland, 1982; Malatesta et al., 1986). Mothers also reserved their positive expressions of smiling, eyebrow raises, and positive vocalizations for periods of mutual attention. Proportional durations of vocalizations were higher towards attentive than towards nonattentive infants. This pattern of results is consistent with Field's (1977) suggestion that maternal vocalizations are used to maintain infant attention and not to regain or attract. However, the present analyses did not address the content of the maternal vocalizations. The relation of the structure of different types of vocalizations (e.g. game-playing, singing, "motherese") to obtaining and maintaining infant attention may be an important area of future research (e.g. Bettes, 1989).

Mother expressive behaviour was associated with preceding infant behaviour at all ages, demonstrating that mothers behaved contingently to their infant's expressions. The only age-related difference was for mothers to behave more contingently at 12 than 20 weeks of age to broadly defined expressions, which is the identical pattern for infant contingent behaviours. Symons and Moran (1987) demonstrated that maternal and infant contingent behaviour is highly associated, particularly for broadly defined expressions. This may account for the same age-related difference appearing for both mother and infant contingent behaviours. Maternal contingent behaviour emphasizes that mothers act after infants action significantly greater than expected by chance. It is important to recognize that maternal framing of infant response predicts that mothers become expressive prior to infant expression and remain so greater than expected by chance. Again, both maternal framing and contingent behaviour may be important at various times during interactions even though they appear to be mutually exclusive phenomenon. To further understand the details of these sequences, however, more information is needed about different conditional events on different behaviours in these interactions.

Responsiveness and Dependency Contribute to Understanding Contingency

Across all ages, there was significant association of mother and subsequent infant behaviour as well as infant and subsequent mother behaviour. This association was present when behaviour was defined either as a smiling onset or as an onset of any of a broader class of positive expressions (i.e., positive behaviours selectively displayed while the infant was attentive to the mother). This high degree of both mother and infant contingent behaviour has been demonstrated in a growing number of traditional contingency analyses where the test statistic is a z score (Malatesta & Haviland, 1982; Malatesta et al., 1986; Moran et al., 1987; Symons & Moran, 1987) or a chi-square from log-linear analyses (Cohn & Tronick, 1987; Cohn & Tronick, 1988; Cohn & Elmore, 1988). The advantage of log-linear analyses was evident in testing the importance of different aspects of a model, such as age or the interaction term that defined "association". Taken alone, however, the measures of association in the present study provided little information regarding specific sequences of behaviour. Watson's (1979, 1985) measures of responsiveness and dependency were utilized to further elaborate on two independent conditional events, both of which could have contributed to the significant association of mother and infant behaviours.

The relative strengths of responsiveness and dependency demonstrated important differences between the contingent behaviours of mothers and infants. Smiles alone and more broadly defined expressions provided very different patterns of results, suggesting that there are very different social functions for these two categories of behaviour. Table 13 shows that the association of two behaviours can be related to significant levels of corresponding measures of either responsiveness, dependency, or some combination of the two. In the sequential analyses of smiling onsets, mother smiles were found to be highly responsive to, but not dependent upon, infant smiles. In other words, a significant above-chance proportion of infant smiles were followed by mother smiles and mothers smiled independently. In contrast, infant smiles were found to be highly dependent upon, but not responsive to, mothers' smiles. That is to say, infants rarely smiled independently and mother smiles were not significantly likely to be followed by infant smiles above the level expected by chance. These patterns suggested that a mother

is largely responsible for her infant's
mother was the "leader" and the infant
& Moran, 1988). These results were con
have contained analyses of the responsi
smiling behaviour in early mother-infan
Symons & Moran, 1988). They also are c
behaviour described previously for a mo
smiling behaviour (Cohn & Tronick, 1987
Moran et al., 1987).

Developmental changes in responsiv
not assessed for statistical significan
appropriate statistical tests to compar
measures. However, some patterns could
consistent trends in responsiveness and
of the study. Sequential analyses of sm
reveal developmental changes across ages
developmental changes in either infant c
their partner's subsequent behaviours.
was not increasingly independent as foun
(Cohn & Tronick, 1987; Kaye & Fogel, 19
however, that mothers were increasingly
smiles across ages. This contradicted W
that responsiveness should decrease with
maintain infant attention to the mother.
sequential relations of smiling behaviou
their consistency across the infant ages

Sequential analyses of broadly defi

yielded results very different from those of smile onsets. Maternal expression onsets were found to be both dependent upon and responsive to those of infants. In other words, mothers reserved their expressions for times after infant expressions and infant expressions were likely to be followed by mother expressions. In the sequences of expressions, infants were found to be responsive at all ages and dependent at 8 and 20 weeks of age. That is, mother expressions were likely be followed by infant expressions and infant expressive behaviour occurred independently at 12 and 16 weeks of age. There were also developmental trends in the sequential relations of general expressive behaviours. These suggested increases in measures of both maternal dependency and infant responsiveness after 12 weeks of age. Age-related increases in maternal dependency were related to significant increases in the association of infant and subsequent mother behaviour at these ages. Increases in infant responsiveness were related to increases in the association of mother and subsequent infant expressive behaviour. The different results between onsets of smiles and broadly defined expressions (see Table 13) are striking given that these are not mutually exclusive categories, (i.e., smiles were a constituent of general expressions). Again, these two ways of defining "behaviour" may possess very different social functions.

Infant responsiveness was found when the definition of behaviour was broadened to include a number of behaviours associated with positive affect (see also Symons & Moran, 1987). The infant rather than the mother was observed to assume a leader's role in the interaction when using a more general level

Table 13

<u>Summary of Results of Sequential Analyses for Mother and Infant Actions</u>

Sequence	Association	Responsiveness	Dependency
Mother smiles follow infant smiles	++	++	-
Mother expressions follow Infant expressions	++	++	< ++
Infant smiles follow Maternal smiles	++	-	++
Infant expressions follow maternal expressions	++	++	+

Note. Results are either significant $p<.01$ at all 4 ages (++), 2 of 4 ages (+), or not significant at any age (-). In sequential analyses of expression onsets, measures of maternal dependency exceeded that of maternal responsiveness at all ages.

of expressive behaviour. This unexpected result was opposite to that of smile onsets. The infant displayed involvement and emerging social competence through increasing responsiveness to general expressions after 12 weeks of age. By this age, the infant was acting independently and responsively, so there was no need for the mother to lead the interaction.

There may be developmental significance to infants displaying more social competence in contingent general expressive behaviour than smiling behaviour. Infants displayed responsiveness to positive expressions at an earlier age than responsiveness to the single most positive expression- a smile. The present results suggested that infants respond to positive affect with similar affect even though they do not yet do so by matching a specific behaviour (see also Malatesta et al., 1986; Moran et al., 1987). Responsiveness to general expressions may be part of a relatively less sophisticated behaviour system that governs the infant's behaviour during the age span of the current study. General expressions, however, may still be developmentally significant as their behavioural components are rich in emotional content and reflect what have been described as primary emotions such as "joy" and "surprise" (see Malatesta & Haviland, 1982; Lewis, Sullivan, Stanger, & Weiss, 1989; Sullivan & Lewis, 1988· Tomkins, 1963).

<u>Contingency Perception, Control, and Expectations</u>

It was impossible to ascertain from behavioural data whether any of these behavioural relationships were <u>perceived</u> by the interactants. Descriptive data details the statistical significance of contingency <u>experiences</u> but not the perception of those contingency experiences. With this qualification in mind, however, it remains possible to describe how the contingency experiences might lead to the perception of control. The concept of control and how it is perceived is intuitively appealing because it is assumed that an ineffective organism that lacks control over some event loses motivation to try. A lack of contingent control is central to the notion of learned helplessness (Seligman, 1975) and generally thought to be characteristic to many forms of pathological communication and decreased motivational states as in clinical states of depression. Given the importance of models of psychopathology with intergenerational components, it is important to detail the impact of contingencies within the earliest social environments.

Watson (1979, 1985) suggested that an interactant's behaviour must be both responsive to and dependent upon that of the interactive partner for perception of control. In his terms of sufficiency and necessity, an infant's behaviour should be both sufficient and necessary to elicit a mother's behaviour for an infant to perceive control over its mother's behaviour. Maternal general expressions at all ages were both responsive to and dependent upon those of infants. According to Watson, then, infants experienced conditions where they might perceive control over their mother's expressive behaviour as their expressions were stochastically both necessary and sufficient to elicit an expression from the mother. By contrast, an infant smile was likely to be followed by a maternal smile, but there was also a high probability of mothers smiling on their own. Infant smiles were sufficient but not necessary to elicit maternal smiles as the latter were responsive to but not dependent upon the former. The infants did not experience conditions where they could perceive control over their mother's smiles. This argues for the analyses of aggregates of expressions as the functional units of behaviour (see also Cohn & Tronick, 1987; Kaye & Fogel, 1980; Symons & Moran, 1987). Maternal expression onsets were more frequent than infant onsets of smiling, but expected base-rates of smiling were accounted for in calculations of responsiveness and dependency. Differences in base-rates are therefore not responsible for this pattern of results.

Kaye (1982) has stressed that infant signals directed at a mother are not necessarily "communication" or "intentional behaviour" even though the mother may respond as though the act was intentional. This underlies the orientation of the current study where the term responsiveness was used in a descriptive sense rather than as an index of intentional responding. Nevertheless, the current study has described social conditions necessary for the development of intentional behaviour (e.g. Lewis & Goldberg, 1969). The contingency environment described may lead to infant expectations of the effects of their own behaviours on that of their mothers given that they experience the conditions necessary for the perception of control. Behaving with the expectation of producing a maternal response may be some of the initial intentional behaviours displayed by infants. Lamb (1981) concurred with others (e.g., Lewis & Goldberg, 1969; Watson, 1979) when he wrote that "perceived effectance develops when an infant recognizes that it is able to elicit certain responses predictably from the environment" (p. 159). The different ways of characterizing the contingency environment experienced by each interactant may contribute to understanding what specific predictions an infant could make about maternal behaviour based on his or her experiences. Relating contingency to the complex notions of intentional behaviour and expectations may require experimental paradigms where expectations can be controlled so that cognitive events such as intentions can be studied (Lamb et al, 1987).

Mothers were also in a position to develop expectations about the behaviour of their infants in early interactions. Infant responsiveness of general expressions may indicate to a mother that her positive expressions are effective at eliciting expressions from her infant. Maternal expressive behaviour was sufficient but not necessary to elicit infant expressions at 12 and 16 weeks of age. Maternal expressions were both sufficient and necessary to elicit an infant response at the other two ages, which are conditions necessary for the perception of control. However, a mother's smiling behaviour had very different effects. Infants were dependent upon rather than responsive to mother smiles, suggesting that mother smiles were necessary but not sufficient to elicit infant smiles. This pattern means that a mother smile may be followed by an infant smile, but rarely would an infant smile occur independent of a mother smile. Maintaining levels of smiling behaviour is therefore a role of the mother, thereby making her responsible for infant smiling. However, infants showed a much greater involvement by sharing responsibility for levels of general expressions. This supports the contention that the mother was the leader in the interaction when considering smiles alone but an equal partner when considering expressions. That is to say, a mother should perceive control over infant expressions but not smiles. As perception of control may be desireable, it can be said that infants displayed more competence in expressive behaviour than smiling behaviour. Taken together, there are many different ways that the mother might perceive influence over their infant's behaviour and begin to feel effective. This may be a factor in the early attachments that caregivers form with infants over whom they feel some efficacy (Goldberg, 1978). The absence of conditions necessary for the perception of control may be a mechanism to study mother-infant dyads with difficulties in early social interactions.

Sroufe (1979; Sroufe & Waters, 1976) has suggested that early socio-emotional experience is deeply intertwined with cognitive growth (see also Fogel & Thelen, 1987; Papousek & Papousek, 1977; Schaffer, 1984; Stern, 1985; Watson & Ramey, 1972). He described the role of the caregiver in development as follows: "The sensitive caregiver provides the proper affective climate, helps the infant achieve and maintain an optimal level of tension, and actually helps it to organize the behaviour to which she then contingently responds" (p. 499). Parallels have been drawn in the current presentation between behaving contingently at a microanalytic level and behaving sensitively at a more molar level as both require appropriate caregiver reaction to an infant signal (e.g. Smith & Pederson, 1988). The measures of responsiveness and dependency in the current study may prove useful in further delineating other definitions of maternal contingency and sensitivity, given its underlying importance to many areas of developmental research. Studies investigating the sensitivity of depressed mothers to their infants, for example, could assess contingency, as well as responsiveness and dependency, to get a full characterization of the sequences of behaviour that can lead to a perception of contingent control.

Individual Differences

The orientation of the current report was to investigate the details of expressive behaviours for regularities across infant ages and not individuals. The justification was that patterns in early interactions can contribute to developmental processes operative to some extent in all individuals. For example, early interactions contribute to cognitive, emotional, and language development, and infants are almost certain to develop basic abilities to think, form relationships, and talk. As microanalytic techniques become more widely understood and accepted, they will be increasingly applied as individual difference measures to predict variability in each of these abilities. They could also be used to predict group differences based on the assumption that various clinical populations of mother-infant dyads are on different developmental trajectories. Thus, where either infants are preterm, mothers are depressed, or infants are handicapped with Down's Syndrome or chronic illness, for example, we might expect to find different types of interactions than with dyads without these problems. The contingent measures developed here could be used to build hypotheses on processes of early social interactions of populations that differ on some characteristic.

Most recently, Tronick (1989) has discussed in detail how the chronic experience of failure in abnormal early interactions can have detrimental effects on developmental outcome. He suggests that psychopathology may arise from persistent and chronic interactive failure. For example, infants who cannot engage their caregivers may learn to be disengaged from parents and their inanimate environment, and have distorted interactions with other people. Tronick (1989) suggests caution with this interpretation as abnormal interactive experiences do not always lead to pathology. For example, a depressed mother with low levels of positive affect may have an infant who lowers its frequency of positive affect to match that of its mother. In this example, the affective tone of the interaction would be lower, but could still be contingently organized if partners are sensitive to low levels of behaviour. The most recent data supports this contention. Cohn et al. (in press) found that depressed mothers and babies behaved no less contingently to each other than non-depressed mothers and babies despite the former being more negative and less positive than the latter.

The present study found no sex differences in analyses of the proportional durations of behaviours. These results have done little to clarify whether male and female infants have different types of early interactions with their mothers as there now appears to be an equal number of studies which have (Cohn & Elmore, 1988; Malatesta & Haviland, 1982; Malatesta et al.,

1989) and have not (Cohn & Tronick, 1987; Kaye & Fogel, 1980; Malatesta et al., 1986; this study) found sex differences.

The current study found continuity across ages in the proportional durations of expressive behaviours that both mothers and infants used during interactions. It had been expected that the variability of state and mood on any given day would wash out tendencies to use similar patterns of behaviours across visits. This was not the case. Malatesta et al. (1989) also found correlations in the amount of emotional behaviour (particularly negative emotions) displayed by infants in interactions during the first half year of life. These results go together well as the current one was of the elements of behaviour and Malatesta's was of emotional expressions composed of these elements.

It is possible to explain the observation of individual differences in expressive behaviours as an experimental artifact. Mothers may have a "response set" of behaviours they use when interacting with their infant in front of spectators or outside their home that are reasonably constant but have little to do with what they do when alone at home. This is analogous to the response bias of social desirability that some individuals more than others consistantly are effected by when filling out paper and pencil measures. The one month interval between visits may have permitted mothers to recall the types of games and behavioural patterns they had utilized during their previous visit. This effect may have been amplified by the identical methodology used for ach visit and the individual differences mothers may have had in responding to the experimental demand characteristics of interacting in the laboratory. This argument is much less tenable for infant behaviour. At the very least, however, the present author agrees with Fogel (Malatesta et al., 1989, p. 111) that individual differences found in descriptive studies of this nature are statistical phenomenon that cannot be clearly attributed to either constitutional or environmental factors of the interactants.

More obviously, it is also possible to explain individual differences as important developmental phenomenon. This would depend on how well microanalytic measures can be used to predict some outcome measure. As the most recent examples, microanalytic measures of maternal contingent behaviour and infant behaviour in the first half year of life have been related to attachment outcomes at 12 (Lewis & Feiring, 1989) and 22 (Malatesta et al., 1989) months of age. This supports the contention that maternal sensitivity is related to attachment outcome (see also Smith & Pederson, 1988).

Successful predictive studies would not only suggest that microanalytic measures are important developmental phenomenon but would also lead to suggestions as to which measures are more predictive than others. Malatesta et al. (1989) defined maternal contingency as the number of infant expressive acts followed by maternal acts. This measure is more appropriately called the number of contiguous events and does nothing to control for expected rates of chance occurrences or test for the statistical significance of these relationships. On this basis alone, their measure is neither a true assessment of contingency nor a measure of conditions necessary for the perception of control. However, their measure has predictive capability. It would therefore be important to know whether prediction becomes better or worse as contingency measures become more statistically precise and complex but less understandable and observable by interactants. The present study has proposed a number of "new ways" to portray contingency that are really old ways derived from animal learning and classical conditioning literatures (Rescorla, 1967; Rovee-Collier, 1986; Watson, 1979, 1985). Future research could show whether these measures prove useful in understanding the interactive dynamics important to the development of social relationships.

Appendix A

A STUDY OF EARLY INFANT COMMUNICATION - 3

Researchers are becoming increasingly interested in mother-infant interactions. In this study, we hope to decribe the development of the essentials of a child's earliest communication skills. Your participation should not only further our understanding of this important developmental process, but ultimately aid in the identification and treatment of children with early difficulties in communication.

What does participation involve?

We will ask you to make your infant comfortable in our infant seat positioned on a table and you will be seated on a chair immediately in front of your infant. Prior to this, you will be encouraged to calm your infant in any way as you both get used to your surroundings and to feed or change him if you so desire. (Our own experience is that babies get particularly hungry at the University for some reason, and for bottle feeders, we do have access to a microwave oven for warming bottles.) The researcher can then discuss the study with you and answer any questions you may have. Each visit is composed of one play session that can be stopped at any time and will last no longer than 5 minutes. Immediately after this, you will be asked a few general questions by one of the researchers. The purpose of this interview is both to gain information and to see how your baby reacts to your divided attention. We will ask you not to use toys during the episodes. All episodes will be recorded on video and audiotape.

The play instructions are as follows:

Play with your infant. Play in whatever manner you feel is appropriate and typical of how you play at home. You may wish to play games or use any amount of "baby talk". We are not looking for anything special in this situation. Don't feel you are performing; we only wish to see you and your infant enjoying each other.

The interview instructions will be explained to you right after the play session.

When you have completed the episode, the researcher will be more than willing to answer any questions you may have about the study and show you the video record of your baby's behaviour.

Appendix B

CONFIRMATION OF INFORMED C

I have read the accompanying description, an hereby agree to participate in an investigation c and Doug Symons, M.A. titled A STUDY OF THE DEVEL COMMUNICATION - 3.

I understand that the videotapes, and any ot participation are strictly confidential (subject t Child Welfare Act which requires that all childre reported to the Children's Aid Society), and will directly involved with the study. I understand th result in any direct benefit to me, but may help t early infant communication. I recognize that part entirely voluntary, and that I may refuse to parti any time for any reason.

____

Signature

Appendix C

Coding System for Study of Early Infant Communication - 3
November 1987

Infant Codes:

Infant - 1st Pass - smile
- wide mouth
- frown
- neutral

1 - Smile: Corners of mouth pulled back and slightly up (mouth open or closed).

2 - Wide Mouth: Mouth opened, roundish, or oval; jaw must drop (don't code parted lips). Consider that this should not be due to talking, but should be held as part of an expression.

3 - Frown: Corners of mouth drawn downward, outward (mouth open or closed). Chin may push up centre of lower lip.

4 - Neutral: Neutral position, or position not described above.

6 - Uncodeable: Usually out of sight for a period of time and behaviour cannot be extrapolated.

Infant - 2nd Pass - eyebrows - raised
- lowered
- neutral

1 - Raised: Brows raised in normal shape. Thickening or bulging of tissue in forehead or long transverse furrows. Nasal root narrowed. Enlarged, roundish appearance of eye region (upper eye furrow may be visible; tissue between upper lid and brow stretched but upper eyelids not raised).

2 - Lowered: Brows are drawn together and slightly or sharply lowered. Bulge and/or vertical furrows between lowered brows.

3 - Neutral: Neutral position or position not outlined above.

6 - Uncodeable: Usually out of sight for a period of time and behaviour cannot be extrapolated.

Infant - 3rd Pass - Gaze - on/alert
- off/alert
- closed
- on/dull
- off/dull

1 - On/Alert: Eyes on face of partner/alert (not dull or closed)

2 - Off/Alert: Eyes not on partner/alert (not dull or closed)

3 - Closed: Eyes closed for at least a 1-sec period (don't code blinks).

4 - On/Dull: Eyes on face of partner/dull (eyes glazed or eyelids drooping; eyes do not show interest)

5 - Off/Dull: Eyes not on partner/dull (eyes glazed or eyelids drooping; eyes do not show interest)

6 - Uncodeable: Usually out of sight for a period of time and behaviour cannot be extrapolated.

Infant - 4th Pass - Vocs - nondistress
- distress
- off
- crying
- non-vocal

1 - Non-Vocal: Sounds not made with the vocal cords such as clicks, whistles, or hand claps.

2 - Nondistress Vocal: Neutral sounds produced with the vocal cords such as babbling or cooing. Ignore minor barely legible non-vocal sounds (minor grunts).

3 - Off: No sound.

4 - Distress Vocs: Vocal sounds that indicate distress or discomfort. Sounds that precede full-fledged crying (whimpering or whining).

5 - Crying: All crying sounds, excluding distress vocs described above.

6 - Uncodeable

Mother Codes:

Mother - 1st Pass - smile
- wide mouth
- frown
- neutral
- uncodeable

For definitions see infant codes above.

Mother - 2nd Pass - eyebrows - raised
- lowered
- neutral

For definitions see infant codes above.

Mother - 3rd Pass - gaze - on
- off
- closed

1 - Gaze On: Eyes on face of partner

2 - Gaze Off: Eyes not on partner

3 - Closed: Eyes closed

6 - Uncodeable: Usually out of sight for a period of time and behaviour cannot be extrapolated.

Mother - 4th Pass - Vocs - vocal
- non-vocal
- off

1 - Non-vocal: Sounds not made with the vocal cords such as clicks, whistles, or hand claps.

2 - Vocal: Sounds made with the vocal cords such as talking, singing, or humming. Whispering should also be included in this category.

3 - Off: No sound. Allow for a 1 - 2 second meaningful gap in code "2 - Vocal" before coding "Off". Consider content of maternal speech and watch for "end of utterances".

6 - Uncodeable

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