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Author(s)	FOGEL, Alan; フォーゲル, アラン
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THE SOCIAL DYNAMICS OF EARLY HUMAN DEVELOPMENT

Alan Fogel

University of Utah

Communication between adults and children is one of the primary contexts for the development of specifically human forms of cognition and action. Communication itself is comprised of actions and postures that have specific meanings to participants in discourse. There is growing evidence that infants develop in relation to the social context, and that the physical sub-strate that supports action (stances, surfaces, and textures) is provided by adults (Fogel, 1990 a; Kaye, 1982; Papousek & Papousek, 1984). Infant's bodies must be given postural support in order to facilitate action (Fivaz, 1987; Thelen & Fogel, 1989; van Wulfften-Palthe & Hopkins, 1984). Most forms of human action and cognition are culturally mediated. Examples are reaching and object manipulation (Fogel, 1990 a; Lyra & Ferreira, 1987), sitting and walking (Bril & Sabatier, 1986; Hopkins & Westra, 1988), climbing (Valsiner, 1987), and tool use (Bruner, 1972; Rogoff, 1990).

SOCIAL DYNAMIC THEORETICAL PERSPECTIVE

I present the outlines of theory of social dynamics that combines a dynamic systems perspective and a Gibsonian ecological perspective to an understanding of the development of action (Fogel, in press). Different physical and social environments afford different opportunities for action. A rattle affords noise making, for example. To activate this affordance, the individual has to identify the specific microscopic movements necessary to evoke sound from the rattle: the arm and wrist movements related to shaking. How does a baby come to acquire this action? Partly by exploratory play, but at first this play is embedded in social interaction.

A social dynamic perspective suggests that during adult-infant interaction, adults identify action affordances that the infant is potentially capable of doing. Then, development occurs by two processes. In the first, the adult engages a child in a joint construction of the action afforded by the situation, helping the child perform the action via a co-regulation of the relevant movement parameters (e. g., demonstrating rattle shaking then placing the object in the infant's hand, or moving the infant's hand. In the second process, the adult transmits or receives information that highlights the relevant parameters of movement related to action affordances. Information, in general, is

that which is needed to specify the relationship between the perceptual aspects of the task and the action parameters responsible for executing the movement (Turvey, 1990). In human interaction, information is embedded in cultural values and cultural systems of expression and communication: touch, gestures, facial expressions and words. Thus, the theory outlined here hypothesizes specific links between culture, action and developmental change.

If this social dynamic view is correct, we should find developmental change arising in social interaction that converges toward a mutual co-regulation of either the movement control parameters or the informational requirements of the perception action linkage, or both. Interactions that are not likely to lead to developmental change are those that (a) expect children to learn whole action patterns via modelling and imitation, or (b) in which one individual over- or under-controls the relevant dynamic parameters relative to the other person, or (c) in which information is not specifically related to the dynamic parameters linking perception and action.

It is assumed that movements are assembled from components that are loosely linked, none of which carries an explicit code for the final macroscopic form of the movement. Movements are therefore self-organizing, emergent from the constraints imposed between the elements of the system as they interact with each other. Since no single component carries the instructions for the movement, and since the movement as a whole has no prior schematic encoding, the main organizer of the movement is the set of parameters linking together the elements of the task, and both the physical and informational aspects linking those elements with relevant aspects of the context. These assumptions follow directly from dynamic systems approaches to movement organization that were developed as a response to Bernstein's degrees of freedom problem (Bernstein, 1967; Kugler et al., 1980; Nicolis & Prigogine, 1977; Singer, 1986; Skarda & Freeman, 1987; Turvey, 1990).

Why is it necessary to have a dynamic theory of co-regulation?

It is not enough, theoretically, to say that social partners jointly co-regulate each other's behavior. This statement is too general to constitute a theory of development. The dynamic systems perspective, since it has already worked out a detailed theory of the relevance of the ecological context in the construction of action, can be readily applied to specify the linkages between the social context and individual action. We can state the notion of co-regulation in more dynamic terms as follows.

First, the co-regulation has to converge on a *location, object, a movement parameter, or information* that has some kind of recognizable ecological or cultural/social significance for the individuals. This will either be a simple bodily state, or a directly experienced ecologically relevant perception-action affordance. A related view is that shared meaning emerges from the co-regulated convergence of adult's and infant's perceptions of Gibsonian-like invariants in the physical environment, i. e., on directly experienced perception-action affordances (Butterworth & Cochran, 1980; Stern, 1985). In research on the development of joint reference in pointing, Butterworth & Groer (1988) found that infants appear to use information from the mutual orientation of own and adult's body, and direction of point to correctly identify the specific target of the

point. Thus, infants can extract information from the local socially co-regulated visual field to locate objects in more distant space.

Second, co-regulation is a self-organized dynamic process. Adults are not following a planned curriculum, nor are infants and children merely copying a model. Universal sequences of developmental change, both within individual ontogeny and within relationships, are natural outcomes of a social system that continually seeks its fundamental dynamic parameters each time the individuals meet and interact (Fogel & Thelen, 1987; Thelen & Fogel, 1989). Mother and infant continue to re-constitute the terms of the dialogue in ways that converge to the best solutions—those containing the best approximations to ecological or cultural task invariants—without necessarily seeking such solutions.

Why is it necessary to have a social dynamic for the development of human action?

It is hypothesized that social communication is fundamental to the development of complex human actions. First, many forms of human action are so complex that the discovery of their dynamics, that is the discovery of all the parameters needed to master the action, would be highly unlikely without the influence, not only of specific interactive partners, but of a cultural history of complex symbols and tools related to those actions. If one lists all the ways the hand is used before the age of one year, that list would be far beyond the imagination of the one-year-old—left to his or her own resources—to discover alone.

Second, it is quite possible that social situation contains unique types of affordances, ones that speed up the individual's ability to isolate the important dynamic parameters of action and/or focus on the relevant information linking perception and action. The fact that joint social action is not entirely self-produced, leads to a heightened awareness of precisely those aspects of action that are not under one's full control, and precisely those aspects of information that are not directly available.

If development is the acquisition of sensitivity to and control over the parameters of an action, once the child "feels" the inherent parameters of a dynamic process, he or she should be able easily to reproduce the action by controlling the correct parameters of that action (Newell, 1986). When adults share in the creation of dynamic action equilibria by the child (allowing the child to experience a new action without a loss of control) this may not only give the child clues about the specific action, but more general clues about how to regulate action by seeking its invariant parameters. Social interactions that lead to developmental change, therefore, should function to highlight dynamic parameters, and ways to identify them.

Third, it is important to study the unique forms of information found in social contexts and their relationship to the dynamics of action. How is culture embedded into the infant's development of action? Culturally based information is directly accessible so long as it is linked to the parameters responsible for the execution of actions performed by the child. Another way to say this is that children acquire cultural actions not by acquiring schemes for whole units of action, but rather because the meaning of the cultural information is directly experienced by the child in terms of the dynamic parameters that regulate the actions.

The social dynamic view suggests that development in social contexts is most likely to occur in actions that the child does not have under complete control. Unlike Vygotskian theories of scaffolding or guidance, which are primarily descriptive of the macroscopic progress of discourse over time, the social dynamic view specifies a process by which this might happen. The adult does not simply intuit the child's need (Papousek & Papousek, 1984) and provide the right kind of scaffold, but rather the adult actually must enter into the dynamic system by which the action is created. No less than the child's, the adult's behavior is the result of this process, not the cause of it.

Finally, there is nothing in the dynamic perspective specifying that the relationship needs to be tutorial, asymmetrical, motivated, or even positive. So long as the discourse uncovers (explicitly or implicitly) a dynamic parameter or new ecologically relevant information, developmental change can occur. This can happen between parent and child or between peers, under conditions of empathy or of manipulation, in dyads and in larger groups. The precise specification of how these types of relationships alter the ways in which dynamics are discovered allows for the theoretical analysis of the formation of individual differences in development and in relationships.

RESEARCH EXAMPLES

In this section of the paper I describe a program of research on early mother-infant communication that is based on a social dynamic perspective. According to the social dynamic approach, the investigator should try to find a social co-regulatory phenomenon in which the actual process can be observed. The dynamic systems view, in general, applies to processes that unfold in time and are studied as they are changing. It is not a cause-effect theory, nor an input-output theory, but rather a theory of emergent processes. Once a co-regulatory phenomenon is isolated, the next step is to observe the process under a number of different contextual conditions that directly alter the dynamics of the co-regulation, in particular: movement parameters and information. Ultimately, the goal is to specify the way in which information is linked to the dynamics.

The following research example will illustrate these principles. The dynamic phenomenon that I have been studying is infant postural co-regulation during mother-infant face-to-face interaction. Although posture has rarely been studied, it plays an essential role in the organization of the face-to-face communication because infants must be given postural support by the mother in order to be able to interact. Postural factors are known to affect the quality of face-to-face communication in children and adults (Bull, 1987; Goodwin, 1981). In mother-infant discourse we find similar patterns, except that infants have immature postural control. Nevertheless, via communicative processes to be discussed presently, infants can take part in the co-regulation of the postures in which their mothers place them. We know that infant postural position has important relationships to communicative processes. How mothers hold their infants in relation to the infant's intended focus may have a marked effect on one infant's resultant emotion expression and later communicative action (Fivaz, 1987; Stern, 1981).

How does posture affect gazing ?

As a first step in studying the effects of posture on face-to-face interaction we induced an experimental manipulation of infant posture in which we, rather than the mother, controlled the infant's postural position (Fogel, Dedo & McEwen, submitted). Twenty infants each were observed at 3, 4 and 5 months of age. Infants were placed in an infant seat while interacting face-to-face with mother in the absence of toys. The angle of inclination of the infant seat (and hence postural position) was adjusted from 0 deg. (supine), to 45 deg. (recline), to 90 deg. (sit) in half the subjects and in the reverse order in the other half. Mothers were asked to play with their infants as they would normally do at home, and they were requested to maintain a similar style of interaction across all three postural positions. Duration of gaze at mother was coded in each trial by coders who were blind to the hypotheses of the study. Order had no effect, and neither did the infant's age, but there was a main effect of postural position. Infants gazed less at their mothers when sitting (28% of the trial), and intermediate amount when reclining (50%), and the most when supine (64%). Infants who were assessed as being able to reach for objects looked less overall than non-reachers, but postural position had similar effects for reachers and non-reachers alike. Manipulation checks showed few differences in maternal behavior across the three conditions, and no effects on gaze at mother related to maternal behavior.

We cannot, from this study, determine exactly why sitting postures led to a decline in looking at mother. It was not due to a lack of head control, since all infants in this study had adequate head control. Rather, when sitting upright the infants appeared to search for things to look at other than the mother's face, including the chair, clothing and hands. Perhaps there is a change in the visual field, or a difference in the vestibular stimulation of having to hold the head up increases alertness. Regardless of the cause of this position effect, this would not be an unusual situation for mothers and infants, and mothers could take advantage of position change to alter their infant's attention.

What is surprising is that this study did not replicate earlier research done on face-to-face interaction in more naturalistic settings in the home. In those studies three-month-olds gaze almost exclusively at mother when toys are not present, but there is a declining amount of gazing at mother over the next three months as infants seek out objects (Cohn & Tronick, 1987; Kaye & Fogel, 1980; Keller & Gauda, 1987). Thus, in the experimental situation when mothers were not able to regulate the infant's posture, even 5-month-olds who normally look little at mother, spend 64% of a trial looking at her when they were placed in supine. Three-month-olds who typically look a lot at mother were only looking at her 28% of the time when placed in a sitting position experimentally.

How does information from the infant co-regulate posture ?

In order to investigate further the relationship between posture and gazing during face-to-face interaction, we used our longitudinal videotapes of mothers and their infants interacting on a chair with no toys between 1 and 6 months. Mothers were asked to "play and talk with your baby," and they were allowed to adjust the infant's

TABLE 1

Number of instances of a gaze shift to LOOK AT mother, LOOK AWAY or CLOSED, as a function of infant affective state (POSITIVE/NEUTRAL or NEGATIVE) and prior and next body position (SUPINE (SUP), UPRIGHT FACE MOTHER (UPM), and UPRIGHT FACE AWAY (UFA)). The total number of gaze shifts in the entire sample was N=2660. A + indicates that the cell is greater than expected by chance ($p < .01$) and a - indicates that the cell is less than expected ($p < .01$).

	Prior Position	Positive/Neutral			Negative		
		SUP	UPM	UFA	SUP	UPM	UFA
LOOK MOTHER	SUP	73 ⁺	71 ⁺	10 ⁻	7 ⁺	4	2
	UPM	53	59	51	4	7	1
	UFA	8 ⁻	117 ⁺	8 ⁻	3	1	0
LOOK AWAY	SUP	91	113 ⁻	102 ⁻	10	11	6
	UPM	112 ⁻	163 ⁻	548 ⁺	12	17	17
	UFA	133	463 ⁺	138 ⁻	13	13	4 ⁻
EYES CLOSED	SUP	36 ⁺	23	8	15 ⁺	11 ⁺	13 ⁺
	UPM	20	19 ⁻	10 ⁻	8 ⁺	14 ⁺	8 ⁺
	UFA	9	11 ⁻	2 ⁻	5 ⁺	3	0

posture freely. Each observation session lasted approximately five minutes. The tapes were coded for the onsets and offsets of actions using a digital clock on the screen on 3 passes through the videotape. On pass 1 we coded infant gaze direction (MOTHER'S FACE, AWAY, eyes CLOSED). On pass 2 we coded infant emotion expression (POSITIVE=smile, laugh, NEGATIVE=fuss, cry). On pass 3 we coded the infant's postural position as held by the mother (SUPINE, UPRIGHT facing MOTHER, UPRIGHT facing AWAY) (Fogel, 1990a).

At each age, the transition probabilities of the mother's changes in the infant's postural position were analyzed with log-linear modeling as a function of infant current affective state at the time of a postural position change, and infant's current gaze direction at the time of a position change. The results show that when the infant looks at the mother, she is likely to leave the infant in the same posture to encourage continued looking at her. When the infant looks away, she may shift the infant to a position that faces away from her, but later tries to regain the infant's attention to her face by shifting the infant's posture towards her. In general, the dynamic relationship between position changing and gaze depends on a number of informational factors in the local context of the action, including the infant's prior gaze state and affect.

Developmentally, however, the infants in this sample spend an increasing amount of time looking away from the mother and the mother spends an increasing amount of time holding the infant upright and facing away from her (and in the direction of the infant's gaze). Now, based on the results of the experimental study it would seem that mothers could always get their infants to gaze more at them simply by placing them in supine. The fact that mothers in the longitudinal study, and in other cross-sectional studies (Kaye & Fogel, 1980), change their infant's posture more when the infant looks

away from them suggests that they have discovered a relationship between attention/gaze and infant posture. So why does the dyadic interaction system tend toward increasing amounts of gaze away from mother and upright postures?

To understand this we have to look at individual differences in the relationship between posture and gazing. We have found that not all the dyads in the study show a developmental match between infant gazing away and postural facing away. For some dyads the infant looks away from mother developmentally earlier than the age at which the mother allows the infant to face away from her (Fogel, in press).

Our results show that about half the dyads have a synchronous developmental pattern (in which the infant's postural position matches the infant's gaze direction) and half have an asynchronous developmental pattern. It appears that looking away from mother in the synchronous infants occurred developmentally after the infant began extended bouts of positive smiling during face-to-face interaction. In these infants, the facing away matched the duration of looking away. In the asynchronous dyads, positive interaction and lengthy smiling occurred developmentally later than extended looking away from mother. Apparently, for this group of infants, the communicative information related to the lack of infant smiling somehow altered the dynamics of the attention-posture synergy, such that the mothers were more likely to override the infant's preference for looking away by turning the infant back toward the mother and attempting to use supine positions. Eventually, however, almost all the infants in the sample acquired smiling and eventually all the dyads negotiated a posture-attention relationship oriented away from the mother (Fogel, in press).

Smiling, therefore, is a source of information from the infant that altered the developmental course of the relationship between posture and gazing. We have just begun to examine the actual process by which the mother changes the infant's posture. In some cases, mothers will change an infant's posture if the child seems relaxed and smiles during the posture change. If the child becomes stiff or tense, or shows negative facial expressions as the posture is being changed, mothers leave the infants in the original position, or seek a different one. Thus it appears that affective information from the infant plays a role in the actual co-regulation of postural position (Fogel, in press).

How does cultural information enter the posture-attention synergy?

Another way to think about the relationship of information to dynamic social co-regulation, is the cultural interpretation the adult places on the infant's behavior, or on her role or task during the interaction. The meaning of the infant's action to the mother (how she interprets information from the infant) depends on a variety of infant behavioral factors, as well as the way in which the mother construes her task. As we saw from the longitudinal results, mothers are not always sensitive to the infant's immediate needs if they seem to have an agenda that focuses on longer term or other goals.

The social dynamic perspective predicts that mother's actions, as well as those of her infant, are emergent from the way in which culturally derived information is integrated into the dynamics of social co-regulation. It is important, therefore, to investi-

gate precisely how specific forms of cultural information are translated by the adult into interactive strategies. Adult action vis-a-vis some dynamic parameter will depend on whether the adult is trying to get an infant's attention, or to soothe an infant, or to teach something to the infant. Some forms of information may lead to a smooth dynamic co-regulation, while other forms of information may lead to under or over control of the social parameters. The research issue to be explored here is how these units of discrete information (to get attention, to teach, etc.) are related to social dynamics. What does an adult attempt to co-regulate when they intend to get a child's attention and how does this differ from other forms of informational goals?

We created an experimental situation in which mothers were asked to get an infants' attention either to their own face or to an attractive toy. Briefly, there were 12 mother-infant pairs studied at each of three ages: 3, 4 and 5 months. At each age there were two counterbalanced conditions: infant and mother with a toy, and infant and mother without a toy. Within each condition there were two 30-second trials. In the first trial the mother was asked to simply play with the infant. Via a wireless microphone the experimenter in another room communicated with the mother who had an earphone. She was asked where the infant was most interested in looking (at her or at the toy in the toy condition; at her or elsewhere in the no-toy condition). Whatever she replied, she was then asked to get the infant's attention to the thing the infant was not looking at. Thus, we can compare attention-getting strategies with free-play strategies, and attention-getting to objects vs. to people at three different ages. The mother's actions and the infant's gaze direction (toy, mother, or elsewhere) was coded continuously in time for each trial.

Preliminary findings from this study (Walker, Fogel, Messinger & Reimers, in prep.) were done by entering all infant and mother codes into a discriminant function analysis comparing free-play with attention getting trials. During the attention-getting trials mothers were significantly more likely to talk and to laugh. More importantly, they were significantly more likely to change their own or their infant's postural position, that is, by moving their face or the toy close to the infant's face, by standing infants up, turning infants toward the intended focus, and moving infants into the line of sight of mother or toy. These patterns of attention getting were significantly associated with infant gaze away from the object of the mother's efforts.

These results confirm those of the other studies we have done. Mothers indeed manipulate the postural position parameter systematically when asked to get an infant's attention. They also combine posture with a variety of other actions in a task-specific manner. The information given in the form of an instruction (to change the infant's attention, vs. just to play with the infant) led to the identification and use of the postural adjustment parameter. Counterintuitively, however, the mothers chose to stand the infant up, rather than lie the infant supine. This may be due to the fact that mothers already have established a routine involving upright postural orientation with their infants, and may be using the upright posture to increase alertness and attention to the mother's other attention directing efforts. In more spontaneous interactions, as we suggested earlier, mothers may time their postural manipulations according to cues from the infant about a readiness to be moved: that is, they allow the postural position

to be co-regulated. In this task they were unable to do this. They chose the “correct” parameter, but over-controlled it.

In this study, therefore, we can begin to see how a cultural construction of the task affects the interaction. The importance of this work is the isolation of a specific mechanism by which cultural information is translated into social action: that is, via its influence over the parameters of the dynamic co-regulation. Some forms of cultural information have a negative effect on the baby, not because the baby understands the instruction or understands that the mother is under some kind of stress, but more directly in the form of a constraint on movement. In this way, cultural information is linked to action dynamics that are directly experienced by the infant. Thus, there is no need to hypothesize some kind of higher order interpreter of cultural information on the infant’s part.

CONCLUSIONS

There is always discussion among social developmental researchers over the advantages and disadvantages of microanalysis and macroanalysis. Microanalysis is thought to be too detailed to capture the more important social developmental phenomena, while macroanalysis captures a broader perspective it often misses out on subtle aspects of interaction process. Which approach is chosen depends on one’s theoretical and clinical orientation. The social dynamic theory suggests how microscopic process (dynamic co-regulations) may be related to macroscopic events (in the form of social and cultural information in a communication system).

The advantage of using a dynamic systems approach for the study of development in social contexts is that dynamic systems has addressed the problem of how the task or context is related to the performance of the person. Information is that which the individual uses to specify the relationship between perception and action. The problem with simple Gibsonian action theory is that information is believed to be directly available to individuals in their ecological setting. While this may be true for simple motor affordances related to gravity, surfaces and textures, it cannot be true for the affordances of cultural tools, objects, symbols and communicative action.

How does the culturally naive infant come to grasp the affordances of a maternal smile or a word? My claim is that this happens because adults make the meaning of the cultural information directly available to the infant by entering into a movement dynamic that the infant can directly experience. Elsewhere (Fogel, in press; Fogel, Nwokah & Karns, in press) I explain how this theory is fundamentally different from other social theories that rely on imitation, reinforcement, sensitivity, scaffolding. The problem with these approaches is that they have to assume the child can directly grasp the macroscopic cultural information systems.

In the final analysis, one cannot prove or disprove a theoretical perspective. A theory derives its value from its ability to explain natural phenomena, and its ability to generate new research. I have presented the outlines of such a research program. The goal of the program is not to prove the theory, but to better understand how infants develop in their social and physical context.

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