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Facial and Vocal Expressions of Emotion

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Abstract

A flurry of theoretical and empirical work concerning the production of and response to facial and vocal expressions has occurred in the past decade. That emotional expressions express emotions is a tautology, but may not be a fact. Debates have centered on universality, the nature of emotion, and the link between emotions and expressions. Modern evolutionary theory is informing more models, emphasizing that expressions are directed at a receiver, that the interests of sender and receiver can conflict, that there are many determinants of sending an expression in addition to emotion, that expressions influence the receiver in a variety of ways, and that the receiver's response is more than simply decoding a message.

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Introduction: Definition and Scope

Smiles, chuckles, guffaws, smirks, frowns, and sobs — these and their milder cousins occurring in the fleeting changes in the countenance of a face and in the tone of a voice are essential aspects of human social interaction. Indeed, expressionless faces and voices are considered to be indicators of mental illness, expressive faces and voices to be windows to the soul. The last chapter in the *Annual Review of Psychology* devoted entirely to this topic (Ekman & Oster 1979) summarized a rich research tradition that was predominant in the study of emotion at that time. Since their chapter, much has changed.

Both scientists and nonscientists traditionally considered smiles, chuckles, and the rest to be "expressions of emotion" (EEs). Ekman and Oster (1979) continued this tradition, but newer work questions the assumptions in both key words, expression and emotion. Signals might be a better term for some cases of EE, although signal, symptom, symbol, manifestation, display, sign, expression and other terms are often used interchangeably, without clear definitions or distinctions. The relation of EEs to emotion (and the nature of emotion) remains unclear. Further, the class of EEs is probably heterogeneous and so any one name will prove misleading. For instance, some EEs are, to use Goffman's (1959) terms, *given* (produced for the purpose of communication) and others are *given off* (side-effects of movements produced for other purposes). The boundaries encircling the class of EEs are not self-evident, leaving us pointing to examples and leaving the category EE conceptually undefined. Indeed, we doubt that it is a scientifically viable unitary category.

History

Traditionally, senders have been thought to "express" or "encode" – that is, emit veridical information about – their internal state, much as a lighthouse broadcasts its visual and auditory

warning to any and all who happen to perceive it. In turn, receivers "recognize" or "decode" the message and benefit thereby. This image of honest and altruistic broadcasting has deep historical roots. Thought of as a God-given and universal language, EEs revealed passions (such as love and hate), virtues (courage), and vices (sloth). These ideas were evident in philosophical, religious, and artistic theories from ancient times to the 19th century, and continued to appear in later work by anatomists, physiologists, and other scientists (Montagu 1994). Among those scientists was Charles Darwin (1872). Although he relied on traditional assumptions about expression and emotion, Darwin substituted natural selection for God and made important observations about cross-species and cross-cultural similarities in EEs to bolster his argument for that substitution.

The modern era of the study of EEs began in 1962 with a theory proposed by Sylvan Tomkins. Like Darwin, Tomkins and those he inspired (Izard 1971, Ekman et al 1972) perpetuated many of the traditional assumptions about expression. To these, Tomkins added another ancient idea, that of a small, fixed number of discrete ("basic") emotions. On Tomkins' theory, each basic emotion can vary in intensity and consists of a single brain process (an "affect program"), whose triggering produces all the various manifestations (components) of the emotion, including its facial and vocal expression, changes in peripheral physiology, subjective experience, and instrumental action. Because they have a single cause, these components tightly cohere in time and are intercorrelated in intensity. Emotions are sharply distinguished from cognitions. The set of theories, methods, and assumptions inspired by Tomkins guided the study of emotion for over a quarter century.

Another assumption found in Darwin and continued by Tomkins – that the same message is encoded and decoded – guided much of the research on EEs: If (except in cases of deliberate,

socially induced deception) EEs broadcast veridical information which the receiver recognizes, then researchers can focus on either the encoding (sending) or decoding (receiving) side. Either could establish which of the small number of basic emotions was expressed by a specific facial or vocal pattern. For practical reasons, most research therefore relied on decoding (judgments by observers) to establish just what emotion a specific EE represents. The actual emotional state of the sender was typically neglected.

Some Key Theoretical Advances

Modern evolutionary theory renders obsolete Darwin's specific analysis of EEs, which relied on a Lamarkian inheritance of acquired characteristics, on group selection pressures, and on a characterization of EEs as vestiges. Modern theory instead emphasizes natural selection, the interests of the individual, adaptation, and function (Dawkins & Krebs 1978, Fridlund 1994, Owren & Rendall 2001). A pivotal recognition in modern theories is that EEs, even when "given" in Goffman's sense, are not broadcast to any and all but are directed at a receiver and evolved to influence that receiver in ways beneficial to the sender. As the interests of sender and receiver only sometimes coincide, it is not always in the sender's interest to provide veridical information. EEs are thus are as capable of being deceptive as honest.

A second key recognition was that the receiving side is more than a reflex-like decoding of a message. If EEs evolved to alter the receiver, then a variety of effects can occur. For instance, vocal stimuli can capture the receiver's attention and alter his or her affective state without any emotion being encoded or decoded (Owren et al 2002). Furthermore, receiving mechanisms were subject to their own course of evolution. The receiver's interest lies not only in detecting cues but also in distinguishing veridical cues from deceptive ones. Receivers also benefit by using cues given off to anticipate the sender's subsequent actions. This last point is

underscored by inadvertent communication, such as when a predator uses the prey's EEs to locate the prey (Seyforth & Cheney 2003).

The theory of basic emotions has also been cogently criticized (Turner & Ortony 1992), and new conceptions of emotion have emerged (Russell 2002). These conceptions include an emphasis on multi-component dynamic processes laced with cognition (Scherer 2001, Smith & Kirby 2001), with a looser, more malleable and context-dependent relation among the components (Bradley & Lang 2000b), and with a role for broad primitive affective dimensions such as pleasure-displeasure and activation (Davidson 2000, Russell & Feldman Barrett 1999).

These theoretical advances led us to separate the study of EEs into two topics: (a) the receiver's response to an EE (including but not limited to an attribution of emotion to the sender) and (b) the sender's production of an EE (there may be a variety of factors influencing the production of a given EE, some of which have little to do with emotion). Evidence on one of these topics cannot be taken as evidence on the other. Evidence on the universality of one cannot be taken as evidence on the universality of the other. Rather than judging emotion attributions as correct or incorrect, we suggest a more descriptive approach on how these two processes work, on what natural selection has bequeathed to the newborn regarding these processes, and on how they develop over the lifetime. Our discussion centers on a psychological analysis of (non-clinical) human adults.

The Response of the Receiver

Recognition of Discrete Emotions

Much research was and still is inspired by the theory that certain EEs signal specific emotions, which receivers "decode." Receivers include human infants (Nelson & de Haan 1997) and nonhuman species (Marler & Evans 1997), although Seyforth and Cheney (2003) observed

that, with the possible exception of the chimpanzee, no other species is currently thought to decode EEs in the way that humans are theorized to attribute emotions to the sender. The process of "decoding" has not been specified, but has been characterized as innate (Izard, 1994), easy (Ekman, 1975), categorical (Calder et al 1996), and immediate: "The initial translation of an expression into some meaning is likely to be so immediate that we are not aware of the process we go through" (Ekman 1997, p.334).

In the typical study, a facial or vocal EE is presented to a receiver who then indicates which emotion it signals. The impressive empirical foundation for this theory is the repeated finding that, despite differences in culture, age, or background, receivers agree on the emotion signaled more often than could be achieved by chance (for facial EEs, see reviews by Elfenbein & Ambady 2002 and Russell 1994; for vocal, Johnstone & Scherer 2000). Agreement is typically higher for facial than vocal EEs (Hess et al 1988, Wallbott & Scherer 1986).

Nevertheless, key problems remain unresolved. One problem concerns the facial or vocal signals chosen for study. The "correct" signal for each specific emotion in these studies was not specified on theoretical grounds, although Darwin's speculations along these lines are sometimes alluded to. Nor was the signal empirically specified by recording the EEs emitted by senders in known emotional states (more on this shortly). Instead, instances were typically obtained from actors asked to convey emotions through their face or voice. Through an iterative process, those portrayals that achieved highest agreement on the emotion conveyed were selected as the correct signals. One technical question is how to interpret the significance of agreement obtained in this way. A deeper theoretical question also arises because this iterative process has not yielded what might have been expected, namely a specific physically characterizable signal for each emotion.

Instead, for each emotion, there is a range of signals that achieve varying degrees of agreement. For example, Ekman and Friesen (1978, Table 11.1) specified 65 different facial patterns that they consider to be signals for anger. Comparable difficulties arose in attempts to specify a vocal signature for each basic emotion (Banse & Scherer 1996). No theoretical rationale for this variety has been offered. Further, the sets of "correct signals" resulting from this iterative process have dubious ecological validity – given that we know of no evidence that acted stimuli used in this research correspond to what persons in the specified emotional states produce spontaneously (and some indirect evidence to the contrary, Russell & Carroll 1997). Indeed, when spontaneous rather than acted EEs are presented to receivers, the amount of agreement on a specific emotion drops or disappears (Motley & Camden 1988 for facial; Johnson et al 1986, Exp. 1, Pakosz 1983 for vocal).

The typical decoding study is also compromised by the task given the receiver. Forcing the receiver to choose one from a short list of emotions can inflate agreement and even produce blatant artifacts (Russell 1994). Providing the receiver with more options lowers agreement (Banse & Scherer 1996). Allowing the receiver to specify any emotion (free labeling) lowers agreement still further (Russell 1994). Some of the artifacts can be eliminated by providing "none of the above" as a response option (Frank & Stennett 1999), and future studies should do so.

A lively discussion centered on the question of universality (Ekman 1994, Izard 1994, Russell 1994, 1995). In an empirical response to that debate, Haidt and Keltner (1999) obtained evidence in the USA and India that was consistent with both proponents and critics. One interesting finding was a "gradient of recognition:" Some emotions are more "recognizable" than others, and the gradient is steep enough that the recognizable fades into the unrecognizable.

(Because the term “recognition” presupposes that the emotion is present in the stimulus to be recognized, a neutral term such as “attribution” would be preferable.) Attribution depends on the similarity between the sender's and the receiver's language and culture; see Russell (1991, 1994) and Elfenbein & Ambady (2002) for facial EEs, Scherer et al (2001) for vocal ones. Attribution of the specific emotion predicted by Tomkins’ theory also declines as one moves further from a Western cultural background. With participants isolated from Western ways, agreement that smiles indicate something positive is high, but agreement on what emotion to attribute to other facial expressions is low and may or may not exceed chance when method artifacts are eliminated (Russell 1994).

Russell and Fernandez Dols (1997) summarized the available evidence as consistent with “minimal universality:” (a) Facial and vocal changes occur everywhere and are coordinated with the sender’s psychological state; (b) Most people everywhere can infer something of the sender’s psychological state from those facial and vocal changes. The challenge for those who would maintain any stronger version of universality (such as the existence of universal signals for specific emotions) is to find evidence that goes beyond what can be accounted for by minimal universality. The implication for everyone is that it is time to pursue other conceptualizations of the response of the receiver. (Kappas et al 1991, Owren et al 2002, and Wierzbicka 1999 arrived at similar conclusions, although for different reasons.)

Alternative Views of the Receiver

Receivers do, sometimes, interpret an EE in terms of a specific emotion, but the nature of the interpretive process remains to be determined. There is evidence that attributing a specific emotion to the sender is more complex than the simple, easy, immediate detection of a signal. For example, even when the stimuli are the hypothesized prototypical facial expressions of

emotion, the emotion attributed to the face depends on the context within which the expression occurs (Carroll & Russell 1996), on the gender of the sender (Widen & Russell 2002), and on the receiver's current affective state (Niedenthal et al 2000). Long ago, Hebb (1946) reported that observers learned how to predict the emotions of chimpanzees, not by decoding emotion signals from their faces or voices, but by learning how the individual chimp's current expressive and other behavior fit into a temporal pattern idiosyncratic to that chimp. Longitudinal studies of clinical samples yielded similar conclusions (Ellgring 1986).

A receiver's typical response might include much more than attribution of an emotion or even be different from that. One well-supported possibility is that the receiver perceives the internal state of the sender in terms of broad bipolar dimensions such as valence (pleasure – displeasure) and activation (sleepy – hyperactivated). Receivers agree with one another in judging EEs along these dimensions. For faces, both dimensions are readily apparent (Russell 1997), even when the receivers are 2-year olds (Russell & Bullock 1986). For voice, activation dominates (Pittam et al 1990); valence is weak (Bachorowski 1999, Pereira 2000). Analyses of confusions among emotions inferred from EEs supports this hypothesis (Russell & Bullock 1986 for faces, Pakosz 1983 for voice). Even in Schröder's (2000) promising study of vocal outburts ("yuck!"), which yield high agreement as to specific emotion, an analysis of confusions among them suggests the presence of valence and activation dimensions.

In addition, faces and voices provide non-emotional information: The receiver notes whether the sender is staring or looking away, laughing with or at someone, shouting because background noise requires it or not. From a facial expression, receivers agree on the sender's situation ("she looks as if she is looking at a small child playing" Frijda 1969, p.169) and likely future action (Frijda & Tchersasoff 1997). Receivers agree that the sender may be conveying a

social message such as “back off”or “hello” to someone (Yik & Russell 1999). And we anticipate that receivers will agree on aspects of the sender’s cognitive state, including attention, uncertainty, puzzlement, determination, anticipated effort, registration of novelty, and sense of control (Smith & Scott 1997).

In short, the receiver probably obtains from an EE information on the sender’s valence, activation, quasi-physical actions (such as staring or talking), current situation, future actions, social attitude, and cognitive state. If so, then the receiver might use this information to infer the sender’s emotion (Russell 1997). Obviously, the reverse is also possible: Decoding a specific emotion from the EE, the receiver could then infer the other information. Clearly, research is needed on what information the receiver extracts first, easily, automatically, at a younger age, or spontaneously from an EE and what information requires effort, training, or measures that guide or channel the receiver’s response into something close to the researcher’s a priori hypothesis. The cross-cultural study of such questions is especially needed.

Still Other Effects

EEs produce a variety of effects other than getting the receiver to think “lo, anger” or some other emotion. Laughs elicit laughter; yawns elicit yawns (Provine 1997); and more generally, receivers “mimic” the EEs of senders (Hatfield et al 1992). A receiver’s facial musculature mirrors a face presented nonconsciously (Dimberg et al 2000). EEs alter the receiver’s physiological state (Dimberg & Öhman 1996, Levenson 1996). Vocal EEs alter the receiver’s self-reported affect (Bachorowski & Owren 2001) – which is not surprising given that EEs are visual and auditory stimuli, which are known to influence affect along the dimensions of valence and activation (Bradley & Lang 2000). Indeed, everyday experience shows that sounds alter the hearer’s affect, as illustrated by sirens, thunder, and an infant’s cry. Receiver’s self-

reported affect reflects the affective tone of a passage heard (Neumann & Strack 2000) or the affective demeanor of a face seen (Wild et al 2001), even when the face is presented nonconsciously (Dimberg et al 2000).

Such evidence is consistent with the theory that EEs function to alter the receiver's state, especially affect. Owren and colleagues (1997, 2001, 2002) questioned the exclusive focus traditionally placed on the receiver's cognitive representation of the message of the EE, suggesting that in addition EEs alter the receiver's state and thereby serve the larger goal of social influence. And indeed, EEs do alter the course of social interaction. Sender's embarrassment (appeasement) elicits self-reported positive feelings in the receiver (Keltner & Buswell 1997). EEs influence the degree of cooperation, dominance/submission, or antagonism in subsequent interaction (Zivin 1977, Tiedens 2001). Norm violators who smile are treated more leniently than those who do not (LaFrance & Hecht 1995). People whose facial expression is imitated feel that they were better understood and that their interaction was smoother (Chartrand & Bargh 1999). Complementary evidence for the same theme comes from the finding that various EEs are differentially susceptible to serving as a conditional stimulus in a Pavlovian conditioning paradigm (Dimberg & Öhman 1996). In this case, EEs would function to alter long-term interaction.

Owren et al's (2002) perspective is nicely illustrated by thinking of EEs as being like infant-directed (ID) speech. ID-speech (baby talk) has known acoustic characteristics (Fernald 1991, Katz et al 1996) and accompanying facial behavior (Chong et al 2002). ID speech is preferred by infants (Cooper & Aslin 1990, Fernald & Kuhl 1987), elicits their attention, alters their emotional behavior, helps direct their attention to a specific stimulus, and facilitates their learning of associations (Kaplan et al 1997). Infants deprived of ID speech (e.g., when their

caregiver is depressed) show significant learning and developmental deficits (Kaplan et al 2002, Murray et al 1996). Perhaps EEs function in a comparable fashion. According to this account, EEs operate on at least two levels. The simple acoustics of the sound elicit attention and alter core affect (valence and activation) directly, but the affect and meaning attributed to the sound also depend on context and prior experience. Thus, hearing laughter is a generally pleasant experience, with voiced more pleasant than unvoiced laughter (Bachorowski & Owren 2001): sound acoustics have a direct effect. On the other hand, the affect-altering effect of EEs also depends on context (J-A Bachorowski et al unpublished manuscript, Vanderbilt Univ., Hess & Kirouac 2000, Kappas et al 1991). For instance, hearing a high pitched shriek might be pleasant during a party but unpleasant when alone in a dark street.

The Sender

Surprisingly few studies have tested the basic claim of EEs: Emotions cause them. Perhaps the claim was simply taken as obviously true, perhaps studies on the receiver's decoding of EEs was mistakenly believed to be an adequate test, perhaps practical and ethical concerns hindered research, or perhaps needed measurement techniques were slow in coming and difficult to use. The studies that have been done almost always focused on either facial or vocal changes rather than their combination (Hess et al 1988 is an excellent counterexample). In this section, we therefore review these two literatures separately. We also consider some alternatives.

Emotions as Causes of Facial Expressions

Measurement. Techniques for facial measurement were slow to develop. Some systems provide not an objective description of facial movement, but a description in terms of the emotion (Izard 1979) or affective dimension (AM Kring & D Sloan, unpublished manuscript,

Univ. of California, Berkeley) inferred, typically from clusters of physically different movements. An objective (but intrusive) technique is electromyography, especially useful for brief or small muscular movement (Fridlund & Cacioppo 1986, Tassinary & Cacioppo 1992). An objective and unobtrusive technique useful for visible movements was developed by Hjortsjö (1969) based on facial anatomy. This technique was subsequently revised and renamed the Facial Action Coding System (FACS) by Ekman and Friesen (1978). An updated version of FACS was recently announced (Ekman et al 2002). H Oster and D Rosenstein (unpublished manuscript, Adelphi Univ.) developed a version of FACS for infant faces. Still another system is Katsikitis and Pilowsky's (1988) FACEM, which assesses facial movement in terms of 12 distances between key points on the face.

Positive Emotions. Does happiness produce a smile? There is a clear association between pleasant feelings and zygomatic activity (smiling) (Davidson et al 1990, Lang et al 1993, Winkielman & Cacioppo 2001). Yet, the relation is far from simple, and happiness is neither necessary nor sufficient for smiling. Kraut and Johnson (1979) found surprisingly few smiling faces among bowlers and hockey fans during happy events – unless they were simultaneously engaged in social interaction (replicated in Spain by Ruiz Belda et al 2002). Fernandez Dols and Ruiz Belda (1995) similarly found smiles limited to social circumstances even for ecstatically happy persons: gold-medal winners at the Olympics. Even in children, smiling is more associated with the particular social interaction in which they are engaged than with their own happiness (Schneider & Unzner 1992, Soussignan & Schaal 1996): Children smile as much after failure as after success, but smiling is coordinated with eye contact (Schneider & Josephs 1991). Smiling also occurs during humorous films in proportion to self-reported amusement (Ekman et al 1990), but this same study found little smiling during another pleasant but non-humorous film.

The proposal that a Duchenne smile (in which zygomatic activity is combined with contraction of the orbicularis oculi) is the index of happiness has yielded mixed results. This distinction has not clarified the causes of smiling or laughter (Keltner & Bonnano 1997, Rosenberg et al 2001) and does not nullify the general finding reviewed in the last paragraph of the social nature of smiles. For instance, Duchenne smiles too occur as much after failure as after success (Schneider & Josephs 1991) and may simply be more intense smiles (Schneider & Unzner 1992).

Negative Emotions. Tomkins' theory predicts that negative basic emotions – fear, anger, sadness, disgust, and, possibly, contempt, shame, and embarrassment – each produce a distinct signal. One interesting examination of this prediction was Camras's (1991) year-long observational study of her own daughter. Camras found "(1) situations in which we believe an emotion is present yet the facial expression is not seen, and (2) situations in which an expression is observed but does not appear to be best described using the discrete emotion categories of differential emotion theory" (Camras, 1991, p.26). In another study, 30 babies were subjected to an arm restraint procedure, to which each baby reacted with distress (Camras et al 1992). Rather than one common pattern of facial response, however, there were many different patterns, few of which fit the criteria for a discrete emotion signal. Clearly, there is great need for ecological research on what facial activity occurs and under what circumstances.

In the laboratory, researchers have tested Tomkins' predictions by using films, slides, and remembered or imagined events to induce emotion, but with similarly weak results (e.g., Fernandez Dols et al 1997). Rosenberg and Ekman (1994) criticized prior laboratory research but also offered new supporting evidence. While participants viewed four films selected to induce intense negative emotions, their faces were surreptitiously recorded. Participants then watched

the films again. This time, they reported each emotion they had experienced and pinpointed the time of its occurrence. What was the proportion of hits? That is, consider all occasions on which participants reported a negative emotion. On what proportion of these occasions did they show the facial expression predicted for that emotion? This figure was not given. Instead, the proportion of hits within a selected subset of these occasions was given, namely, those occasions in which a negative emotion was reported and some facial expression had occurred. For these selected occasions, the proportion of hits was .42 ($p > .10$) for one film and .50 ($p < .05$) for another; no figures were given for the remaining two films. Clearly these figures are inflated because the excluded occasions (on which an emotion was reported but no facial expression occurred) were all misses. (Also ignored were occasions on which a facial expression occurred but no emotion was reported.) In addition, it was not clear exactly which facial expressions were considered correct and which incorrect for a given emotion.

A more promising approach capitalized on the fact that some subjects become embarrassed in the laboratory when asked to pose facial expressions (Keltner 1995). In these cases, embarrassment was associated not with a single static configuration (something that could be captured well in a photograph or painting) but with a complex sequence of face and body movements.

Surprise. In the most sophisticated set of laboratory studies on this topic to date, Reisenzein (2000) addressed prior technical criticisms and examined the coherence among four components of surprise: cognitive appraisal of the stimulus as unexpected, self report of surprise, reaction time, and facial expression. Reisenzein found, “Even with an optimal data analysis design (raw data, within-subjects), the average linear correlations between the different surprise components were – with the important exception of the correlation between [a cognitive

appraisal of] unexpectedness and [self-reported] surprise (r = .78) – only low to moderate, ranging from .19 ([reaction time]-expression) to .46 (surprise feeling-expression)" (p. 28).

Emotions as Causes of Vocal Expressions

Measurement. Measurement of vocal acoustics is guided by the source-filter model developed in the 1950s (Fant 1960, Stevens & House 1955, Titze 1994). The "source" refers to the vocal folds, which vibrate in a quasi-periodic fashion during phonation. The rate of vibration directly corresponds to the fundamental frequency (F_0), and is highly correlated with the perception of pitch. Mean F_0 and measures of F_0 variability have been the most commonly studied acoustic cues in research on vocal EEs. More recent advances in digital cue-extraction and modeling techniques have made it increasingly feasible to measure these and other sound properties of interest, including minute perturbations in the amplitude and frequency of vocal-fold vibration (Bachorowski & Owren 1995, Protopapas & Lieberman 1997) and glottal airflow characteristics (Cummings & Clemments 1995).

The resonance properties of the various cavities and articulators in the supralaryngeal vocal tract contribute to "filter" effects, which are typically indexed by formant frequencies (see Johnson 1997, Lieberman & Blumstein 1988). Recently, emphasis has also been given to the long-term average spectrum (LTAS), which represents the average distribution of energy over the course of continuous speech (Pittam & Scherer 1993). LTAS assessment has the advantage over most other measures of being quick and less susceptible to measurement error. A significant drawback, however, is that LTAS does not directly correspond to sound production at any given moment.

Nonlinguistic Vocalizations. Laughs, cries, sighs, yawns, and other such vocal outbursts seem at first to be good examples of expressions of discrete (although not necessarily basic)

emotions: A funny joke elicits amusement, which produces a laugh; a loss elicits sadness, which produces crying; an uninspired lecture elicits boredom, which produces a yawn. Mounting evidence, however, questions whether such vocalizations are each linked to a specific, discrete state.

Infant crying is a good illustration of this conclusion. Different cries were once thought associated with different states, such as frustration, fear, hunger, cold, pain, fatigue, or a soiled diaper (Berry 1975). The evidence instead is that the cry more simply indexes the degree of the infant's distress (Barr et al 2000). The cry's typical acoustic features (abrupt onset, high F_0, high amplitude, and characteristic pulsing) serve to attract the attention of and to cause negative affect in the receiver. The marked variability in these acoustic features serves not to mark different states (frustration, etc) but to lessen the chances of the receiver habituating. The receiver then infers the infant's specific state largely from context (Bachorowski & Owren 2002).

Laughter also illustrates this conclusion. Laughs are produced not only by humor, but also by anger and anxiety (Darwin 1872), attempted self-deprecation (Glenn 1991/1992), attention (Martin & Gray 1996), appeasement or submission (Adams & Kirkevold 1978, Deacon 1997, Dovidio et al 1988, Grammer & Eibl-Eibesfeldt 1990) and sexual interest (Dunbar 1996, Grammer 1990, Grammer & Eibl-Eibesfeldt 1990). From this variety, one might be tempted to hypothesize that different types of laughs correspond to different states. We know of no empirical support for this hypothesis. Although laugh acoustics are remarkably variable both within and between laughers (Bachorowski et al 2001, Grammer & Eibl-Eibesfeldt 1990), they have not been found to vary as a function of self-reported emotion. Instead, laughter varies with social factors such as the sex of and familiarity with one's social partner (J-A Bachorowski et al, unpublished manuscript, Vanderbilt Univ., Devereux & Ginsburg 2001). Laughs also provide

cues to individuality (Edmonson 1987) and elicit affective responses in listeners (Bachorowski & Owren 2001). The emerging picture is one in which laughter serves to elicit cooperation and a positive relationship with a specific receiver (Owren & Bachorowski 2001).

Vocal Expression in Speech. Many studies have examined the vocal characteristics of speech in hopes of defining a vocal signature for each basic emotion. Leinonen et al (1997) and Johnstone and Scherer (2000) recently provided detailed summaries. So far, the strongest single association found for vocal acoustics has been with the sender's general arousal level (Bachorowski 1999, Cowie 2000, Kappas et al 1991). The still unanswered question is whether reliable patterns beyond this simple relationship can be established.

A pattern of vocal cues unique to a valence (pleasure) dimension has proven elusive (Bachorowski 1999, Leinonen et al 1997, Millot & Brand 2001, Paeschke & Sendlmeier 2000, Pereira 2000, Protopapas & Lieberman 1997, Tolkmitt & Scherer 1986, Trouvain & Barry 2000). For example, anger and joy can both produce high F_0 and high amplitude. These basic acoustic effects have been shown for acted portrayals as well as naturally produced speech (Johnstone & Scherer 2000, Scherer 1989) and suggest that the speech acoustics reflect what joy and anger have in common (such as arousal). In a study of speech utterances produced immediately after affectively charged success or failure feedback, changes in three F_0-related measures reflected increases in arousal (Bachorowski & Owren 1995). Effects associated with valence were more ambiguous and depended on interactions with talker sex and trait differences in emotional intensity.

Vocal differences due to arousal and valence are consistent with a dimensional account of emotion, and therefore a test of predictions from Tomkins' theory best focuses on negative emotions. An important study by Banse and Scherer (1996) typifies this work. Twelve

professional stage actors were asked to read two sentences for each of 28 scenarios (14 emotions X 2 scenarios per emotion). A large number of acoustic features was examined. As expected, the major differentiation was provided by mean F_0, which most reliably indexes arousal. In addition, statistically significant but modest differentiation occurred for separate emotions. Nevertheless, two factors render this result questionable. First, acted portrayals do not necessarily correspond to naturally produced vocal EEs; after all, the actors' job was to convey emotion. Second, tests of differentiated patterning were based not on all 1,344 vocal samples obtained but on a subset of 224 judged as the best acted.

Recent studies have attempted to induce emotion in the laboratory rather than to merely simulate it using actors (Bachorowski & Owren 1995, Kappas 1997, Millot & Brand 2001, Sobin & Alpert 1999) or to analyze recordings made outside the laboratory such as in radio and television interviews (Gregory & Webster 1996) or horse-race commentaries (Trouvain & Barry 2001). These studies again confirm the link of vocal expression with sender's general arousal, and, importantly, sometimes show different patterns than those obtained with acted portrayals (Streeter et al 1983). A vocal signature for each hypothesized basic emotion, however, remains elusive.

Future Directions

Kappas (2002, p.10) summarized research on emotion and facial movement: "We might be on safer ground than simply insisting, against our better knowledge, that there are fixed links between facial expression and emotions." The theory that a small number of discrete emotions produce a corresponding set of facial signals has yielded at best weak results. And outside Western societies, there is practically no relevant evidence. The evidence on vocal outbursts and

on vocal characteristics of speech corroborates this trend. This same research, however, has provided some hints of more promising directions.

First, research should not be limited to a small list of emotions or small set of signals. For example, research in which the face or voice is the dependent variable has found many different patterns. The traditional view of facial expressions focused on static visual configurations (the sort of thing that can be captured in a painting, or later, in a photograph), one per emotion. Thus much is neglected, such as blushing, paling, and blinking (see, for example, Leary et al 1992). We suggest a much broader focus on the many possible dynamic patterns in nonverbal facets of action. Although, in many respects, facial and vocal systems are separate, more study of their joint occurrence (evident in laughter, sobbing, and yelling) is also needed.

In analyzing EEs, it is helpful to move beyond overly simple dichotomies. In response to technical criticisms of research claimed to support Tomkins' theory (Russell 1994) and to the presentation of an alternative to that theory (Fridlund 1994), Rosenberg (1997, p. 88) stated, "implicit in Russell's argument and explicit in Fridlund's is the notion that the face has nothing to do with emotion." Of course, there is some association between EEs and emotion, but the question is the nature of that association.

Perhaps facial and vocal changes are more closely tied with what have been thought of as components of the emotion and thus only indirectly with emotion per se. One possible such component is the simple core affect of pleasure and activation (Bradley & Lang 2002b, Russell 2002). Another is the various cognitive steps involved in the processing of the emotion-eliciting stimulus (Scherer 2001, Smith & Scott 1997). Still another is preparation for instrumental action (Frijda & Tcherkassoff 1997). Because the components of emotion are at best loosely associated,

one can find individual components in the absence of a full emotion and vice versa. The interesting empirical question is what facial and vocal changes occur in these dissociated cases.

Evidence on the social nature of smiles suggests that more scrutiny of social norms and context is warranted for EEs in general. This topic has typically been discussed through an idea introduced by Klineberg (1940) and later named "display rules" (Ekman 1972): that persons learn to voluntarily inhibit, produce, or alter their natural EEs. EEs are clearly influenced by culture (Kupperbusch et al 1999), gender (LaFrance & Hess 1999), and group membership (Kirouac & Hess 1999) – although whether "display rules" are the explanation remains largely untested and perhaps untestable (Fridlund 1994).

Owren and Bachorowski's (2001) account of smiling builds on modern evolutionary theory. Two different but related systems underlie the smile (Rinn 1984). Smiles produced by either system manipulate receiver affect. This account is thus consistent with evidence that smiles are highly dependent on the presence of an audience (although that audience can be psychologically rather than physically present, Fridlund 1994). A phylogenetically older, simpler, reflex-like system produces "spontaneous" smiles as reliable signs of positive feelings toward a specific receiver. Positive affect is therefore necessary but not sufficient for their production. The second system is a more recently evolved version of the first in which "volitional" smiles are produced in a controlled process. In contrast to spontaneous smiles, volitional smiles are emancipated from affect in that they can occur during the experience of any affective state. Sometimes thought of as being "deceptive" or "dishonest," the power of volitional smiles lies in their inherent unreliability as a cue to the sender's state.

Fridlund's (1994) evolutionary account places a similar emphasis on the smile being directed at a receiver but substitutes "friendly intentions" for "positive feelings." Although not

denying that emotions and feelings exist or are correlated with EEs, Fridlund argued that the most coherent causal story can be told in more behavior-relevant or functional terms. Fridlund applied the same analysis to other EEs as well, centered on other social intentions, including aggression, appeasement, and help-seeking. Perhaps because this account strays from the traditional assumptions associated with EEs and maintained in previous accounts, it has been frequently misunderstood. For example, "intentional" should not be taken to mean a conscious state, but simply involving a behavioral disposition aimed at a specific receiver. Fridlund's account does not require a simple correlation between the amount of signaling and the degree of sociality of the situation. Nor does Fridlund's account deny that EEs can occur when the sender is alone. Indeed, he offered evidence that EEs produced when alone are directed at an imaginary, implicit, or animistic audience. Like Owren and Bachorowski's, Fridlund's account suggests the power of modern evolutionary theory to overturn long held assumptions and open the door to fresh perspectives on EEs.

Conclusion

The scientific study of emotional expressions has been pursued now for about two centuries (e.g., in 1806, Bell published on the anatomical basis of facial expression). During most of that time, the field was in the grip of an ancient set of assumptions, long ago incorporated into common sense and embedded in our language: That "emotional expressions" express emotions is a tautology, hardly something that seems to require empirical verification. Even the best scientists, including Darwin, implicitly held these presuppositions. Of course, science can progress even with dubious assumptions, but only so far. Emotional expressions may not be expressions and may not be related to emotions in any simple way.

Modern views of evolution are supplanting Darwin's 130-year-old analysis. Rather than broadcast for the benefit of anyone who happens to observe them, at least some EEs are directed at a specific receiver. These serve to shape the affective and behavioral stance of the receiver and likely evolved to do so. Other EEs are simply given off, by-products of actions performed without communicative purpose. Still other EEs likely have other causal histories.

It is unlikely that the receiver simply decodes an emotional message in any simple, reflex-like manner. There are quick, simple, and automatic responses to EEs, but these cannot be assumed to reflect "decoding the emotion." Receivers do sometimes attribute emotion to senders, but doing so is not always quick or simple. Receivers make a variety of interpretations of an EE besides emotional ones.

Of course, most of our conclusions here are tentative and await empirical test. Probably the more important development in the study of EEs in the last decade is a shift in perspective. Old assumptions need to be critically scrutinized, new ideas encouraged and pursued, rather than vice versa. What is exciting is that the hold of the "vice versa" on the field is steadily yielding.

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