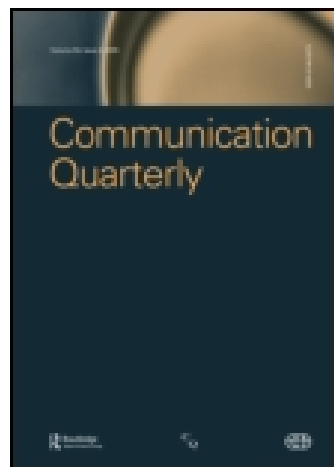


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Effects of Brain Laterality on Accuracy of Decoding Facial Displays of Emotion

Kory Floyd and Alan C. Mikkelson

The human face is capable of producing numerous unique expressions and comprises the primary nonverbal channel for the communication of emotion. In this study, we investigated the effects of sex and neurological hemispheric dominance on the ability to decode facial expressions of emotion accurately. On the basis of a battery of measures assessing handedness, familial sinistrality, and immune disorders, we classified participants as having standard, anomalous, or mixed hemispheric dominance. Consistent with previous studies, we found that hemispheric dominance and sex interacted to influence participants' abilities to decode facial displays of affect from photographs. Specifically, mixed dominant females had the highest accuracy in the decoding of facial emotion, whereas mixed dominant males had the lowest accuracy. We discuss these findings within the context of communibiology and comment on their implications for the study of neurology and social behavior.

KEY CONCEPTS emotion display, hemispheric dominance, communibiology

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The human face is a remarkably communicative instrument. It is capable of producing numerous unique expressions and efficiently conveying complex information about the sender's attitudes, cognitions, and moods (see, e.g., O'Sullivan, 1982). One of its primary communicative functions, however, is the expression of emotion. Although emotional cues are conveyed verbally and through other nonverbal channels (e.g., posture and voice), the face is unparalleled in its ability to encode messages about affect accurately and efficiently (Barrett, 1993; Ekman, 1982).

The efficacy of the face in *encoding* emotion is partially dependent on the ability of humans to *decode* facial displays of affect accurately. Although this ability is certainly affected by the nature of the displays themselves (e.g., whether they are spontaneous or posed; see Fujita, Harper, & Wiens, 1980), it is also influenced by characteristics of

the decoder. For the study described below, we proposed that one characteristic that may affect one's ability to decode facial displays of affect accurately is the decoder's neurological hemispheric dominance – that is, whether the decoder is predominantly "left brained," predominantly "right brained," or has mixed hemispheric dominance. Following are a review of research on the facial display of emotion, an explication of our theoretic position, which is rooted in communibiology, in general, and modular theories about neurological influence, in particular, and, finally, the questions we addressed in the current investigation.

Facial Displays of Affect¹

In his seminal work on the expression of emotion, Darwin (1872/1965) proposed three general principles regarding forms of affect displays, the first two of which had particular relevance for the present study. The first, known as the *principle of serviceable associated habits*, recognizes that humans perform certain physical actions to meet specific needs or desires (e.g., plugging one's nose in the presence of a foul odor to block that odor from entering the nasal passages), and suggests that when people experience states of mind similar to those they experience when they have these needs or desires, "[T]here is a tendency through the force of habit and association for the same movements to be performed, though they may not then be of the least use" (p. 28). For instance, when confronted with an offensive person or an especially bad idea, one might plug one's nose to express contempt because his or her state of mind in such a situation is similar to that experienced in the presence of an offensive odor and, thereby, to plug his or her nose out of habit or association. The action is functional in the primary situation (i.e., it protects one from an offensive odor), but it is merely symbolic in the associated situations and serves to convey the message that "you (or your ideas) stink." Second, the *principle of antithesis* suggests that when we experience states of mind that are opposite those that lead to the types of behaviors generated by serviceable associated habits, we tend to perform the opposite behaviors (e.g., in the presence of a sweet odor, instead of plugging one's nose, one takes a long, deep breath).

Inherent in these two principles is the idea that emotional states approximate mental states that are associated with physical needs. The need for protection from physical threats mentally approximates the emotional desire to protect oneself from offensive or distasteful ideas, interactions, or social situations, according to these principles; therefore, the behaviors associated with each are similar. Two important implications of Darwin's analyses are that the repertoire of behavior associated with each specific emotional state ought to be relatively stable across individuals and cultures and that there ought to be relative consensus across individuals and cultures in recognizing the behavior that conveys each emotion. Darwin devoted much of his 1872 book to detailing the behavioral repertoire associated with each major emotional state and predicted a great deal of similarity across races and cultures in both the encoding and decoding of such emotions, a proposition that later received support in cross-cultural comparisons conducted by Ekman, Friesen, and Ellsworth (1972), Eibl-Eibesfeldt (1972), Izard (1971), and others. Although some studies, such as those conducted by Fernández-Dols, Sánchez, Carrera, and Ruiz-Belda (1997), and Fernández-Dols and Ruiz-Belda (1994), have failed to support the primacy of the "basic emotions" with respect to the link between the experience and expression of the emotions, the studies by Ekman et al., Eibl-Eibesfeldt, and Izard each demonstrated beyond-chance consistency in the interpretations of facial expressions of the basic emotions across multiple diverse cul-

tural groups.

If one accepts the notion that facial displays of affect are (at least, sometimes) representative of underlying physical or emotional states, then there can be little question that the ability to decode such displays accurately proffers an adaptive advantage to the decoder.² For example, if an individual experiencing a grave threat facially displays fear, those who can accurately decode the display should, on average, be better able to avert the threat themselves than those with inferior decoding abilities. Those in the former category should, therefore, have greater success with viability (survival) and fertility (procreation) than those in the latter category. Likewise, the ability to recognize facial and oculesic displays of attraction should similarly advantage themselves in terms of their long-term procreative success (for discussion, see Redican, 1982).

Some previous empirical investigations have examined the individual-level characteristics that influence people's decoding abilities for facial displays of emotion. One of the more common findings from this line of inquiry is that women surpass men in their ability to decode facial displays of affect accurately (see, e.g., Wagner, MacDonald, & Manstead, 1986; Zuckerman, Hall, DeFrank, & Rosenthal, 1976; Zuckerman, Lipets, Koivumaki, & Rosenthal, 1975). Other research indicates that such characteristics as sensitivity (Sabatelli, Buck, & Dreyer, 1980), social competence (Zuckerman, Larrance, Hall, DeFrank, & Rosenthal, 1979), and the decoder's own attitudes (Fernández-Dols, Wallbott, & Sánchez, 1991; McHugo, Lanzetta, & Bush, 1991) influence the ability to decode facial displays of affect accurately.

We do not question the validity of these findings. Rather, in the current study, we investigated the extent to which decoding ability is resident in neurological processing tendencies. That is, we attempted to determine whether particular people are predisposed neurologically in ways that make them better than others at decoding facial displays of affect accurately. The discovery of such differences could have important implications not only for what and how we teach about communication skills, but also for how we study them by drawing greater attention to the biological bases of communicative behavior. Our investigation was grounded in the principles of communibiology, in general, and of neurological hemispheric dominance, in particular.

Communibiology

Beatty and McCroskey proposed communibiology as a paradigm rather than as a specific theory (Beatty & McCroskey, 1997, 1998, 2000a, 2000b; Beatty, McCroskey, & Heisel, 1998; Beatty, McCroskey, & Valencic, 2001). The fundamental premise of this paradigm is that all human activity—whether kinesic, cognitive, or emotional—depends on physiological activity in general, and neurological activity in particular. Because humans are living organisms, neither their thoughts and feelings nor their behavior can be separate from the activity of their bodies; therefore, all thoughts, feelings, and behavior are, in a very real sense, biologically based. Whereas the field of psychobiology applies this principle to the study of psychological characteristics, communibiology applies it to the study of human communicative behavior.

That communication should be grounded in biological characteristics is anathema to some in the communication discipline, most of whom have been trained, in the tradition of learning theory (e.g., Bandura, 1971), to focus on the influences of one's social environment as the primary determinant of behavior. This perspective posits that communicative behavior is acquired primarily and, thus, should show consistency within sets of environmental influences (such as traditions, reinforcements, or characteristics

of the physical environment) and variability across sets. The communibiological approach does not reject the influence of environmental factors; rather, it proposes that biological characteristics ought to account for more variance in communicative behavior than do environmental characteristics. It further holds that any environmental or social construct one posits as influencing behavior must be consistent with neurological physiology and that constructs that are inconsistent with what we know about neurology cannot be viable.

As a paradigm, communibiology provides a focused point of departure for the development of specific models and theories of communicative behavior, insofar as it conceptualizes such behavior as a manifestation of neurological activity. In developing such theories, then, the researcher has the task of drawing connections between particular aspects of neurology and particular behavioral tendencies. Indeed, researchers in some fields have focused on "mapping the brain" to identify the region or regions responsible for specific behaviors (see, e.g., Morton, 1986). Herein, we apply the principles of one such approach—that of hemispheric dominance—to the study of decoding of facial affect. Specifically, our goal in the present study was to ascertain whether hemispheric dominance, alone or in its interaction with biological sex, influences the accuracy with which people decode and interpret facial displays of affect.

Hemispheric Dominance and Facial Recognition

Brain-related research has substantial implications for understanding communication. Specifically, it indicates that the encoding and decoding of messages is controlled by the information processing of the brain. How the brain processes information in general, whether in predominantly "right brained" ways or predominantly "left brained" ways, could influence the decoding of messages in particular. Below, we discuss modular theories of the brain, brain-related research in general, and the different types of hemispheric dominance. We then discuss how differences in hemispheric dominance could affect the decoding of facial emotion.

To explore the possible implications of hemispheric dominance, we must first examine some basic neuroanatomical concepts. The brain is divided into two halves by what is known as the longitudinal fissure. These halves are named the right and left cerebral hemispheres. The two hemispheres of the human brain generally perform different functions even though they are connected by the corpus callosum, which consists of the largest set of associate fibers in the brain (Springer & Deutsch, 1985). The main function of the corpus callosum is to keep each hemisphere aware of the activities of the other (Gazzaniga, 1985). Each hemisphere functions to control the body's opposite side. For example, the left hemisphere controls the right arm and the right hemisphere the left. Furthermore, information arriving from one half of the body is initially transmitted to the opposite hemisphere (Andersen, Garrison, & Andersen, 1979).

The most prominent and supported contemporary theory of the brain is modular theory (Stacks & Andersen, 1989), which posits that left and right hemispheres function as two control centers, each responsible for certain functions. For example, the left hemisphere is employed for the functions of language, whereas the right hemisphere is utilized for nonverbal functions. However, neither hemisphere functions completely independently; rather, the two function interdependently (see Gazzaniga 1985; Sperry 1985). For example, the brain transmits information arriving from one half of the body initially to the opposite side and then to the other side through the corpus callosum for further interpretation (Andersen et al., 1979). Consequently, information is processed

by both sides of the brain, with each hemisphere's contributing to the comprehension of the information through the specific processing activities of each side (Stacks & Sellers, 1986). This perspective conceives of the brain as holistic in its processing of information, such that the brain processes information using both hemispheres. The idea of an holistic brain emphasizes the specialized processing of each part of the brain and how that specialization influences the entire system (Ornstein, 1978; Stacks & Andersen, 1989). Consequently, no information processing occurs exclusively in one hemisphere; however, each hemisphere does specialize in the processing of particular kinds of information.

Primary control of language is a function of the left hemisphere. However, verbal aspects of communication are not a function of the left hemisphere alone. The right hemisphere has potential for language, and the existence of right hemisphere language (see Searleman, 1977) does have an effect on how the communication system operates (Stacks & Sellers, 1986). Furthermore, Zaidel (1985) has suggested that in most individuals, the right hemisphere plays a supportive role in the processing of language. Consequently, both hemispheres serve some language-processing functions, and each has a particular function in the processing of that language. More important, however, the two hemispheres "communicate" with one another, through the corpus callosum, before one makes a final interpretation or takes an action.

Primary control of nonverbal functions resides in the right hemisphere (Bouma, 1990; Gazzaniga, 1987). Specifically, the right hemisphere manages subtle pattern discriminations, such as facial recognition. Furthermore, the left hemisphere can process nonverbal communication, although in a rudimentary fashion (Andersen et al., 1979; Bouma, 1990). Thus, the left hemisphere is specialized for language, and the right hemisphere for nonverbal function, but both hemispheres contribute to the processing of all information.

Modular theory explains how a majority of people processes information. However, in other literature (see Geschwind & Galaburda, 1987), there is a distinction between standard and anomalous hemispheric dominance. Standard and anomalous hemispheric dominance is an application of modular theory, wherein the brain is still holistically processing information, with each hemisphere specializing in the processing of particular types of information. However, the distinction is that common specialization (left for verbal and right for nonverbal) is not the same for every individual; in some people, these specializations are more symmetrical or even the reverse.

Standard and Anomalous Dominance

A majority of the population and an even larger majority of right-handed people exhibit standard hemispheric dominance (SD), which consists of strong left hemisphere specialization for language and strong right hemisphere specialization for other functions, including nonverbal communication (Geschwind & Galaburda, 1987). "Empirical research supports a left hemisphere specialization for verbal tasks and a right hemisphere specialization for nonverbal tasks for right-handed persons" (Andersen et al., 1979, p. 81). Moreover, the left hemisphere is responsible for the logical, analytical, and social interpretations of incoming information, whereas the right hemisphere is responsible for the analogic, emotive, and holistic interpretation of the same information (Stacks & Andersen, 1989). In any conversation, for example, people will process spoken words primarily in the left hemisphere, while at the same time processing nonverbal elements, such as the vocalics, facial expressions, and nonverbal gestures associ-

ated with the verbal message, in the right hemisphere. Furthermore, the left hemisphere is better suited for analytical processes and decision, whereas the right hemisphere is better suited for non-analytical or emotional processes and decisions (Stacks & Sellers, 1986). For example, in a heated debate with a friend, the left hemisphere would primarily be responsible for processing the arguments themselves and determining whether or not they are valid, whereas the right hemisphere would be primarily responsible for processing the emotional content of the messages.

Individuals demonstrating anomalous dominance (AD) have different and more variable patterns of language than do those with standard dominance. Geschwind and Galaburda (1987) noted that the anomalous dominant brain is reversed from the SD brain for handedness, language, and other skills, or is at least symmetrical in its processing of these functions. Thus, language would be more specialized in the right hemisphere than in the left, or would be processed symmetrically in both. Geschwind and Galaburda (1987) estimated that anomalous dominance exists in 30% to 35% of individuals. They suggested that AD could be genetically determined in some instances or due to environment influences, such as birth stress. Other explanations include a delayed development in the left hemisphere and the accelerated growth of the right due to the presence of testosterone. Because the anomalous dominance group consists of people in whom the development of asymmetry has been altered at various periods and to different degrees, Geschwind and Galaburda indicated that those with anomalous dominance could be present in individuals at both the high and low ends of the scale of accomplishment. Thus, they would be a more variable population than SD individuals on a variety of performance measures. For example, there is an increased rate of lefthandedness (most likely to be AD) in those who are mathematically gifted (Kolata, 1983), as well as a high frequency of lefthandedness in cases of mental disability (Hicks & Barton, 1975).

Some people cannot reliably be categorized as having standard *or* anomalous dominance and so form a third group. The mixed dominance (MD) group consists of those individuals who share the marker characteristics of *both* standard *and* anomalous dominance. As such, however, MD individuals do not necessarily exhibit a blend of left- and right-brained processing, nor do their abilities necessarily reside in the median between standard and anomalous dominance. We know comparatively little about MD individuals. Since mixed dominance is not a distinctive category in itself, but is instead a default category for those individuals who have the markers of both SD and AD, researchers sometimes exclude those individuals who exhibit mixed dominance from the samples of hemispheric dominance studies to maximize systematic variance (as in the case of Bodary & Miller, 2000).

Differences in the development of the brain structure (SD or AD) may also influence other cognitive systems, such as how the brain processes information. Geschwind and Galaburda (1987) determined that, for AD individuals, language would be more specialized in the right hemisphere than for SD individuals. Furthermore, the reverse would be true for the managing of nonverbal functions: in AD individuals, nonverbal functions would be more specialized in the left hemisphere than would be the case for SD individuals. These differences in the hemispheric specialization of nonverbal functions between SD and AD individuals could influence the processing of information in general, including the decoding of emotion displays, which, in humans, are primarily manifested facially.

Decoding of Facial Displays of Emotion

In SD people, the right brain hemisphere normally specializes in nonverbal communication and nonverbal decoding, which includes facial expressions and emotion (Andersen et al., 1979). How their decoding ability compares to that of AD people is unclear, however. In AD people, the right side of the brain is larger or equal in size to the left side (Geschwind & Galaburda, 1987). The excessive right brain development could contribute to exceptional talents in activities involving spatial skills and perceptions of nonverbal communication (Bodary & Miller, 2000). However, deficits are evident among left-handers, who are often AD, with respect to procedures that strongly rely on visuospatial skills, compared with more verbal activities (Iaccino, 1993). Consequently, contradictory thoughts exist as to whether AD people will have exceptional skills or skill deficits when performing primarily right hemispheric activities, including the decoding of emotional displays.

Differences in brain specialization do not exist only in patterns of hemispheric dominance, but also in biological sex. Evidence exists that women tend to be more hemispherically integrated or symmetrical than men (Andersen et al., 1979). Specifically, researchers have found that when the left hemisphere is damaged, the right hemisphere can recover language more easily in women than in men. Iaccino (1993) also reported that in general, women are less lateralized and more symmetrical in their brain functioning than men. Consequently, it appears as though the brain functions differently in men and women; thus, sex could have a significant effect on nonverbal decoding abilities. In fact, past research has shown that women decode nonverbal expression more accurately than men (Wagner et al., 1986; Zuckerman et al., 1975; Zuckerman et al., 1976), which could be partially due to sex differences in brain functioning.

Although men and women differ in how their brains function and process information in general, brain dominance may also interact with sex to affect decoding abilities. Bodary and Miller (2000) found, in a study of communicator style, that AD males were more open and attentive than SD females, who were more open and attentive than SD males. However, they also indicated that AD females reported communication style preferences similar to SD males. The deficit of AD females, in comparison to AD males and SD females, is odd when one considers that AD females should also excel at primarily right brain activities. Consequently, it appears as though hemispheric dominance may interact with sex to produce effects that dominance alone would not.

Again, Iaccino (1993) reported that women are less lateralized and more symmetrical in their brain specialization than men. This would explain why AD males would be similar to SD females. Women are less lateralized than men to begin with; thus, it appears logical that the least lateralized men (AD) would be similar to the most lateralized (SD) women. However, it does not seem logical that the AD females, the least lateralized women, would be similar to SD males, the most lateralized men. Bodary and Miller (2000) concluded that, "Individuals with anomalous dominance reported style preferences contrary to traditional sex expectations and more in line with results which might be predicted from psychological gender" (p. 93). It is possible that sex and hemispheric dominance interact differently than previously expected. Given the contradictory nature of much of the literature on the effect of brain dominance, we raised and addressed the following research questions instead of making directional predictions:

RQ1: Does hemispheric dominance affect the decoding of facially expressed emotion?

RQ2: Do hemispheric dominance and sex interact to affect the decoding of facially expressed emotion?

Of final interest in the present study was the extent to which decoding accuracy may vary simply as a function of the specific emotion being expressed. Some research suggests that pleasant emotions are easier to decode accurately than unpleasant ones (e.g., Custrini & Feldman, 1989; Feinman & Feldman, 1982; Horatcsu & Ekinci, 1992). Other research indicates instead that expressions of emotions that are similar in their intensity, valence, and level of engagement will be more difficult to distinguish than expressions of emotions with dissimilar intensity, valence, or engagement (e.g., Schlosberg, 1952, 1954; Wagner et al., 1986; Wiggers, 1982). Thus, one might have difficulty discriminating between expressions of anger and expressions of disgust, but would be less likely to have difficulty discriminating between expressions of anger and expressions of joy. It may also be the case that expressions of emotions that are basic or primary (such as happiness, sadness, or fear) are easier to decode accurately than expressions of emotions that are more complex (such as interest or determination). To address the potential effects of the type of emotion on accuracy of decoding, we posed a final research question:

RQ3: How, if at all, is decoding accuracy for displays of facial affect affected by the specific emotion being displayed?

METHOD

Participants

Participants ($N = 531$) were 208 male and 323 female undergraduate communication students from a large university in the Southwestern United States. Participants ranged in age from 16 to 54 years ($M = 22.59$ years, $SD = 4.32$).³

Procedure

We collected data via a written questionnaire administered in undergraduate courses in communication. Participants completed the questionnaire during regular class time and returned it to the researchers. Participation was voluntary and carried extra course credit. We eliminated duplicate questionnaires completed by students enrolled in more than one of the participating classes prior to data entry and analysis.

Measures

To ascertain *hemispheric dominance*, we used a modified multiple-gate procedure. The modification was that, instead of having participants complete one assessment multiple times, we had them complete multiple assessments concurrently. The measures were those used by Bodary and Miller (2000) and included (1) Coren's (1993) Handedness Inventory, which assesses the extent to which participants are right-handed, left-handed, or ambidextrous on a variety of common tasks; (2) a familial sinistrality questionnaire, which assesses the handedness of the participants' blood relatives; and, (3) Rich's (1989) learning and immune disorder inventory, which reveals whether participants have been diagnosed and/or treated for several learning and immune disorders.

The use of measures of sinistrality and physical disorders as markers of hemispheric dominance is grounded in Geschwind and Galaburda's (1987) theory of anomalous dominance (see also Galaburda, Corsiglia, Rosen, & Sherman, 1987). The central premise of the theory is that prenatal testosterone affects brain development. Geschwind and Galaburda (1987) cited a number of studies showing that prenatal testosterone accelerates the growth of the right hemisphere and inhibits the growth of the left hemisphere, which suggests that the right hemisphere would most frequently function as the dominant hemisphere for those with high levels of prenatal testosterone. As a result, one would predict on the basis of this theory that left-sided laterality is more prevalent in men than women, and there is ample evidence that this is the case (see Halpern & Coren, 1991; Hardyck, Goldman, & Petrinovich, 1975; Porac & Coren, 1981). This also explains why disorders in cognitive functions (such as dyslexia, stuttering, and other language disorders), which are usually under left-hemisphere control, are more common in men than in women (see Skinner & Shelton, 1985; Vandenberg, 1987). Geschwind and Galaburda also pointed out that the thymus gland, which is important for the immune system because it is the maturation site of the T-lymphocytes, is adversely affected by prenatal testosterone (see, Dougherty, 1952; Frey-Wettstein & Craddock, 1979). This led to the hypothesis that left-sided laterality would be associated with immune system disorders. Indeed, in line with this hypothesis, previous research has shown that left-sided laterality, as indicated by primary left-handedness, is associated with a range of immune disorders, including asthma, eczema, rhinitis, urticaria, Type I diabetes, Crohn's disease, ulcerative colitis, and allergies (see, e.g., Benbow, 1986, 1988; Searleman & Fugagli, 1987; Smith, 1987).

As markers, then, both handedness and learning/immune disorders have been strongly linked to brain laterality. Clarke and Zaidel (1994) determined that self-reported handedness was a significant predictor of performance on brain lateralized tasks, including dichotic listening (a task in which two different vowel sounds are presented to participants simultaneously, one sound in one ear and the other sound in the other ear) and semantic facilitation (a task in which participants are shown semantically similar and semantically different pairs of words for 60 milliseconds at a time). Research by Geschwind and Behan (1982), and Geschwind and Galaburda (1984), further verified that both handedness and learning/immune disorders manifest associations with laterality (see also Knecht, Deppe, Dräger, Bobe, Lohmann, Ringelstein, & Henningsen, 2000; Knecht, Dräger, Deppe, Bobe, Lohmann, Flöel, Ringelstein, & Henningsen, 2000). Moreover, measures of handedness and learning/immune disorders are used as operational indicators of hemispheric dominance and these markers show fairly high levels of correspondence with each other (see, e.g., Halpern & Cass, 1994; McNamara, Blum, O'Quin, & Schachter, 1994; Tan, 1991).

The measures of handedness used in the current study have been extensively validated with laboratory studies in which participants show high degrees of correspondence between their actual and reported hand use (see, e.g., Coren, 1993; Coren & Porac, 1978). Although Rich's (1989) learning and immune disorder inventory comes from an unpublished doctoral dissertation, the learning and immune disorders that are included in the inventory have demonstrated empirical links with laterality in previous research (Benbow, 1986, 1988; Halpern & Cass, 1994; Searleman & Fugagli, 1987; Smith, 1987).

We scored the scales in the manner Bodary and Miller (2000) recommended. Respondents received three markers of hemispheric dominance, one from each of the

three measures. Scores on the Coren Handedness Inventory ranged from 12 to 36. We classified respondents scoring 19 or lower as left-handed (signifying anomalous dominance); those scoring from 20 to 28 were ambidextrous (signifying mixed dominance); and, those with scores higher than 28 were right-handed (signifying standard dominance). A second marker came from the familial sinistrality questionnaire. If all first-degree relatives from a participant's family of origin (mother, father, brother, or sister) were left-handed or ambidextrous, this constituted a marker of anomalous dominance, whereas having all right-handed first-degree relatives constituted a marker of standard dominance.

Finally, scores for Rich's disorders checklist ranged from 0 to 60 for immune disorders and from 0 to 8 for learning disorders. For each disorder on the checklist, participants could mark one of four options: (a) they did not have the disorder, which received a score of 0; (b) they thought they might have the disorder but that it had never been diagnosed by a physician, which received a score of 1; (c) the disorder had been diagnosed by a physician but it had not been treated, which received a score of 2; and, (d) the disorder had been diagnosed and treated, which received a score of 4. The modal response for all immune and learning disorders was 0. Scoring higher than 4.78 for immune disorders or 0.31 for learning disorders constituted a marker of anomalous dominance, whereas scoring below these values but greater than 0 signified mixed dominance, and scoring 0 for both types of disorders signified standard dominance.⁴ We classified respondents as being of standard, mixed, or anomalous dominance on the basis of a preponderance of the evidence. Those who received one marker for each type of dominance were mixed, whereas those receiving two or three markers for standard were standard, and those receiving two or three markers for anomalous were anomalous. As Bodary and Miller (2000) have noted, this procedure is not the only option for classifying brain laterality, but because it is such a low-inference operational definition, it is generally preferred over psychosocial instruments, such as the Herrmann Brain Dominance Instrument (HBDI) or Torrance's Styles of Learning and Thinking (SOLAT) measure.

Decoding ability for facial expressions of emotion we assessed using Part I of the Facial Meaning Sensitivity Test (FMST; Leathers & Emigh, 1980). This instrument consists of a series of ten photographs, each depicting a young woman's facial expression of a particular emotion. From ten emotions listed, the participant is to match the emotion with the picture in which he or she sees it depicted. This instrument is sometimes referred to as the Loren Lewis Series, in recognition of the model appearing in the photographs. The ten emotions are: disgust, happiness, interest, sadness, bewilderment, contempt, surprise, anger, determination, and fear. The FMST also has two other parts that are more complex and assess higher-order decoding skills. We opted in this study to use Part I only because it is the most efficient of the three parts of the test.

RESULTS

On the basis of Bodary and Miller's (2000) scoring procedure (described above), we classified 374 participants (147 male, 227 female) as having standard dominance, 100 participants (38 male, 62 female) as having mixed dominance, and 57 participants (23 male, 34 female) as having anomalous dominance.

To examine the potential relationships of sex and hemispheric dominance to decoding ability, we computed accuracy scores for each of the ten emotions by scoring participants' responses as either accurate or inaccurate, on the basis of Leathers and

Emigh's (1980) scoring key. Each instance of accurate decoding received a score of "1" and each instance of inaccurate decoding a score of "0." We then computed total accuracy scores by summing the scores for individual emotions. Total accuracy scores, which have a theoretic range of 0 to 10, therefore, represented the number of facial expressions of emotion that participants correctly identified. Accuracy scores for the sample as a whole ranged from 2 to 10, with a mean of 6.47 ($SD = 1.55$).

The first two research questions concerned whether hemispheric dominance, alone or in interaction with biological sex, would influence participants' accuracy in decoding facial expressions of emotion. We analyzed potential differences by means of two-way analysis of covariance (ANCOVA), with sex and hemispheric dominance as the factors and total accuracy as the dependent variable. The covariate was the participant's age, which we included in the model because it bore a significant linear relationship to accuracy, $r(522) = .09, p = .04$ (2-tailed). The ANCOVA revealed a significant main effect for sex, $F(1, 517) = 5.27, p = .017$, partial $\eta^2 = .01$, and a significant sex-by-hemispheric dominance interaction, $F(2, 517) = 5.49, p < .001$, partial $\eta^2 = .05$. Means and standard deviations for each of the six groups (SD males, SD females, MD males, MD females, AD males, AD females) appear in Table 1. Of the six groups, MD females had the highest mean accuracy score. *Post-hoc* analysis with the Tukey-b test indicated that MD females' mean accuracy score was significantly higher than that of MD males (who had the lowest mean accuracy score) and SD males (who had the second-lowest mean accuracy score).

TABLE 1
Means and Standard Deviations in Decoding Accuracy Scores

Group	Mean	<i>SD</i>	<i>n</i>
SD males	6.05	1.51	147
MD males	5.92 ^a	1.58	38
AD males	6.78 ^a	1.35	23
SD females	6.64	1.50	227
MD females	6.98	1.61	62
AD females	6.65 ^b	1.50	34

Notes. Scores are on a theoretic scale of 0 to 10, wherein higher scores indicate greater decoding accuracy. SD = standard dominance; MD = mixed dominance; AD = anomalous dominance. Mean scores marked with different subscripts differ significantly from each other ($p < .05$), per Tukey-b test.

Although the main effect of sex was significant, it was uninterpretable because of the disordinal nature of the sex-by-hemisphere interaction effect. The main effect for hemispheric dominance was nonsignificant.

The third research question addressed whether decoding accuracy would differ for individual emotions. We examined decoding accuracy separately for each of the ten emotions. Table 2 shows the percentages of correct decoding for the specific emotions. We computed overall percentages of accuracy, as well as the percentages for each of the six groups. For exploratory purposes, we ascertained the most commonly occurring decoding errors for each emotion. Following Leathers and Emigh (1980), we additionally analyzed participants' overall decoding accuracy for each individual emotion against chance expectations. In step one of the FMST (used in this study), decoders operating at a chance level would accurately decode one emotion in ten. In light of this expected level of chance agreement, we calculated chi-square values representing the

comparison of observed to expected levels of decoding accuracy for each individual emotion. All of the chi-square values were significant.

A perusal of Table 2, which reports the percentages of the time that participants correctly decoded each individual emotional expression, suggests a clear division between what might be called *basic emotions* (happiness, sadness, anger, fear, surprise) and *complex emotions* (interest, bewilderment, determination, contempt, disgust).⁵ Overall, participants correctly decoded expressions of the basic emotions 94.1% of the time, compared to only 35.4% of the time for the complex emotions. This difference was statistically significant, $z = 19.57, p < .001$.

TABLE 2
Accuracy of Decoding of Facial Expressions for Specific Emotions

Emotion	SD Male	MD Male	AD Male	SD Female	MD Female	AD Female	Overall Accuracy	Most Common Errors	$\chi^2 (1)$
Disgust	12.2	7.9	26.1	15.9	19.4	11.8	14.9	Bewild. (67.9) Contempt (9.2)	14.17
Interest	37.4	36.8	26.1	37.4	48.4	47.1	38.8	Disgust (37.2) Determ. (11.2)	490.65
Bewilderment	18.4	18.4	34.8	28.2	29.0	23.5	24.9	Interest (20.4) Disgust (14.8)	130.81
Surprise	89.8	84.2	95.7	96.0	98.4	97.1	93.8	Fear (5.6)	4150.60
Determination	45.6	36.8	39.1	57.3	58.1	61.8	52.2	Interest (21.6) Contempt (14.2)	1051.68 4709.20
Happiness	99.3	97.4	100.0	99.6	100.0	97.1	99.2	Interest (0.2)	
Sadness	98.0	94.7	100.0	98.2	100.0	97.1	98.1	Bewild. (0.9) Determ. (0.8)	4590.74
Contempt	38.1	44.7	65.2	46.7	54.8	47.1	46.0	Disgust (24.8) Determ. (14.7)	764.64
Anger	84.4	32.1	91.3	90.7	93.5	85.3	89.1	Determ. (3.6) Contempt (3.6)	3697.34
Fear	82.3	78.9	100.0	93.8	96.8	97.1	90.4	Bewild. (2.1) Determ. (1.9)	3821.61

Notes. Accuracy figures are expressed as percentages. All chi-square values are significant at $p < .001$.

DISCUSSION

In this study, we investigated the effects of neurological hemispheric dominance and biological sex on one's ability to decode displays of facial affect accurately. Although we had speculated that hemispheric dominance would influence decoding accuracy, the existing research provided abundant reason to expect the influence of hemispheric dominance to be moderated by biological sex. Our results, which showed a significant dominance-by-sex interaction, confirmed this. The main effect of hemispheric dominance was not significant, and the significant main effect of sex was uninterpretable due to the disordinal nature of its interaction with hemispheric dominance.

Importantly, the interaction was disordinal only by virtue of the relative position of AD males, whose mean accuracy score of 6.78 was substantially closer to the average accuracy score for women (6.76) than to the average accuracy score for men (6.25). Bodary and Miller (2000) suggested that women and AD men process nonverbal information similarly. In effect, they proposed, anomalous dominance in men has effects similar to those seen for psychological femininity, including a heightened interper-

sonal sensitivity (relative to that observed in other men).

The clearest conclusion to be drawn from these data is that, in terms of facial affect decoding ability, mixed hemispheric dominance is an asset to women but a detriment to men. Women apparently benefit from being neither predominantly left-brained nor predominantly right-brained when it comes to interpreting facial displays of affect; mixed dominance appears to make their already superior decoding skills even sharper. For men, the opposite seems to be the case. The difference highlights the extent to which biological sex moderates neurological processing tendencies. Similar results have surfaced in studies of spatial ability, such as those conducted by Harshman, Hampton, and Berenbaum (1983), Sanders, Wilson, and Vanderberg (1982), and Yen (1975).

SD and AD men and women clustered in the middle of the distribution for decoding skills. This suggests that being predominantly left-brained or predominantly right-brained mattered little in a simple affect decoding task. Not only did these four cells cluster in the middle of the distribution, but they also varied little from each other. SD males and AD males differed the most (a mean difference of .73), but there was only a .13 difference (on a ten-point scale) between AD males and AD females, and only a .14 difference between AD males and SD females. Mixed hemispheric dominance appeared to manifest the greatest variability. Whether a higher level of variance among the types of hemispheric dominance might emerge under more cognitively demanding decoding tasks awaits investigation in future studies.

In our analysis for the third research question, we discovered that participants correctly decoded the basic emotions of happiness, sadness, anger, fear and surprise 94.1% of the time, but the remaining (more complex) emotions only 35.4% of the time. By comparison, participants in Leathers and Emigh's (1980) study decoded expressions of the basic emotions with only slightly greater accuracy (95.1%) than did our participants. However, Leathers and Emigh's participants decoded expressions of the complex emotions with considerably greater accuracy (86.8%). The exact reason for this difference in decoding accuracy is unknown, but one obvious possibility is that, because Leathers and Emigh's participants were older on average than were our participants, they had more experience on which to draw when making decoding decisions regarding emotions whose expressions are more complex (and more challenging to interpret) than those of the basic emotions.⁶

This conjecture received support in *post hoc* analyses of our data, which revealed a significant linear relationship between age and overall decoding accuracy, $r(522) = .09$, $p = .04$. To explore this issue further, we calculated separate accuracy scores for the basic and complex emotions and conducted correlations between age and those scores separately. We discovered that age was not significantly related to decoding accuracy for the basic emotions, $r(522) = -.05$, $p = .27$, but was for the complex emotions, $r(522) = .14$, $p = .002$, albeit not to a strong degree. These correlation coefficients differed significantly from each other, $t(521) = 26.46$, $p < .001$.

Overall, the results of the current investigation point to the interaction between biological sex and neurological hemispheric dominance as one precursor for the ability to decode facial displays of affect accurately. Certainly, there is evidence to suggest that this interaction and/or the main effects of sex and hemispheric dominance could also influence other communicative competencies. We are investigating these possibilities in research currently underway. Of course, neither we nor anyone working in communibiology would suggest that neuroanatomy is the only influence on communicative behavior; researchers in evolutionary psychology, communibiology, and psy-

chobiology agree that social behavior is affected by interactions between nature and nurture (for an excellent contemporary discussion, see Pinker, 2002). Rather, we propose that a fuller understanding of human social interaction will elude communication researchers until they incorporate relevant data from these fields.

Limitations and Conclusions

The primary limitation of the current study was the sample. The education level, modal age, and lack of variance in age make generalization beyond a restricted population problematic. Of course, if hemispheric dominance influences perception and the interpretation of communicative behavior, then there is little reason to assume that it would not have the same types of effects across ages or education levels; alternatively, hemispheric dominance may interact with these characteristics to influence perception. Investigation of these possibilities must be deferred to future studies, however.

A similar limitation may be our use of such a simple decoding task; however, the high amount of variability we observed in respondents' accuracy across the various emotions argues against that. It is certainly conceivable that hemispheric dominance (either alone or in combination with biological sex) could exert different forms of influence on different types of decoding tasks. Future research could examine these possibilities by means of tasks that demand a higher level of discrimination (e.g., tasks that require the participant to ascertain *dimensions* of displays of affect, rather than simply their categories). In addition, the exclusive use of female faces in the emotion decoding task should also be considered a limitation, given evidence that women are more emotionally expressive than are men, on average (for reviews, see Ashmore, 1990; Brody & Hall, 1993; Hall, 1984).

A third limitation may implicate the nature of the pretest we used to determine hemispheric dominance. As Bodary and Miller (2000) have pointed out, using a battery of self-report measures as we did in our pretest is certainly not a state-of-the-art approach. Because they are such low-inference measures, they are preferable to alternative self-report measures (such as the HBDI or SOLAT; see Geschwind & Galaburda, 1987; Rich, 1989). However, a more sophisticated approach, using PET or fMRI, could be used to "map" the specific regions of the brain that are activated in a facial emotion decoding task and could be used to differentiate patterns in individuals' hemispheric processing.

Despite these shortcomings, we are encouraged by the finding that hemispheric dominance is implicated in the ability to decode facial displays of affect. As we mentioned above, we certainly do not expect that human behavior is fully predictable by neuroanatomy, immune to environmental and cultural influences, and none of our colleagues in communibiology would claim this either. Rather, we believe that the current investigation, and the ones to follow, will demonstrate that a more sophisticated understanding of neuroprocessing will enhance the ability of researchers to predict and explain human social behavior.

NOTES

- ¹ Unless noted otherwise, we use the terms *affect* and *emotion* interchangeably.
- ² We acknowledge here that facial displays of affect need not be *representational* (meaning that they are reflective of genuine emotional states), but may instead be *presentational* (meaning that they convey emotional states that the encoder is not actually experiencing at the time). A good example of the distinction is evident in the difference between the social smile (or, unfelt

smile), in which the primary facial musculature movement is that of the zygomatic major, which draws the corners of the mouth away from each other, and the genuine smile (or, felt smile), in which the movement of the zygomatic major is accompanied by that of the orbicularis oculi, which produces the "crow's feet" effect on the outer sides of the eyes. Research indicates that naïve viewers can accurately discriminate between these two types of expressions (see, e.g., Frank, Ekman, & Friesen, 1993; Scherer & Ceschi, 2000).

- ³ No other demographic information was collected for the sample.
- ⁴ Each of these figures represents the sum of the mean and standard deviation for the respective type of disorder. By this procedure we identified those whose scores deviated from the mean by more than a standard deviation, a procedure recommended by Bodary and Miller (2000).
- ⁵ Researchers do not agree concerning how many basic emotions there are, nor on what they are (Cornelius, 1996). We acknowledge that Ekman (1971) included disgust in his list of basic, universal emotions and that others have offered different lists of emotions that ought to be considered basic and universal (e.g., Izard, 1977; Tomkins, 1962, 1963). However, all of these theorists have included sadness, fear, surprise, anger, and happiness (or joy) in their lists of the basic emotions.
- ⁶ Although Leathers and Emigh (1980) did not report exact age data for their sample, they did indicate that only 31% of their participants were university students (compared to 100% of the present participants); the rest were corporate executives, engineers, and members of civic and fraternal organizations. Thus, it is certainly reasonable to assume that the average age of the Leathers and Emigh sample exceeded that of the present sample.

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