CHAPTER 2

Physiological Aspects of Emotional Knowledge and Rapport

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We come into the world prepared by evolution to have emotions—crying and grimacing with the first independent breath. These nascent emotions are sufficiently well-formed so that from the beginning of life we are able to alert others to how we feel. We also come into the world prepared to know emotions—our own or those of others. However, in this realm, development proceeds much more slowly. Some emotional knowledge appears quite early. For example, the infant quickly learns to discern between the mother's pleasure and displeasure. However, the process of attaining additional emotional competence continues throughout life. The path to competence in emotional knowledge and rapport is often long and tortuous, with the rate and extent of progress differing greatly from person to person.

At first consideration, the constituent processes underlying emotional knowledge and emotional rapport might seem to be largely cognitive, consisting of such functions as perception, attention, communication, and categorization. If these cognitive processes were the entire story, there would be little to write about in a chapter attempting to link physiology with emotional knowledge and rapport. However, human emotion is clearly a phenomenon of both body and mind. Emotion can be thought of as having a structure consisting of biological and mental layers. At its core are highly adaptive evolved biological mechanisms that we share with many species that came before us. These are the bodily actions and reactions that represent time-tested solutions to some of the most basic problems of survival—defending what is ours, establishing and maintaining social hierarchies, avoiding things that would harm us, drawing forth caring and nurturing behavior from others, reproducing, and protecting our young. Around this biological core are layers of evolved mental processes, some of which we share with other species and some of which are uniquely human. If emotion is so intrinsically an admixture of the biological and the mental, then is it not eminently reasonable to expect that both physiology and cognition will play important roles in such fundamental emotional processes as emotional knowledge and rapport?

Emotion is arguably the prototypical mind–body phenomenon. Because physiology is such a crucial ingredient, we believe that all emotion-related processes occur in a biological context. Thus, if one comes to know emotion, whether in self or other, part of that knowledge is based on and encompasses the physiological elements of emotion. If one experiences emotional rapport with another, there will be an element of physiological rapport as well.

SYNCHRONY IN PHYSIOLOGICAL SYSTEMS: AN EXPRESSION OF EMOTIONAL KNOWLEDGE AND RAPPORT

A striking number of physiological systems have shown evidence of synchrony across individuals, without any intentional attempt by those individuals to achieve this state. In this section, we briefly review a number of these physiological systems, considering both the evidence for interpersonal synchrony and the possible relation of such synchrony to emotional knowledge and rapport.[1]

Monthly Onset of Menstruation

One of the more fascinating manifestations of physiological synchrony in humans was first reported by McClintock (1971), who described the tendency of women who were college roommates and close friends to have menstrual cycles that became increasingly synchronized over time (i.e., their days of onset became closer). Many studies of this phenomenon have been conducted over the ensuing years, with most aimed at documenting the conditions under which menstrual synchrony occurs or fails

[1]The interested reader is referred to Hatfield, Cacioppo, and Rapson (1994) for a consideration of some of these physiological systems and other nonphysiological systems in terms of "emotion contagion."

to occur. In addition, there have been a small number of studies attempting to establish the mechanisms responsible for such synchrony.

The evidence from these studies provides strong support for the existence of menstrual synchrony, especially under conditions in which women live in close proximity or otherwise have a great deal of exposure to each other (see Weller & Weller, 1993, for a review). The mechanism responsible for this effect, however, has not been established with any certainty. In female rodents, pheromones are known to play an important role in influencing estrus cycles. Along these same lines, the role of pheromones as a candidate for explaining menstrual synchrony in humans has received some empirical support (e.g., Preti, Cutler, Garcia, Huggins, & Lawley, 1986). Although the functional basis of menstrual synchrony in humans is unknown, it is not difficult to imagine conditions in hunter–gatherer societies under which there would be reproductive advantages to having most female members of the group fertile or infertile at the same time.

The fact that the conditions of close proximity and exposure, which are necessary for menstrual synchrony to occur, are contexts that would be conducive to emotional knowledge and rapport is certainly consistent with our hypothesis of a relationship between emotion and physiological synchrony. However, it does not appear that menstrual synchrony is any greater in conditions where one would expect emotional closeness to be maximal. For example, Weller and Weller (1992) found menstrual synchrony to be no higher in lesbian couples than among women living in less intimate relationships. Thus, although menstrual synchrony in human females provides a striking example of how interpersonal synchrony in a physiological system can occur, of all the physiological systems that we will be reviewing, the evidence in support of a relationship between synchrony and emotional knowledge and rapport is perhaps the weakest.

Autonomic Nervous System Synchrony

Interpersonal synchrony on measures of autonomic nervous system activity has been studied extensively. Our review of the relevant research will be organized in terms of the specific contexts in which autonomic synchrony has been found.

Patients and Therapists

In psychotherapy research, the study of autonomic synchrony between patient and therapist fits nicely with a major concern in the literature with the nature of the patient–therapist relationship. Two theoretical notions

appear to have motivated the search for signs of physiological synchrony between therapist and patient. The first of these is the notion of transference and countertransference as found in Freud's psychoanalytic therapy; the second is the notion of therapeutic empathy as found in Rogers's client-centered therapy.

The transference relationship in psychoanalytic theory refers to the tendency of the patient to have emotional reactions to the therapist that, in actuality, primarily reflect feelings about other significant people in the patient's life (e.g., parents, children, spouses). The countertransference relationship refers to a similar tendency in the therapist's reactions to the patient. Although the implications of the transference and countertransference relationship for therapy are thought to be quite different (e.g., transference is generally welcomed in the early stages of therapy and is considered conducive to therapeutic progress; countertransference is not), the manifestation of both tendencies indicates that the emotional connection between therapist and client is becoming more intense.

Although precursors are found in Freud's concept of "identification" and Reik's description of the therapist "oscillating in the same rhythm" with the client (see Gladstein, 1984, for a review), the elevation of therapeutic empathy to center stage came with Rogers's client-centered therapy (Rogers, 1951). In client-centered therapy, the therapist strives for attunement with the client, perceiving and understanding the client's feelings. For the therapy to be successful, the therapist not only has to understand the client's feelings, but the client has to feel that he or she is being understood. As was the case with transference in psychoanalytic therapy, in client-centered therapy, therapeutic empathy reflects an intensifying of the emotional connection between patient and therapist.

These theoretical notions motivated a spate of studies in the 1950s searching for an "objective" measure of the patient–therapist connection based on psychophysiological methodology.[2] DiMascio, Boyd, Greenblatt, and Solomon (1955) studied heart rate data obtained during long-term therapy from a therapist and from a patient said to be suffering from a neurotic disorder. The authors observed that the patient's and therapist's heart rates "often varied together and at other times varied inversely from each other" (p. 9). Applying some simple statistical tests, they reported a positive correlation of .79 between patient and therapist heart rates during one therapy segment of several minutes' duration and a negative correlation of –.44 during another. Coleman, Greenblatt, and Solomon (1956) studied therapist and patient heart rates during four different kinds

[2]We will only consider studies in which physiology of both patient and therapist was measured and compared. There are also a number of studies in which physiology was measured from only one of the participants (usually the patient).

of emotional episodes (anxiety, depression, extrapunitive hostility, and intrapunitive hostility). With the exception of those times when the therapist was said to be distracted by other concerns, they found that heart rate changes during these episodes were generally similar for both patient and therapist. DiMascio, Boyd, and Greenblatt (1957) studied patient and therapist heart rates during the first 12 therapy sessions. They found that the therapist's and patient's heart rates moved in similar directions as the levels of "tension" in the interview varied, but moved in opposite directions when the patient expressed "antagonism" toward the therapist.

More recently, Stanek, Hahn, and Mayer (1973) reported periods of concordance between therapist and patient heart rates in the initial sessions of psychoanalytic therapy with patients with cardiac phobias (e.g., fear of heart attacks). Reidbord and Redington (1993) applied nonlinear dynamical analysis to second-by-second heart rate data obtained from a therapist during five sessions of psychotherapy with a grieving patient. Heart rate data were classified into four categories representing different patterns of change over time. Although the focus of this report was on data from the therapist, similarities with equivalent data obtained from the patient were observed in terms of the relative prevalence of the four patterns and their durations.

In the case of autonomic synchrony between patients and therapists, a direct connection to empathy was made in Kaplan and Bloom's (1960) review of the early studies. The authors interpreted the findings they reviewed as indicating a physiological component of "empathy." This theme was echoed by Ax (1964) when he speculated that empathy could be thought of "as an autonomic nervous system state which tends to simulate that of another person" (p. 12). In reality, all of the patient–therapist studies were plagued by methodological problems that make it difficult to determine how much weight to give to these conclusions. Sample sizes were extremely small; empirical connections to conceptually important variables such as empathy, therapeutic progress, or outcome were lacking; and attempts to establish discriminant validity (e.g., when synchrony does not occur) were not adequate. Still, the patient–therapist relationship is one in which emotional knowledge and rapport are critical, and signs that autonomic linkage does occur in this context lend some preliminary support to notions of a connection between these variables.

Dyads and Groups

Although most of the early work on physiological synchrony was done in patient–therapist dyads, Kaplan, Burch, and Bloom (1964) conducted two studies of skin conductance synchrony in small discussion groups that were constituted on the basis of sociometric ratings. In the first study, there were three four-man groups, one in which all subjects disliked each other, one in which all subjects liked each other, and one comprising a mixture of liking and disliking. Groups were studied during five 45-minute discussion sessions, and data were analyzed in terms of two-man dyads. Results indicated that dyads within the group that disliked each other were more likely to show significant correlations in skin conductance than dyads in the other two groups. In the second study, two-person groups of female subjects were formed. In 10 of the dyads, the subjects liked each other, in 10 they disliked each other, and in 10 they were neutral. Groups were studied during two 20-minute discussions. As with the male groups, results again indicated that subjects paired on the basis of mutual dislike were more likely to show significant correlations in skin conductance than those paired on the basis of liking or neutrality.

Mother and Infants

A great deal of research has examined the interactions between mothers and infants to determine the extent to which certain behavioral states (e.g., engagement and disengagement) are synchronized. The general notion being tested in this work is that there will be greater behavioral synchronization in harmonious mother–infant interactions than in nonharmonious ones (e.g., Beebe, Jaffe, Feldstein, Mays, & Alson, 1985). Most of this work has focused on the relationship between behavioral synchrony and other variables, such as infant gender (Tronick & Cohn, 1989) and maternal depression (Field, Healy, & LeBlanc, 1989), without directly studying the possibility of physiological synchrony between mother and infant. One exception is the study by Field et al. (1989) in which high degrees of heart rate synchronization were found between mothers and infants when the mothers were playing with their babies. Interestingly, the extent of this synchronization was the same for both depressed and nondepressed mothers. Assuming that emotional rapport is quite high during mother–infant play, this study could be viewed as evidence for a connection between emotional rapport and heart rate synchrony. On the other hand, because the study was not designed to test this connection explicitly, the requisite experimental conditions and analyses are not available.

Viewing Oneself

Work in our laboratory has provided evidence of autonomic synchrony when people view and rate their own emotional behavior. This finding was obtained in the course of our attempts to solve a particularly vexing methodological problem at the start of what was to become a long-standing collaboration with John Gottman devoted to studying marital interaction. The problem we faced was how to obtain continuous self-report measures of affect (paralleling the continuous measures of physiology and behavior we were already capable of obtaining) during marital interactions. All prior attempts to obtain self-reports of affect during marital interaction were either "discrete" (e.g., a single preinteraction and a single postinteraction assessment) or "semicontinuous" (e.g., interrupting the flow of the interaction periodically to obtain an affect rating).

Our solution to this problem made use of a video recall procedure. Couples came to the laboratory to have naturalistic uninterrupted conversations about topics relevant to their marriages. During these interactions, the physiological responses of both spouses were monitored continuously and their behavior was recorded on videotape. Several days later, spouses returned separately to the laboratory and viewed the videotapes of their interactions. As the interaction unfolded on the monitor, the spouses used a rating dial to provide continuous ratings of how they had been feeling moment-to-moment during the interaction. As was the case during the original interaction sessions, physiology was measured continuously during the video recall sessions.

To our relief, the couples seemed quite comfortable with this entire procedure—both in terms of having these kinds of intimate conversations under laboratory conditions and in terms of coming back to view and rate the videotapes of their interactions. As most people who have viewed their own behavior on videotape will confirm, the experience is quite powerful—drawing you immediately and powerfully back into the original experience. Consistent with this, our sense and that of our couples was that they began actually to reexperience the feelings they had in the original interaction and thus could report them quite accurately.

Of course, we needed to put some empirical meat on these impressionistic bones. Thus, we conducted the typical kinds of validity analyses one might expect with these kinds of data (e.g., establishing that spouses' ratings of their emotions using the video recall method agreed with similar ratings obtained from trained coders who viewed the same videotapes). Less conventional was our decision to compare spouses' physiological responses that had occurred during the original interaction with those that occurred several days later when they were viewing the interaction on videotape and providing affect ratings. Although initially designed as a way of validating the video recall procedure, these analyses provided a unique opportunity to determine systematically whether spouses' physiology when viewing and rating a videotape of a prior interaction would be synchronized with their physiology during the actual interaction.

We reported an analysis of physiological synchrony in 30 couples (Gottman & Levenson, 1985), each of whom had engaged in two 15-minute conversations during which four physiological measures were obtained. This gave us 480 opportunities to test for physiological synchrony (30 couples × 2 spouses × 2 conversations × 4 measures), which were reduced to 474 opportunities because of missing data. Using a measure of coherence, which assesses the degree of linear association between two time series, we found significant physiological synchrony between a spouse's responses in a given physiological measure when in the interaction and that spouse's responses in the same physiological measure when viewing the videotape of that interaction in 431 of the 474 tests (91%). Estimates of the size of this relationship based on the average coherence across measures, conversations, and spouses indicated that 36% of the variance was shared between physiology across the two occasions.

To provide an illustration of what this synchrony can look like, Figure 2.1 plots a wife's cardiac interbeat interval during a 15-minute discussion of a marital conflict and also while she was watching and rating the videotape of that interaction several days later. The close mirroring of these physiological responses is quite evident. It should be noted that the responses were normalized prior to plotting. Typically, the magnitude of the physiological response when viewing the videotape is somewhat smaller than that of the response during the actual interaction.

Of course, physiological synchrony across these two contexts was not perfect, approximating a correlation of .6. However, when one considers all of the differences between the two contexts (e.g., the passage of time,

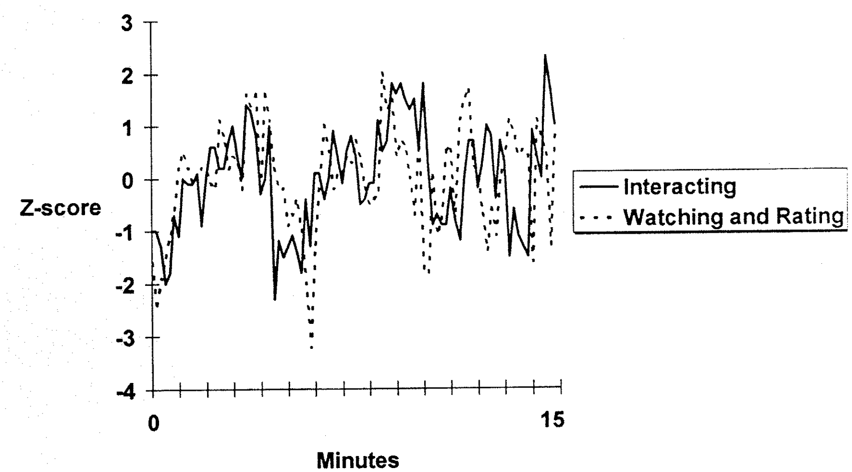

FIGURE 2.1. Wife's normalized heart rate while discussing problem area with husband (solid line) and when watching and rating the videotape of that interaction several days later (dotted line).

change of visual perspective, familiarity with the "plot" of the interaction in the recall session derived from prior exposure), this .6 correlation seemed to us to be an impressive demonstration of physiological synchrony.

We (Gottman & Levenson, 1985) interpreted these findings of physiological synchrony as indicating emotional synchrony, hypothesizing that subjects who view and rate videotapes of themselves in emotion-laden situations actually "relive" the emotions they had experienced in the original interaction. Because we believe that certain emotions activate the autonomic nervous system in characteristic ways (e.g., Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990), we would expect that a person who reexperienced the same emotions in approximately the same temporal sequence when viewing a videotape of an interaction as when in the actual interaction would evince the same patterns of physiological response on both occasions.

Interactions between Spouses

Our marital interaction paradigm also allowed us to assess another kind of physiological synchrony, which we termed "physiological linkage" (Levenson & Gottman, 1983). By considering the relationship between the autonomic and somatic responses of the two spouses as they unfolded over time, we were able to capture the kind of "interpersonal" physiology that was envisioned by those who had worked with therapists and patients almost 30 years earlier.

Physiological linkage between spouses turned out to be a much more variable phenomenon than the "intrapersonal" synchrony between a person's physiology during an interaction and that same person's physiology while viewing a videotape of the same interaction later on. The extent of physiological linkage between interacting spouses was found to vary both as a function of the nature of the interaction and the spouses' level of satisfaction with their marriage (both of these relationships are discussed later in this chapter).

The Autocorrelation Problem

Because we wanted to characterize the relationship between physiological responses across spouses, we needed first to control for aspects of the physiological responses within spouses that might distort the estimate of interpersonal linkage. In this regard, the problem of autocorrelation had to be addressed. An individual's physiological responses measured over time are not independent observations. For example, all physiological systems have time constants that specify the maximum rate of change possible per unit of time. The heart can accelerate or slow its rate of contraction quite rapidly—but not infinitely so. By comparison, changes in skin temperature (which are controlled by electrodermal and vascular systems) occur much more slowly. Because of factors such as these, a physiological measurement obtained at any given time will be constrained by the state of that physiological system in the preceding time period.

A second deviation from independence results from inherent or induced cyclicities in physiological responses over time. A well-known example of an induced cyclicity is the respiratory sinus arrhythmia, which is a periodic rise and fall in heart rate that is associated with breathing (the heart speeds during inspiration and slows during expiration by virtue of vagally mediated reflex mechanisms). Because of such cyclicities, what might appear to be physiological synchrony across spouses could instead merely reflect similarities in inherent or induced physiological cycles.

To control for these kinds of autocorrelations within spouses when assessing physiological linkage between spouses, we utilized a bivariate time-series analysis (Gottman, 1981) that removed the effect of within-spouse cyclicities from estimates of the physiological relationship between spouses. For each physiological variable, this analysis produces two chi-square values, one that indexes the extent to which the wife's physiological activity accounts for variance in the husband's physiological activity (beyond that accounted for by his own activity) and a second that indexes the extent to which the husband's physiological activity accounts for variance in the wife's (beyond that accounted for by her own activity).

The resulting measure of physiological linkage turned out to be quite sensitive to context. Examining linkage for five physiological variables in a sample of 79 married couples, it can be seen in Figure 2.2 that linkage between spouses was clearly greater when the couples were having a conversation about a problem area in their marriage than when they were having discussions about the events of the day or about a pleasant topic.

In a sample of 30 married couples (Levenson & Gottman, 1983), correlations were computed between an index of overall physiological linkage between spouses during each of two 15-minute conversations and the couples' overall level of marital satisfaction (measured using standard self-report instruments). Physiological linkage when couples were discussing the events of the day was found to be unrelated to marital satisfaction ($r = -.04$). However, physiological linkage when couples were discussing a problem area in their marriage was significantly correlated with marital satisfaction ($r = -.31$) such that the less satisfied the couple was with their marriage, the more they evinced physiological linkage.

Why might physiological linkage be greatest during the most conflictual marital interactions and in the most dissatisfied marriages? And how might that be related to emotional knowledge and rapport? Our hypothe-

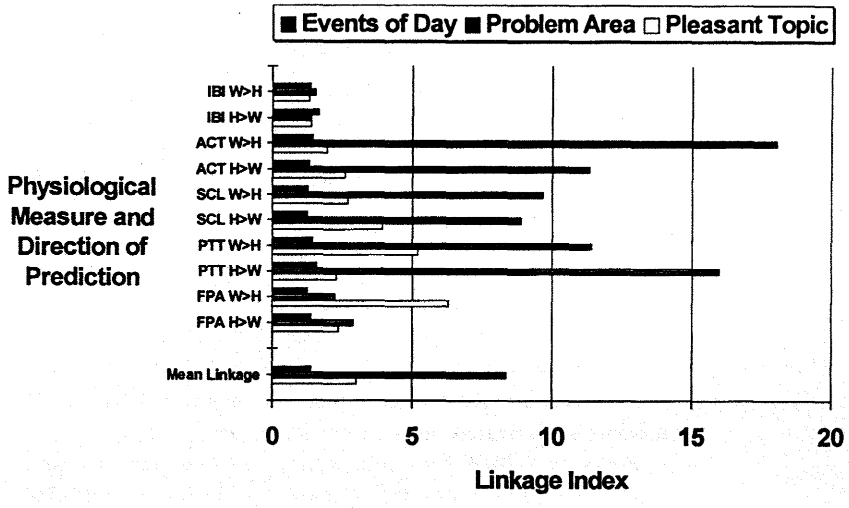

FIGURE 2.2. Physiological linkage between husband and wife during three 15-minute conversations on the topics of the events of the day, a problem area in their marriage, and something pleasant. IBI, interbeat interval; ACT, somatic activity; SCL, skin conductance; PTT, pulse transmission time to the finger; FPA, finger pulse amplitude; W > H, wife's physiology predicts husband's physiology; H > W, husband's physiology predicts wife's physiology.

sis is that emotional similarity across spouses is the most likely cause. Moreover, based on a series of studies (Carstensen, Gottman, & Levenson, 1995; Levenson, Carstensen, & Gottman, 1994; Levenson & Gottman, 1983), the pattern of findings suggests that it is not similarity of any emotion, but rather similarity of negative emotion that is most responsible. In our work, the greatest amount of physiological linkage between spouses was found during the conflict conversation. We have consistently found the conflict conversation to be more productive of negative affect (whether measured by self-report or by coded emotional behavior) than the events of the day and pleasant topic conversation.

Our work has also revealed that the greatest amount of physiological linkage between spouses was found in those couples who were the most dissatisfied with their marriages. We have consistently found that dissatisfied couples evince more negative affect than satisfied couples (again, regardless of whether self-report or coded emotional behavior was measured).

We believe that discussions of marital conflicts and the interactions of dissatisfied couples are conducive to spouses engaging in cycles of negative affect that are characterized by reciprocity (i.e., one spouse's negative affect is responded to with negative affect by the other spouse, which leads

the first spouse to respond with another burst of negative affect) and patterns of escalation/deescalation (i.e., the spouses' level of negative affect gradually rises until it reaches some threshold, at which point one or both spouses either introduce positive affect or withdraw as a way of reducing their level of arousal). The emotions that are produced in these cycles of negative affect are assumed to cause parallel rises and falls in autonomic nervous system activity in both spouses. In contexts (e.g., pleasant conversations) and couples (satisfied marriages) where the density of positive emotion is greater, there should be less parallelism in physiological activation, because positive emotions generally do not produce as high a level of autonomic activation as do negative emotions (Levenson, Ekman, & Friesen, 1990).

The findings that greater physiological synchrony is associated with greater negative affectivity echo those of earlier studies of small groups in which the highest correlations among group members' skin conductance responses were found in groups whose members disliked each other (Kaplan et al., 1964). These findings also suggest that physiological synchrony is a marker of those times when spouses' emotional states are closely related. We believe that such states are highly conducive to emotional knowledge.

One of the somewhat counterintuitive implications of these findings concerning relationship qualities, physiological synchrony, and emotional rapport is that high levels of emotional knowledge may not always be the province of good relationships. In the distressed married couples we have studied who evidence high levels of negative affect reciprocity and high levels of physiological linkage, spouses often know exactly what the other spouse is feeling, but they do not act on that knowledge in a constructive way. In these couples, spouses know quite clearly when the other spouse is feeling bad, but seem much less aware about what has caused these feelings, what to do about them, and how to avoid them in the future. These deficits in other kinds of knowledge are consistent with findings by Ickes and colleagues (Simpson, Ickes, & Blackstone, 1995; see also Ickes & Simpson, Chapter 8, this volume) that relationship distress is associated with low levels of cognitive empathy (i.e., in unhappy relationships, partners are not very good at knowing what the other person is thinking).

Postural Mirroring

Postural synchrony across individuals can often be seen in interpersonal contexts. For example, an intricate choreography of mirrored movements often occurs when individuals are deeply engaged in conversation (Hatfied, Cacioppo, & Rapson, 1994; Kendon, 1970). In three studies, LaFrance and colleagues found postural mirroring to increase with increasing psychological involvement. In the first study, LaFrance and Broadbent (1976) found that the more college students in small seminars mirrored the posture of their teacher, the higher they rated their sense of involvement. In another study, LaFrance (1979) found that the more postural mirroring there was among classmates, the greater was their sense of rapport. Finally, in a third experimental study (LaFrance, 1985), groups of subjects had to determine whether suicide notes were false or real. Subjects were randomly assigned to situations that varied in the extent that cooperative action was rewarded. Arm mirroring was found to be greater in cooperative conditions than in competitive ones.

Based on these studies, the most parsimonious interpretation of postural mirroring is that it is epiphenomenal, resulting from and reflecting interpersonal closeness, rather than causing that closeness. However, postural synchrony may also have the capacity to cause people to feel closer. Several studies support this possibility. For example, Dabbs (1969) had confederates either deliberately mirror subjects' body movements or not mirror them. Subjects reported liking those confederates who mirrored their body movements more than those who did not mirror. Maurer and Tindall (1983) studied the impact of postural mirroring by high school counselors on how empathic they were rated by their student clients during a 15-minute interview. Results indicated that counselors in conditions in which they deliberately mirrored clients' arm, leg, and head positions were rated as being more empathic than those in nonmirroring conditions.

The link between postural mirroring and emotional rapport (and, to a lesser extent, emotional knowledge) is patent in these studies, with subjects reporting increases in qualities such as empathy, liking, and psychological involvement the more that physiological synchrony (mirrored movements) was evident.

Facial Mimicry

Among the various kinds of physiological synchrony that have been studied, facial mimicry has been the subject of a particularly large body of research. Because of the centrality of the face in emotion, facial mimicry is arguably the expressive behavior most closely tied to emotional processes in general and to emotional rapport and knowledge in particular. In fact, as the following discussion should make clear, both theory and data suggest that the synchrony of interactants' facial expressions can lead fairly directly to the commonality of emotional states across individuals.

In humans, the facial muscles are capable of producing an enormous

number of expression changes. Many of these serve such functions as speech and eating, whereas others function in the service of emotional expression. Among the myriad possible facial expressions, certain ones seem to have the capacity to "automatically" bring forth similar expressions in others, thus resulting in a kind of spontaneous facial synchrony. The basis for this phenomenon likely resides in an inherent human tendency toward facial mimicry. For example, spontaneous mimicry of facial movements has been documented in human infants as early as the first few days of life (Field, Woodson, Greenberg, & Cohen, 1982; Meltzoff & Moore, 1977, 1983). In adults, mimicry has been found for more complex emotional facial expressions (e.g., Dimberg, 1982; Laird et al., 1994). While almost all facial expressions have the capacity to induce mimicry, it seems that some are particularly powerful. In the emotional realm, for example, smiles seem to be especially potent, having the capacity to induce smiles in others directly and almost irresistibly, without any appreciable cognitive mediation.

Voluntary Facial Action and Emotion

A possible bridge that links facial mimicry to emotional rapport and knowledge can be found in studies suggesting that facial expressions can give rise to emotions directly.

One set of studies tested the capacity of voluntary facial movements to modulate the emotional response produced by some independent stimulus. In most of these studies, the subjects were presented with an emotion-eliciting stimulus and were asked to produce, exaggerate, or inhibit a given emotional expression. The typical finding was that the manipulated facial behavior produced a parallel effect on the subjective experience of the relevant emotion (e.g., having subjects smile increased how humorous they found a cartoon to be; Laird, 1974). Most persuasive are those studies that manipulated subjects' facial expressions in a way that minimized the extent to which subjects were cued to the emotional meaning of the expression. Strack, Martin, and Stepper (1988) found that having subjects hold a pen between their teeth (which simulated smiling) caused an increase in how funny they found cartoons to be. Similarly, Larsen, Kasimatis, and Frey (1992) attached two golf tees to subjects' foreheads and found that having them try to move the two tees together (which simulated frowning) caused an increase in how negatively they rated unpleasant photographs.

In a second set of studies, researchers have manipulated facial expressions absent any external emotional stimulus and then measured the effects on subjective emotional experience and emotion-relevant physiology. Again, the most convincing evidence derives from studies in which subjects were not directly cued to the emotional nature of the expressions. In research from our laboratory, we gave subjects muscle-by-muscle instructions to move certain combinations of facial muscles, some of which produced prototypical emotional expressions. In three studies using this procedure, we (Levenson et al., 1990) found that subjects who received these instructions reported feeling the emotion associated with the combination of facial movements at greater than chance levels. More importantly, the associated emotion was reported most often when the instructed movements were produced most accurately (i.e., the resulting expression was closest to the prototype for that emotion). In addition to emotional experience, the voluntary facial actions produced autonomic nervous system changes appropriate to the associated emotion (e.g., heart rate increases during anger expressions), and these autonomic changes also were most pronounced when the ensemble of facial movements most closely resembled the emotion prototype.

Theoretical Explanations

One theoretical explanation for the findings from studies of voluntary facial actions derives from the "facial feedback hypothesis" (e.g., Buck, 1980; Izard, 1971; Laird, 1974; Lanzetta, Cartwright-Smith, & Kleck, 1976; Tomkins, 1984). According to this hypothesis, when the facial muscles move they produce afferent feedback, which plays a primary causal role in the generation and shaping of emotion. In our work (e.g., Ekman et al., 1983) we have pointed out that none of the studies of voluntary facial actions (including our own) provides a test of the central tenet of the facial feedback hypothesis, namely, that it is afferent feedback from the movement of the facial muscles that causes the emotional experience. There are clearly other explanations for the findings from these studies. One possibility is that associations between particular configurations of facial muscle activity and particular emotions are learned. Another is that there are "pattern detecting" mechanisms in the brain that scan patterns of efferent impulses to the facial muscles and, when they recognize patterns associated with emotional facial configurations, activate other aspects of the complete emotional response (i.e., emotional physiology, emotional experience).

Regardless of the underlying mechanism, the findings from studies of voluntary facial actions suggest a bridge between facial mimicry and emotional knowledge and rapport. If one person is in the throes of an emotion and is displaying the facial expression appropriate to that emotion, another person might view that expression and either automatically (via processes of facial mimicry) or intentionally produce the same facial expression. The person who mimics the facial expression of another could

then begin to experience the subjective experience of the associated emotion as well having the associated physiological responses activated. In terms of empathic accuracy, the receiver of an emotion transferred in this way would have access to additional clues to how the other person was feeling beyond those that derive from observing that person's behavior and considering the environmental context. Now, receivers could obtain supplemental information about the other person's emotions by considering their own emotional state.

In our own work with voluntary emotional facial expressions, we speculated about this kind of mechanism:

> Combined with our findings, a new social role for facial expression is suggested. By making the configuration seen on the face of another person, the imitator may begin to experience the same affective and physiological state as the other person. Viewed in this way, facial expression may not be simply a social signal, but may also provide a means for establishing mutual feeling, thereby playing a role in the establishment of empathy, attachment, and bonding. (Levenson et al., 1990, p. 382)

We also related this phenomenon to a quote attributed to Edgar Allan Poe, which suggests that intentional facial mimicry can be used for similar purposes:

> When I wish to find out how wise or how stupid or how good or how wicked is anyone, or what are his thoughts at the moment, I fashion the expression of my face, as accurately as possible, in accordance with the expression of his, and then wait to see what thoughts or sentiments arise in my mind or heart, as if to match or correspond with the expression. (quoted in Levenson et al., 1990, p. 382)

PHYSIOLOGICAL SYNCHRONY, EMOTIONAL CONTAGION, AND EMPATHIC ACCURACY

In previous sections the possible links that physiological synchrony has with emotional parallelism, and, ultimately, with emotional knowledge and rapport have been repeatedly drawn. In this section, we will review the findings from studies that directly tested these various links. We start with studies that have tested whether observing another person's emotions can produce emotion in the observer, move on to studies that show that the same emotion is produced in the observer as in the person observed, and then consider studies showing a relationship between person A's physiology and the accuracy of person B's ratings of person A's emotions. We end with a study of our own that directly tested for and found a relationship between physiological synchrony and emotional knowledge (empathic accuracy), and a follow-up study that provided a preliminary test of the role that emotional contagion might play in mediating that relationship.

Observing Another's Emotion Produces Emotion in the Observer

The results of a number of studies suggest that viewing the emotional behavior of another person can induce emotion in the observer. In one set of studies concerned with individual differences in empathy and prosocial behavior, observing a person in distress was found to produce pronounced facial expressive, subjective, and autonomic signs of emotion in the observer (Eisenberg et al., 1988, 1989; Stotland, 1969; Wiesenfeld, Whitman, & Malatesta, 1984). For example, Eisenberg et al. (1989) had subjects watch a videotape in which a mother talked about the injuries her children had suffered in a serious car accident and the problems that had ensued. The greater the emotional activation this story produced in adult observers the more likely they were to express willingness to help the family. Wiesenfeld et al. (1984) studied the emotional and physiological responsivity of female subjects to videotaped scenes of smiling, quiescent, and crying infants. Women who scored high on a self-report measure of empathy responded with larger electrodermal responses, were more likely to respond with matching facial expressions, had more extreme happiness and sadness reactions, and indicated stronger desire to pick up the infants than those scoring low in empathy.

Observing Another's Emotion Produces the Same Emotion in the Observer

The results of another set of studies indicated that viewing the emotional displays of another person can result in the observer exhibiting emotional displays that are similar to the person being observed. In these studies, physiology is only monitored from the observer, and typically the observer's emotional displays are accompanied by autonomic activation (Dimberg, 1982; Lanzetta & Englis, 1989; McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985; Vaughan & Lanzetta, 1980). Most of these studies used a vicarious classical conditioning paradigm in which subjects viewed the emotional responses of others (the unconditioned stimulus). Then an attempt was made to condition their vicarious emotion responses (the unconditioned response) to other stimuli such as nonemotional words (the conditioned stimulus). Of greatest interest for our purposes was the finding that viewing one person's emotional displays could induce a corresponding emotion in the observer (referred to as "vicarious instigation" in these studies). For example, Vaughan and Lanzetta (1980) had subjects view a videotape of another person's facial responses to electric shock and found that this produced activation in the observer of (1) skin conductance and (2) the muscles that encircle the eye (the same muscles that were activated in the face that was being viewed).

Accuracy of Subjects' Emotion Ratings and Targets' Physiology

None of the foregoing studies was concerned with the accuracy of emotion ratings, and all were primarily concerned with the emotional responses of the observers—not the targets. In the "sender–receiver" paradigm, observers ("receivers") are instructed to rate the emotions being experienced by targets ("senders") and the accuracy of those ratings is related to the level of physiological arousal in the sender. The general finding from these studies has been that high physiological arousal on the part of the sender is associated with low accuracy in the receiver's ratings of the target's affect (Buck, Miller, & Caul, 1974; Buck, Savin, Miller, & Caul, 1972; Lanzetta & Kleck, 1970). For example, Buck et al. (1974) showed pleasant and unpleasant slides to senders and measured their skin conductance and heart rate responses. Receivers viewed the faces of the senders on a television monitor and had to indicate how pleasant or unpleasant the slide was that the sender was viewing. Findings indicated that for male subjects (but not for females), the greater the skin conductance reactivity on the part of the sender the less accurate the receiver was in rating the affective quality of the viewed slides.

At first glance, these findings that subjects are not very accurate in rating the emotions of physiologically aroused targets might seem to run counter to one of the central notions in this chapter. However, it is important to note that physiological activation on the part of the person being rated (or of the person doing the rating, or of both persons) does not necessarily mean that the two people are in a state of physiological synchrony. Physiological synchrony refers to the extent to which both persons' level of physiological arousal shows similar patterns of change over time; it does not refer to any particular level of arousal. Only one study reviewed in this section evaluated the relationship between changes in the sender's and receiver's level of physiology (Buck et al., 1972). In that study, the subjects' and targets' physiological responses were found to be uncorrelated overall; however, no attempt was made to determine if differences in the extent of this correlation were related to differences in rating accuracy.

Physiological Synchrony and Empathic Accuracy

Attempting to integrate the findings from the literatures on physiological synchrony, emotional contagion, and empathic accuracy with findings from our studies of marital interaction, we advanced an integrative model in which we postulated the existence of a physiological substrate for empathic accuracy, mediated in part by a process of emotional contagion (Levenson & Ruef, 1992). Our primary hypothesis was that empathic accuracy—a state in which one person (the subject) can accurately tell what another person (the target) is feeling—will be marked by physiological parallelism between subject and target. This parallelism results in part from a process of emotional contagion through which the subject comes to have emotions that are similar in type and timing to those experienced by the target.

Based on our studies of marital interaction, we felt that we were on fairly firm ground as far as knowing how to measure the extent of physiological synchrony between subject and target. The existing literature, however, had not produced measures of empathic accuracy that met what we considered to be six important criteria for ecological validity[3]:

1. The measure needs to be based on judgments of continuous streams of emotional behavior rather than on static displays (e.g., photographs) or short behavioral excerpts. In such streams, emotional content often changes rapidly; thus, subjects need to be able to update their emotional judgments continuously so that they reflect the current emotional state of the target.
2. Emotional judgments need to be based on the kinds of information that are typically available in real-world contexts; thus, subjects should be given both visual and auditory information, rather than relying solely on transcripts, silent videotapes, or audiotapes.
3. The emotional behavior to be judged should be naturalistic, rather than staged. Staged behaviors may be fundamentally different in the density, intensity, sequencing, signs, and timing of emotion; ability to detect emotion in such staged behavior may be unrelated to the ability to detect emotion in more naturalistic contexts.
4. The emotional behavior to be judged should occur in an interpersonal context; this is arguably the most common context in which emotions occur.

[3]Working independently, Ickes and colleagues (Ickes, Stinson, Bissonnette, & Garcia, 1990) also developed an ecologically valid measure of empathic accuracy based on subjects' discerning of the content of targets' thoughts.

5. Both the ability to detect positive emotion and the ability to detect negative emotion should be assessed; these abilities may be independent.
6. Accuracy should be determined in some objective manner; subjects' emotional ratings should be compared with some objective measure of what the "correct" emotions are.

The measure of empathic accuracy that we developed to meet these criteria made use of methods we had developed in our research on marital interaction. Subjects viewed videotapes (culled from our previous studies) of 15-minute naturalistic marital interactions and used a rating dial to indicate continuously how they thought one of the spouses in the interaction was feeling. Empathic accuracy was assessed by comparing subjects' ratings of the targets' feelings with targets' ratings of their own feelings that had been obtained previously. Accuracy for negative and positive affect was determined separately. An opportunity to assess the relationship between physiological synchrony and empathic accuracy was made possible by comparing continuous physiological measures obtained from the subject during the rating task with the same measures obtained from the target during the actual interaction.

Finding a Viable Measure of Accuracy

One of the first questions we asked was how closely subjects could track targets' emotions. We initially tried a measure of accuracy in which deviations of the subject's ratings from the target's ratings were determined at different temporal lags and then averaged. To receive a high score on this measure, a subject would have to be able to track variations in the target's affect ranging from the smallest fluctuations to the largest changes. In pilot work evaluating this kind of measure, we found that hardly any subjects were able to exceed chance levels of accuracy. Apparently, empathic accuracy at this fine a grain is not possible between strangers using these kinds of materials and procedures.

We next tried a cruder measure of accuracy in which we identified the more extreme positive and negative moments within the target's affect ratings (i.e., 10-second periods in which the dial rating was at least 1 point from the midpoint and at least one-half a standard deviation from the target's mean rating). We then determined whether the subject's ratings of these moments (calculated in the same manner) matched those of the target. In our pilot sample, mean empathic accuracy measured in this way was close to chance levels, with a fairly normal distribution. Thus, it appeared that some subjects were very competent at detecting these more extreme moments of positive and negative affect, whereas others were not. The range and distribution of accuracy scores seemed adequate for determining whether there were other variables associated with individual differences in this measure of empathic accuracy.

Empathic Accuracy and Physiological Linkage

In our first study (Levenson & Ruef, 1992), 31 subjects each rated two 15-minute segments of marital interaction, in one segment focusing on a husband and in the other on a wife. We found that empathic accuracy for negative affect was related to the degree of physiological linkage between the subject and the target. Accuracy of rating negative emotion moments was greatest when the subject and target evidenced high levels of physiological linkage across time (correlation sizes were approximately .50). A different relationship was found for accuracy of rating positive affect moments. Accuracy of detecting positive emotion was found to be related to a state of low cardiovascular arousal in the subject, but not to the degree of physiological linkage between the subject and the target. Interestingly, using this objective behavioral measure of empathic accuracy, there were no differences between male and female subjects in level of empathic accuracy, no relationship between traditional self-report measures of empathy (Gough, 1987; Mehrabian & Epstein, 1972) and empathic accuracy, and no relationship between how accurate subjects thought their ratings were and how accurate they actually were.[4]

Interpretation of Findings

Our putative explanation for the found relationship between empathic accuracy for negative emotions and the physiological linkage between subject and target was based on the notion of emotional contagion and on the patterns of autonomic nervous system activation associated with certain negative emotions. We reasoned that subjects who are empathically accurate are those who are most sensitive to emotional contagion and thus are most likely to experience the same emotions as the target at approximately the same time. These emotions would produce similar patterns of autonomic activation in both subject and target, thus creating physiological linkage.

To explain the lack of finding of an association between empathic accuracy and physiological linkage for positive emotions, we again drew on findings that negative emotions are more likely than positive emotions to produce patterned autonomic nervous system activity (Levenson et al.,

[4]Such findings turn out to be typical for behavioral measures of empathic accuracy (e.g., Ickes et al., 1990; Marangoni, Garcia, Ickes, & Teng, 1995; see also Graham & Ickes, Chapter 4, this volume).

1990). In our view (Levenson, 1992), emotions produce autonomic activation so that the necessary physiological support is available for patterns of behavior that are prototypical for those emotions. Because negative emotions are more closely associated with behavioral patterns that make higher metabolic demands (e.g., fleeing in fear, fighting in anger) than positive emotions, the negative emotions are more likely to produce the kind of strong autonomic nervous system activation necessary for physiological linkage to occur between the subject and the target.

Our explanation for the found relation between empathic accuracy for positive emotions and low levels of physiological arousal draws on several other lines of evidence. We believe that the accurate detection of positive affect during a complex social interaction may require more extensive and subtle kinds of cognitive activities and judgments than are involved in detecting negative affect. Negative affect in most contexts appears to have greater salience than does positive affect (e.g., Hansen & Hansen, 1988; Pratto & John, 1991). This may be particularly true in social contexts such as marital interaction, where negative emotions are likely to be particularly clear-cut, intense, and attention grabbing. Negative emotions are also more finely differentiated by facial expression than positive emotions (Ekman & Friesen, 1978). In contrast to positive emotions, many of which share a single signal (the smile), negative emotions are more readily differentiated by means of their associated patterns of facial movements (e.g., anger vs. fear). Because of this, it is easier to distinguish negative emotions visually.

A great deal of psychophysiological research over the past several decades has investigated the notion that high levels of cardiovascular arousal dampen the activity of higher brain centers by action of the baroreceptor reflex (e.g., Lacey, Kagan, Lacey, & Moss, 1963). Such dampening may make the brain less sensitive to the subtleties inherent in identifying positive emotions. Further, it is generally thought that during situations in which levels of physiological arousal are high, there is an accompanying narrowing of perceptual focus. In such aroused states, those things that are most important to survival are most likely to be noticed. In the realm of emotion, negative emotions often have much greater importance to survival than do positive ones (e.g., conspecifics' anger vs. their amusement). Thus, it might be only in states of low arousal that sufficient surplus attentional resources will become available for processing positive emotions accurately.

Evidence for Mediation by Emotional Contagion

The methods used in our first study did not enable us to test the part of our model that hypothesized that the physiological linkage with targets shown by empathically accurate subjects resulted from emotional contagion (i.e., subjects experiencing the same emotions as the targets). To provide a preliminary test of this notion, we (McCarter, Ruef, & Levenson, 1995) conducted a study in our laboratory in which coders rated the faces of subjects in our previous study of empathic accuracy (Levenson & Ruef, 1992) for signs of emotion. The results indicated that subjects who showed the most emotion on their faces when rating the emotions of the targets were the most empathically accurate. For example, in the second tape rated, emotion on the face of subjects doing the ratings was correlated significantly with their accuracy in rating targets' negative emotion ($r = .54, p = .005$) and positive emotion ($r = .51, p = .009$). Further, emotion on the face of subjects doing the ratings was correlated significantly with physiological linkage between subject and target in the measure of pulse transmission time to the finger ($r = .40, p = .048$). The results of this study provide some preliminary support for emotional contagion as mediating between empathic accuracy and physiological linkage. However, we have not yet determined whether the empathically accurate subjects experienced the same emotions at the same time as did the targets they were rating.

FINAL THOUGHTS ON THE RELATIONSHIPS AMONG PHYSIOLOGICAL SYNCHRONY, EMOTION, AND EMPATHY

In this chapter we have reviewed evidence establishing the striking capacity of many physiological systems to show synchrony both within and across individuals. This evidence spans neuroendocrine, autonomic, and somatic systems under such diverse conditions as close social proximity, psychotherapy, discussion groups, mother–infant play, viewing oneself on videotape, marital interaction, students and teachers in classrooms, and observing and evaluating the emotions of others. In most, if not all, of these contexts and across all of these physiological systems, a recurrent theme was that physiological synchrony is an outgrowth and by-product of emotional synchrony. Interestingly, this emotional synchrony could take the form of emotional rapport (with the emotions of one person being "in synch" with those of another) or emotional knowledge (with one person coming to know the feelings of another). Further, although the relationship between emotional synchrony and physiological synchrony clearly occurs when two people who know each other intimately are engaged in actual face-to-face interaction, it appears to be sufficiently robust that it is not limited to such close encounters, but rather can occur across rather large expanses of psychological space (e.g., videotape) and interpersonal space (e.g., between strangers).

Physiological Synchrony as an Epiphenomenon

A phenomenon as pervasive and robust as physiological synchrony invites speculation: Why might such synchrony exist and what functions might it serve? Perhaps the simplest answer is that there are benefits under certain conditions for social species to have a mechanism for quickly and efficiently rendering all members of the group into a similar physiological state. Examples are not difficult to muster. Under dangerous conditions that pose threats to survival, it is advantageous for the behavioral and motoric adjustments of one or more individuals to spread rapidly throughout the group, encompassing even those members who are too far away to have directly experienced the threatening event. Group reactions such as preparing for fleeing can be seen in species as disparate as birds and humans (panic reactions in human groups have been especially well-documented). In considering such instances of physiological synchrony in groups, we are once more thrust in the direction of viewing physiological synchrony as an epiphenomenon of emotional synchrony—in these examples, through processes of emotional contagion, the emotion appropriate to the situation spreads rapidly throughout the group, in each member activating its appropriate pattern of physiological response, and thus rendering the group into a state of physiological synchrony.[5]

Physiological Synchrony as a Primary Phenomenon

Although we think it is most parsimonious and empirically justifiable to view physiological synchrony as a by-product of emotional synchrony, it is also possible to reverse the causal arrow, viewing physiological synchrony as cause and emotional synchrony as effect. In this chapter we reviewed the evidence suggesting that certain kinds of motor activity (both general somatic and facial) can trigger emotional experience and associated autonomic nervous system activity fairly automatically, with only the most rudimentary cognitive mediation. Of course these kinds of findings do not lack for theoretical precedent. The notion that motoric behaviors can give rise to emotions has been around for at least a century, tracing back to the musings of James and Lange (e.g., James, 1884). In the James–Lange model, motor activities such as running or freezing are sufficient conditions for the occurrence of an emotion such as fear.

[5]Less certain is the precise temporal sequencing of the various facets of the spreading emotion. We simply do not know what comes first among the concomitant postural changes, autonomic activation, facial expressions, and subjective experience. What is clear is that all emotional subsystems onset extremely rapidly in such group elicitations.

Although most of the evidence we reviewed in this chapter suggests that it is the facial muscles that have the capacity to initiate emotion, there is some empirical support for the kind of emotion initiation by large muscle activity that James and Lange emphasized. For example, Duclos et al. (1989) found that having subjects assume postures that were appropriate for the emotions of fear, sadness, and anger increased the likelihood of their reporting feeling the associated emotion. Thus, if one accepts the existence of a mechanism by which full-blown emotion can be elicited directly by certain patterns of muscle activity, the notion of physiological synchrony as a primary phenomenon rather than merely an epiphenomenon becomes viable. Of course, such a view requires postulating a mechanism by which such physiological synchrony occurs initially (e.g., via hardwired reflexive responses that cause bodily systems in conspecifics to react to certain environmental situations in the same way).

The Reinforcing Qualities of Physiological Synchrony

Finally, it is probably worth noting that, in humans, physiological synchrony seems to be inherently reinforcing, perhaps helping to account for the large number of contexts in which it appears. Humans appear to derive both aesthetic and visceral pleasure from being in physiologically synchronous states. Examples abound. Young children and adults revel in mimicry rituals, regardless of whether they involve postures, vocalizations, or facial expressions. The coordinated movements of participants in dance appear to assume an important role in all cultures, with great pleasure derived from direct participation and from mere observation, and from movements both simple (e.g., line dancing) and complex (e.g., ballet). Beyond dance, other forms of coordinated group bodily movements also seem to be pleasurable (e.g., the "wave" at sports events, group swaying at concerts, marching). Pleasure is also attained in physiological synchrony of the more visceral type—we need only look to human erotic and sexual practices for examples.

CONCLUSION

In this chapter we have made the case that physiological synchrony is a highly pervasive phenomenon that is woven throughout the human experience. Physiological synchrony is also clearly intertwined with the processes of emotional synchrony, especially those of emotional rapport and emotional knowledge. The closeness of this connection is underscored by the existence of evidence of bidirectional causality—emotional synchrony can produce physiological synchrony, and physiological synchrony can produce emotional synchrony. Finally, we have argued that physiological synchrony is highly reinforcing in its own right, which may help account for its ubiquity across physiological systems, contexts, stages of life, and cultures.

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