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Hand, Arm, and Facial Actions of Young Infants to a Social and Nonsocial Stimulus

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LEGERSTEE, MARIA; CORTER, CARL; and KIENAPPLE, KIM. *Hand, Arm, and Facial Actions of Young Infants to a Social and Nonsocial Stimulus*. CHILD DEVELOPMENT, 1990, 61, 774-784. Do 9-15-week-old infants produce differentially organized hand and arm actions in relation to affective states when presented with social and nonsocial stimuli? This question was examined by observing 8 infants longitudinally. They were observed when facing their active and passive mother and an active and passive doll during 4 visits at biweekly intervals. Videotapes were coded in real time using the following measures: Vocalization, Gaze, and Gaze Avert; for face, Smiling, Distressed, and Neutral; for hands, Pointing, Open, Curled, and Closed; and for arms, Extended and At Side. Co-occurrence and lag sequential analyses showed that hand actions were organized with other infant actions to form unique behavioral linkages in each of the 4 conditions. The implications of these findings for the development of nonverbal communication are discussed.

Previous research (Legerstee, 1986; Legerstee, Pomerleau, Malcuit, & Feider, 1987) has shown that when 2-month-old infants are faced with a communicative adult, they smile, vocalize, and alternate their gazes. When presented with an object that moves and sounds contingently upon their eye contact, babies engage in intense arm activity while staring at the object continuously. When confronted with an unresponsive (e.g., "still-faced") adult, infants begin to cry and turn their heads. In these studies, systematic comparisons with other conditions showed that a familiar static object does not evoke comparable responses from infants. Rather, infants' behavior is similar to that when facing the contingently responding object. These results indicate that 2-month-old infants are able to discern social and nonsocial contexts and that their responses are context specific.

Recently, Fogel and Hannan (1985) have found that when engaged in face-to-face in-

teractions with their mothers, young infants also seem to have specific hand actions that are systematically organized into sequences with their gaze and their vocal and facial behaviors. Using a real-time coding system based on their previous observations and those of others (Fogel, 1982; Hannan, 1981; Papousek & Papousek, 1977; Trevarthen, 1977), Fogel and Hannan (1985) found that between 9 and 15 weeks of age the infants produced such hand actions as pointing before or after mouthing, spreading of the fingers when the baby was looking away from the mother, and curling of the fingers during vocalizations. In contrast, the action of grasping, defined as holding on to clothing or mother, was not related to the facial gestures.

In a recent review, Fogel and Thelen (1987) offer a theoretical account for the early appearance and further development of these expressive actions. They suggest that these early manual actions are not direct precursors

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to later expressive behavior, nor is there a complete absence of a relation between early and later forms. They propose, instead, that the actions in early infancy coalesce dynamically from subcomponents in relation to specific infant states and eliciting contexts. Arm extensions, for instance, may be elicited by a graspable object nearly continuously from the early months. A point, on the other hand, would be topographically stable in one context in early infancy (as during face-to-face interactions with an adult), and the same motor configuration may be appropriate for use in another context later in the first and second year (as a referential communicative act used to refer to things external to the face-to-face interaction).

Support for this hypothesis is supplied partially by a longitudinal study by Hannan (1987). This author assessed the development of pointing cross-sequentially in 3–12-month-old infants during a mother-alone condition and during a condition where the mother presented an object in front, but out of reach, of the infant. Contemporary perspectives (Leung & Rheingold, 1981; Murphy & Messer, 1977) suggest that referential “pointing” emerges sometime during the second half of the first year out of open-handed, undifferentiated forward arm movements through parental reinforcement and modeling. If this is the case, then one would expect to find few points during the first half of the year in both conditions, and more points during the second half of the year during the mother-object condition than during the mother-alone condition. Instead, Hannan (1987) found that pointing occurred significantly more during the mother-alone condition, and that the amount of pointing varied little throughout the developmental period studied. Thus there does not appear to be a functional continuity between early index finger extensions and later referential pointing.

However, there may exist, in addition to the topographical or structural continuity, a continuity of the *state* of the infant that gives rise to pointing in the various contexts. Thelen and Fogel (in press) suggest that since pointing is often accompanied by a neutral and attentive affective state when it first appears in infancy, it seems part of an orienting response. Since the purpose of mature pointing is to orient both the mother and infant to things external to the dyadic interchange, it is possible that the parameter that controls the shift of pointing from one context to the other is the affective state of the infant. “Thus, the pointing gesture seems to develop from an

early non-instrumental association with attention and alertness to the more focused orientation later in the first year” (Thelen & Fogel, in press).

Closing the hand appears to be another action related to affective state. Papousek and Papousek (1977) noted that when young infants appeared distressed they often had their hands in a closed position.

If babies have specific expressive hand actions that are state related, one would expect to find more of a certain hand action in a situation where a particular state is prevalent. For instance, as shown in our earlier work, the communicative mother elicits a predominantly interactive and positive hedonic state in the baby, coupled with increased vocalizations, whereas the unresponsive, passive mother induces a withdrawn and negative state in the baby and a decrease in vocalizations. When interacting with objects, on the other hand, very few affective behavioral changes are noted. Rather, the baby appears to be largely in a neutral state while directing arms and hands toward the object (Legerstee et al., 1987). If expressive sequential linkages such as curling the fingers with vocalizations are the product of a certain affective state brought about by behaviors of the communicating mother, we would expect to find fewer or different types of these behavioral linkages in the situation where the mother is not communicating. For instance, although Fogel and Hannan (1985) found that the infants used a pointing action during the active-mother condition, in observations of babies interacting with their communicative and impassive (still-faced) mothers at weekly intervals during the first 6 months of life, Fogel, Diamond, Langhurst, and Demos (1982) found that the particular hand action of pointing increased when babies faced their still-faced mother. Since none of the other behaviors increased, the authors suggested that this gesture could not simply be a general arousal response but was related to the specific emotional and attentional state elicited by the still-faced mother condition. Thelen and Fogel (in press) argue that strong evidence of the significance of such gestures could come only from experimental studies in which infants are placed in tasks where these expressive actions typically are elicited and where the levels of behavioral activation are varied.

Taken together, the above studies provide grounds for hypothesizing that there are specific state-related movements of the hand. Given the limited range of social and nonso-

cial tasks that the babies have been exposed to in many of these experiments, it is not clear whether hand and arm movements differ depending on the context. If such differential responsiveness exists in early infancy, it would imply that before babies develop the use of more mature social gestures, they display a configuration of facial, arm, and hand actions to express affective states. To test this hypothesis directly, the infants were observed systematically in social and nonsocial contexts. They were presented alternately with their communicative mother and a graspable doll that moved and sounded when they looked at it. Making the nonsocial stimulus move contingently is a necessary control since adults communicating with infants naturally respond in a contingent fashion to the eye contact of their infants (Legerstee, 1983; Legerstee, Kienapple, & Walsh, 1989; Papousek & Papousek, 1984; Watson, 1972). Similarly, since a noncontingent social stimulus seems to elicit particular hand and arm gestures in babies, the infants were also presented with their passive mother and a noncontingent (passive) doll. By studying the infants under these conditions, we may be able to determine what behavioral linkages of the face, hand, and arms are produced in the presence of social and nonsocial stimuli. Infants 9 to 15 weeks of age were studied because this period has been examined in earlier related work (Fogel et al., 1982; Fogel & Hannan, 1985). Although it has already been established that infants respond differentially to social and nonsocial stimuli (e.g., Field, 1979; Klein & Jennings, 1979; Legerstee & Bowman, 1989; Legerstee et al., 1987), the claims about different configurations of facial, arm, and hand actions that express different affective states have not been fully tested. The particular aim of this research is to try to discover how the patterns of display differ in their organization between a social and nonsocial context.

Method

Subjects.—Eight infants (five boys and three girls) and their mothers participated in the study at 9, 11, 13, and 15 weeks (a total of 32 sessions). They were all healthy, full-term babies with high Apgar ratings, and weighed an average of 3,060 grams at birth. They were from middle-income French Canadian families. The mothers, who were in their mid-twenties (range = 24–27 years), were contacted at the maternity hospital and were informed of the nature of the filming sessions and the duration of the study. They were orig-

inally recruited as part of a longitudinal study of interactions between babies and their mothers, strangers, and objects during the first year of life (Legerstee et al., 1987). Only tapes of the infant/mother and the infant/object interactions were used.

Apparatus.—The interactions were videotaped in a laboratory setting resembling an infant's room. Infants were placed in a specially constructed infant seat. This seat supported the head and trunk and permitted free movement of arms and legs. Minimal physical restrictions seem most conducive to infant vocalizations (Lewis & Freedle, 1973) and to promote bodily movement (Trevarthen, 1977).

Sessions were filmed using two video cameras, positioned out of the infants' line of vision and 1.8 m from the subjects. Using these cameras and a split-screen generator, the infants' and mothers' behaviors were simultaneously recorded on videotapes, which were later coded with an S & K Portable Event Recorder. The MADAP (Kienapple, 1987) observational data analysis package was used to generate proportion, co-occurrence, and lag sequential summary measures.

Procedure.—Mothers and babies were filmed biweekly from 9 to 15 weeks of age during times when the babies were content and alert. In the social condition, the mother sat in front of the infant at no more than a 50-cm distance. In the *active* condition she was asked to talk with her infant as she would at home but to refrain from touching the baby. In the *passive* condition she was asked to remain silent, to keep a "friendly" face, and again not to touch the baby. In the nonsocial conditions, a doll was suspended in front of the baby at a reachable distance (not more than 50 cm). This toy, a 40 cm long stuffed doll with a smiling face and big black eyes, had been chosen because it had on previous occasions attracted sustained attention in very young infants. In the active condition, the experimenter let the doll, which had bells attached, dance and sound each time the infant looked at it. In the passive condition the doll remained immobile.

Each condition lasted 60 sec and was presented in random order to control for effect of presentation. If infants became distressed during the sessions they were comforted until they were again in an alert and content state (State 4; Wolff, 1966). Due to experimental error, fatigue, or persistent crying, not all sessions were completed for some babies. The amount of missed stimulus pre-

TABLE 1
CATEGORIES OF BEHAVIOR USED TO CODE INFANT BEHAVIOR

Mode and Category	Description	Mean	SD
Gaze:			
On	Looking at stimulus	.48	.21
Off	Looking away from stimulus	.40	.28
Avert	Lowering of eyelids, without closing eyes, and a subsequent diversion of gaze	.12	.07
Vocalization:			
On	Any noncry sound	.12	.09
Off	No vocalizations	.88	.21
Face:			
Smile	Lip corners turned up, happy face	.09	.06
Neutral	Mouth and face relaxed	.73	.30
Distress	Lip corners turned down, sad face	.05	.04
Other	Yawns, burps, hiccup, crying, etc.	.13	.26
Right hand:			
Point	Index finger extension, other fingers curled, either moving or static	.05	.03
Open	Hand open more than $\frac{3}{4}$, fingers spread, bye- bye, moving or static	.19	.17
Curl	Fingers open less than $\frac{3}{4}$, static or moving	.34	.28
Closed	All fingers closed, either loosely or tight	.28	.16
Other14	.26
Right arm:			
Extension	Arms moved toward stimulus	.23	.21
Side	Arms moved to, or resting at, side	.27	.18
Other50	.36

NOTE.—Because of the similarities between right hand and arm and left hand and arm displays, only the values for the right side are reported here.

sentations represents less than 7% of the total number of presentations for all babies.

Behavioral categories.—From previous research indicating a possible link between affective states and actions of the face, hands, and arms (Fogel et al., 1982; Fogel & Hannan, 1985; von Hofsten, 1984; Legerstee et al., 1987; Papousek & Papousek, 1977; Trevarthen, 1977) we chose 15 behavioral categories (see Table 1). A total of seven separate runs were made through the tapes to score these measures. Each time a continuous coding of behavior into mutually exclusive categories was accomplished, as follows: (1) Gazing, Gaze Aversion, and “gaze away”; (2) Vocalization and “no vocalization”; (3) Smiling, Distressed, Neutral, and “other facial expressions” (the latter category includes yawning, burps, hiccups, and crying, although few cries were noted in this study); (4) right arm movements: Extended, At Side, and “other”; (5) left-arm movements: Extended, At Side, and “other”; (6) right-hand movements: Pointing,

Open, Curled, Closed, or “other”; and (7) left-hand movements: Pointing, Open, Curled, Closed, or “other.” The categories “no vocalization,” “gaze away,” “other face,” “other arm,” and “other hand” were coded in order to form exhaustive categories with other behaviors. They were, however, not used in the data analyses.

The videotapes were coded at normal speed from a monitor with a 54-cm screen. One side of the video monitor was covered so that only the baby was visible. Thus the observers were blind with respect to the experimental condition. The nonvocal categories were scored without sound. According to Hannan (1982), manual actions less than 1.5 sec in duration are not reliable. Thus, discrete manual actions lasting less than 1.5 sec were eliminated from the data. The coder was trained to reach a minimum reliability of 90% interrater agreement with an experienced coder on the onset of a particular behavior. Intrarater reliability on the onset of a category

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was also measured at 90% at four points throughout the coding. For a reliability check, the trained coder, working independently, coded 10% of the sessions. Again, an agreement was scored if the coder identified the onset of the same category within ± 1 sec of that scored by the experienced coder. Again, 90% agreement for all behavior categories was obtained.

The onset times of the behavior categories were recorded by the observer onto a computerized event recorder (S & K Computers, Toronto). The timer of the event recorder was synchronized by coder signal with the beginning of a session. The coder also manually signaled the termination of a session (by pushing an off button). The seven data streams were subsequently coordinated according to the session start and stop times using a computerized sort-merge procedure (Kienapple, 1987). Thus the complete data records, with synchronized onset time indicators, were available for the subsequent analyses.

Results

In order to account for slight variations in the mothers' entrance and exit times, the total durations of each response were transformed into proportional durations (total duration of a response/total duration of a session). The means and standard deviations of the proportional durations for each behavior category are listed in Table 1. Because of the similarities between right hand and left hand and right arm and left arm displays, only the values for the right side are listed. To examine the effects of age and order of presentation of the four conditions, the proportional durations of each behavior category were submitted to an age (4) \times order of presentation (6) MANOVA using a multivariate approach to the analysis of repeated measures. (In the present study, only four of the original six conditions of the Legerstee et al. [1987] study are being used.) The purpose of the examination of order effects was to determine whether the still-face conditions had an effect on subsequent trials. No significant effects for age or placement were found.

Co-occurrence analyses.—To determine whether these young infants would display reliably different co-occurring behaviors toward a doll and their mother, we examined (1) whether specific hand actions co-occurred with specific facial behaviors, (2) what type of arm actions these hand actions occurred with, and (3) whether these co-occurring face/hand

actions and hand/arm actions were a function of condition. A co-occurrence measure was derived between each of Smiling, Distressed, Neutral, Vocalization, Gazing, and Gaze Aversion and each of the right and left hand behaviors (Pointing, Open, Curled, and Closed), and between each of these hand actions and each of the right and left arm behaviors (At Side and Extended) within each condition.

Following the procedure outlined by Fogel and Hannan (1985), a Wilcoxon matched-pairs signed-ranks test was used to assess whether observed co-occurrence values differed significantly from expected co-occurrence values. Observed co-occurrence was determined by calculating the proportion of total session time during which the two behavior categories of interest occurred simultaneously. Expected co-occurrence was defined as the joint probability of each behavior category occurring (i.e., the product of the proportional session durations for each category). Observed and expected values were derived for each infant.

The results showed that the co-occurrences between the left hand and other behaviors that were significant were similar to those found between the right hand behaviors and other actions, but that the right hand produced additional significant co-occurrences not found with the left hand. Therefore, we discuss only the significant measures involving the right hand. Table 2 shows the significant co-occurrences between the right hand and the other actions for the four conditions.

Active mother.—Pointing was significantly more likely to occur than would be expected by chance during Smiling and Gazing, Open during Gazing and Arm Extension, and Curling during Neutral expression and Gazing. The hand action Closed also co-occurred with Gazing, but it was significantly less likely to co-occur than would be expected by chance with Neutral expression.

Passive mother.—In this condition, Closing of the hands co-occurred significantly more often than would be expected by chance with a Distressed expression, Gaze Aversion, and arms At Side. Curling was significantly more likely to occur than would be expected by chance during infant Vocalization and arms At Side.

Active and passive object.—Except for Pointing, all hand behaviors co-occurred at levels significantly above what would be ex-

TABLE 2

CO-OCCURRENCE ANALYSES FOR RIGHT HAND, ARM, AND FACE FOR THE MOTHER AND DOLL
CONDITIONS: WILCOXON MATCHED-PAIRS SIGNED-RANKS TEST

FACE/ARM BEHAVIORS	HAND BEHAVIORS			
	Point	Open	Curl	Closed
Mother active:				
Gaze	7/0*	11/1*	20/2***	17/0***
Neutral	10/4	13/7	21/7**	6/12*
Smile	11/5*	9/3	8/14	14/8
Right Extension	2/3	8/1*	9/4	7/2
Mother passive:				
Gaze	10/3	10/4	13/13	12/5
Neutral	11/4	10/3	12/14	9/8
Vocalization	3/3	6/3	15/6*	3/9
Distress	1/1	5/2	10/7	9/2*
Gaze Avert	3/2	4/6	13/7	15/4**
Right Side	6/6	4/5	13/6*	10/3*
Object active:				
Gaze	2/0	15/0***	18/1**	15/0***
Neutral	1/0	14/0***	6/1	13/1**
Right Side	0/1	2/4	8/0*	6/1
Object passive:				
Gaze	7/6	13/0**	23/1***	13/0**
Neutral	6/1	17/1**	21/3*	16/0***
Right Side	5/2	2/4	9/3	11/2**
Right Extension	8/4	14/5**	12/8	7/8

NOTE.—For each behavior pair, the values represent the number of observations in which the observed probability of co-occurrence was greater than expected compared with the number of observations in which the expected probability of co-occurrence was greater than the observed (obs. > exp./exp. > obs.).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

pected by chance with Gazing and Neutral expression during the active and passive doll conditions. In the active doll condition, Curling was found to co-occur significantly with arms At Side, while, in the passive object condition, (a) Open and arms Extended, and (b) hands Closed and arms At Side co-occurred significantly more often than would be expected by chance.

In summary, when these young infants were faced with their active mother, they produced specific clusters of behaviors that did not occur toward the passive mother or toward the active and passive doll. When they pointed at the active mother, smiles and gazes accompanied the action, and when they opened their hands, their arms were extended toward her. When the infants had curled hands they gazed at their mother with a neutral facial expression, but when they made a closed hand it was unlikely to occur with a neutral facial expression, although the infants continued to gaze at their mother. During the passive mother condition, however, the closed hands were associated with distressed

facial expressions, averted gazes, and arms to the side, whereas curled hands were produced with vocalizations and with the arms directed to the side.

When the infants faced the active object, they gazed at it with neutral facial expressions while keeping their arms to the side with the hands curled. In the presence of the passive object, the infants kept their arms at the side with the hands closed, or extended their arms forward with the hands open.

Sequential analyses.—Co-occurrence provides information about behaviors occurring simultaneously, whereas lag sequential contingencies describe the sequencing of the behaviors (Sackett, 1979). To examine whether the hand and arm categories were sequentially related to the eye, face, and vocal categories, a time interval lag sequential analysis (Kienapple, 1987; Quera & Estany, 1984) was performed. The z score calculation was taken from Allison and Liker (1982). Following Fogel and Hannan (1985), the criterion categories were the facial actions Smiling,

TABLE 3

LAG SEQUENTIAL ANALYSIS—MEAN CONTINGENCY OF RIGHT HAND AND ARM ACTIONS

FACE/GAZE BEHAVIORS	HAND/ARM BEHAVIORS				
	Point	Closed	Open	Extension	Side
Mother active:					
Neutral	5.98***	-4.00***		14.70***	8.54***
Smile	5.46***	-3.37***		13.60***	2.85**
Distress					
Gaze	7.27***	-5.79***		14.70***	2.01*
Gaze Avert					
Vocalization	8.27***	-4.62***	7.42***	12.60***	3.26***
Mother passive:					
Neutral	5.19***			20.30***	-5.40***
Smile					
Distress	2.50*		2.19*	11.70***	
Gaze	6.23***	-3.48***		23.80***	-3.07***
Gaze Avert	3.11***			13.00***	
Vocalization	6.20***			28.80***	-3.82***
Doll active:					
Neutral				5.66***	
Smile					
Distress					
Gaze				8.22***	-2.41*
Gaze Avert					
Vocalization					
Doll passive:					
Neutral				2.07*	
Smile					
Distress					
Gaze				4.74***	-3.49***
Gaze Avert					
Vocalization					

NOTE.—Values shown are significant z scores for the five 1-sec intervals that followed the onset of a target behavior.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Neutral, and Distressed; the action Vocalization, and the actions Gazing and Gaze Aversion, while the lagged behavior categories were the right and left hand categories Pointing, Open, Curled, and Closed, and the right and left arm categories Extended and At Side. Starting from the end of each occurrence of a criterion behavior category, the data were inspected across five 1-sec intervals for the onset of a lagged category.

Again, because of similarities between right and left hand displays, only the results for the right hand will be presented here. The reported z scores were significant for the five 1-sec intervals.

Table 3 presents the significant mean contingencies (Sackett, 1979) of the lag sequential analyses for the right hand and other actions in all four conditions.

Active mother.—Pointing followed Smiling, Neutral expressions, Gazing, and Vocal-

ization significantly more often than would be expected by chance. Extension and arms At Side also followed these behavioral categories, although Closed was significantly less likely to follow Neutral, Smiling, Gazing, and Vocalization than would be expected by chance.

Passive mother.—The sequential analysis showed that during the passive-mother condition, Pointing followed Neutral, Distressed, Gaze Aversion, Gazing, and Vocalization. Extension also followed these behaviors, but arms At Side was significantly less likely to follow Neutral, Gaze, and Vocalization than would be expected by chance. In addition, Closed occurred less significantly than expected by chance with direction of Gaze during the passive-mother condition, whereas Open followed Distressed significantly more often than would be expected by chance.

Active and passive objects.—The only behaviors that showed a sequential organiza-

tion in this condition were arm movements. Extension followed Neutral and Gazing at the active and passive doll, whereas Side was significantly less likely than would be expected by chance to follow Gazing during these conditions.

Thus, the results of the sequential analyses supported and expanded the behavioral trends indicated by the co-occurrence analyses. They showed that the 9–15-week-old infants produced discrete hand actions that followed specific facial expressions at a rate greater than expected by chance when the infants faced their active or passive mother, or an active or passive graspable doll. When the mother communicated, the pointing actions the infants produced occurred in sequence with positive affective behaviors (e.g., Smiling, Vocalization, and Gazing) and extended arms. Closed was least likely to follow positive affect during this condition. When the mother remained passive, Closed was least likely to follow Gaze, but now Point occurred sequentially with negative affect (e.g., Distressed, Vocalization, Gaze Aversion) and extended arm, although arms to side was inhibited by some of these facial expressions. When the infants were facing the doll, their Neutral facial expressions and Gazes at the stimulus were most likely to be followed by arm extensions.

Discussion

The main purpose of this study was to determine whether young infants produce differentially organized hand and arm actions in relation to affective expressions when placed in different social and nonsocial contexts. Our results showed that babies as young as 9 weeks of age respond with consistently different sequentially organized face, hand, and arm behaviors to social and nonsocial contexts. That infants at this age produce manual actions in relation to affective states, gazes, and vocalizations when interacting with their mothers has been shown by previous authors (Fogel & Hannan, 1985). The present study provides new empirical data concerning the specificity of these behavioral linkages produced by infants when in social and nonsocial contexts.

To facilitate interpretation of the results, the discussion has been organized according to the social and nonsocial conditions in which the infants were tested.

Active mother.—A variety of interesting sequential behavioral linkages was identified during this condition. The behavioral organization of Pointing with behaviors such as Gaz-

ing, Smiling, and Vocalization to the communicating mother seems to be in agreement with previous studies (e.g., Hannan, 1981; Fogel & Hannan, 1985; Platzman, 1983) in which the development of Pointing was examined at various ages during the first year of life while the infants interacted with their mother. In these studies, Pointing systematically preceded or followed mouthing and occurred in sequential organizations with affective expressions such as Smiling, although Neutral and shifts in gaze away from mother also seemed to accompany Pointing in infants aged 1 to 10 months (Platzman, 1983).

Open with Gazing, Extension, and Vocalization formed another behavioral organization during the communicative-mother condition. In contrast, Fogel and Hannan (1985) had found that Open (labeled Spread in their study) only co-occurred with gaze away. They therefore interpreted this hand behavior in infants of this age to indicate “a relative withdrawal from the interaction” (p. 1277). Since Vocalization often occurs when the 2-month-old infant is affectively aroused (Brazelton, Koslowki, & Main, 1974), the relation between Open and Vocalization suggests an association with moderate affective states.

Interestingly, when the infants closed their hands during this condition, there was a suppression of the behaviors indicating positive tone in the baby (e.g., Neutral, Smiling, and Gazing, as well as Vocalization).

Passive mother.—A behavioral organization involving the Closed hand was also identified when the mother refrained from communicating. The distressed faces and averted gazes that accompanied this hand action indicated negative tone and stress in the baby. Similar findings have been found recently in 3- and 6-month-old infants when the mother failed to communicate with her baby (Fogel, 1989, personal correspondence, January 6, 1989). The author suggested that these behavioral displays of the baby are the result of an internal affect shift caused by the unusual behavior of the mother. “Thus, positive expressions decline when contingent responses are not forthcoming, smooth limb movements may degrade into jerky alternating flexions and extensions that are not modulated by the active mother’s phonological contours and touches” (Fogel, personal correspondence, 1989). Although research suggests that caretakers do not seem to respond to such hand actions as Pointing or Open very early in the baby’s life (Hannan, 1987; Trevarthen, 1977), they do appear to respond to closed hands as an indicator of distress even if

no other indices are available. In a recent study, Papousek and Papousek (1987) presented adults on several trials with a picture of a baby with a neutral facial expression of which only the hand position changed at each trial. They found that when adults were asked to rate the emotional state of the baby, only the picture that was accompanied by closed hands was interpreted as indicating anxiety or distress.

Another interesting behavioral linkage identified during the passive-mother condition concerned the hand action Pointing. This behavioral organization corroborates earlier findings by Fogel et al. (1982), who also found more Pointing, Distressed facial expressions, and Gaze Aversion during the still-faced procedure. The authors suggested that Pointing can be considered an alternative expression of attention to the mother. The findings that the infants gaze away from their mother does not necessarily mean that the infants lose interest in her during the silent period; rather, "they express their interest in a different way, preferring to point instead of look" (Fogel et al., 1982, p. 48). The co-occurrence of Pointing with Distress during the still-faced condition suggests that in addition to being aware of the passive mother the infants are upset as well.

A notable feature of Pointing is that it co-occurs with Smiling/Vocalization or Distressed/Vocalization. Trevarthen (1977) also found that Pointing often co-occurred with Vocalization and mouthing, which he called "prespeech movements." The sequential linkage of Pointing with negative or positive affect and Vocalization, which was present during the social conditions but absent during the nonsocial conditions, seems to suggest that Pointing is a social action associated with affective states of both positive and negative tone.

Passive doll.—Two interesting behavioral linkages were present during the passive-doll condition: (a) Closed with Gazing, Neutral, and arms At Side, and (b) Open with Gazing, Neutral, and arms Extended. Von Hofsten (1984) also found two types of hand and arm movements between 2 and 3 months of age. He also (1984, Fig. 3, p. 385) found that there was a short period (approximately between 7 and 11 weeks) where the infants kept their hands closed and their arms remained at the side, but they gazed at the stimulus. Von Hofsten (1984) (see also Mounoud & Vinter, 1981) suggested that the absence of the forward extension of arms to the object at that time is the result of a dissociation of the synergistic extension-flexion

pattern that involves both the hand and arm, observed in infants prior to 9 weeks of age, when the arm is being triggered toward the perceived object but no correction of the arm seems possible. This dissociation seems a necessary prior developmental step to adaptive reaching and grasping. Sequential linkages of Open, Gazing, and Extension of the type observed in our study seem to have been produced by infants in the von Hofsten (1984) study primarily around 3 months of age (see Fig. 5, p. 387), and rather than being part of the previous orientation reaction, these open-handed reaches appeared to be meaningful adaptive behaviors, intended to explore the object since they occurred primarily when the infant looked at the target.

Active doll.—When facing the dancing and sounding doll, the infants kept their hands curled and moved their arms sideways, rather than extending them forward, even though the infants fixated the object. It seemed that the spectacle absorbed the infant but inhibited forward extension of the arm. Thus, the action Curling seemed to be related to a state of alertness. This hypothesis is further supported by the observation that when the curled hands were produced during the active- and passive-mother conditions, they were always produced when the infants were neither in a distressed nor a happy mood. Fogel and Hannan (1985) and Papousek and Papousek (1977) reported similar behavioral states in babies in relation to the hand action Curl.

General Conclusion

Taken together, the present results provide evidence for the existence of specific social and nonsocial manual and arm patterns in the third and fourth month of life in human infants. These findings lend support to the assertion of previous authors that when young infants communicate with their mother they exhibit behavioral linkages that reflect affective states (Fogel & Hannan, 1985; Papousek & Papousek, 1977; Platzman, 1983; Trevarthen, 1977). The previous studies had utilized only limited settings, and the relation of these hand and arm actions to specific states had not been completely described. By using a variety of social and nonsocial contexts, the present study was able to show that these discrete hand actions were, like other facial and vocal actions, a display of affect during participation in the predominantly expressive face-to-face exchanges of early infancy. Their adaptive value lies in the fact that mothers respond to their infants primarily on the basis of the overall state of the infant (Fogel, 1982; Kaye

& Fogel, 1980; Legerstee, 1983). Closed hands and distressed faces may give the mother a clearer sense of the affective state of the infant than would a single expressive action (Fogel & Hannan, 1985).

Are these early expressive actions such as Pointing and Open likely to be related to later referential gestures of indicating and requesting? Although our study does not lend itself to longitudinal interpretations, the fact that these hand actions coexist in 9–15-week-old babies and are produced differentially in social and nonsocial contexts seems to suggest that later mature social gesturing may not develop entirely out of earlier reaches and grasps through parental modeling and reinforcement (Leung & Rheingold, 1981; Murphy & Messer, 1977). How, then, can the “too early” existence of these hand actions be explained? Fogel and Thelen (1987) suggest that a heterochronic model may better explain the ontogenesis of manual actions. That is, some actions may maintain a degree of structural continuity but not of function. For instance, a communicative action cannot be performed unless all of the component skills are present. With cognitive and physical maturity, these skills become reorganized and coalesce around a specific task, to serve increasingly specific functions, voluntary as well as intentional.

As an example, early closed hands may be part of a sequentially organized set of behaviors that reflect a generalized infant state. These behaviors may induce the parents to respond to the infant in a certain way. With development, through maturation of the physical components that support the closed hand, and with cognitive changes leading to a growing awareness of how the closed hand is used in our society, the act may become the mature social gesture indicating anger or defiance. The processes involved in the development of intentional gestures have been summarized succinctly by Thelen and Fogel (in press). Whereas early manual actions may be state-related expressions, the emergence of their intentional form is a “dynamic, multicausal phenomenon,” involving the simultaneous development of motor control and a cognitive understanding of self and other. Further research of a longitudinal nature is needed, aimed at revealing the actual dynamic process by which these expressive patterns coalesce.

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