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Biological Substrates of Empathy and Facial Modulation of Emotion: Two Facets of the Scientific Legacy of John Lanzetta[1]

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The impact of John Lanzetta's emotion research on our understanding of the interplay between psychological and physiological processes in emotion is examined. Lanzetta's work in two areas is reviewed along with related work by others. The first area concerns the biological substrates of empathy. Here Lanzetta studied emotional contagion, and in particular the conditions under which viewing another person's emotions can cause expressive and physiological changes in the observer. The second area concerns the facial modulation of emotion. Here Lanzetta studied the capacity of voluntary facial expression to alter the physiological and subjective aspects of emotion. The article closes with a personal reflection on Lanzetta as a scientist and as a person.

John Lanzetta's research had significant implications for our understanding of emotion. Lanzetta was not the type of scientist who was drawn into the kinds of debates that have come to characterize a great deal of the recent writing on emotion (e.g., Are there basic emotions? Is the primary function of emotion interpersonal or intrapersonal? Can there be emotion without prior cognition?). Rather he had a research style that was phenomenon-driven. He would isolate some interesting aspect of emotion, and then set out to deepen his understanding, designing elegant experiments that pro-

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vided a test of the limits of his ideas about what emotions are and how they work.

In this article, I will review two areas in which Lanzetta did important and pioneering emotional research. My primary focus will be on his work concerning the biological substrates of empathy. Here, Lanzetta investigated whether viewing the emotions of others can cause expressive and physiological changes in the observer. I will also review briefly his work on the relationship between facial expression and other aspects of emotion. Here, Lanzetta asked whether voluntary facial expression can modulate physiological and subjective aspects of emotion. In keeping with the theme of this issue, I will not focus exclusively on Lanzetta's work. Rather, I will attempt to place his research in these two areas in their larger context and will include my own work, upon which his influence was quite substantial.

BIOLOGICAL SUBSTRATES OF EMPATHY: LANZETTA'S WORK

Emotions evolved to support both intrapersonal and interpersonal functions (Levenson, 1994), serving the most elemental survival needs of the individual and the group. In the early days of emotion research, the spotlight focused primarily on the intrapersonal domain. Questions such as what kinds of physiological changes occurred during different emotions (e.g., Ax, 1953) loomed large on the empirical landscape. Despite the fact that a large portion of his work dealt with intrapersonal issues (e.g., the interplay between facial expression and other aspects of emotion), Lanzetta was clearly in the forefront of what was to become a major movement toward considering the interpersonal functions of emotion and studying emotion in an interpersonal context. Nowhere is this more evident than in his work on emotional contagion and empathy.

Varieties of Emotional Empathy

Lanzetta appeared to be fascinated by the ways in which one person's emotions were transmitted to another person, especially when the transmission occurred without a great deal of conscious awareness. This phenomenon can best be termed emotional "contagion," a capacity of emotion that has significant implications for group cohesion (e.g., smiles as a semiotic for acceptance, approval, and bonding) and group survival (e.g., fearful facial displays and vocalizations as a means for alerting other members of the group to imminent danger). Lanzetta's interests, however, extended beyond the elemental mechanisms of contagion to encompass the more highly cognated forms of interpersonal emotion, most of which are now subsumed under the broad rubric of "empathy." In current empirical parlance, empathy encompasses (a) emotional contagion (feeling what another person is feeling), (b) empathic reaction (responding to another person's emotions), and (c) empathic accuracy (knowing what another person is feeling); Lanzetta's work touched primarily on the first two of thee areas—emotional contagion and empathic reaction.

Emotional Contagion and Empathic Reaction

In a series of studies, Lanzetta and his collaborators (Lanzetta & Englis, 1989; McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985; Vaughan & Lanzetta, 1980) demonstrated that viewing the emotional displays of another person could result in the observer exhibiting emotional displays that were similar to those of the person being observed. In addition, observers typically showed activation or relaxation of the autonomic nervous system as would be appropriate for the emotion being observed (e.g., activation when observing pain, relaxation when observing enjoyment). One implication of this work was that merely viewing another person's emotion was sufficient to induce an analogous emotional response in the observer.

Vicarious Condition. Lanzetta was well schooled in the principles and methods of learning theory, especially those of classical conditioning. Accordingly, to study emotional contagion, he and Katherine Vaughan (Vaughan & Lanzetta, 1980) adopted a vicarious classical conditioning methodology. In their prototype paradigm, observers viewed videotapes of subjects memorizing word pairs. On some trials the subjects on the tapes were purportedly shocked and on others they weren't. On the trials that they were shocked, subjects on the tapes showed painful emotional displays. The conditioning model worked as follows:

> Unconditioned stimulus (UCS): The painful emotional responses of the subjects on the tapes.
>
> Unconditioned response (UCR): Observers' vicarious emotional responses to seeing the pain and distress of the person on the tape. For Lanzetta, such a response was quite automatic, thus, it qualified as an UCR.
>
> Conditioned stimulus (CS): A word form one of two categories (e.g., trees or flowers) that was presented for 10 s preceding the shock. For each subject, words from one category (CS+) were always presented prior to shock trials and words from the other category were always presented prior to trials without shock (CS–).
>
> Thus, it would be expected that only the CS+ words would come to be associated with the shock.
>
> Conditioned response (CR): The observer's emotional responses (facial behavior, autonomic activity) in the period following presentation of the CS+, but before the painful response of the subject on the tape.

These studies provided evidence for the power of this particular form of emotional contagion. Finding that an unshocked observer had a powerful emotional response to watching another person who appeared to be shocked was impressive enough. But even more striking was the finding that observers who came to have an emotional response to a neutral word that preceded the shock received by another person. As the authors interpreted their findings:

> when the person on the tape is being shocked, the observers' "autonomic and facial muscle systems behave. . .as though they are in pain"; and when the word that has preceded the shock is presented, the observers' "autonomic and facial muscles systems behave as though they are anticipating shock." (Vaughan & Lanzetta, 1980, p. 921)

Isomorphism of Emotional Contagion. Having demonstrated that observers' responses mimic those of the person being observed (i.e., observers evidence pain in response to observing another person's pain), in his typical fashion, Lanzetta set out to test the limits of these findings. Lanzetta and Englis (1989) questioned whether emotional contagion is always so well matched. In this study, subjects viewed a videotape of another person either smiling in response to receiving a reward or grimacing in response to getting an electric shock. In one condition subjects were led to believe they would be having a cooperative interaction with the person being observed and in the other they believed the interaction would be competitive. In the cooperative condition, "same-type" contagion occurred: Observing smiles to rewards led to smiles and autonomic relaxation on the part of the observer; grimaces led to grimaces and autonomic activation. In the competitive condition, however, the findings reversed: Observed smiles led to grimaces and autonomic activation and observed grimaces led to smiles and autonomic relaxation on the part of the observer. Clearly, what had at first glance appeared to be an automatic and homologous was much more complex; emotions expressed by one person could beget quite different emotions in the observer.

Consistency Across Aspects of Emotions. Lanzetta tested the limits of other features of the contagion phenomenon as well. In Vaughan and Lanzetta (1980), only facial behavior and autonomic activity were measured and they both told pretty much the same story (i.e., in the observer, both emotion systems closely mirrored those of the person observed). Thus, it was quite reasonable for him to ask whether other aspects of emotion also fall in line during emotion contagion. In one of his more memorable studies, Lanzetta tested this proposition in a highly creative way, making use of a cultural icon of the day—the face of Ronald Reagan.

McHugo et al. (1985) had subjects view videotaped excerpts from speeches, press conferences, and debates in which Ronald Reagan had shown emotional facial expressions. Prior to viewing these excerpts, they assessed how favorably subjects felt toward the President. As in the earlier work on pain, both facial expression and physiology was measured, but now subjective emotional experience was assessed as well. Patterns of findings for facial expression and physiology were the same as those found in the pain work: Observers responded to the President's positive expressions with smiles and autonomic relaxation, and responded to his negative expressions with frowns and autonomic activation. Notably, this pattern of findings for facial and autonomic data was consistent regardless of how subjects felt toward the President. However, contagion of self-reported emotion was greatly influenced by these prior feelings. Those who liked the President reported feeling emotions similar to his expressions and those who did not like the President reported negative feelings regardless of whether his expressions were positive or negative.

Unresolved Issues

Contagion Versus Reaction. Lanzetta's studies highlight several important issues that continue to plague empathy research. One of these is the difficulty inherent in distinguishing between emotional *contagion* and emotional *reaction.* We generally think of emotional contagion as meaning that one person's emotions are somehow transmitted directly to another person, who then has the same emotion. For this reason, when different emotions are experienced by observers than by those they observe (as in the competitive condition in Lanzetta & Englis, 1989), this would not be considered to represent emotional contagion. Lanzetta (Lanzetta & Englis, 1989) dealt with this issue by distinguishing between empathy (the observer has the same emotion as the person observed) and counterempathy (the observer has an oppositely valenced emotion from that of the person observed). Whether an observer has an empathic or a counterempathic response depends on such factors as the context (e.g., competition or cooperation) and prior experience with the person being observed (e.g., favorable or unfavorable).

Although this distinction is a useful one, it does not totally disambiguate contagion and reaction. as the term is typically used, emotional contagion implies automaticity; merely having the same emotion as the person being observed is not sufficient to establish automaticity. Put more simply, if Person A smiles when observing Person B smiling, it is difficult to know if Person A is smiling *with* (contagion) or *at* (reaction) Person B.

Parallel Measurement of Observer and Observed. Another issue raised by Lanzetta's work is the extent to which contagion occurs in different aspects of emotion. If emotional contagion is defined as the observer having the same emotion as the person observed, then, strictly speaking, contagion cannot be established for a given aspect of emotion unless that aspect is measured in both observer and observed. Absent this dual measurement, the extent of sameness of response cannot be determined. In Lanzetta's work, it was only facial behavior that was consistently measured in both the observer and observed. Because autonomic nervous system response was typically not measured in the observer, his work only established emotional contagion for facial expression. Lanzetta believed that contagion existed for both facial and autonomic aspects of emotion. As will be seen in the following sections,[3] considerable empirical evidence indicates that both kinds of emotional contagion do in fact exist.

EMPATHY AND EMOTIONAL CONTAGION: RELATED WORK

Observing Another's Emotion Produces Emotion in the Observer

A substantial body of research indicates that viewing the emotional behavior of another person can induce emotion in the observer (see Hatfield, Cacioppo, & Rapson, 1994, for a review). In a group of studies concerned with individual differences in empathy and prosocial behavior, observing a person in distress was found to produce pronounced facial expressive, subject, 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. 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 a stronger desire to pick up the infants than those scoring low in empathy.

[3]When Craig Smith and Greg McHugo approached me about contributing a paper on Lanzetta's contribution to research on empathy for this special issue, I was already involved in preparing a review of this literature for a volume on empathic accuracy being edited by William Ickes (Levenson & Ruef, in press). With the prior agreement of Smith and McHugo, the following sections draw heavily and often quote directly from that review.

Facial Mimicry

One of the basic building blocks of emotional contagion, facial mimicry, has also been well studied. In humans, the facial muscles are capable of producing an enormous number of changes in facial appearance. Many of these serve functions such as speech and eating, whereas others act in the service of emotional expression. Among the myriad possible facial expressions, certain expressions 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, Alibozak, Davainis, 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.

Autonomic Synchrony

A substantial body of research now exists examining whether emotional contagion occurs in the autonomic nervous system. Much of this work operationalized contagion in relatively simple ways, obtaining autonomic measures from two interactants and averaging them over short time periods. Other work has taken a more microanalytic, time-series approach, examining the relationship between two interactants' moment-to-moment fluctuations in autonomic responses over longer periods of time, a phenomenon that I have referred to elsewhere as autonomic "synchrony" (e.g., Levenson & Gottman, 1983). In the following sections I will review the evidence that emotional contagion can occur in the autonomic nervous system. I will also attempt to place this phenomenon in a larger context, relating it a hypothesis that synchrony of the autonomic responses of two people is associated with heightened emotional closeness and greater capacity for empathic accuracy.

Patients and Therapists. One of the first areas in which autonomic synchrony was investigated was that of psychotherapy. Research investigating similarities between patients' and therapists' autonomic responses began appearing in the 1950s and has continued to appear periodically. These studies have been motivated by a long-standing need in psychotherapy research for objective indicators of the quality and closeness of the patient-therapist relationship.

DiMascio, Boyd, Greenblatt, and Solomon (1955) studied heart rate data obtained during long-term therapy from a therapist and from a patient with a neurotic disorder. Applying simple statistical tests, they reported significant positive correlations between patient hart rate and therapist heart rat during some therapy segments and significant negative correlations during others. Coleman, Greenblatt, and Solomon (1956) studied therapist's and patient's heart rates during four different kinds of emotional episodes (anxiety, depression, extrapunitive hostility, and intrapunitive hostility). 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 hart 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. Similarities with equivalent patient data were observed in the relative prevalence of the four patterns and in their durations.

In reviewing the studies of patients-therapist physiology, a direct connection to emotional empathy was made by Kaplan and Bloom (1960), who interpreted the findings as indicating a physiological component of "empathy," a theme that was echoed in Ax's (1964) speculation that empathy is "an autonomic nervous system state which tends to simulate that of another person" (p. 12). As intriguing as these notions are, the patient-therapist studies were all plagued by methodological problems that bring the validity of their conclusions into question. Sample sizes were extremely small; empirical connections to conceptually important variables such as objective measures of 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 therapist-patient relationship is one in which emotional empathy is arguably quite critical (e.g., Gladstein, 1984; Rogers, 1951). Findings that autonomic synchrony occurs in this context are suggestive of a connection with emotional empathy.

Dyads and Groups. 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 4-man groups, one in which all subjects disliked each other, one in which all subjects liked each other, and one in which some subjects liked and some subjects disliked each other. Groups were studied during five 45-min discussion sessions and data were analyzed in terms of two-man dyads. The 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-min discussions. As with the male groups, result 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.

These studies indicate that the nature of the emotional connection between interactants that is associated with increased autonomic contagion or synchrony may not always be based on positive emotion. Because it was groups in which members disliked each other that showed the greatest physiological synchrony, it is likely that their dominant emotions were negative, not positive. This connection between shared negative emotions and physiological synchrony will be revisited below when I consider studies of satisfied and dissatisfied married couples.

Intrapersonal Physiological Synchrony: Viewing Oneself in an Emotional Situation. Studies in my laboratory have shown that autonomic synchrony occurs when people view their own emotional behavior. In this research, couples come to the laboratory and have naturalistic uninterrupted conversations about topics relevant to their marriages. During these interactions, the physiological responses of both spouses are monitored continuously and their behavior is recorded on videotape. Several days later, spouses return to the laboratory and view the videotapes of their interactions. As the interaction unfolds on the television monitor, each spouse uses a rating dial that traverses a continuous scale ranging from *very negative* to *neutral* to *very positive* to provide moment-to-moment ratings of how he or she was feeling *during the interaction*. As in the original interaction sessions, physiology is measured continuously from spouses when the ratings are obtained.

Using these kinds of data, we (Gottman & Levenson, 1985) analyzed the physiological synchrony that occurs when viewing one's own behavior in a sample of 30 couples who had engaged in two 15-min conversations during which four physiological measures were obtained. This gave us 470 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 [91% of the statistical tests (431 of 474) were significant]. Estimates of the size of this relationship indicated that 36% of the variance was shared between physiology across the two occasions.

We (Gottman & Levenson, 1985) interpreted these findings of physiological synchrony as reflecting emotional synchrony, hypothesizing that subjects who viewed and rates videotapes of themselves in emotion-laden situations actually "relive" the emotions they experienced in the original interaction. Believing that certain emotions activate the autonomic nervous system in characteristic ways (e.g., Ekman, Levenson, & Friesen, 1983; Levenson, 1992; Levenson, Ekman, & Friesen, 1990), I expect that a person who reexperiences the same emotions in approximately the same temporal sequence when viewing a videotape of an interaction as when in the actual interaction will evince the same patterns of physiological response on both occasions.

Interpersonal Physiological Synchrony: Interactions Between Spouses. The marital interaction paradigm also allows assessment of physiological synchrony *across* spouses (Levenson & Gottman, 1983). To quantify the extent of physiological similarity between interactants, we (Levenson & Gottman, 1983) applied a bivariate time-series analysis (Gottman, 1981), which removes the effects of autocorrelations (within-spouse cyclicities) from estimates of the physiological relationship between spouses. Examining linkages for five physiological variables in a sample of 79 married couples, the linkage between spouses was much greater when a couple was 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-min 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.

Thus, the extent of physiological linkage between interacting spouses was found to vary both as a function of the topic of the conversation and the spouses' level of satisfaction with their marriage. These findings raise two questions: (a) Why is physiological linkage greatest during the most conflictual marital interactions and in the most dissatisfied marriages? (b) What does this linkage reflect?

It seems likely that emotional similarity between spouses is the most likely cause of physiological linkage. Moreover, I believe that it is not similarity of *any* emotion, but rather similarity of *negative* emotion that is most likely to be responsible. In these studies, the greatest amount of physiological linkage between spouses was found during the conflict conversation, which we have found across couples of all ages to consistently produce more negative affect (whether measured by self-report or by emotional behavior rated by trained coders) than the events of the day and pleasant topic conversation (Gottman, & Levenson, 1995; Levenson, Carstensen, & Gottman, 1994; Levenson & Gottman, 1983). We have also found that the greatest amount of physiological linkage between spouses is found in those couples who are the most dissatisfied with their marriages. Given that dissatisfied couples of all ages consistently evince more negative affect than satisfied couples (Carstensen, et al., 1995), Levenson et al., 1994; Levenson & Gottman, 1983), a connection between physiological linkage and negative emotion is again implicated. And these findings that physiological synchrony is associated with greater negative affectivity also echo those of the studies of small groups reviewed earlier in which the highest correlations among group members' skin conductance responses were found in groups whose members disliked each other (Kaplan et al., 1964).

One somewhat counterintuitive conclusion from my work may be worth considering in terms of its relationship with Lanzetta's findings regarding counterempathy. In my work, levels of emotional sameness and emotional knowledge don't always seem to be the province of good relationships. In distressed marriages that evidence high levels of negative affect and high levels of physiological synchrony, spouses often know exactly what the other spouse is feeling, but don't seem very aware of what caused these feelings, what to do about them, and how to avoid having more negative feelings in the future. These deficits are consistent with findings by Simpson, Ickes, and Blackstone (in press) 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). They are also reminiscent of two of Lanzetta's most important findings: (a) Prior feelings about another person can disrupt and distort the contagion of some aspects of emotion (e.g., subjective emotional experience in

McHugo et al., 1985); and (b) certain contexts can result in counterempathic responses (e.g., competitive situations in Lanzetta & Englis, 1989).

Physiological Synchrony and Empathic Accuracy. Attempting to integrate the findings from the literatures on physiological synchrony, emotional contagion, empathic accuracy, and marital interaction, Anna Ruef and I postulated the existence of a physiological substrate for empathic accuracy, mediated in part by 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 synchrony between subject and target. This synchrony 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.

In our first study (Levenson & Ruef, 1992), subjects viewed two 15-min segments of marital interaction and used the kind of rating dial described earlier to indicate continuously how they thought one of the spouses in the interaction was feeling. Empathic accuracy was assessed by comparing each subject's ratings of the target spouse's feelings with that spouse's rating of his or her own feelings obtained previously. Physiological synchrony was assessed by comparing continuous physiological measures obtained from the subject during the rating task with the same measures that had been obtained from the target spouse during the actual interaction. The results revealed that empathic accuracy (for negative affect) was related to the degree of physiological linkage between the subject and the target spouse (correlation sizes were approximately .50).

Our putative explanation for the found relationship between empathic accuracy for negative emotions and the physiological synchrony between subject and target spouse was based on 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.

In a follow-up study, we (McCarter, Ruef, & Levenson, 1996) tested our notion that the physiological synchrony with targets shown by empathically accurate subjects resulted from emotional contagion (i.e., subjects experiencing the same emotions as the targets). Coders rated the faces of subjects in the Levenson and Ruef (1992) study 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 and showed the most physiological linkage. These results provided some preliminary support for emotional contagion as the mediator 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.

Biological Substrates of Empathy: Summary

John Lanzetta's work on emotional contagion makes an important contribution to what has become a quite strong case for the elegant capacity of the human organism to transmit emotional information through processes both automatic (e.g., the contagion of facial expression that Lanzetta found when subjects viewed another person's distress) and deliberate (e.g., the on-line rating of another person's feelings in work from my laboratory). The mirroring of facial muscle activity that Lanzetta observed is an important component of a widespread interpersonal physiological synchrony, which includes the autonomic nervous systems, and which appears to be an integral feature of the transmission of emotion and of emotional information between conspecifics.

FACIAL MODULATION OF EMOTION: LANZETTA'S WORK

Lanzetta was one of the first researchers to use an experimental paradigm to test the extent to which the face could modulate other aspects of emotion, notably subjective experience and autonomic nervous system activity. This work has important implications for theories that view the face not only as a signal system for emotion and emotion communication but also as playing a central role in the very formation of emotion (e.g., Darwin, 1872; Tomkins, 1962).

Prior to Lanzetta's experimental studies, most research on the relationship between facial expression and physiology used correlational designs, asking whether people who are characteristically facially expressive are more or less physiologically reactive than those who are characteristically nonexpressive. Interestingly, Lanzetta (Lanzetta & Kleck, 1970) carried out one of these studies, finding that the more facially expressive subjects were in a singled shock task the less they were physiologically aroused.

This inverse relationship between facial expression and physiological reactivity was typical of findings that utilized the correlational methodology. Research in both the "internalizer-externalizer" tradition (Buck, 1979; Field & Walden, 1982; Funkenstein, King, & Drolette, 1954; Jones, 1935; Notarius & Levenson, 19779) and in the "repressive coping style" tradition (e.g., Levenson & Mades, 1980; Weinberger, Schwartz, & Davidson, 1979) support the conclusion that people who are characteristically inexpressive ("internalizers," "repressors") are more physiologically reactive than are those who are characteristically expressive.

With the adoption of an experimental methodology, Lanzetta found the same kinds of coherence and parallelism between facial expression and physiology that he had found in his work on emotional contagion. Again, pain was the emotional phenomenon he chose to start with. In his first studies (Lanzetta, Cartwright-Smith, & Kleck, 1976), subjects were instructed to either inhibit or exaggerate their facial responses to electric shock. Inhibition of facial response diminished the autonomic response to shock as well as diminishing self-reported pain. In a follow-up study using varying levels of shock, inhibition of facial responses again diminished the autonomic response to shock. A third study (Bush, Barr, McHugo, & Lanzetta, 1989) used this same kind of facial manipulation, but changed the emotional stimuli to comedy routines and changed the autonomic measure from skin conductance to heart rate. Subjects who inhibited their facial responses reported less subjective amusement, but this time there were no autonomic effects.

FACIAL MODULATION OF EMOTION: RELATED WORK

Inhibition and Exaggeration of Facial Expressions

The experimental paradigm that Lanzetta used, in which he had subjects inhibit or exaggerate facial expressions when they were emotionally aroused by an independent stimulus (e.g., pain, film) and measured the effects on physiology and/or subjective report has been used by several other investigators as well. Leventhal and Mace (1970) had children inhibit their facial responses to a humorous film, finding that this produced less favorable attitudes toward the film in girls (but more favorable attitudes in boys). Zuckerman, Klorman, Larrance, and Spiegel (1981) had subjects inhibit facial expressions to pleasant and unpleasant films, finding that this resulted in smaller physiological responses than in subjects instructed to respond naturally or to exaggerate their facial responses.

In three studies in my laboratory, James Gross and I (Gross & Levenson, 1993, in press) had subjects inhibit their expressive responses to films known to elicit disgust, amusement, or sadness. Examining a broad range of autonomic variables, we found that this inhibition produced a complex pattern of autonomic reactivity. Heart rate slowed (likely mediated by the parasympathetic branch of the autonomic nervous system in response to the reduction in somatic activity that occurred when subjects inhibited their expressive behavior), but other cardiovascular functions mediated by the sympathetic branch of the autonomic nervous system showed greater levels of activation (sometimes accompanied by increases in skin conductance as well).

Voluntary Facial Expressions

Another set of studies relevant to the capacity of the face to influence other aspects of emotion tested the potential of voluntary facial movements to *modulate* the emotional response produced by an independent emotional 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 were 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 somewhat different paradigm, researchers manipulated facial expressions absent any external emotional stimulus and 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 increased during anger expressions), and these autonomic changes also were most pronounced when the ensemble of facial movements most closely resembled the emotion prototype.

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 et al., 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) provide an adequate 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 (e.g., learned associations between particular configurations of facial muscle activity and particular emotions).

Regardless of the underlying mechanism, the findings from studies of voluntary facial actions suggest a bridge that links the two facets of Lanzetta's work that I have reviewed—emotional contagion and facial modulation of other aspects of emotion—with empathic processes. 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 as 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. The observer could obtain supplemental information about the observed person's emotions by considering his or her own emotional state.

JOHN LANZETTA: A PERSONAL REFLECTION

In honoring the memory of an important scientist such as John Lanzetta, it is eminently sensible to emphasize the body of his theory and research and its influence on the field. In Lanzetta's case, as this Special Issue richly demonstrates, this influence was profound and widespread. The primary conduits for scientific influence are often seen as residing in impersonal realms, such as papers, books, and chapters. It is undeniable that a great deal of the commerce of science is transacted in these ways. However, before ending this article, which has been devoted to the influence of John Lanzetta's published work, I want to say something about the ways that his ideas and his personality conveyed influence in more personal ways.

Although I never studied or collaborated with him, John Lanzetta had a substantial influence on my research career both through his work and through a number of personal contacts over the years. As a graduate student and fledgling psychophysiologist in the 1970s who was fascinated with the interplay between mind and body, I remember vividly being captivated by the controversy between the Lanzetta group's findings that low levels of emotional expressive behavior were accompanied by *low* levels of physiological activation (e.g., Lanzetta et al., 1976) versus the Buck group's findings that low levels of emotional expressive behavior were accompanied by *high* levels of physiological arousal (e.g., Buck, Miller, & Caul, 1974). This was the kind of clear cut controversy that made science interesting—and fun. Here were two highly regarded laboratories presenting well-replicated findings that were completely contradictory.

I remember at the time thinking that Lanzetta's findings couldn't possibly be right. For I was being schooled in the psychodynamic tradition of the day, which suggested that humans were a psychophysiological zero-sum game, operating according to a hydraulic principle that dictated that, whenever energy was constrained somewhere in the system, it was honor-bound to be expressed somewhere else. Lanzetta's work taught me a valuable lesson about the power of sound empirical data to call into question even the most aesthetically pleasing and compelling of theories.

In the midst of my grappling with this dilemma, I had a chance to attend a conference where Lanzetta was to give a talk. I think I half-expected that this would-be puncturer of the venerable psychodynamic balloon would be some sort of invective-hurling devil incarnate. Much to my surprise, his talk was a paragon of reasonableness, common sense, and good science. I went up to ask him a question after the talk, fully expecting to be melted on the spot, and again I was surprised. Despite an appearance that could most charitably be described as imposing, and a voice that gave new meaning to the term "gravelly," Lanzetta seemed most approachable, surprisingly gentle, and genuinely interested in my questions and ideas. It was one of those seminal experiences, where I, someone who was tentatively trying on a new identity as a scientist, was made to feel welcome instead of foolish. As I came to know John a bit over the years and as I came to know others who knew him much better, it was clear that this experience of mine was typical of the respect, kindness, and encouragement that he showed for others.

John Lanzetta ended up having quite an influence on my subsequent research and that of my students in the two areas I have reviewed in this article. Both Cliff Notarius (my first Ph.D. at Indiana University) and James Gross (my first Ph.D. at Berkeley) pursued research on aspects of the relationship between emotional expression and physiological reactivity (Notarius & Levenson, 1979; Gross & Levenson, 1993, in press). Two of my current doctoral students at Berkeley, Anna Ruef and Loren McCarter, have been studying the physiological and facial aspects of emotional empathy (Levenson & Ruef, 1992; McCarter et al., 1996). And Paul Ekman, Wallace Friesen, and I conducted a series of studies of the extent to which voluntarily produced facial expression could instigate autonomic and subjective aspects of emotion (Ekman et al., 1983; Levenson, Carstensen, Friesen, & Ekman, 1991; Levenson et al., 1990; Levenson, Ekman, Heider, & Friesen, 1992). All of these strands of research, tracing back in part to John Lanzetta's influence, continue actively in my own laboratory and those of my former students. This kind of multigenerational influence bears further testimony to the lasting quality of John Lanzetta's ideas and to a very personal part of his scientific legacy.

John Lanzetta was truly a scientist's scientist, a fine teacher, and a wonderful human being. While it may not be true that only the good die young, John Lanzetta was truly one of the good people who died way too soon. We can only lament the research that he will never do, the students he will never train, and the people along the way who would have benefited enormously from his wisdom, kindness, and encouragement.

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