



University of Pennsylvania  
**ScholarlyCommons**

---

Departmental Papers (ASC)

Annenberg School for Communication

---

February 1991

## The Biological Origins of Automated Patterns of Human Interaction

Joseph N. Cappella  
*University of Pennsylvania*, [jcappella@asc.upenn.edu](mailto:jcappella@asc.upenn.edu)

Follow this and additional works at: [https://repository.upenn.edu/asc\\_papers](https://repository.upenn.edu/asc_papers)

---

### Recommended Citation

Cappella, J. N. (1991). The Biological Origins of Automated Patterns of Human Interaction. *Communication Theory*, 1 (1), 4-35. <https://doi.org/10.1111/j.1468-2885.1991.tb00002.x>

This paper is posted at ScholarlyCommons. [https://repository.upenn.edu/asc\\_papers/106](https://repository.upenn.edu/asc_papers/106)  
For more information, please contact [repository@pobox.upenn.edu](mailto:repository@pobox.upenn.edu).

---

## The Biological Origins of Automated Patterns of Human Interaction

### Abstract

The biological origins of automated patterns of human interaction are explored. Automated patterns of interaction are distinguished from deliberate patterns. Automated patterns consist of two particular types: stimulation regulation and emotional responsiveness. Evidence for the biological origins of these patterns is obtained by studying the early interactions of infants and neonates, surveying the ethological parallels, exploring the evolutionary adaptiveness of the specific patterns, and ascertaining physiological, psychopharmacological, and brain mechanisms responsible for the patterns. Although circumstantial, the case for a biological basis for stimulation regulation and emotional responsiveness is very suggestive.

---

Joseph N. Cappella

## **The Biological Origins of Automated Patterns of Human Interaction**

---

*The biological origins of automated patterns of human interaction are explored. Automated patterns of interaction are distinguished from deliberate patterns. Automated patterns consist of two particular types: stimulation regulation and emotional responsiveness. Evidence for the biological origins of these patterns is obtained by studying the early interactions of infants and neonates, surveying the ethological parallels, exploring the evolutionary adaptiveness of the specific patterns, and ascertaining physiological, psychopharmacological, and brain mechanisms responsible for the patterns. Although circumstantial, the case for a biological basis for stimulation regulation and emotional responsiveness is very suggestive.*

Consider what one can mean by the origins of a set of human behaviors. Origins can be located in learning, through the social, cultural, and environmental forces impinging on the organism. They can be located in the set of causal forces that produce the immediate behaviors under scrutiny. Origins can also be found in the set of logical operators that give rise to the set of all possible behaviors within a given domain, as Chomsky's (1957) grammatical operators did for language. Finally, the origins of a set of behaviors can be located in the biological, genetic, and evolutionary forces that are ultimately responsible for the behavior set. These four domains may be labeled nurture, proximate causality, logical generation, and nature.

A student of human behavior interested in understanding behavior in its fullest would be unwise to neglect any of these aspects of a behavior's origins. To do so would be like trying to understand the volume of a complex geometric figure (like a duodecahedron) by measuring its height. It just will not work. That caveat offered, the focus of this article will nevertheless be limited to the biological origins of human interaction, locating itself on nature's side of the nature-nurture debate.

Why should one focus on the biological origins of human interaction? Forgetting about the "human interaction" component for the moment, several factors recommend a consideration of the ultimate origins of a behavior pattern. First, in the field of communication studies, the preeminent forms of explanation of human behavior have been the social and psychological. The reasons for this are as much accidents of history, linked to the roots of communication studies in social psychology, as they are a result of rational consideration of the set of explanatory forces operative in human conduct. Recent trends indicate an even larger role in

explaining human communication being given over to social forces. Although I have no bone to pick with proponents of these trends, a balancing is necessary. One of my goals is to show that biological origins are as important to understanding aspects of human communication as are its social origins.

Second, a swing toward the biological is necessary because we are, after all, biological organisms. This is not to hold for some sort of naive biological determinism but reflects the simple observation that in addition to existing within societies, to harboring abstract knowledge, and to requiring cultural rituals, grandiose and mundane, we also possess brains, genetic material, psychopharmacological chemicals, and animal relatives, near and far. To pay homage exclusively to the social while ignoring the tangible and material, our physical and biological heritage, can promote a myopia that will be costly to any science of human behavior in the long run.

Third, a focus on the role of culture and socialization in understanding human communication is a focus on what separates us from the experience of other cultural groups. Certainly, the emphasis in a large proportion of studies on communicative behavior has been to focus on differences, whether they be gender differences, personality differences, situational differences, social and economic status, cultural differences, and so on. Such a preponderance of interest is defensible in that the explanation of heterogeneity serves social goals and scientific curiosity. At the same time, research and theory needs to understand the extent to which peoples are united in a common heritage and if, indeed, they are. What is exciting about Ekman's work (Ekman, 1972; Ekman et al., 1987) on cross-cultural uniformity in the display and interpretation of facial emotion is the finding that a fundamental communication system operates across peoples and cultural experiences. The search for biological origins is the search for processes fundamental to diverse peoples and perhaps diverse species. If we are to discover not only what separates us from other organisms but also what unites us to them, then studies of biological origins must be undertaken.

Fourth, the search for biological origins of a set of phenomena, if successful, will help to identify those phenomena as central to the human experience and not mere artifacts of particular patterns of socialization within a culture. One of the charges easily leveled against much research in communication is that ephemeral processes become the objects of intense scrutiny, only to disappear with changing times, changing populations, and changing research trends. The discovery that a particular set of phenomena is linked biologically to fundamental human experiences is a warrant not easily dismissed.

Fifth, the search for origins turns the research community toward a set of evidence that may have been of only peripheral interest in answering questions related to immediate causality or nurture. In this essay, evidence on developmental processes, animal behavior, cultural similarities and differences, physiological and psychopharmacological processes, and evolutionary considerations are considered as central sources of evidence. This turn broadens the evidentiary search that an already cross-disciplinary field like communication research must undertake but, at the same time, yields data that provide a counterpoint to what is otherwise an adult, human, Western, highly cognitive, and purely symbolic basis of evidence.

Sixth, the field of communication studies, like other fields in the behavioral and social sciences, is trying to establish itself as a science. A science should not be equated with its methods but rather with the kinds of knowledge claims it establishes. In my view, scientific methods can be used to study any number of phenomena that have no possibility of yielding scientific knowledge. For example, public-opinion polling results are dependent upon scientific methods but do not yield scientific knowledge. They do yield knowledge claims and precise ones at that. However, I would argue for the position that scientific knowledge is knowledge that is stable, pancultural, and ahistorical.<sup>1</sup> Whether such knowledge is achievable in the social and behavioral sciences is anything but a settled issue (Fiske & Shweder, 1986). I believe that scientific knowledge claims in human communication will, at a minimum, be constrained knowledge claims. If a claim is to meet the criteria of being pancultural and ahistorical, it must be either at very high levels of abstraction (e.g., equity principles but not what counts as equitable) or very low levels of abstraction (e.g., physiological linkages between partners in emotional interactions). It is these latter, low levels of abstraction that lead me as a final reason to the study of biological forces shaping human interaction. Simply put, the emphasis on biological origins is one potentially rich location for the discovery of truly scientific knowledge about human interaction. What is certain is that ignoring the biological origins of human behavior will produce less complete and more skewed understanding than giving it serious consideration.

---

#### **Automated Interaction Patterns**

Interaction is *not* simply the generation of social symbols or social signals; neither is it reducible solely to the reception or interpretation of such symbols or signals. Nor can interaction be understood to be the interleaved monologues of two schizophrenics unresponsive to each other's words. Although interactions are made up of components identifiable as production and comprehension, and although interactions may include long monologues by one or the other party, they are not equivalent to these parts without losing the essence of interaction: regular patterning of exchange.

In this essay, interaction means the regularized patterns of messages from one person that influence the messages sent in turn by the other over and above what they would otherwise be (Cappella, 1985, 1987). Note that this definition emphasizes *pattern* of exchange between two persons and *not* the behavior of one or the other person even though that behavior occurred in the context of an interaction with another. For example, using my definition, your rude remark during cocktails is not an interaction; in itself it is merely a rude remark. But your rude remark followed by my sarcastic reply and your insult in turn *is* an interaction representing a fairly common and regular pattern of escalating hostility.

---

#### **Classifying Interactions**

The domain of possible types of interaction is incredibly broad, ranging from the ritualistic insults of young teenagers (Labov, 1972) through the hostile exchanges

of spouses in conflict (Gottman, 1979) to the studied politeness of requests and refusals in class conscious societies (Brown & Levinson, 1987). Such a domain is rich enough to be studied for a lifetime by a phalanx of scholars.

The aims of this article are somewhat more modest (but not much). The set of interactions scrutinized here will be restricted. Interactions may be separated in terms of how *deliberate* or *automatic* the enacted pattern is (Anderson, 1985; Berger & Roloff, 1980; Kahneman, 1973; Langer, 1978; Langer, Blank, & Chanowitz, 1978). At one pole, some interactions are deliberate in the sense that how one responds is for the most part purposeful, conscious, and voluntary, involving the allocation of one's cognitive resources to the choices that are being made. The decision to share secrets about oneself with another, to reciprocate or withdraw from a deliberate touch, to minimize another's compliment, to offer excuses in response to an accusation or transgression, and to stare back at an impolite stare are all examples of deliberate interactions. As interesting and important as these interactions are, they are excluded from consideration in what follows. My reasons for excluding them will, I hope, become clear as we progress. However, these interaction patterns are more likely to have strong components of learning and to be culturally and historically bound.

At the other pole, some interactions are automatic in the sense that how one responds is without reflection on the behavior itself so that few cognitive resources are being allocated to the behavioral choices being made. It is not that these patterns cannot be brought to consciousness or made to operate under voluntary control (for indeed they can), but rather, for the most part, they are not. For example, the hostile tone of voice that develops as conflict intensifies, picking up an accent when talking to a business associate from London, the increasing loudness after just 15 minutes with your boisterous sisters, and the contagious pace of conversation with an exuberant colleague are all examples of automatic interactions. Despite their apparent triviality and seemingly innocuous role in human affairs, it is precisely these interactions that will be the focus here.

Obviously, realistic interactions weave the deliberately enacted and automatically produced signs of human conversation together, sometimes creating a masterful tapestry and at other times a knotted jumble. Focus here is on the automatic features of interaction both because they are assumed to be less susceptible to cultural and historical variations and because, as I hope to show, they are central to human communication, human development, and human affairs.

---

### **Patterns of Adult Interaction**

The study of adult (automatic) interaction has been summarized elsewhere (Cappella, 1981, 1983, 1985, 1987; Cappella & Greene, 1982). On the basis of these reviews three broad patterns of adult interaction can be identified: turn taking, stimulation regulation, and emotional responsiveness. Turn taking refers to the processes by which people allocate the speaker and hearer roles during ordinary processes of interaction. Turn taking will not be considered further since, even though the parallelism with infant development of this skill are fascinating,<sup>2</sup> evidence of other biological origins is not available. Stimulation regulation refers

to those processes by which persons control one another's expressed levels of activation (as measured by intensity and rate of behavior). Emotional responsiveness refers to the tendency to approach or withdraw from, to mimic or mismatch the expressed emotional state of another.

In the case of both of these broad patterns of interaction, an important aspect of the psychological and social life of the actors is controlled. With stimulation regulation, intensity and excitation are transmitted and accepted or rejected. In the case of emotional responsiveness, particular emotional states (including especially anger, sadness, joy, fear, disgust, surprise, interest, distress) are communicated; more generally, the hedonic tone (positive or negative) of the sender leads to either approach or withdrawal by the receiver.

---

### **Supportive Research**

The amount of research relevant to these broad patterns of interaction is, for the most part, quite extensive. One indicator of stimulation is the tempo of the conversation as measured by the rate of speech of the partners and their quickness (or latency) to respond. Numerous studies support the claim that partners converge partially toward one another's conversational tempos (see, e.g., Cappella & Planalp, 1981). A recent study (Street & Cappella, 1989) on 3–6-year-old children with an adult partner obtained a similar effect for speech rate, especially for children who were skilled enough to be topically responsive. Thus, the regulation of conversational tempo exists in children just beginning their linguistic careers.

If speech rate and latency were the only behaviors indicative of stimulation regulation, then this pattern would be a weak and uninteresting one indeed. Instead a wide variety of behaviors are involved. Cappella, Palmer, and Donzella (1989) found that partners adjusted the social stimulation (an index of several vocal and kinesic behaviors) that they expressed in response to the degree of stimulation expressed by the partner as the interaction unfolded. These data and findings are unique in observations on adults because of their temporal nature and consistency across individual dyads. Buder (1985) has reported adjustments by adult speakers to one another's fundamental vocal frequency during periods of simultaneous speech. Fundamental frequency, technically known as  $f_0$ , is commonly associated with arousal; the higher the  $f_0$ , the higher the arousal (Scherer, 1986). Convergence in vocal amplitude has been carefully studied by Natale (1975a, b). He found that persons tended to converge over the course of time to the loudness levels of their partners, especially if their need for approval was high.

The above findings indicate that, in adults, stimulation is contagious, but it is not always so, sometimes being rejected through some form of withdrawal. Indeed, adults seem to find others' social stimulation arousing for the most part and respond with an increase in their own expressed activity or an imitation of the other's behavior. But the same cannot be said for the stimulation caused by close interpersonal distance. Such distances are experienced as anxiety producing (in neutral or negative social settings) for the most part (Cappella, 1983) and lead to withdrawal primarily in the form of reduced gaze, more indirect orientation, and quicker responses. Cappella and Greene (1984) found this same effect in one

study but also found that persons who viewed arousal as rewarding (high sensation seekers (Zuckerman, 1979)) rather than punishing (low sensation seekers) exhibited less withdrawal. These findings suggest that the control of arousal mediates the proximity-withdrawal effect.

Emotional responsiveness studies would normally be concerned with the matching or mismatching of particular emotional states as revealed through facial displays of emotion (Ekman, 1972; Ekman et al, 1987). To my knowledge very few studies of facial displays of emotion between adults in natural social interaction have been conducted. In a recent article, Krause, Steimer, Sanger-Alt, and Wagner (1989) cite previously unpublished research from their laboratory indicating that interactions between schizophrenic patients and their healthy partners lead to a depression of facial activity in the healthy partners, especially involving fewer positive emotional displays in comparison with facial displays when healthy subjects interact with healthy partners.

Part of the reason for the paucity of work on spontaneous facial displays in natural conversational settings may be the concern that displayed facial emotions will be confounded by cultural display rules and facial emblems so that displayed facial configurations will represent voluntary and controlled reactions rather than spontaneous subjective states (Motley & Camden, 1988). Despite a lack of research on matching and mismatching of specific emotions, research on the matching or mismatching of more general hedonic tone has been carried out.

Gottman's (1979) work is central and exemplary here. His work with interactions between married partners has shown that hostile affect tends to be matched in both well-adjusted and less well-adjusted couples. This finding has been replicated by Pike and Sillars (1985), Margolin and Wampold (1981), and others. Noller's (1984) studies of married couples reveal convergence on eye-gaze patterns between husbands and wives for both satisfied and dissatisfied couples. In an experimental context with a different group from married partners, Bavelas and colleagues (Bavelas, Black, Chovil, Lemery, & Mullett, 1988; Bavelas, Black, Lemery, MacInnis, & Mullett, 1986) observed that when subjects were exposed to a target who was about to be injured, observers leaned with or grimaced with the victim when the victim could see the observer's reaction but did so less when eye contact from the target was absent. Apparently the communicative value of the expressed emotional response was significant in encouraging its elicitation.

As with stimulation regulation, matching seems to be the rule for which exceptions exist. The clearest example is that of Kaplan, Firestone, Kline, and Sodikoff (1983). Kaplan and colleagues manipulated the hedonic tone of a confederate to appear to be increasingly affiliative and observed the approach and withdrawal reactions of persons exposed to the confederate. For those persons who had been led to believe beforehand that the confederate was very similar to them, approach resulted; for those who were led to believe that the confederate was very different from them, strong avoidance resulted. These findings were clear and decisive; not only did the subjects take into account the hedonic tone of the confederates' actions but weighed those relative to their expectations about the confederate's attitude toward them.

The only studies that come close to the specific emotional matching and



mismatching that should be characteristic of emotional responsiveness are those of Buck (1975, 1976, 1979). Using a slide-viewing paradigm, Buck has his subjects watch certain types of slides chosen for their ability to elicit facial reactions from the particular subject group. The watchers are surreptitiously videotaped and their facial displays shown to another group of dissimilar or similar judges whose task is to guess what emotion is being displayed. Accuracy of judges is determined by comparing judges' with slides' emotional content and comparing judges' ratings of the sender's emotion with that reported by the sender. With college students and 3-6-year-old children, communication accuracy is above chance levels for both types of accuracy. Also, those who are more accurate senders of facial emotion show less skin conductance responding than those who are less accurate senders. Overall, emotional states, spontaneously generated, are communicated accurately, carrying information about the subjective state of the sender and the condition eliciting the emotion, at least for subjects who are "externalizers" of their subjective states and do not hold in their emotional reactions. This paradigm is as close as the adult research comes to a study of discriminative emotional responsiveness.

---

#### **Significance of Adult Interaction Patterns**

The stimulation and emotional patterns are certainly interesting features of adult social interaction, but, then, South American tree frogs are certainly interesting to zoologists. Before making complicated questions about the origins of these patterns, we should also raise questions about the social value of studying them.

Patterns of interaction and their disruption can be the symptoms of some underlying personal or relational disability or can be associated with some positive or negative interpersonal outcome. Street (1982) found that when interviewees' speech patterns had converged to those of an interviewer, judges evaluated the interviewees more positively than those who had not converged. Feldstein, Konstantareas, Oxman, and Webster (1982) studied the speech convergence of autistic teenagers and found that they failed to show convergence with either parents or therapists while the parents and therapists exhibited convergence with one another. Similar findings were obtained with adult schizophrenics (Glaister, Feldstein, & Pollock, 1980) and depressives (Jaffe & Anderson, in press). Thus, speech convergence seems to be recognized as interpersonally positive, and its absence seems to be characteristic of certain abnormal adult interactions.

It is the findings on matching in negative affect that are most striking. Although reciprocal negative affect is common in studies of married couples, Pike and Sillars (1985), Gottman (1979), and others have found that less well-adjusted and less satisfied couples exhibit greater reciprocity in hostile affect. Although it is not clear whether the similarity in hostile affect is a symptom of marital discord or results in marital discord, its replicable association with marital unhappiness is a promising, if unhappy, result. In a recent update and extension of these findings, Levenson and Gottman (1983) found once again that negative affect reciprocity distinguished distressed from nondistressed marriages. In addition, the linkage

between husbands and wives on four physiological measures of arousal taken during the interaction very strongly predicted distress with the more strongly linked couples also the more distressed. These findings are especially important because the physiological measures of arousal parallel the findings for the interactional measures of negative affect in predicting marital distress. When these results are coupled with Ekman, Levenson, and Friesen's (1983) (controversial) findings that heart rate acceleration accompanies the negative emotions of fear, sadness, and anger, we have the exciting possibility that coupled emotional states, measured physiologically and behaviorally, distinguish distressed from nondistressed couples.

The story would not be complete without mention of Levenson and Gottman's (1985) follow-up to their 1983 study. In this case, they recontacted the couples studied earlier to determine the state of their marital relationship after 3 years. Once again the decline in marital satisfaction 3 years after the initial lab interactions and physiological measurements was strongly predicted by negative affect reciprocity and by the couple's physiological arousal (in this case it was the mean level of couples' arousal and not their temporally linked arousal). What is remarkable of course is the strength of the findings and their persistence over such a long time span.

In sum, two patterns of interaction characterize the spontaneous aspects of adult conversations. In all cases, matching and approach responses are the typical modes of reaction. Under certain circumstances mismatching and withdrawal can and does occur. These interactions are also important indicators of relational state and possibly indicative of individual competency.

Given the pervasiveness and significance of these interaction patterns, the curious cannot help but speculate as to their origin. Have they been learned in particular cultural and social settings? Are they the remnants of some primitive biological and genetic dispositions?

---

### **Searching for Evidence about Origins**

Discussions about origins inevitably come down to questions about biology and society, nature and nurture. Unsurprisingly, answering questions about the ultimate cause of certain behaviors will not be definitive. The case must inevitably be circumstantial. This is not equivalent to guessing, but does require that a complex web of interlocking facts and evidence is used to piece together a puzzle that is no less complete and compelling than if we had a definitive set of studies. But, what types of evidence could plausibly distinguish the two explanations?

*Evidence from the Study of Neonates and Infants.* If adult patterns are present in the interactions of infants and their primary caretakers, then the influences of culture and socialization have had little opportunity to exert influence suggesting that some type of biological disposition for the pattern (or at least for the mechanisms that give rise to the pattern) exists. The earlier the pattern emerges, the more likely the pattern is the result of some wired-in mechanism, rather than some learned associations. Of course, the neonate is not an adult (e.g., differs the

terms of brain structure (Buck, 1982) and visual acuity, among many other things) so that the patterns of interaction must be studied within the bounds of these physical limitations.

*Evolutionary Adaptiveness.* Here the argument is made that a particular behavior has adaptive value, not in general, but specifically in terms of the survival of members of the species. If a particular behavior pattern has adaptive value for the species, then presumably the pattern will enable the individuals employing the behavior to meet some contingency in the environment to survive while others fail to meet the environmental demands. It is this difference, manifested behaviorally but allowing an edge to subsequent propagation of the genes, which accounts for the genetic base of the behavioral pattern.

The argument from evolutionary adaptiveness and selection by itself is not a very strong argument, since one could also argue that societies and groups will adopt social norms for future behavior that have been successful in the past in producing effective and viable members of the society. In short, learning, like evolution, may be biased in the direction of learning what is socially and, perhaps, even biologically advantageous. However, in combination with evidence from neonatal and infant development, physiological structures, and ethological parallels, the arguments for adaptive selection and genetic endowments can be strengthened to produce a highly suggestive, if not airtight, case.

*Evidence from Physiological Structures Responsible for the Observed Patterns.* If physiological structures and processes can be identified that are linked to the behavioral patterns under scrutiny, then, while social conditions may *elicit* the behavioral patterns, psychophysiological structures may be the necessary causal mechanisms through which socialization occurs. This research becomes an especially important component of the evidentiary base because elemental causal mechanisms allow testing under certain conditions and link ultimate and proximate explanations.

*Cross-Cultural Similarities.* To the extent that a given behavior pattern is observed across cultures, that behavior pattern is more likely to have a biological or panhuman basis with cultural influences playing a smaller role. Given the difficulty of conducting cross-cultural research and the ethnocentrism of much social and behavioral research, only a little cross-cultural evidence is available to make this portion of the case.

*Ethological Analogies.* Parallels between human and other animal species may be of two general types: analogies and homologies. An homology traces similarities in behavior between two or more species to a common ancestor responsible for the existence of the trait or behavioral pattern in the offshoots of the common ancestor. An analogy merely notes similar behavior patterns in different species and may be the result of an homologous relationship, although the origin is indeed unknown and certainly unverified. The former is clearly more difficult to establish but also is a stronger argument for the biological basis of a given behavior pattern. On the other hand, the complete absence of information of an analogous sort allows no inference to biological origins, no matter how weak that inference might be. In short, analogies between human and other species are better than nothing.

What is clear is that no single source of evidence can be definitive in establishing the biological origins of a particular behavior pattern. However, the pattern of evidence can lead to the construction of a circumstantial case permitting reasoned, if tentative, speculation. Evidence in each of the above areas will be introduced.

---

### **Interaction in Neonates and Infants**

*Stimulation Regulation.* The typical pattern of playful mother–infant interaction (for normal mothers and infants) during the first 9–12 months of infancy can be characterized as follows: (1) the mother is passive while the infant gazes away; (2) the mother engages the infant through modifying facial, vocal, intonational, and gestural (that is, movement) behaviors; (3) the mother and infant remain in visual contact, vocalizing, gesturing, moving, smiling, and being facially animated; (4) the infant terminates the interchange with gaze averted from the mother (Cohn & Tronick, 1987).

The evidence for this pattern of normal play is quite extensive (Field, 1987), and only a few recent works will be summarized here. What is crucial to stimulation regulation is what happens during the third and fourth period in the above sequence. Jasnow and Feldstein (1987) found matching in speech latencies for mothers and their 9-month-old infants (although latencies from infant to mother were negative). Berneri, Resnick, and Rosenthal (1988) had judges rate the tempo or synchrony of mother and infant (ages 14–18 months) during play and found that those of mothers with their infants were rated as more synchronous than those of mothers with a different infant. Stern, Hofer, Haft, and Dore (1985) studied matching in intensity, timing, and shape of activity between mothers and their 11 month olds, finding matching across modalities (e.g., gestural rhythm by infant matched by vocal rhythm of mother).

The stimulation matching observed with older infants also occurs earlier. Cohn and Tronick (1987) studied 54 mother–infant pairs at 3, 6, and 9 months of age. One of their central conclusions is that across all three ages it is the infant who breaks the stimulation interchange while the mother remains engaged throughout. This indicates that the infant is self-regulating. Symons and Moran (1987) observed vocalization, gaze, and smiling for both mother and infant (ages 13–16 weeks) under play, imitation, and attention-getting sessions finding that infants were responsive to mothers and mothers to their infants from one second of time to the next (in play and imitation sessions only). Similar findings have been obtained in studies of noncontent speech in 4 month olds (Beebe, Jaffe, Feldstein, Mays, & Alson, 1985; Stevenson, Ver Hoeve, Roach, & Leavitt, 1986), pitch matching in 6 month olds (Kessen, Levine, & Wendrich, 1979), and affective behavior in 3, 6, and 9 month olds (Cohn & Tronick, 1988). One should not conclude, however, that the infant is being molded by the mother but rather regulates the interaction as well, perhaps as early as 8 to 9 weeks of age (Murray & Trevarthen, 1986).

The significance of these periods of play and the infant's sensitivity to the mother's activity levels is demonstrated clearly when disruptions occur. Murray

and Trevarthen (1985) had mothers adopt a blank facial expression at one point in interacting with their infants who were 6 to 12 weeks of age. The result of this blank expression in comparison with a normal play period was striking with the infants exhibiting more signs of distress, less smiling and relaxation, and less gaze toward the mother. In a variation on this theme, these same authors played back to the infant a videotape of the mother playing in a previous session with her infant. The mother is behaving normally on the tape but her behavior is "out of sync" with that of her infant. The infant responded to the "out of sync" mother in a manner parallel to the "blank faced mother" suggesting that synchrony rather than affect is the regulative force.

Signs of this ability to respond to and withdraw from the mother's stimulation appear very early in the infant's development. Hoffman (1978) notes that neonates commonly engage in contagious crying in hospital nurseries and that this crying is a quite vigorous response to external cries. In a remarkable demonstration of synchrony in stimulation, Berghout-Austin and Peery (1983) conducted a statistically reliable test of movement synchrony between neonates and an experimenter. The experimenter simply talked to the neonate at a facial distance of 19 cm. Movement synchrony was present in all five infants who were only 30 to 56 hours old!

Together with an array of other data (see Field, 1987), the above studies suggest a pattern of stimulation regulation in early and later infancy parallel to the stimulation regulation described in adults. The effect is pervasive and shows signs of occurring very early in the life of the neonate.

*Emotional Responsiveness.* Like studies in the adult domain, infant studies of specific emotional responsiveness are few. Although the evidence for the pancultural and innate character of facial emotional display and its interpretation is very strong (Fridlund, Ekman, & Oster, 1987), the ability of infants to display and recognize facial emotions is under considerable dispute (Field, 1985a; Haviland & Lelwicka, 1987; Izard & Malatesta, 1987; Nelson, 1987). Izard and Malatesta (1987) argue that four basic emotions are present at birth and able to be expressed by the infant in facial displays: smiling (though perhaps not the social smile), disgust, distress, and interest. The other facial emotions develop and emerge over the next 7 months or so. Nelson (1987) argues that infants' abilities to recognize faces is quite limited due to lack of development of the visual system. He does not deny, however, that facial displays when richly articulated and accompanied by vocal cues may be recognizable in certain of their features.

Some findings seem to contradict aspects of Nelson's characterizations of infant's abilities to recognize and express emotion. Meltzoff and Moore (1977) conducted two carefully controlled experiments of infants 12 to 21 days old interacting with an experimenter who displayed specific facial and finger configurations. These infants imitated both facial and digital movements even when other, nonimitative behaviors were taken into account. Field (1985b) studied 48 full term neonates who were approximately 45 hours old. Half were exposed to their mother's face versus a stranger's and half were exposed to their mother's face and voice versus a stranger's. In terms of visual regard, 17 of 24 looked longer at their mother's face and 21 of 24 looked longer at their vocalizing mother than the

stranger. Exposure to the mother before the study could have been no more than 4 discontinuous hours. Field, Woodson, Cohen, Garcia, and Greenberg (1982) had a female model pose happy, sad, or surprised expressions to a group of preterm neonates (35 gestational weeks) and a group of full-term normals. They observed few differences between the mouth expressions of the pre- and full-term infants finding basically that the happy faces elicited more widened lips, the sad faces more pouting lips, and the surprise faces more wide open mouths. Field's data suggest an ability *at birth* to recognize significant faces and to imitate features of the facial expressions of their partners (but see Kaitz, Meschulach-Sarfaty, Auerbach, & Eidelman, 1988, for alternative results).

Haviland and Lelwicka (1987) discovered that infants produce adult-like affective reactions to facial displays and vocal behaviors that some others suggest should not yet exist in the infant's repertoire. Six boys and six girls who were 10 weeks old were studied in an experimental situation with their mothers. The mothers randomly produced a facial and vocal expression of anger, sadness, or happiness. Facial expressions of the mothers and the infants were coded and their vocal expressions judged as well. The infants showed some matching of their mother's facial responses, specifically the happy and angry faces but not the sad faces. Interestingly, the infant's expressions of joy tended to decrease over repetitions being replaced by interest expressions. Anger expressions to the mother's anger increased over time while interest expressions were generally inhibited. Although mother's sadness did not elicit sad faces, joy, anger, and interest reactions by the infants to her sadness were below expectation and mouthing activities (usually associated with sucking) were above expectation.

Although strict imitation was not found across all sessions or all emotions, the observed patterns of interaction certainly make sense if one attributes an adult conception of emotional interpretation to the infants. Positive emotions, like joy, elicit an initially joyful response with subsequent decrease of joy but increase of interest. Anger elicits lack of interest and, when it persists, begins to elicit an angry response. Sadness elicits a lack of emotional responding and an attempt to retreat into a safer, more reinforcing activity (simulated sucking). The anger finding is particularly interesting because it parallels the findings of Gottman and others on hostile affect reciprocity.

Research by Termine and Izard (1988) with 9-month-old infants supports the findings of Haviland and Lelwicka but with an older group. Mothers posed facial expressions of sadness and of joy with appropriate vocal behaviors while their infants watched them or played with toys. The infants showed more joy expressions to their mother's posed joy than to posed sadness and showed more anger and sadness to posed sadness than to posed joy. Additionally, gaze aversion to the posed sadness was greater than to the posed joy. The question, of course, is how infants could have such a sophisticated appreciation of emotion so young.

---

### **Significance of Infant-Mother Interaction**

Common sense would suggest that the patterns of interaction between mother and infant will be important to the immediate and future well-being of the infant.

In this section, these common-sense ideas are tied to a base of research; in addition, the conditions under which asynchronous interaction patterns might arise are discussed.

Long-term effects of mother–infant interaction have been posited for language acquisition and learning basic concepts such as contingency. The turn taking associated with stimulation regulation and vocalization and movement patterns in early infancy may establish the necessary “protoconversations” prerequisite to the learning of language. For example, Coates and Lewis (1984) studied interactions between mothers and infants at 3 months and followed up the infants’ cognitive and linguistic abilities 6 years later. They found some positive relationships between certain of the cognitive and linguistic measures at 6 years and mother–infant responsiveness at 3 months. They speculated that the pattern of responsiveness at 3 months remained throughout infancy and early childhood explaining the developmental success of certain of these children. The concept of contingency so central to all types of social and physical action is also embodied in the very definition of interaction: my action will affect yours and yours mine. Without the development of back-and-forth turn taking, infants may have trouble in the teaching and learning settings required for language acquisition (Bateson, 1975; Bruner, 1977).

Perhaps, the most important effect associated with stimulation regulation and emotional responsiveness is their association with the development of a positive affective bond between infant and mother. Secure attachment by the infant is central to exploration, cognitive growth, the development of later interactional ties, and to the functioning of all primate species (Ainsworth, 1978; Bowlby, 1969). Unfortunately, the data directly evaluating this claim are both sparse and methodologically weak. Ainsworth (1978) found that securely attached infants at 12 months (as measured via the Strange Situation) had more sensitive interactions with their mothers at 3 months. These findings were replicated in Germany as well (Grossman, Grossman, Spangler, Suess, & Unzer, 1985). A recent study (Isabella, Belsky, & von Eye, 1989) provided a more direct test of the synchrony–attachment hypothesis. Mothers and their infants were observed interacting at 1, 3, and 9 months of age and categorized as primarily synchronous or asynchronous during the observed interactional period. These pairs were categorized as secure, avoidant, or resistant at 1 year old according to criteria of Ainsworth’s Strange Situation. Pairs that were synchronous at ages 1 and 3 months were categorized as securely attached at 1 year. Although this is useful evidence, one might look upon certain types of emotional responsiveness (positive ones) and stimulation regulation (synchronous ones) themselves as part of the definition of attachment or, at least, as the mechanism through which attachment is achieved. More will be made of this argument later.

Of course, not all interaction patterns run smoothly and disruptions can occur. For example, at-risk infants who are preterm rather than full-term seem to be easily overstimulated. A study by Lester, Hoffman, and Brazelton (1985) of infants at 3 and 5 months of age showed that interactions with the mother were less coherent (that is, less synchronous) for preterm infants than for the full-term

infants. Certain aspects of synchrony increased for the full-term infants from 3 to 5 months. Thus, the preterm infants' interactions were unlike those of their full-term counterparts. These at-risk infants also typically gaze away more, vocalize less, and have more elevated heart rate than less risky infants (Field, 1977, 1982). Lester, Hoffman, and Brazelton (1982; cited in Field, 1987) showed that the synchrony in heart rate between infant and mother in social play was stronger than that between infant and stranger. Overall, these findings suggest not only a behavioral synchrony but also a physiological synchrony early in the social interactions of infants and their mothers.<sup>3</sup>

Mothers, too, can be the source of interactional problems for their infants. Although there do not appear to be any studies of chronic depression in mothers and the effect of that chronic depression on interaction, studies in which mothers are asked to "look depressed" (e.g., adopt blank affect) when they are not, leads their infants to exhibit greater facial distress, higher activity and heart rate, and attempts to engage the mother in normal interaction (Cohn & Tronick, 1983). When mothers who were depressed were asked to "look depressed" their infants' responsiveness was no different from what it was when the mothers were asked to interact normally with their infants. These infants seemed less agitated and less active overall and also exhibited lower heart rates (Field, 1984). Field and colleagues (1988) have also shown that the interactional patterns of 3–6-month-old infants with depressed mothers is maintained when the infant interacts with a stranger who is not herself depressed.

Gianino and Tronick (1988) have speculated that because periods of asynchronous interaction are common in normal infant–mother interactions, these periods provide the infant with an opportunity to learn coping skills by reinstating the desired level of stimulation, reducing excessive stimulation, or developing an effective means for dealing with an unresponsive partner. The crucial, unanswered question is what effects result from continued failures by the infant to regulate the social stimulation that he or she requires. A great deal more research is necessary in this area before we know whether these interaction patterns of depressed mothers with their infants have negative long-term consequences for the mother–infant bond and for long-term individual development.

Perhaps, the most chilling outcome for interactional asynchrony has been proposed by Ira Chasnoff (cited in Revkin, 1989). Chasnoff has observed that infants born to mothers who were cocaine users during pregnancy appear to be hypersensitive to social stimulation for periods from 8 weeks to up to 4 months. They tend to find intimate contact excessively stimulating and to withdraw from it. He speculates that this condition, presumably cocaine induced, may result in failed attachment and an increased likelihood of child abuse.

---

### **In Sum**

So far the research evidence suggests that the broad patterns of adult and infant–adult interactions are parallel to one another. Rudimentary elements of adult patterns exist in the very early interaction of infants and even neonates. Also,



these patterns are important to the proper functioning of the psychological and social life of the adult and of the infant. The patterns, when they are disrupted from their normal sequences, may be symptomatic of individual or relational difficulty or, when they are operating as they should, may be indicative of relational solidarity and attachment.

I find this parallelism and significance for what on their surface appear to be trivial behaviors to be both exciting and curious. If these behaviors exist in the early life of the organism and yet remain until much later in the life span of the adult organism, what would explain this continuity? One explanation could be that early learning persists throughout the developmental cycle. Another could be that physiological and genetic forces are the ultimate causes (though not the proximate causes) of the patterns and that the structures behind these forces remain throughout the lifespan though they are overwritten by cognitive and cultural demands. Despite social influences, they do not disappear but are manifest within the sequences of more verbalized and ritualized interactions.

---

### **Arguing from Evolution**

Next, I want to argue that both emotional responsiveness and stimulation regulation increase the *inclusive fitness* of the species, not directly but as mediators from other behaviors to reproductive success. By inclusive fitness is meant the “survival value of genes stemming from reproductive success” (Petrovich & Gewirtz, 1985, p. 280). When behavior is adaptive and the genetic materials responsible for successful coping with an environmental contingency are passed on to subsequent generations, the gene pool in those subsequent generations becomes biased in the direction of the adaptive behavior (or at least the mechanisms for producing the adaptive behavior). The form of the argument is teleonomic in that “behavioral outcomes that reflect demands exerted by ecological contingencies in the history of the particular species” (Petrovich & Gewirtz, 1985, p. 264) are selectively passed on through the gene pool.

In constructing an argument from organic evolution, several features must be specified. What are the “ecological contingencies” for the species? What behaviors meet these ecological contingencies? Do these behaviors increase the “inclusive fitness” of the species? That is, do they increase the reproductive success of the species? I will not argue that stimulation regulation and emotional responsiveness are themselves functionally adaptive but rather they are part of the mechanism through which inclusive fitness is advanced.

Even when the above criteria are satisfied, evolutionary arguments are, in themselves, weak ones. Adaptiveness per se does not exclude learning since cultures would certainly seek to develop behavioral patterns that advance the species. Second, most arguments from evolutionary adaptiveness, while rationally plausible within the context of evolutionary theory, fall far short of identifying the specific genes responsible for the adaptation. Therefore, successful arguments from evolutionary selection supplement their claims with evidence from other domains: cultural, physiological, and ethological.

Two arguments are made in the next two sections:

1. Effective caretaking and monitoring of infants is innate and biologically adaptive, and emotional responsiveness is the mechanism through which these goals are achieved.
2. Mother–infant attachment is innate and biologically adaptive and stimulation regulation is the mechanism through which attachment is achieved.

In making these arguments the “ecological contingencies“ necessitating attachment and effective caretaking and monitoring must be made clear. They are simple and, I think, self-evident:

1. Human primates are an altricial species; that is, they are helpless for extended periods after birth.
2. Nonhuman primates in their natural state are subject to predatory pressures, as were human primates, presumably in the distant past.

The first of these implies that extensive caretaking of infants by their parents is necessary for survival. The second implies that proximity to the caretaker is important as is a system for warning when danger is present.

---

### **The Origins of Emotional Responsiveness**

Actually it was Darwin (1872/1955) himself who argued for the adaptiveness of innate emotional expression. He argued both for the innateness of emotional expression in general and for the innateness of specific emotional expressions. Only the former needs to be considered here especially in the context of infant emotional displays. Izard and Malatesta (1987) maintain that in order for the caregiver to meet the needs of its dependent organism, the infant must be born with at least a rudimentary form of emotional expressiveness that carries information about its internal state to the caregiver. In turn, the caregiver must have the ability to recognize correctly the internal state of its infant in order to provide the appropriate care. The infant must have the ability to recognize the expressions of emotion of the caregiver for the information that those displays provide about danger and social attachment. In short, the organism born with an innate and rudimentary communication system that allows it to represent its own internal states to the caregiver, recognize at least some of the internal states of the caregiver, and allows the caregiver to know the internal states of the infant, permits effective and efficient caregiving, thus, making the survival of the infant more likely.

To establish the innateness of this rudimentary communication system that I have labeled emotional responsiveness requires that three features of innateness be established: (1) the production of facial emotions is innate; (2) the recognition of facial features is innate; (3) the second leads to emotionally adaptive responses. Let us take up each of these in turn.

*Production.* The portrayal of each of six basic emotions possibly including contempt, distress, and interest is universal having been demonstrated in a variety

of Western, non-Western, and preliterate cultures (Ekman, 1972; Fridlund et al., 1987). Photographs of these facial displays have been accurately decoded at well above chance levels by members of other cultural groups.

Izard and Malatesta (1987) have summarized the work on facial expressions in infants noting the following: (a) All muscle movements of adult facial displays are present in both full and preterm infants (Oster, 1978). (b) The interest expression is present from birth and is associated with gaze fixation and the typical heart rate deceleration of information intake; this expression is associated with attention to moderate novelty, attention to the human face, and attention to movement suggesting an adaptive value in information acquisition and social interaction. (c) The smile expression is present from birth but the social smile does not develop until about 3–4 weeks; the smile of the neonate seems to result from heart rate deceleration experienced during REM sleep (Sroufe & Waters, 1976). It occurs for both normal and congenitally blind infants (Eibl-Eibesfeldt, 1973). (d) The disgust expression is present from birth and can be produced in response to taste and smell stimuli (Steiner, 1973). The adaptive value of this expression is obvious as the caregiver is promptly informed about the ingestion of the infant. (e) Distress is also present at birth and is elicited by painful stimulation or some other discomfort.

The other four emotions (surprise, anger, fear, and sadness) are manifested sometime during the next 7 months of the infant's life. For example, anger has been observed in response to receiving DPT injections around 2 months of age (Izard, Hembree, Dougherty, & Spizzirri, 1983).

Although specific locations in the brain for the production of individual emotions have not been able to be found as yet, the best current information is that emotional production is closely allied with the "old brain" regions, particularly the limbic area, rather than the higher regions of the neocortex (Buck, 1984). Fox and Davidson (1986, 1987, 1988) have isolated the frontal, rather than parietal, regions of the left and right hemispheres of the brain lateralized for positive and negative emotions with the left frontal region showing greater activation for positive (and approach) emotions and the right frontal region showing greater activation for negative (and withdrawal) emotions. Also, a considerable amount of evidence indicates that the right hemisphere is primarily responsible for the production of spontaneous displays of facial emotion (Buck & Duffy, 1980).

*Recognition.* Studies reviewed earlier suggest that neonates are capable of recognizing their mother's faces and voices within a few hours of birth and capable of imitating the facial displays of sadness, surprise, and happiness of a model at least with their mouth movements. The research of Haviland and Lelwicka (also reviewed earlier) confirms that infants as young as 2<sup>1</sup>/<sub>2</sub> months are capable of recognizing emotions of anger, joy, and sadness. In a careful review of the facial emotion recognition literature, Nelson (1987) concluded that young infants might be capable of discriminating a single facial feature in a rich stimulus (e.g., real mother's face) but are probably not able to distinguish a complete facial gestalt. However, when one considers the fact that mothers regularly use both facial and vocal cues (to which infants are highly sensitive (Papousek, Papousek, & Bornstein, 1985)) and exaggerate their facial displays considerably, then infant

recognition of adult displays of emotion seems less problematic in reality than it is in the research context (Caron, Caron, & Myers, 1985; Ludeman & Nelson, 1988).

There is also a neurological basis for facial recognition. Parrett, Rolls, and Caan (1982) studied the reactions of rhesus macaques to a wide array of photographs of monkeys and humans posing neutral facial displays. Electrical responses of 497 cells in a certain region of the right occipital lobe were made. Forty-eight of these cells were especially responsive to faces with 23 of these cells responsive specifically to the eyes. This same general area of the right occipital lobe is implicated in the failure of brain-damaged adults to recognize faces (Damasio, Damasio, & Van Hoesen, 1982). In adults without brain damage, the right hemisphere of the brain is also implicated in the recognition of facial emotion (Buck, 1984; Buck & Duffy, 1980), although the evidence is confused somewhat by the findings of Davidson and Fox (1982) that the left hemisphere is involved in the processing of positive emotions while the right is involved in the processing of negative emotions (but see Borod, Koff, Lorch, & Nicholas, 1986). Although a complete picture of the neurological basis for the recognition of emotion is many years away, current evidence is sufficiently strong to hold that specific brain locations exist for emotional processing.

*Understanding.* The last feature of the argument about emotional responsiveness concerns whether facial recognition leads to response patterns that would suggest understanding of the facial display. The Haviland and Lelwica study suggests that the response patterns of 2<sup>1</sup>/<sub>2</sub> month olds to facial displays and vocal displays by their mothers do indicate understanding of these displays even though they do not always imitate them.

Other evidence of understanding comes from studies with older infants (usually more than 7 months) in contexts such as the "visual cliff" or "unfamiliar toys" paradigm. Various researchers (Klinnert, 1984; Sorce, Emde, Campos, & Klinnert, 1985; Zaratany & Lamb, 1985) have shown that when mothers are trained to exhibit facial expressions of fear as opposed to happiness or neutrality, their infants use these facial cues as information about approach to or withdrawal from the unusual stimulus. Obviously, the infant's reactions to the facial displays indicate some form of understanding of the meaning of the display for otherwise their actions would be inappropriate in the context and dangerous.

Some studies with rhesus macaques help to make the case that recognition and understanding of facial displays have an unlearned component. Sackett (1966) reared rhesus macaques in social isolation presenting them with slides of other monkey's facial displays. Appropriate responses to the slides (e.g., in the form of vocalizations, lip smacking, and other disturbances) began to develop around 2 months of age. He concluded that responses to threat and to other infant monkeys have an unlearned component and that threatening faces (in other monkeys) are innate releasers for fear displays.

Kenny, Mason, and Hill (1979) carried Sackett's work one step further by rearing macaques at three levels of social isolation. These animals were presented with a mirror or with slides of a human experimenter beginning at 1 week of age through 129 days. Responses began at around 20 days with lip smacking (a sign

of friendliness) to the mirror images and grimaces (a sign of fear) to the human faces. The rearing condition increased the intensity of the responses but even the complete isolation condition produced the same effects. These data underscore Sackett's conclusions that an unlearned component of recognition and understanding exists in the organism.

In human infants as young as 4 months of age, the ability to discriminate types of fearful facial expressions is quite good (Nelson & Lundeman, 1987, cited in Nelson, 1987) even though infants' experience with negative facial expressions is much less frequent than their experience with positive facial displays (Malatesta & Haviland, 1982). It is possible that experience with facial expressions is less important than the character of the expression itself.

A wholly different and indeed quite speculative argument for how facial expressions are understood derives from a combination of the findings of early facial imitation with what has been called the "facial efference" hypothesis (Adelman & Zajonc, 1989; Zajonc, 1985). Unlike the usual direction from the subjective experience of emotion to facial reactions, this hypothesis holds that the positioning of facial muscles can alter and even initiate emotional experience possibly by modifying cerebral blood flow or the temperature of cerebral blood flow through the venous cavities. Cerebral blood flow or its temperature may, in turn, affect the presence or level of neurotransmitters associated with emotional experience. Although the "blood flow-neurotransmitter" portion of the efference hypothesis must be considered quite speculative, evidence that facial muscle position modulates and initiates emotional experience is not (Adelman & Zajonc, 1989). Combining infants' control of facial musculature with their inclination to attend to faces and imitate their expressions, one has in the efference hypothesis an explanation of how infants might "understand" another's emotional state (via facial attention, imitation, and change in cerebral blood flow) without positing an innate mechanism for understanding facial reactions per se.

---

#### **Argument for Attachment**

Bowlby (1969) was the first to argue on evolutionary and ethological grounds that attachment between mother and infant had a biological rather than a psychodynamic basis. Since the young of all altricial species (which includes all primate species) are relatively helpless for a considerable period after birth, they are in need of care for feeding, in need of care to have other survival needs met, and in need of protection from predatory species. Bowlby argued that secure attachment increases the inclusive fitness of the species by insuring a strong bond between infant and caretaker and by insuring that the protective caretaker is in close proximity when the infant is at risk or in need of care.

The loss of attachment through separation and isolation is known to have serious deleterious consequences for the organism. The typical reaction to loss of or temporary separation from the caretaker is a syndrome with two phases: agitation and then depression. In humans, there is evidence, at every age level, that significant loss or separation has psychological, physiological, and even immunological effects (Capitiano, Weissberg, & Reite, 1985; Reite & Capitiano,

1985). On the positive side, some evidence suggests that the existence of social attachments is associated with good health.

Since the effects of separation and loss cannot be studied ethically in experimental situations, the strongest findings come from studies of nonhuman primates and other species. Prolonged separation can lead to depression and later withdrawal from social interaction even when the opportunities for it reappear. Early separation from the mother can also lead to immature sexual response and inappropriate rearing behaviors (Petrovich & Gewirtz, 1985). Some of Harlow's studies show that the response pattern of pigtail and rhesus monkeys separated from their mothers is parallel to that of human infants during separation (Deets & Harlow, 1971; Harlow, 1971).

In short, not only is attachment of central importance to the functioning of the human and nonhuman primate infant, but its absence (at least in certain nonhuman primates) is associated with direct loss of reproductive success. Additionally, the development of attachment is observed across cultures with every human society exhibiting some form of caretaking for its infants. Certainly not all societies achieve caretaking in the same way. For example, the Efe, a pygmy tribe of Zaire, employ a form of communal infant caretaking and attachment with several women responsible for the attention to and feeding of the infant (Tronick, Winn, & Morelli, 1985). Finally, attachment and caretaking is observed in a widely divergent set of nonprimate species as well, including rodents, birds, canines and so on (Petrovich & Gewirtz, 1985).

The evidence for the adaptive value of attachment between mothers and their infants is strong and indeed well established over many years of research. Tiffany Field (1985b, 1987) has recently argued that the concept of attachment (as applied to human infants) is circular in that the benefits that appear to accrue to the organism through secure attachment are by indirect inference only. Only by studying the negative consequences of separation are the positive consequences of attachment inferred. Indeed, there are significant negative consequences to separation and loss for the infant as well as the mother. But if we do not know what the mechanisms for the development of attachment are, then, first, we have no understanding of the attachment process (only its absence) and, second, we have no clear ideas about how to intervene in insecurely attached relationships to improve the security of attachment.

Neither Field nor I have complete answers to this question but one speculation is to treat attachment as a process whose function is to promote behavioral and physiological synchrony between mother and infant. In short, stimulation regulation in the form of synchrony in positive affect, autonomic arousal, and behavioral arousal is hypothesized as the mechanism through which attachment is achieved. This notion is not far afield from Bowlby's (1969) initial ideas. Bowlby held that attachment was achieved through the behavioral attachment systems that operated as homeostatic mechanisms around a set goal of close physical proximity. The homeostatic mechanisms were never fully explicated. These mechanisms may be found in the physiological and behavioral synchronizations that characterize mother-infant attachment.

The above speculation is based upon several converging lines of evidence some

of which have already been reviewed. Let me summarize these lines of convergence briefly.

*Attachment in Animals and Humans.* Studies with pigtail and bonnet monkeys (Reite & Capitanio, 1985) following separation from their mothers clearly indicate physiological differences during periods of agitation and depression (due to separation) as compared with periods of nonseparation. If separation, which is the disruption of attachment, leads to a disruption of normal physiological processes, then the mechanism of attachment must be tied to processes that regulate or are regulated by physiological arousal.

Synchronous stimulation regulation is implicated in the control of arousal. Lester, Hoffman, and Brazelton (1982) found rhythmic synchrony between mother and infant in cardiac activity and in behavioral activity that was greater than that between infant and stranger. Field (1982) found elevated heart rate by preterm infants in interactions with their mothers more so than full-term infants. Reite and Capitanio (1985) found strong evidence of the role of arousal in attachment and separation with their study of two pigtail monkeys. These monkeys were separated from their mothers at birth and raised together for about 6 months. At this age, they had heart rate and body temperature devices implanted surgically. These devices allowed continuous monitoring during a baseline, separation, and reunion period. The correlations between the heart rates for the twosome (controlling for obvious circadian rhythms and so on) was greater during baseline and reunion than during separation. This was especially the case for the first 5 days of separation. (No comparable findings for body temperature were obtained.)

Disruptions of stimulation regulation are implicated in infant distress and in difficulty of bonding. Studies of unresponsive mothers (either due to experimental manipulation or due to temporary depression) show that infants gaze away more, show more facial distress, and are less responsive (at least after initial attempts to reengage the mother). At-risk infants (such as preterm, Down Syndrome, etc.) are difficult to engage in interaction, smile less, exhibit more gaze aversion, less complete facial responses, and are easily overstimulated (Emde, Katz, & Thorpe, 1978). The consequence is that the parents of these infants are sometimes "disappointed" in the engagement that their infants exhibit in social interactions. No studies have researched the long-term implications of interaction patterns with these infants in comparison to normal controls.

*Brain Opioids.* Jaak Panksepp (1982; Panksepp, Siviy, & Normansell, 1985) has carried out a fascinating program of research on the psychopharmacological bases of affect and social attachment. He argues basically that social attachment is an addiction. His studies with a wide variety of animals indicate, for example, that the distress cries of chicks and mouse pups upon separation from their mothers can be quieted by a variety of opioid agonists (agents). A wide variety of other psychopharmacological agents do not have the same effectiveness as the opioids in quieting distress vocalizations except one, Clonidine, which is commonly used to alleviate opium withdrawal symptoms in humans. Panksepp and colleagues point out (Panksepp et al., 1985) that if the opioids are implicated directly in social attachment and affect, then opioid receptor site blockades (such

as noxalone) should have the effect of increasing distress vocalizations because the receipt of the opioids at the receptor site will have been blocked. Although the effects are not completely consistent in that the noxalone does not always increase distress vocalizations, it is sufficiently replicable to add evidence to the theoretical claims: opioids and opioid receptor sites are implicated in social attachment and separation in certain animal species.

---

### **In Sum**

The arguments for the biological bases of stimulation regulation are certainly more circumstantial than those for emotional responsiveness. Yet, the evidence is sufficient to entertain seriously the hypothesis that the deleterious effects of maternal separation are not the result of some generalized stress associated with loss but rather the result of the loss of a *specific regulatory process*, namely the modulation of arousal through social stimulation and control of stimulation.<sup>4</sup> This same argument has been made by Hofer (1984) with regard to separation and attachment in mother and infant mice. His research shows that specific aspects of the mother–infant interaction are related to specific biological deficits when that interaction is lost. For example, a depletion of the growth hormone in the mouse pup was associated with a lack of activity provided by the mother. Providing activity to the mouse pups via another means increased the presence of the growth hormone. Hofer (1987) also believes that specific stimulation by mother rats controls rat pups' responsiveness probably through the catecholaminergic system responsible for behavioral arousal. In human infants, it may be that the attachment between mother and infant is created through synchronous stimulation regulation of both behavioral and physiological systems perhaps mediated by the addictive responses of the brain opioids.

---

### **Conclusions**

The previous pages have offered a type of sociobiological analysis for two patterns of social interaction, stimulation regulation and emotional responsiveness. In order to understand the evolutionary adaptiveness of these behavioral patterns, certain adaptive behavioral traits are introduced. I argued that secure attachment and effective caretaking are functionally adaptive for the human infant meeting the ecological contingencies associated with rearing human infants, namely protecting them from predators and from their own helplessness. The former contingency, while a part of the distant environmental history of the organism, is no longer a significant cultural factor in child rearing; the latter contingency, however, remains even in modern cultural settings. In meeting past and current environmental contingencies, effective caretaking and secure attachment are presumed to have advanced the inclusive fitness of the species in the past and, where environmental contingencies have remained constant, to continue to advance inclusive fitness.

To understand how stimulation regulation and emotional responsiveness are directly implicated in the evolutionary psychological account a two-tiered expla-



nation is added. The first tier maintains that stimulation regulation and emotional responsiveness patterns are the behavioral processes through which attachment and effective caretaking occur, respectively. The second tier maintains that stimulation regulation not only controls overt behavioral excitation but also regulates autonomic arousal and perhaps secures attachment through the release and control of opioid agents in the brain. Emotional responsiveness may arise through processes of attention to the face, simple imitation, and alterations in blood supply or temperature of blood to the brain as the face is modified. Coupled with innate mechanisms of recognition for facial configurations, a simple system of emotional communication is thus provided. These simple physiological and biological mechanisms are assumed to exist as hard-wired into the psychophysiological structure of the infant, governing its early interactions with the primary caretaker, but remaining, perhaps in a form overwritten by cultural forces, as a causal mechanism governing in part the social interactions of adults.

Sociobiological explanations of social behavior have been subject to devastating criticisms by many commentators (Archer, 1988; Gould & Lewontin, 1979; Kitcher, 1985; Symons, 1989). Among the criticisms offered are accusations that stories accounting for the adaptive significance of social behaviors are too facile, are untestable or without testable implications, offer ultimate explanations when proximate ones are more informative, and operate within assumptions about evolutionary biology that are simplistic and outmoded. A recent set of modifications to the research program of sociobiology has included several amendments. First, such explanations should employ the adaptive significance of a set of behaviors as the starting point and not the end point of inquiry. Once one has specified the environmental contingencies, the behaviors necessary to meet those contingencies, and argued how such behaviors will support the propagation of the gene pool, the theorist has completed a preliminary specification of an adaptive problem to be solved. In a second phase, the solution to the problem is advanced when the explanation advances beyond these initial steps clearly to specify the phenotypes (structures, mechanisms, processes, etc.) through which a behavioral pattern operates in improving the organism's inclusive fitness. Third, the solution is advanced to a stage of testability when the environmental contingencies that operated as selection pressures in the past are able to be assessed as continuous with or discontinuous from the conditions of modern culture. Immediate, testable implications should be able to be derived when past selection pressures remain. Tooby and Cosmides (1989), in a sophisticated defense and exegesis, call this set of amendments to sociobiology, "evolutionary psychology."

The aims of evolutionary psychology are to avoid simplistic explanations of the adaptive function of social behaviors as the end goal of sociobiological explanations. Instead these are beginnings from which reasoned speculations about the mechanisms through which those behaviors achieve their evolutionary goal (reproductive success) are offered. The hypothesized mechanisms in turn become the basis for testable implications. The evolutionary orientation offers perspective on what psychological, causal mechanisms are important to the functioning of the organism. Thus, evolutionary psychology amends sociobiology by making its simplistic functionalism more causal and, hence, more testable, and amends psy-

chology by forcing its choices of causal mechanisms to be more functional to the evolution of the organism.

By now it should be obvious that the task of this essay has been to offer a preliminary evolutionary psychology in which two significant patterns of social interaction play a significant role. What may not be so obvious are the implications that such a view holds for adults, for infants, and for their relationships. Since predatory pressures are no longer an environmental threat to modern infants, this contingency is irrelevant to the kind of infant-caretaker relationship that communication creates. However, the human infant is still helpless for extended periods in modern culture, and processes that help to secure strong attachment, namely stimulation regulation and effective caregiving, should be associated with greater inclusive fitness of the infant. This means that synchrony in stimulation regulation and accuracy in emotional signalling should be associated with healthier infants whose profile for reproductive success should be positive. At the same time, individual or cultural conditions that interfere with synchronous stimulation regulation or accuracy in emotional signalling should have negative consequences for the health and inclusive fitness of the infant. One might speculate on the basis of arguments forwarded by Chapple (1971) and recently formalized by Warner (1988) that mismatches in behavioral rhythms between infants and primary caretaker, perhaps resulting from different biological or cognitive rhythms, would affect the likelihood of strong attachment. One might hypothesize that, with careful selection of matched samples, infants would have less synchronous interaction patterns with their adoptive parents than infants with their biological parents. If the adaptive significance of stimulation regulation is correct and if physiological rhythms differ by individual while being relatively stable (rather than plastic), then psychological and physical health of adopted infants with less synchronous interaction patterns should be lower than that of adopted infants with more synchronous patterns.

One of the goals of evolutionary psychology is to provide a justification for and an account of the existence of certain significant phenotypes (or causal mechanisms). The case for inclusive fitness in relation to stimulation regulation and emotional responsiveness clearly applies only to infants' social interactions and not to adults' interactions. Nevertheless, if the proposed mechanisms linking the behavioral trait (secure attachment) to inclusive fitness exists as a part of the psychophysiology of the human infant, those mechanisms may continue to shape the interactions of human adults, perhaps masked by other cultural, normative, and relational forces. Specifically, not only should research expect to find that stimulation regulation and emotional responsiveness are reliable patterns in adult social interactions but that these interaction patterns are associated with feelings of attachment to the partner. Indeed, research with adults, reviewed earlier, has shown that stimulation regulation and emotional responsiveness are commonly observed patterns of interaction, albeit modest in their magnitude (Cappella, 1984). The research of Gottman (1979) and others has linked hostile affect reciprocity to relational maladjustment while research by Noller (1984) has found accuracy in emotional judgment to be associated with relational satisfaction. Others have speculated upon and brought evidence in support of the synchrony-

attachment relationship (Bernieri et al., 1988; Cappella et al., 1989; Warner, 1988). What remains to be shown in adult social interaction is that the pattern-outcome association is actually mediated by processes like those proposed for infant social interactions.

I have tried to make a case for the biological basis of certain patterns of adult interaction. I have no illusion that these patterns exhaust all or even necessarily the most important aspects of human interaction. However, there is ample evidence that they are functionally important to the adult and to the infant-adult relationship. In looking for biological sources of ultimate causation for patterns of human interaction, one is not easily brought to a position of biological determinism. Rather, I think that one comes to appreciate the intricate relationship between social and biological behavior and the common biological bases that we all share as human primates in that most human of activities, communication.

---

**Author**

Joseph N. Cappella, an ICA Fellow, is Professor of Communications in the Annenberg School, University of Pennsylvania, Philadelphia, PA 19104. A version of this essay was delivered as the Department of Communication Studies' Van Zelst Lecture at Northwestern University, May 9, 1988. The author wishes to thank the Van Zelst Trust and the Department of Communication Studies at Northwestern University for the opportunity to prepare this article. Comments from Judee Burgoon, Chris Nelson, Peter Andersen, Becky Omdahl, and anonymous reviewers were much appreciated, as were questions from Larry Gross, Carolyn Marvin, Robert Hornik, and Klaus Krippendorff.

---

**Notes**

<sup>1</sup> This position is certainly not shared by all social scientists and has been vigorously attacked both by defectors (Gergen, 1973, 1982) and by critics (Harré & Secord, 1972). Although this is not the time for a defense of what appears to be a simplistic view, my position on scientific knowledge is based upon what I perceive to be the goals of science, namely prediction, causal explanation, control in principle, and understanding. Scientific knowledge is knowledge that achieves these goals, which, by corollary, require the knowledge to be pancultural and ahistorical. Obviously, scope conditions may modify the degree of universality of scientific knowledge claims but such modifications must be principled ones and not ad hoc.

<sup>2</sup> This feature of interaction would seem to be a likely candidate for slow acquisition by the infant, especially after he or she has begun to exercise linguistic skills. However, some evidence suggests that turn taking develops earlier. Rutter and Durkin (1987) studied the turn-taking activity of two groups of children ranging in age from 9 to 36 months. Overlapping of speech segments began to drop by the second year and gaze at the end of one's turn segments (an adult cue) developed by 18 months. Mayer and Tronick (1985) studied whether adult turn-taking cues produced responses (such as vocalizations and smiles) in infants. They found that the usual set of turn-taking cues, namely, intonation, drawl, hand movements, and head movements, regularly predicted infants' responses. Kaye (1977) reasoned that alternation, which is the basis of turn taking, may be developed very early in the learned alternation required in other contexts between mother and infant. He studied infants in their second day and second week of life observing the feeding rhythms of infants with their mothers during breast or bottle feeding. Although infants have a regular rhythm of sucking and then pausing, mothers tend to jiggle them (or the bottle or the breast) to encourage additional sucking. Infants do not tend to start sucking again until the jiggling stops, whereupon another burst of sucking begins. By the second week some accommodation has been reached with the jiggle-stop sequences of the mother shortened. What is fascinating about this sequence is that it is driven by primal forces (feeding routines) that result in nonoverlapping patterns of action.

This evidence certainly suggests that infants develop adult cues rather early, are sensitive

to adult cues even earlier, and from birth seem attuned to the need for interleaved action. They also seemed to be sensitive to the rhythms of activity from birth. Miller and Byrne (1984) summarize research indicating that rhythmic audio and visual stimuli are soothing for infants whereas arrhythmic ones are not and tend to be arousing. Research summarized by Miller and Byrne indicates that infants are born with a "central pacemaker" that beats in the range of 1–1.2 hz (hertz) and is based in the hippocampus. Their evidence is that natural sucking rhythms are in the range of 1 hz and that consoling rhythms are in this same range (later the frequency of this central pacemaker increases to about 6 hz). Rhythmic activity also plays a role in stimulation regulation between infant and mother especially during play.

In short it seems that one of the fundamental aspects of human conversation, the alternation of turns, occurs early in the social life of infants and may in some naive form be present even from birth.

<sup>3</sup> At this point a couple of caveats are necessary. First it is difficult to say whether the Lester, Hoffmann, and Brazelton study is a stimulation regulation or emotional responsiveness study. They examined a variety of behaviors that were summed into an overall index that included a gross judgment of facial positiveness and one of facial distress for both mother and infant. Other behaviors do not clearly have an emotional component—e.g., vocalizations—though they are given a positive or negative score. The second point to be made here is that the so-called studies of positive and negative affect, like the Lester, Hoffman, and Brazelton (1985) study, usually only involve positive facial displays on the part of the mother. Malatesta and Haviland (1982) have noted that, in open-ended observations of mother–infant play, mothers almost always employ positive facial displays. As some developmental research turns toward the comparison between abused and nonabused children, some of these narrowly displayed emotions will give way to a broader set of displays. In the meantime, I think that it is fair to consider studies of positive and negative facial emotion and smiling as little more than studies of stimulation regulation skewed primarily toward the positive side of the positive–negative emotional continuum.

<sup>4</sup> Indeed, Schanberg and Field (1988) describe studies with rat pups who, deprived of specific stimulation from the mother, exhibit less growth and lower levels of a specific brain chemical necessary for tissue growth and differentiation compared with controls even though caloric intake is equal. When the mother's licking is simulated with strokes from a painter's brush, growth levels return to normal. Similarly, preterm infants given a regimen of stimulation for as little as 3 15-minute periods for 10 days show more weight gain and higher Brazelton scores than controls who do not receive the stimulation. Although the specific form of stimulation is less clear in the case of the human infants than the rat pups, the parallels are exciting nonetheless.

- Adelman, P. K., & Zajonc, R. B. (1989). Facial efference and the experience of emotion. In M. R. Rosenzweig & L. W. Porter (Eds.), *Annual review of psychology* (Vol. 40, pp. 249–280). Palo Alto, CA: Annual Reviews.
- Ainsworth, M. D. (1978). *Patterns of attachment: A psychological study of the strange situation*. Hillsdale, NJ: Erlbaum.
- Anderson, J. R. (1985). *Cognitive psychology and its implications* (2nd ed.). New York: W. H. Freeman.
- Archer, J. (1988). The sociobiology of bereavement: A reply to Littlefield and Rushton. *Journal of Personality and Social Psychology*, 55, 272–278.
- Bateson, M. C. (1975). Mother–infant exchanges: The epigenesis of conversational interaction. *Annals of the New York Academy of Sciences*, 263, 101–113.
- Bavelas, J. B., Black, A., Chovil, N., Lemery, C. R., & Mullett, J. (1988). Form and function in motor mimicry: Topographic evidence that the primary function is communicative. *Human Communication Research*, 14, 275–299.
- Bavelas, J. B., Black, A., Lemery, C. R., MacInnis, S., & Mullett, J. (1986). "I show you how I feel." Motor mimicry as a communicative act. *Journal of Personality and Social Psychology*, 50, 322–329.
- Beebe, B., Jaffe, J., Feldstein, S., Mays, K., & Alson, D. (1985). Interpersonal timing: The application of an adult dialogue model to mother–infant vocal and kinesic interactions. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 217–248). Norwood, NJ: Ablex.
- Berger, C. R., & Roloff, M. E. (1980). Social cognition, self awareness, and interpersonal

---

## References

- communication. In B. Dervin & M. J. Voight (Eds.), *Progress in communication sciences* (Vol. 2, pp. 1–50). Norwood, NJ: Ablex.
- Berghout-Austin, A. M., & Peery, J. C. (1983). Analysis of adult–neonate synchrony during speech and nonspeech. *Perceptual and Motor Skills*, 57, 455–459.
- Berner, F. J., Resnick, J. S., & Rosenthal, R. (1988). Synchrony, pseudosynchrony, and dissynchrony: Measuring the entrainment process in mother–infant interactions. *Journal of Personality and Social Psychology*, 54, 243–253.
- Borod, J. C., Koff, E., Lorch, M. P., & Nicholas, M. (1986). Deficits in facial expression and movement as a function of brain damage. In J. Nespoulet, P. Perron, & A. R. Lecours (Eds.), *The biological foundations of gestures* (pp. 271–293). Hillsdale, NJ: Erlbaum.
- Bowlby, J. (1969). *Attachment and loss: Vol. I. Attachment*. New York: Basic Books.
- Brown, P., & Levinson, S. (1987). *Politeness: Some universals in language use*. Cambridge: Cambridge University Press.
- Bruner, J. S. (1977). Early social interaction and language acquisition. In H. R. Schaffer (Ed.), *Studies in mother–infant interaction* (pp. 271–289). London: Academic Press.
- Buck, R. (1975). Nonverbal communication of affect in children. *Journal of Personality and Social Psychology*, 31, 644–653.
- Buck, R. (1976). A test of nonverbal receiving ability. *Human Communication Research*, 2, 162–171.
- Buck, R. (1979). Measuring individual differences of nonverbal communication of affect: The slide-viewing paradigm. *Human Communication Research*, 6, 47–57.
- Buck, R. (1982). Spontaneous and symbolic nonverbal behavior and the ontogeny of communication. In R. S. Feldman (Ed.), *The development of nonverbal behavior in children* (pp. 29–62). New York: Springer-Verlag.
- Buck, R. (1984). *The communication of emotion*. New York: Guilford.
- Buck, R. & Duffy, R. (1980). Nonverbal communication of affect in brain-damaged patients. *Cortex*, 16, 351–362.
- Buder, E. (1985). *Coherence of speech rhythms in conversations: Autocorrelation analysis of fundamental vocal frequency*. Unpublished master's thesis, University of Alberta, Edmonton.
- Capitanio, J. P., Weissberg, M., & Reite, M. (1985). Biology of maternal behavior: Recent findings and implications. In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 51–92). Orlando, Florida: Academic Press.
- Cappella, J. N. (1981). Mutual influence in expressive behavior: Adult–adult and infant–adult dyadic interaction. *Psychological Bulletin*, 89, 101–132.
- Cappella, J. N. (1983). Approaching and avoiding others: Involvement in dyadic interaction. In J. M. Wiemann & R. P. Harrison (Eds.), *Nonverbal interaction* (pp. 113–148). Beverly Hills, CA: Sage.
- Cappella, J. N. (1984). The relevance of the microstructure of interaction to interpersonal relations. *Journal of Social and Personal Relationships*, 1, 239–264.
- Cappella, J. N. (1985). The management of conversations. In M. L. Knapp & G. R. Miller (Eds.), *The handbook of interpersonal communication* (pp. 393–438). Beverly Hills, CA: Sage.
- Cappella, J. N. (1987). Interpersonal communication: Fundamental questions and issues. In C. R. Berger & S. Chaffee (Eds.), *The handbook of communication science* (pp. 184–238). Beverly Hills, CA: Sage.
- Cappella, J. N., & Greene, J. O. (1982). A discrepancy–arousal explanation of mutual influence in expressive behaviors for adult–adult and infant–adult interactions. *Communication Monographs*, 49, 89–114.
- Cappella, J. N., & Greene, J. O. (1984). The effects of distance and individual differences in arousability on nonverbal involvement: A test of discrepancy–arousal theory. *Journal of Nonverbal Behavior*, 8, 259–286.
- Cappella, J. N., Palmer, M. T., & Donzella, B. (1989, June). *The temporal stability of adaptation in social interaction*. Paper presented to the Nags Head Conference on Social Interaction, Nags Head, North Carolina.
- Cappella, J. N., & Planalp, S. (1981). Talk and silence sequences in informal conversations III. Interspeaker influence. *Human Communication Research*, 7, 117–132.
- Caron, R. F., Caron, A. J., & Myers, R. S. (1985). Do infants see emotional expressions in static faces? *Child Development*, 56, 1552–1560.

- Chapple, E. (1971). Toward a mathematical model of interaction: Some preliminary considerations. In P. Kay (Ed.), *Explorations in mathematical anthropology* (pp. 141-178). Cambridge, MA: MIT Press.
- Chomsky, N. (1957). *Syntactic structures*. The Hague: Mouton.
- Coates, D. L., & Lewis, M. (1984). Early mother-infant interaction and infant cognitive status as predictors of school performance and cognitive behavior in six-year-olds. *Child Development, 55*, 1219-1230.
- Cohn, J. F., & Tronick, E. Z. (1983). Three-month-old infants' reaction to simulated maternal depression. *Child Development, 54*, 185-193.
- Cohn, J. F., & Tronick, E. Z. (1987). Mother-infant face-to-face interaction: The sequence of dyadic states at 3, 6, and 9 months. *Developmental Psychology, 23*, 68-77.
- Cohn, J. F., & Tronick, E. Z. (1988). Mother-infant face-to-face interaction: Influence is bidirectional and unrelated to periodic cycles in either partner's behavior. *Developmental Psychology, 24*, 386-392.
- Damasio, A. R., Damasio, H., & Van Hoesen, G. W. (1982). Prosopagnosia: Anatomic basis and behavioral mechanisms. *Neurology, 32*, 331-341.
- Darwin, C. (1955). *The expression of emotion in man and animals*. New York: Philosophical Library. (Original work published 1872)
- Davidson, R. J., & Fox, N. A. (1982). Asymmetrical brain activity discriminates between positive and negative affective stimuli in human infants. *Science, 218*, 1235-1237.
- Deets, A., & Harlow, H. F. (1971). *Early experience and the maturation of agonistic behavior*. Paper presented at the American Association for the Advancement of Science.
- Eibl-Eibesfeldt, I. (1973). The expressive behavior of the deaf and blind born. In M. von Cranach & I. Vine (Ed.), *Social communication and movement: Studies of interaction and expression in man and chimpanzee* (pp. 163-194). London: Academic Press.
- Ekman, P. (1972). Universals and cultural differences in facial expressions of emotions. In J. R. Cole (Ed.), *Nebraska Symposium on Motivation 1971* (pp. 207-283). Lincoln, NE: University of Nebraska Press.
- Ekman, P., Friesen, W. V., et al. (1987). Universals and cultural differences in the judgments of facial expressions of emotion. *Journal of Personality and Social Psychology, 53*, 712-717.
- Ekman, P., Levenson, R. W., & Friesen, W. V. (1983). Autonomic nervous system activity distinguishes among emotions. *Science, 221*, 1208-1210.
- Emde, R. N., Katz, E. L., & Thorpe, J. K. (1978). Emotional expression in infancy: II. Early deviations in Down's syndrome. In M. Lewis & L. A. Rosenblum (Eds.), *The development of affect* (pp. 351-360). New York: Plenum.
- Feldstein, S., Konstantareas, M., Oxman, J., & Webster, C. D. (1982). The chronography of interaction with autistic speakers: An initial report. *Journal of Communicative Disorders, 15*, 451-460.
- Field, T. (1977). Effects of early separation, interactive deficits, and experimental manipulations on infant-mother face-to-face interactions. *Child Development, 48*, 763-771.
- Field, T. (1982). Affective displays of high risk infants during early interactions. In T. Field & A. Fogel (Eds.), *Emotion and early interaction* (pp. 101-125). Hillsdale, NJ: Erlbaum.
- Field, T. (1984). Early interactions between infants and their postpartum depressed mothers. *Infant Behavior and Development, 7*, 527-532.
- Field, T. (1985a). Individual differences in the expressivity of neonates and young infants. In R. S. Feldman (Eds.), *Development of nonverbal behavior in children* (pp. 279-298). New York: Springer-Verlag.
- Field, T. (1985b). Attachment as psychobiological attunement: Being on the same wavelength. In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 415-454). Orlando, FL: Academic Press.
- Field, T. (1987). Affective and interactive disturbances in infants. In J. D. Osofsky (Ed.), *Handbook of infant development* (2nd ed., pp. 972-1007). New York: Wiley.
- Field, T., Healy, B., Goldstein, S., Perry, S., Bendel, D., Schanberg, S., Zimmerman, E. A., & Kuhn, C. (1988). Infants of depressed mothers show "depressed" behavior even with nondepressed adults. *Child Development, 59*, 1569-1579.
- Field, T., Woodson, R., Cohen, D., Garcia, R., & Greenberg, R. (1982). Discrimination

- and imitation of facial expressions by term and preterm neonates. *Infant and Behavior Development*, 6, 485-490.
- Fiske, D. W., & Shweder, R. A. (Eds.). (1986). *Metatheory in social science*. Chicago: University of Chicago Press.
- Fox, N. A., & Davidson, R. J. (1986). Taste elicited changes in facial signs of emotion and the asymmetry of brain electrical activity in newborn infants. *Neuropsychologia*, 24, 417-422.
- Fox, N. A., & Davidson, R. J. (1987). Electroencephalogram asymmetry in response to the approach of a stranger and maternal separation in 10-month-old infants. *Developmental Psychology*, 23, 233-240.
- Fox, N. A., & Davidson, R. J. (1988). Patterns of brain electrical activity during facial signs of emotion in 10-month-old infants. *Developmental Psychology*, 24, 230-236.
- Fridlund, A. J., Ekman, P., & Oster, H. (1987). Facial expressions of emotion: Review of literature, 1970-1983. In A. W. Siegman & S. Feldstein (Eds.), *Nonverbal behavior and communication* (2nd ed., pp. 123-224). Hillsdale, NJ: Erlbaum.
- Gergen, K. J. (1973). Social psychology as history. *Journal of Personality and Social Psychology*, 26, 309-320.
- Gergen, K. J. (1982). *Toward transformation in social knowledge*. New York: Springer-Verlag.
- Gianino, A., & Tronick, E. Z. (1988). The mutual regulation model: The infants' self and interactive regulation and coping and defense capacities. In T. M. Field, P. M. McCabe, & N. Schneiderman (Eds.), *Stress and coping across development* (pp. 47-68). Hillsdale, NJ: Erlbaum.
- Glaister, J., Feldstein, S., & Pollock, H. (1980). Chronographic speech patterns of acutely psychotic patients. *Journal of Nervous and Mental Disease*, 168 (4).
- Gottman, J. M. (1979). *Marital interaction*. New York: Academic Press.
- Gould, S. J., & Lewontin, R. C. (1979). The spandrels of San Marco and the Panglossian paradigm: A critique of the adaptationist programme. *Proceedings of the Royal Society of London B*, 205, 581-598.
- Grossman, K. E., Grossman, K., Spangler, G., Suess, G., & Unzer, L. (1985). Maternal sensitivity and newborn orientation responses as related to the quality of attachment in N. Germany. In I. Bretherton & E. Waters (Eds.), *Growing points of attachment theory and research. Monographs of the Society for Research in Child Development*, 50 (1-2, Serial No. 209), 233-256.
- Harlow, H. F. (1971). *Learning to love*. San Francisco: Albion.
- Harré, R., & Secord, P. F. (1972). *The explanation of social behavior*. Oxford: Blackwell.
- Haviland, J. M., & Lelwicka, M. (1987). The induced affect response: 10-week-old infants' responses to three emotional expressions. *Developmental Psychology*, 23, 97-104.
- Hofer, M. A. (1984). Relationships as regulators: A psychobiological perspective on bereavement. *Psychosomatic Medicine*, 46, 183-197.
- Hofer, M. A. (1987). Early social relationships: A psychobiologist's view. *Child Development*, 58, 633-647.
- Hoffman, M. L. (1978). Toward a theory of empathic arousal and development. In M. Lewis & L. A. Rosenblum (Eds.), *The development of affect* (pp. 227-256). New York: Plenum.
- Isabella, R. A., Belsky, J., & von Eye, A. (1989). Origins of mother-infant attachment: An examination of interactional synchrony during the infant's first year. *Developmental Psychology*, 25, 12-21.
- Izard, C. E., & Malatesta, C. Z. (1987). Perspectives on emotional development, I: Differential emotions theory of early emotional development. In J. D. Osofsky (Ed.), *Handbook of infant development* (2nd ed., pp. 494-554). New York: Wiley.
- Izard, C. E., Hembree, E. A., Dougherty, L. M., & Spizzirri, C. L. (1983). Changes in facial expressions of 2- to 19-month-old infants following acute pain. *Developmental Psychology*, 19, 418-426.
- Jaffe, J., & Anderson, S. (in press). Speech rate studies in major depressive disorders: Degree of response to medication. In S. Feldstein, D. Crown, & J. Welkowitz (Eds.), *Speech sounds and silences: A social psychological approach to clinical concerns*. Hillsdale, NJ: Erlbaum.

- Jasnow, M., & Feldstein, S. (1987). Adult-like temporal characteristics of mother-infant vocal interactions. *Child Development*, 57, 754-761.
- Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.
- Kaitz, M., Meschulach-Sarfaty, O., Auerbach, J., & Eidelman, A. (1988). A reexamination of newborns' ability to imitate facial expressions. *Developmental Psychology*, 24, 3-7.
- Kaplan, K. J., Firestone, I. J., Kline, K. W., & Sodikoff, C. (1983). Distancing in dyads: A comparison of four models. *Social Psychology Quarterly*, 46, 108-115.
- Kaye, K. (1977). Toward the origin of dialogue. In H. R. Schaffer (Ed.), *Studies in mother-infant interaction*. London: Academic Press.
- Kenny, M. D., Mason, W. A., & Hill, S. D. (1979). Effects of age, objects, and visual experience on affective responses of rhesus monkeys to strangers. *Developmental Psychology*, 15, 176-184.
- Kessen, W., Levine, J., & Wendrich, K. A. (1979). The imitation of pitch in infants. *Infant Behavior and Development*, 2, 93-99.
- Kitcher, P. (1985). *Vaulting ambition: Sociobiology and the quest for human nature*. Cambridge, MA: MIT Press.
- Klinnert, M. D. (1984). The regulation of infant behavior by maternal facial expression. *Infant Behavior and Development*, 7, 447-465.
- Krause, R., Steimer, E., Sanger-Alt, C., & Wagner, G. (1989). Facial expression of schizophrenic patients and their interaction partners. *Psychiatry*, 52, 1-12.
- Labov, W. (1972). Rules for ritual insults. In D. Sudnow (Ed.), *Studies in social interaction* (pp. 120-169). New York: Free Press.
- Langer, E. J. (1978). Rethinking the role of thought in social interaction. In J. H. Harvey, W. J. Ickes, & R. F. Kidd (Eds.), *New directions in attribution research* (Vol. 2, pp. 36-58). Hillsdale, NJ: Erlbaum.
- Langer, E. J., Blank, A., & Chanowitz, B. (1978). The mindlessness of ostensibly thoughtful action: The role of "placebic" information in interpersonal interaction. *Journal of Personality and Social Psychology*, 36, 635-642.
- Lester, B. M., Hoffman, J., & Brazelton, T. B. (1982). *Spectral analysis of mother-infant interactions in term and preterm infants*. Paper presented at the meeting of the International Conference on Infant Studies, Austin, Texas.
- Lester, B. M., Hoffman, J. & Brazelton, T. B. (1985). The rhythmic structure of mother-infant interaction in term and pre-term infants. *Child Development*, 56, 15-27.
- Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: Physiological linkage and affective exchange. *Journal of Personality and Social Psychology*, 45, 587-597.
- Levenson, R. W., & Gottman, J. M. (1985). Physiological and affective predictors of change in relationship satisfaction. *Journal of Personality and Social Psychology*, 49, 85-94.
- Ludeman, P. M., & Nelson, C. A. (1988). Categorical representation of facial expressions by 7-month-old infants. *Developmental Psychology*, 24, 492-501.
- Malatesta, C. Z., & Haviland, J. M. (1982). Learning display rules: The socialization of emotion expression in infancy. *Child Development*, 53, 991-1003.
- Margolin, G., & Wampold, B. E. (1981). Sequential analysis of conflict and accord in distressed and nondistressed marital partners. *Journal of Consulting and Clinical Psychology*, 49, 554-567.
- Mayer, N., & Tronick, E. Z. (1985). Mother's turn-taking signals and infant turn-taking in mother-infant interaction. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 199-216). Norwood, NJ: Ablex.
- Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science*, 198, 75-78.
- Miller, C. L., & Byrne, J. M. (1984). The role of temporal cues in the development of language and communication. In L. Feggans, C. Garvey, & R. Golnikoff, with M. T. Greenberg, C. Harding, & J. N. Bohannon (Eds.), *The origins and growth of communication* (pp. 77-101). Norwood, NJ: Ablex.
- Motley, M. T., & Camden, C. T. (1988). Facial expression of emotion: A comparison of posed expressions versus spontaneous expressions in an interpersonal communication setting. *Western Journal of Speech Communication*, 52, 1-22.
- Murray, K., & Trevarthen, C. (1985). Emotional regulation of interactions between two-month-olds and their mothers. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 177-198). Norwood, NJ: Ablex.



- Murray, L., & Trevarthen, C. (1986). The infant's role in mother-infant communications. *Journal of Child Language*, 13, 15-29.
- Natale, M. (1975a). Convergence of mean vocal intensity in dyadic communication as a function of social desirability. *Journal of Personality and Social Psychology*, 32, 790-804.
- Natale, M. (1975b). Social desirability as related to convergence of temporal speech patterns. *Perceptual and Motor Skills*, 40, 827-830.
- Nelson, C. A. (1987). The recognition of facial expressions in the first two years of life: Mechanisms of development. *Child Development*, 58, 889-909.
- Nelson, C. A., & Lundeman, P. (1987). *The categorical representation of facial expressions by 4 and 7-month-old infants*. Unpublished manuscript, Institute of Child Development, University of Minnesota.
- Noller, P. (1984). *Nonverbal communication and marital interaction*. Oxford: Pergamon.
- Oster, H. (1978). Facial expression and affect development. In M. Lewis & L. Rosenblum (Eds.), *The development of affect* (pp. 43-76). New York: Plenum.
- Panksepp, J. (1982). Toward a general psychobiological theory of emotions. *Behavioral and Brain Sciences*, 5, 407-467.
- Panksepp, J., Siviy, S. M., & Normansell, L. A. (1985). Brain opioids and social emotions. In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 3-50). Orlando, FL: Academic Press.
- Papousek, M., Papousek, H., & Bornstein, M. (1985). The naturalistic vocal environment of young infants: On the significance of homogeneity and variability in parental speech. In T. Field & N. Fox (Eds.), *Social perception in infants* (pp. 269-298). Norwood, NJ: Ablex.
- Parrett, D. I., Rolls, E. T., & Caan, W. (1982). Visual neurones responsive to faces in the monkey temporal cortex. *Experimental Brain Research*, 47, 329-342.
- Petrovich, S. B., & Gewirtz, J. L. (1985). The attachment learning process and its relation to cultural and biological evolution: Proximate and ultimate considerations. In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 259-292). Orlando, FL: Academic Press.
- Pike, G. R., & Sillars, A. L. (1985). Reciprocity and marital communication. *Journal of Personal and Social Relationships*, 2, 303-324.
- Reite, M., & Capitanio, J. P. (1985). On the nature of social separation and social attachment. In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 223-258). Orlando, FL: Academic Press.
- Revkin, A. C. (1989). Crack in the cradle. *Discover*, 10, 63-69.
- Rutter, D. R., & Durkin, K. (1987). Turn-taking in mother-infant interaction: An examination of vocalizations and gaze. *Developmental Psychology*, 23, 54-61.
- Sackett, G. P. (1966). Monkeys reared in isolation with pictures as visual input: Evidence for an innate releasing mechanism. *Science*, 154, 1468-1473.
- Scherer, K. (1986). Vocal affect expression: A review and a model for future research. *Psychological Bulletin*, 99, 143-165.
- Schanberg, S. M., & Field, T. M. (1988). Maternal deprivation and supplemental stimulation. In T. M. Field & N. Schneiderman (Eds.), *Stress and coping across development* (pp. 3-25). Hillsdale, NJ: Erlbaum.
- Sorce, J. F., Emde, R. N., Campos, J. J., & Klinnert, M. D. (1985). Maternal emotional signalling: Its effects on the visual cliff behavior of 1-year-olds. *Developmental Psychology*, 21, 195-200.
- Sroufe, L. A., & Waters, E. (1976). The ontogenesis of smiling and laughter. *Psychological Review*, 83, 173-189.
- Steiner, J. E. (1973). The human gustofacial response. In J. F. Bosma (Ed.), *Fourth symposium on oral sensation and perception*. Rockville, MD: U. S. Department of Health, Education and Welfare.
- Stern, D. N., Hofer, L., Haft, W., & Dore, J. (1985). Affect attunement: The sharing of feeling states between mother and infant by means of intermodal fluency. In T. M. Field & N. A. Fox (Eds.), *Social perception in infants* (pp. 249-268). Norwood, NJ: Ablex.
- Stevenson, M. B., Ver Hoeve, J. M., Roach, M. A., & Leavitt, L. (1986). The beginning of conversation: Early patterns of mother-infant vocal responsiveness. *Infant Behavior and Development*, 9, 423-440.

- Street, R. L., Jr. (1982). Evaluation of noncontent speech accommodation. *Language and Communication*, 2, 13-31.
- Street, R. L., & Cappella, J. N. (1989). Social and linguistic factors influencing adaptation in children's speech. *Journal of Psycholinguistic Research*, 18, 497-519.
- Symons, D. (1989). A critique of Darwinian anthropology. *Ethology and Sociobiology*, 10, 131-144.
- Symons, D. K., & Moran, G. (1987). The behavioral dynamics of mutual responsiveness in early face-to-face mother-infant interactions. *Child Development*, 58, 1488-1495.
- Termine, N. T., & Izard, C. E. (1988). Infants' response to their mother's expression of joy and sadness. *Development Psychology*, 24, 223-229.
- Tooby, J., & Cosmides, L. (1989). Evolutionary psychology and the generation of culture, Part I. *Ethology and Sociobiology*, 10, 29-49.
- Tronick, E. Z., Winn, S., & Morelli, G. A. (1985). Multiple caretaking in the context of human evolution. Why don't the Efe know the Western prescription for child care? In M. Reite & T. Field (Eds.), *The psychobiology of attachment and separation* (pp. 292-322). Orlando, FL: Academic Press.
- Warner, R. (1988). Rhythm in social interaction. In J. E. McGrath (Ed.), *The social psychology of time* (pp. 63-88). Newbury Park, CA: Sage.
- Zajonc, R. B. (1985). Emotion and facial efference: A theory reclaimed. *Science*, 228, 15-21.
- Zarbatany, L., & Lamb, M. E. (1985). Social referencing as a function of information source: Mothers vs. strangers. *Infant Behavior and Development*, 8, 25-33.
- Zuckerman, M. (1979). *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, NJ: Erlbaum.