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Neuropsychological Aspects of Facial Asymmetry During Emotional Expression: A Review of the Normal Adult Literature[1]

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This review focuses on facial asymmetries during emotional expression. Facial asymmetry is defined as the expression intensity or muscular involvement on one side of the face ("hemiface") relative to the other side and has been used as a behavioral index of hemispheric specialization for facial emotional expression. This paper presents a history of the neuropsychological study of facial asymmetry, originating with Darwin. Both quantitative and qualitative aspects of asymmetry are addressed. Next, neuroanatomical bases for facial expression are elucidated, separately for posed/voluntary and spontaneous/involuntary elicitation conditions. This is followed by a comprehensive review of 49 experiments of facial asymmetry in the adult literature, oriented around emotional valence (pleasantness/unpleasantness), elicitation condition, facial part, social display rules, and demographic factors. Results of this review indicate that the left hemiface is more involved than the right hemiface in the expression of facial emotion. From a neuropsychological perspective, these findings implicate the right cerebral hemisphere as dominant for the facial expression of emotion. In spite of the compelling evidence for right-hemispheric specialization, some data point to the possibility of differential hemispheric involvement as a function of emotional valence.

KEY WORDS: Facial asymmetry; lateralization for emotion; neuroanatomy of facial expression; emotion; valence; posed and spontaneous expression; gender.

INTRODUCTION

The human face is not always symmetrical with respect to the vertical midline; observation has revealed asymmetries in the resting face, as well as while emoting or speaking. This paper focuses on facial asymmetries during emotional expression. Facial asymmetry is defined as the expression intensity or muscular involvement on one side of the face ("hemiface") relative to the other side. Based on the knowledge that the lower two-thirds of the face is predominantly innervated by the contralateral cerebral hemisphere, facial asymmetry has been used as a behavioral index of hemispheric specialization for facial expression.

Over the past two decades, numerous experiments have addressed various aspects of facial asymmetry during emotional expression. In addition, a number of reviews have attempted to systematize and synthesize the findings (e.g., Campbell, 1986; Skinner and Mullen, 1991; Thompson, 1985). The purpose of the current paper is to expand the scope of previous summaries, as well as our own reviews (Borod, 1993; Borod and Koff, 1984), by presenting a more detailed description of these studies, with a focus on methodological issues. Such an analysis, we believe, could be of great use both conceptually and pragmatically to investigators studying facial asymmetry. Toward this end, we will be presenting a comprehensive description of 49 experiments of facial

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asymmetry in the adult literature, organized in tabular form for ease of review.

This review is oriented around a number of important neuropsychological distinctions, as follows. *Emotional valence*, or the pleasantness/unpleasantness of an emotional expression, is evaluated because of its centrality for contemporary neuropsychological theories regarding hemispheric specialization for emotion (e.g., valence hypothesis, right-hemisphere hypothesis). *Elicitation condition* refers to whether an emotional expression was deliberately produced (i.e., posed) or spontaneously/involuntarily elicited, and is examined because of speculation that the two types of expression are mediated by different neuroanatomical systems. For similar purposes, expressions are separated according to *face part*, that is, whether the lower (bottom) part of the face or whole face was analyzed for facial asymmetry. Finally, demographic variables, such as gender and handedness, are described because they are known to affect brain/behavior organization.

BACKGROUND AND HISTORY

The face is widely recognized as a critical organ for communication and emotional experience. Among the mammals, the human being has the most extensively developed facial musculature and is heavily dependent on facial behavior to facilitate social interaction (e.g., Roberts, 1966). Anatomists, painters, and actors preceded psychologists in the study of facial expression. A 19th-century anatomist, Sir Charles Bell, was one of the first to comment on the importance of facial anatomy and musculature for the painter and the actor (Woodworth and Schlosberg, 1954). Further scientific attention followed, and by the end of the 1800s, Charles Darwin (1890) had defined the fundamental emotions as laughter, surprise, fear, rage, crying, and disgust; described facial expressions associated with each emotion; and characterized these emotional expressions as functional products of evolution.

Quantitative Asymmetries

Darwin appears to have been the first to describe the phenomenon of facial asymmetry during emotional expression. His 1872 discussion of "Sneering and Defiance" (Darwin, 1890) contains the first documented assessment of the quantitative aspect of facial asymmetry. Based on reports that Australian natives, when angry, drew the upper lip to one side, Darwin asked four subjects to uncover the canine tooth on one side of the face as in sneering. Two exposed the canine on the left side and one on the right side; the fourth showed no asymmetry. This distribution, albeit based on a very small sample, foreshadowed the findings in the literature over 100 years later.

Sixty years after Darwin, Lynn and Lynn (1938, 1943) conducted the first extensive quantitative study of facial asymmetry during emotional expression and introduced the term "facedness" to denote the relative extent of muscular movement on the two sides of the face. With their invention, the facial cinérecorder (Lynn, 1940), the Lynns measured facedness during spontaneous smiling and laughter and found the majority of their subjects to show no asymmetry. Fewer, but equal numbers of, subjects were found to be right- and left-faced. Interestingly, the focus of the Lynn's work was not on the phenomenon of asymmetry but on the relationship between facedness and personality traits.

In the 1970s, this quantitative aspect of facial asymmetry began to be studied more systematically. Our own research in this area began in the early 1970s and was stimulated by anecdotal observations of asymmetries during facial emotional expression. More specifically, we (Borod and Caron, 1976) noticed that one hemiface, relative to the other hemiface, often appears more intense and moves more extensively. In our first study (Borod and Caron, 1979, 1980), we sought to determine which hemiface was more involved during posed emotional expression. At that time, we put forth two different predictions regarding the direction of facial asymmetry. The first hypothesis was derived from the lateral dominance literature and proposed that facedness represented another lateralized motoric function like handedness and footedness, which might be controlled by the dominant cerebral hemisphere. Thus, facial expression would be right-sided for right-handers and left-sided for left-handers. The second hypothesis emanated from the emotional processing literature available in the early 1970s (Gainotti, 1972; Gardner, 1975; Heilman *et al.*, 1975) and proposed that the facial expression of emotion might be mediated by the right hemisphere. Thus, facial expression would be left-sided in right-handers, but not necessarily predictable in left-handers.

Almost simultaneously, in addition to our work, five other groups of investigators in North America, Europe, and India (Campbell, 1978; Chaurasia and Goswami, 1975; Moscovitch and Olds, 1979; Sackeim and Gur, 1978; Strauss and Kaplan, 1979) conducted studies of facial asymmetry during emotional expression in normal adults. What was striking about all of these studies, as well as our own, was the consensus that the left side of the face (or "hemiface") was more active than the right side of the face during emotional expression, regardless of methodology used to assess the asymmetry (i.e., composite photos, slow motion videotape, naturalistic observations). Since the lower portion of the face is predominantly innervated by the contralateral hemisphere (Borod and Koff, 1984; Rinn, 1984), the finding of greater left than right hemiface activity was interpreted as reflecting right cerebral dominance for facial emotional expression.

The study of facial asymmetry was quickly recognized to have important implications for neuropsychology and behavioral neurology, to provide a way to more directly study hemisphere specialization for expression in the normal subject, and to offer a window into brain/behavior relationships for emotional expression.

Qualitative Asymmetries

The study of facial asymmetry for emotional quality was pioneered by Hallervorden in 1902 (Hallervorden, 1902). (See Güntürkün, 1991, for a review of morphological body asymmetries that predated and influenced Hallervorden's work.) Hallervorden developed the composite photograph technique by taking a photograph of the whole face, creating an original and mirror-reversed print, bisecting each print at the vertical midline (by using the midpoint between the eyes, nose, upper lip, and chin), and joining the two right hemifaces and the two left hemifaces into separate composite photos (i.e., right-right and left-left composites). As noted by Borod (1993), Hallervorden, whose papers were written in German, described the right hemiface as "apperceptive, thinking capably, lucid, sensible," "energetic and active," and the left hemiface as "perceptive, affective, having dark unformed content, and directionless" (1902, 1929). This work was continued by Wolff (1933, 1943), who proposed that the right hemiface projects a vital sociable facade, whereas the left hemiface reveals one's passive unconscious self. Recent observations of epilepsy patients during unilateral amobarbital injections (i.e., Wada Test) provide evidence that social emotions (e.g., affection) appear to be mediated by the left hemisphere and primary emotions (e.g., happiness) by the right hemisphere (Ross *et al.,* 1994).

These observations regarding qualitative asymmetries are of interest as they parallel one of the contemporary emotion theories (i.e., the motoric direction hypothesis), which posits that the left hemisphere (right hemiface) mediates "positive/approach" emotions and that the right hemisphere (left hemiface) mediates "negative/withdrawal" emotions (Davidson, 1984; Davidson *et al.,* 1990; Fox, 1991; Kinsbourne, 1982; Kinsbourne and Bemporad, 1984). The approach/withdrawal distinction rests on the biological notion (Schnierla, 1959) that organisms have two basic choices of action in response to a stimulus—they can approach or they can stop and withdraw. Withdrawal/avoidance emotions are linked with the involvement of the right hemisphere in arousal, habituation, and undifferentiated automatic movement, whereas approach behaviors are linked with specialization of the left hemisphere for activation, focal attention, fine motor control, and sequentially executed movement (Borod, 1992; Davidson *et al.,* 1990; Tucker and Williamson, 1984). The approach/withdrawal distinction is further based on Sokolov's notion of the orientation response (e.g., Rozhe *et al.,* 1960); for discussions of this issue, see Kinsbourne and Bemporad, 1984, and Tucker and Williamson, 1984.

Contemporary laterality studies examining facial emotional qualities have confirmed the original observations of Hallervorden and Wolff that the two sides of the resting face reflect different qualities (e.g., Karch and Grant, 1978; Kowner, 1995; Lindzey *et al.,* 1952; Rappeport and Friendly, 1978; Seinen and Van Der Werff, 1969; Stringer and May, 1981; cf. Sackeim *et al.,* 1984). However, no consensus has emerged on the specific emotions associated with each hemiface and its contralateral hemisphere.

Nonemotional Asymmetries

Facial asymmetry during nonemotional unilateral facial movement appears to have been first studied by Chaurasia and Goswami in 1975. Examples of nonemotional unilateral facial movement are "closing one eye" (upper face movement) and "pulling the mouth out to the side" (lower face movement). In the literature concerning nonemotional facial activity, the lower part of the face appears to be more facile or mobile on the left side in normal right-handed adults (Borod and Koff, 1983; Campbell, 1982; Chaurasi and Goswami, 1975; Ekman *et al.*, 1981; Koff *et al.*, 1981), whereas the upper part of the face appears to show no consistent asymmetries. Some findings for the upper face are left-sided (Chaurasia and Goswami, 1975; Moscovitch and Olds, 1982), some are right-sided (Alford and Alford, 1981), and some show no differences (R. Alford, personal communication, March 3, 1982; Borod and Koff, 1983; Koff *et al.*, 1981).

EXPRESSION ELICITATION CONDITION

In the neuropsychological study of emotional expression, there is an important distinction drawn between posed and spontaneous expression (Borod and Koff, 1984; Rinn, 1984). Movements that are deliberately intended by or requested of an individual are classified as posed or voluntary movements, while movements that arise as part of an instinctual reaction to an appropriately evocative emotional stimulus are classified as spontaneous or involuntary movements (Myers, 1976). This distinction grew out of the clinical neurological literature, which has long documented a behavioral dissociation between voluntary and spontaneous movement, wherein impairment of one type of movement and preservation of the other is not uncommon. Researchers in other areas of psychology, most notably social psychology (Allport, 1961; Goffman, 1958), also have found it useful to treat the voluntary and spontaneous dimensions of communication as separate.

NEUROANATOMY

The distinctions between posed and spontaneous behavior have been interpreted as reflecting different and independent neuroanatomical pathways (Kahn, 1964; Tschiassny, 1953), and different mechanisms of control have been suggested for the two behaviors (Borod and Koff, 1984, 1991). Voluntary (posed) behavior is believed to be contralaterally innervated by cortical structures through the monosynaptic connections within the pyramidal system, whereas involuntary (spontaneous) behavior is presumed to be bilaterally innervated by subcortical structures through the multisynaptic extrapyramidal system. The most important concern for neuropsychologists regarding the two modes of facial expression is whether facial innervation is contralateral, ipsilateral, or bilateral.

The following section of this paper delineates the neuroanatomical basis of facial asymmetry, separately for posed and spontaneous expression. For a more extensive review of the literature and a more detailed discussion of this topic, see Borod and Koff (1984).

Posed Expression

The facial communication channel lends itself well to behavioral laterality paradigms, and thus to the study of emotional expression. The study of posed expression has been based on the assumption that the face is contralaterally controlled by neocortical structures. This is not entirely the case, however. For the muscles of the upper portion of the face (i.e., forehead, upper eyelid), there is strong evidence for substantial bilateral projections from the precentral gyrus of the motor cortex. For the muscles of the lower portion of the face (i.e., lower eyelid, nose, cheeks, lips, neck), there is good evidence for contralateral projections (e.g., DeJong, 1979). Some anatomists maintain that control of the lower face is strictly contralateral (e.g., Chusid and McDonald, 1976; Diamond and Frew, 1979). Others suggest that control is predominantly contralateral (e.g., DeJong, 1979; Kuypers, 1958), which is consistent with clinical observations (e.g., Geschwind, 1979; Van Gelder and Van Gelder, 1990) that unilateral lesions of the motor face region do not always produce weakness or paralysis in the contralateral hemiface. Such observations suggest that there must be some additional ipsilateral innervation and that innervation of the system for voluntary facial expression may be analogous to that for auditory and visual perception.

Spontaneous Expression

For spontaneous emotional expression, the neuroanatomy is more complex than that for posed expression. Posed facial expression appears, for the most part, to be mediated by cortical structures that innervate the upper face bilaterally and the lower face contralaterally. While spontaneous expression is believed to be controlled by subcortical structures (e.g., thalamus and globus pallidus) that innervate the face bilaterally (Crosby and De Jonge, 1963; De Jong, 1979; Diamond and Frew, 1979; Miehlke, 1973), the possibilities of cortical involvement (Damasio and Maurer, 1978) and unilateral innervation (Dyken and Miller, 1980) also have been suggested. Further, there is no agreement about whether pathways for spontaneous expression are crossed or uncrossed and how they distribute to the portions of the facial nucleus that innervate the upper and lower face (Borod and Koff, 1984, 1991; Van Gelder and Van Gelder, 1990). In fact, it has been noted (Borod, 1992) that several studies that examined facial asymmetry during posed and spontaneous facial expression in normal (Borod, Koff, and White, 1983; Dopson *et al.,* 1984; Hager and Ekman, 1985 [for negative emotions]) and brain-damaged (Borod and Koff, 1991) subjects found no differences in direction and degree of facial asymmetry between the two conditions.

REVIEW OF THE FACIAL ASYMMETRY LITERATURE

Our review of the literature pertaining to facial asymmetry during emotional expression identified 35 relevant sources—journal articles, conference presentations, and doctoral dissertations. We examined their contents and broke them down according to whether they considered posed or spontaneous emotional expression. Because posed and spontaneous expression cannot be examined simultaneously, we conceptualized research involving one or the other as separate experiments. Using this guideline, the 35 sources yielded 49 experiments, 26 dealing with posed facial expression (16 whole face, 10 lower face) and 23 dealing with spontaneous facial expression (13 whole face, 10 lower face) in normal adult subjects. In light of the neuroanatomical literature suggesting that the upper face is bilaterally innervated, only studies examining the lower or whole face have been included.

Description of Tables

To aid the reader in organizing the literature on posed and spontaneous facial expressions, four tables are presented, which break experiments down by the posed whole face (Table I), posed lower face (Table II), spontaneous whole face (Table III), and spontaneous lower face (Table IV). These 49 experiments are further broken down into 82 observations involving either positive or negative emotion. The tables describe each of the 49 experiments referred to above with respect to posers, elicitation procedures, individual emotions, raters, rating procedures, and asymmetry results. All posers are adults and presumably normal. For posers and for raters, data are provided in terms of number, gender, and handedness (right or left), if available.

For each experiment, the number of discrete emotions is provided (if available), and the emotions are categorized by valence (i.e., positive/pleasant or negative/unpleasant) so that the results can be examined in terms of the two primary neuropsychological theories of emotional lateralization (i.e., right-hemisphere and valence hypotheses). In terms of valence, for posed facial expression, positive emotions refer to pleasantly toned emotions (e.g., happiness and excitement), and negative emotions refer to unpleasantly toned emotions (e.g., sadness and disgust). For spontaneous expression, positive emotions are elicited through visual stimulation (e.g., viewing an entertaining film) or auditory stimulation (e.g., a joke or funny question from the examiner); negative emotions, similarly, are elicited visually (e.g., viewing slides depicting surgical procedures) or auditorially (e.g., being yelled at by the examiner).

Both elicitation and rating procedures are described. For posed expression elicitation, detailed instructions given to the subject/poser by the examiner are included, using the authors' words whenever possible. In most instances, the instructions are self-explanatory. The term "oral command" refers to a request by the examiner that the subject pose a specific emotion at a particular point in time; the term "visual imitation" refers to a request by the examiner for the subject to produce the same emotion as that portrayed by a visual model. For spontaneous expression elicitation, the detailed procedures for evoking emotional expressions in the poser are presented.

Rating techniques employed to assess facial asymmetry for the emotional expressions produced by posers include descriptions of the medium and the measure. In regard to "medium," two types of information are conveyed. First, the physical technique used to register the facial expression is indicated (i.e., video, photo, or live). Unless qualified with the word

Table I. Experiments of Posed Facial Expression (Whole Face Examined)[a]

No.	Source: Authors and Year	Posers No.	Posers Gender	Posers Handedness	Elicitation Procedures	Emotions Positive	Emotions Negative	Raters No.	Raters Gender	Raters Handedness	Ratings Medium	Ratings Measure	Results Positive	Results Negative
1.	Baribeau *et al.*, 1987	12 12	M F	? ?	"Photographed expressing"	1	4	15 15	M F	? ?	Congruent composite (photo)	The more emotionally expressive	L	L
2.	Borod *et al.*, 1988	16	M	RH	Oral command and visual imitation	3	4	1 1	M F	RH RH	Hemiface (video still)	Intensity	L	L
3.	Borod *et al.*, 1990	16	M	RH	Oral command	1	1	20	F	RH	Whole (video still)	Intensity and muscular involvement	L	L
4.	Cacioppo and Petty, 1981	4	M	RH	Feign	0	1	50	?	?	Congruent composite (photo)	Intensity and emotionality	—	=
5.	Campbell (Exp. 2), 1978	5 4	M F	RH RH	Oral command	1	0	13 11	M F	? ?	Congruent composite (photo)	Happier	L	—
6.	Campbell, 1979	20 4	M F	LH LH	Oral command	1	0	7 7	M F	? ?	Congruent composite (photo)	Happier	L	—
7.	Dopson *et al.*, 1984	9 14	M F	RH RH	Oral command	1	1	3 31	M F	RH RH	Congruent composite (photo)	Emotional expressiveness	L	L
8.	Hager and Ekman, 1985	33	F	RH	Oral command	1	4	1	M	?	Whole (video)	AU asymmetry	L	=
9.	Heller and Levy, 1981	5 4	M M	RH LH	Oral command *or* in response to examiner's smile or joke	1	0	12 12	M M	RH LH	Incongruent composite (photo)	Happier	L	—
10.	Kowner (Exp. 5), 1995	11 11	M F	RH RH	Oral command	1	0	17 21	M F	? ?	Congruent composite (photo)	The more intensive expression	L	—
11.	Mandal *et al.*, 1993	6	?	?	"Pose"	1	4	10	M	RH	Congruent composite (photo)	More expressive	L	L
12.	Mandal and Singh, 1990	?	M	?	"Pose"	0	4	90	M	RH	Congruent composite (photo)	Judged with greater accuracy	—	L
13.	Sackeim and Grega, 1987	4 4	M F	RH RH	Accentuate expression on each side of face	1	1	84 89	M F	RH RH	Whole (photo)	Emotional intensity	=	L
14.	Sackeim and Gur, 1978	12 2	M&F M&/orF	RH ?	Requested facial movement	0	4	57 29	M F	? ?	Congruent composite (photo)	Intensity of emotion	—	L
15.	Strauss and Kaplan, 1980	12 18	M F	RH RH	Display	1	1	12 18	M F	RH RH	Congruent composite (photo)	More intense emotion	=	=
16.	Strauss *et al.* (Exp. 3), 1980	8 8	M F	RH RH	Display	1	0	10 10	M F	? ?	Congruent composite (photo)	More intense emotion	L	—

[a]? = unknown. RH = right-handed; LH = left-handed. The dash — = not applicable. FACS = Facial Action Coding System (Ekman and Friesen, 1978). AU = action unit; EMG = electromyography. L = left-sided facial asymmetry; R = right-sided facial asymmetry; "=" = no difference between the left and right sides of the face. M = male; F = female.

Table II. Experiments of Posed Facial Expression (Lower Face Examined)[a]

No.	Source: Authors and Year	Posers No.	Posers Gender	Posers Handedness	Elicitation Procedures	Emotions Positive	Emotions Negative	Raters No.	Raters Gender	Raters Handedness	Ratings Medium	Ratings Measure	Results Positive	Results Negative
1.	Borod and Caron, 1980	12 19 8 12	M F M F	RH RH LH LH	Oral command and visual imitation	3	5	3	F	?	Whole (video)	Intensity and muscular involvement	=	L
2.	Borod, Koff, and White, 1983	18 19	M F	RH RH	Oral command and appropriate for an emotionally provocative slide	2	2	3	F	?	Whole (video)	Degree of muscular involvement	L (Ms) = (Fs)	L (Ms and Fs)
3.	Kop *et al.*, 1991	23	M&F	RH	Lift up and pull back mouth corner	Yes	Yes	—	—	—	Whole (live)	Rating valence and mood	=	=
4.	Moreno *et al.*, 1990	90	F	RH	Oral command	2	2	3	F	RH	Congruent composite (photo)	Intensity and muscular involvement	L	L
5.	Schiff and Lamon (Exp. 1), 1989	4 8	M F	? ?	Pull back and lift mouth corner (contraction)	Yes	Yes	—	—	—	Whole (live)	Report emotional experience	R	L
6.	Schiff and Lamon (Exp. 2), 1989	30	M&F	RH	Perform two contractions with each mouth corner	Yes	Yes	2	?	?	Whole (live)	Report emotional experience	R	L
7.	Schiff and Lamon (Exp. 3), 1989	36	M&F	RH	Perform two contractions with each mouth corner	Yes	Yes	2	?	?	Whole (live)	Tell a story to TAT cards	=	L
8.	Schwartz *et al.*, 1979	10 10	M F	RH RH	Oral command	2	2	—	—	—	Whole (live)	EMG of zygomatic muscle	=	=
9.	Sirota and Schwartz, 1982	18	F	RH	Oral command	1	1	—	—	—	Whole (video)	EMG of zygomatic muscle	=	=
10.	Wylie and Goodale, 1988	8 5 7 11	M M F F	RH LH RH LH	Oral command	1	0	?	?	?	Whole (video)	Displacement: mouth corner upper lip	= (Ms and Fs) R (Ms) L (Fs)	— — —

[a]? = unknown. RH = right-handed; LH = left-handed. The dash — = not applicable. FACS = Facial Action Coding System (Ekman and Friesen, 1978). AU = action unit; EMG = electromyography. L = left-sided facial asymmetry; R = right-sided facial asymmetry; "=" = no difference between the left and right sides of the face. M = male; F = female.

Table III. Experiments of Spontaneous Facial Expression (Whole Face Examined)[b]

No.	Source: Authors and Year	Posers			Elicitation Procedures	Emotions		Raters			Ratings		Results	
		No.	Gender	Handedness		Positive	Negative	No.	Gender	Handedness	Medium	Measure	Positive	Negative
1.	Cacioppo and Petty, 1981	4	M	RH	Read an emotional passage	0	1	50	?	?	Congruent composite (photo)	Emotionality, intensity	—	=
2.	Dopson *et al.*, 1984	9 14	M F	RH RH	Mood induction	1	1	3 31	M F	RH RH	Congruent composite (photo)	Emotional expressiveness	L	L
3.	Ekman *et al.* (Study 2), 1981	13	F	?	Viewing a film	0	1	1	M	?	Whole (video)	Asymmetries evaluated	—	=
4.	Hager and Ekman, 1985	33	F	RH	Examiner elicited during task performance	1	0	1	M	?	Whole (video)	AUs and asymmetries evaluated	=	—
5.	Lynn and Lynn, 1938	342[a] 56	M&F M&F	RH LH	During conversation or an eye-dominance examination	1	0	3	?	?	Whole (live)	Expressive asymmetries (i.e., relative length of eye-mouth line)	=	—
6.	Monserrat, 1984	8 8	M F	RH RH	Viewed films	3	1	2 2	M F	RH RH	Whole (video)	Intensity of dynamic expression	L	=
7.	Moscovitch and Olds (Exp. 2), 1982	42 22	M F	? ?	Observation	Yes	Yes	1 1	M F	? ?	Whole (live)	Unilateral expressions	L	L
8.	Moscovitch and Olds (Exp. 3), 1982	27 18	F M	RH RH	Observation	Yes	Yes	?	?	?	Whole (live)	Unilateral expressions	L =	L (Fs) = (Ms)
9.	Moscovitch and Olds (Exp. 4), 1982	10 10 7 7	M F M F	RH RH LH LH	Relate a past emotional experience	1	2	2	?	?	Whole (video)	Unilateral expressions	L (RHs only)	L
10.	Sackeim and Gur, 1978	12 2	M&F ?	RH ?	During a facial posing session	1	0	57 29	M F	? ?	Congruent composite (photo)	Intensity	=	—
11.	Schiff and MacDonald, 1990	24	?	RH	Word production during a difficult and an easy task	Yes	Yes	60	?	?	Congruent composite (photo)	Which hemiface changed more	R	L
12.	Wemple *et al.* (Condition 1), 1986	36	F	RH	Yelled at by examiner during slide-viewing while being observed	—	1	1	FACS		Whole (video)	Hemiface on which expression occurred more strongly at the apex	—	L
13.	Wemple *et al.* (Condition 2), 1986	40	F	RH	Yelled at by examiner during slide-viewing while not being observed	—	1	1	FACS		Whole (video)	Hemiface on which expression occurred more strongly at the apex	—	L

[a] Adults and children.
[b] ? = unknown. RH = right-handed; LH = left-handed. The dash — = not applicable. FACS = Facial Action Coding System (Ekman and Friesen, 1978). AU = action unit; EMG = electromyography. L = left-sided facial asymmetry; R = right-sided facial asymmetry; "=" = no difference between the left and right sides of the face. M = male; F = female.

Table IV. Experiments of Spontaneous Facial Expression (Lower Face Examined)[a]

No.	Source: Authors and Year	Posers			Elicitation Procedures	Emotions		Raters			Ratings		Results	
		No.	Gender	Handedness		Positive	Negative	No.	Gender	Handedness	Medium	Measure	Positive	Negative
1.	Borod, Koff, and White, 1983	18 19	M F	RH RH	Viewed slides	4	4	3	F	?	Whole (video)	Muscular involvement	L (Ms) = (Fs)	L (Ms and Fs)
2.	Brockmeier and Ulrich, 1993	24	M	RH	Mood induction, life-event recollection, and imagination of hypothetical situations	1	1	1	?	?	Whole (video)	Mouth deviation from horizontal line	R	L
3.	Chaurasia and Goswami, 1975	250 50 26 4	M F M F	RH RH LH LH	Observed during conversation	1	0	1	?	?	Whole (live)	Hemiface more pronounced	L (RHs only)	—
4.	Ekman *et al.* (Study 2), 1981	28	F	?	Viewed film	1	0	1	M	?	Whole (video)	Asymmetries in zygomatic major muscle	=	—
5.	Remillard *et al.*, 1977	25	?	?	Response to joke or funny question	1	0	?	?	?	Whole (photo)	Movement of mouth corner and nasolabial fold flattening	=	—
6.	Rinn *et al.*, 1982	6 13	M F	RH RH	While explaining the meaning of proverbs	1	0	2	?	?	While (video)	Movement of mouth corner and depth of nasolabial fold	L	—
7.	Schwartz *et al.*, 1979	10 10	M F	RH RH	Respond to questions	2	2	—	—	—	Whole (live)	EMG of zygomatic muscle	R	L
8.	Sirota and Schwartz, 1982	18	F	RH	Mood induction and imagination	1	1	—	—	—	Whole (live)	EMG of zygomatic muscle	R	=
9.	Wyler *et al.* (Exp. 1), 1987	23 23	M F	RH RH	Viewed a cartoon and provoked by E	1	0	?	?	?	Whole (film)	Mouth asymmetry	L	—
10.	Wylie and Goodale, 1988	8 6 9 9	M M F F	RH LH RH LH	Provoked by examiner	1	0	?	?	?	Whole (video)	Displacement of mouth corner and lip	L	—

[a]? = unknown. RH = right-handed; LH = left-handed. The dash — = not applicable. FACS = Facial Action Coding System (Ekman and Friesen, 1978). AU = action unit; EMG = electromyography. L = left-sided facial asymmetry; R = right-sided facial asymmetry; "=" = no difference between the left and right sides of the face. M = male; F = female.

"still," "video" refers to expression in motion. Second, the type of facial display is indicated (i.e., whole face or composite [bisected at the vertical midline]). If composite facial displays were employed, they are specified as either congruent (i.e., same type of expression on both sides of the composite) or incongruent (e.g., left hemiface sad and right hemiface neutral). In regard to "measure", the technique used to evaluate the actual facial asymmetry (i.e., the dependent variable) is described. Three basic measurement techniques are widely used: (a) intensity (also called expressivity and emotionality); (b) accuracy; and (c) muscular involvement (also termed movement, displacement, depth, and deviation). Other techniques include the use of quantifiable muscle action units (i.e., "FACS" developed by Ekman and Friesen, 1978, and "Max" developed by Izard, 1983) and electromyography (mostly on the zygomatic muscle) to evaluate the direction and degree of muscular movement. In addition, posers sometimes are asked to report their emotional experiences while producing unilateral facial movements.

One frequently used technique involves whole-face ratings from videotaped facial expressions (Borod and Caron, 1980). Slow motion replay is used to locate the film frame containing maximum or peak expression. Typically, this procedure is carried out by an experimenter and a naïve observer (not a rater). Consensus regarding the peak frame is required. Raters are naive about experimental hypotheses and poser characteristics, and are trained for interrater reliability. Facial asymmetry is typically defined as the extent of muscular involvement or intensity on one hemiface relative to the other (e.g., Borod *et al.*, 1981). A 15-point Likert scale is often used, ranging from a score of -7 (*extreme left-sided*) to a score of +7 (*extreme right-sided*), with the midpoint score of 0 indicating symmetry. Videotaped stills also have been used to examine hemifaces, and composites have been created from photographed stills. In such studies, the hemiface or composite is rated for intensity, for example, on a 7-point scale from *minimal* (a score of 1) to *maximal* (a score of 7) muscular involvement. To obtain an index of facial asymmetry, scores for right hemifaces or right-right composites are compared to scores for the left hemifaces or left-left composites. For a more extensive description of these types of techniques and for visual examples of facial asymmetry, see Borod and Koff (1990).

Finally, the last column of each table summarizes the results from each experiment, separately for positive and negative emotions. Results for the 82 observations are based on group means; include significant findings ($p < .05$) and two trends ($p < .10$); and are denoted by "L" (left-sided asymmetry), "R" (right-sided asymmetry), or "an equal sign" (no difference between left and right hemifaces). We will now turn to our analyses of the results of the observations presented in Tables I–IV.

Analyses

Emotional Valence

Results are considered in terms of emotional valence (i.e., pleasantness level) to ascertain whether the right hemisphere or the valence hypothesis is more strongly supported by the facial asymmetry data. The right hemisphere hypothesis maintains that the right hemisphere is specialized for all emotions, regardless of valence (e.g., Borod, Koff, and Caron, 1983; Silberman and Weingartner, 1986). The valence hypothesis, in contrast, holds that the right hemisphere is specialized for negative/unpleasant emotions and the left hemisphere for positive/pleasant ones (e.g., Davidson, 1984; Fox, 1991). Negative emotions include, for example, sadness, anger, fear, and disgust. Positive emotions include, for example, happiness, pleasant surprise, interest, and excitement. If the right hemisphere hypothesis is operative, then emotional expressions, regardless of type (i.e., valence), should be expressed more intensely on the left than right hemiface. On the other hand, if the valence hypothesis is operative, negative emotions should be expressed more strongly on the left hemiface and positive emotions should be expressed more strongly on the right hemiface.

To determine the direction of facial asymmetry in the 82 observations described in Tables I-IV, we examined the quantitative data presented by the authors and then classified the data as showing overall left-sided, right-sided, or no asymmetry of expression intensity or extent of movement. In all but 3 cases, when a finding was categorized as asymmetrical, it was significant at the .05 level. Two of the three exceptions reported trends ($p < .10$) (Campbell [Exp. 2, 1978]; Wemple *et al.* [Condition 2, 1986]), and one presented qualitative data (Mandal and Singh, 1990). To deal with situations in which different phases of the expression were analyzed, we included only the data referring to the peak or apex of the expression.

We restricted our focus to those emotional expressions generally agreed upon to be positive or negative. Thus, expressions, such as surprise, startle, and indifference/neutral, were not included. In terms of the gender of the posers, the data for males and females were combined unless significant differences were unambiguous. In regard to poser and rater handedness, we focused on right-handers. We included data from left-handers only if their data did not differ significantly from the data for right-handers. Only those observations made by normal adult raters were included. The results of these examinations are presented in Table V separately as a function of emotional valence (positive vs. negative), elicitation condition (posed vs. spontaneous), and facial part (whole vs. lower).

In general, as displayed in Table V, the left hemiface is judged as more intense/expressive and as moving more extensively than the right hemiface. This was the case for all individual comparisons, with the exception of positive lower face studies. The binomial test was used for statistical comparisons of left-sided vs. right-sided asymmetries. (The equal category was not included in these analyses.) For negative emotions, across condition and face part, expressions were left-sided, reflected by three significant findings. For positive emotions, the frequency of left-sided expressions was lower, and only one of four findings was significant (i.e., positive posed whole).

Elicitation Condition

Facial asymmetry results were next examined to determine whether expressions produced during spontaneous conditions were less lateralized (i.e., less asymmetrical), presumably reflecting more bilateral innervation, than those produced during posed conditions. In light of the differences as a function of valence reported above, findings for condition were considered separately for positive and negative emotions. If condition effects are present, one would expect more asymmetrical expressions in the posed condition than in the spontaneous condition. Four separate posed vs. spontaneous comparisons were conducted: lower face positive, lower face negative, whole face positive, and whole face negative. Contingency tables were constructed, combining "equal" and "right" categories, and Fisher exact probability

Table V. Number of Observations (N = 82) in Which a Hemiface is More Intense or Moves More Extensively on the Left or Right Side or in Which the Hemifaces Show No Asymmetry[a]

			Facial Asymmetry[b]			*p* Value for Binomial Test[c]	
Valence	Elicitation Condition	Face Part	Left	Equal	Right	Individual	Total
Negative	Posed	Whole	8	3	0	.004	
		Lower	6	3	0	.016	
		W + L	14	6	0		<.001
	Spontaneous	Whole	7	4	0	.008	
		Lower	3	1	0	na	
		W + L	10	5	0		<.001
Positive	Posed	Whole	11	2	0	<.006	
		Lower	3	7	3	.656	
		W + L	14	9	3		.006
	Spontaneous	Whole	5	4	1	.109	
		Lower	5	3	3	.363	
		W + L	10	7	4		.090

[a]W = whole face. L = lower face. na = No analysis; too few data for statistics.
[b]Observations classified in "Left" or "Right" categories had significant findings ($p < .05$) in all but three cases.
[c]Comparison between frequencies for left-sided versus right-sided facial asymmetries; the "Equal" category was excluded from these analyses.

tests were applied. As can be seen in Table VI, the distributions between posed and spontaneous conditions were remarkably similar, and none of the four analyses yielded significant results.

Social Display Rules

Finally, findings were analyzed in terms of social display rules (Ekman and Friesen, 1969; Tucker, 1986), in light of suggestions that asymmetries are more likely to occur in the presence of an observer (or videocamera) and when an individual is aware that he or she is being observed (or videotaped; Buck, 1984; Hager and Ekman, 1985; Wemple *et al.*, 1986). For these analyses, only the data from the spontaneous condition were examined because this is the condition in which display rules would be relevant. Accordingly, the 36 observations including a spontaneous condition were classified according to two methodological criteria: (1) the subject was reported to be alone when facial expressions were elicited, and (2) the camera (or observer) was reported to be concealed. (Although we had also planned to determine whether subjects were aware that facial expression was the object of study, this information was not available in some of the studies reviewed.) If neither criterion was met (Category A—"Maximal Display Rules"), social display rules were most likely to operate; if both criteria were met (Category C—"Minimal Display Rules"), the operation of social display rules should be minimized. When one or the other methodological criterion prevailed, social display rules might be operative (Category B—"Intermediate Display Rules").

After sorting the experiments into categories A, B, and C, they were examined for direction (left vs. equal vs. right) of asymmetries and for presence (yes vs. no) of facial asymmetries in general. As can be seen in Table VII, categories A and C (which should have displayed the most disparate results) had virtually identical distributions. When chi square tests were conducted on the data presented in Table VII, no significant findings emerged for either direction ($\chi^2 = 0.07$, $df = 1$, $p > .700$) or presence ($\chi^2 = 0.01$, $df = 1$, $p > .900$) of asymmetries. (Note that it was necessary to collapse across categories due to small cell frequencies.) In addition, the distributions for the 36 spontaneous observations were separately evaluated by face part and by emotional valence, i.e., negative whole face, positive whole face, negative lower face, and positive lower face. The pattern of findings for direction and presence of facial asymmetries did not vary across these four conditions.

The data from Table VII lend themselves to another type of analysis concerning the presence or absence of left-sided asymmetries. It has been suggested in several studies that left-sided facial expressions occur more frequently when subjects are embarrassed (Libby and Yakovlevich, 1973), self-conscious (Rinn, 1984), shy and insecure (Lynn and Lynn, 1938), or concealing feelings (Alford, 1983). To examine this issue, the data in Table VII were recast into presence ("yes") or absence ("no") of left-sided facial asymmetries. While the intermediate category showed relatively fewer left-sided asymmetries, there were no significant differences between this category

Table VI. Comparison of Facial Asymmetry Distributions Between Posed and Spontaneous Observations as a Function of Face Part and Valence

Face Part	Valence	Elicitation Condition	Facial Asymmetries: Left	Equal	Right	*p* Value[a]
Lower	Positive	Posed	3	7	3	ns[b]
		Spontaneous	5	3	3	
	Negative	Posed	6	3	0	ns[b]
		Spontaneous	3	1	0	
Whole	Positive	Posed	11	2	0	ns[b]
		Spontaneous	5	4	1	
	Negative	Posed	8	3	0	ns[b]
		Spontaneous	7	4	0	

[a]Comparison of distributions involving left, equal, and right asymmetry categories. Contingency tables were constructed by combining "Equal" and "Right" categories, and Fisher tests of exact probability were conducted.
[b]ns: Nonsignificant.

Table VII. Number of the 36 Observations in the Spontaneous Condition Showing Facial Asymmetries with Respect to Social Display Rules Across Valence and Face Part

Category	Display Rules Operating?	Direction of Asymmetries			Presence of Asymmetries		Presence of Left-Sided Asymmetries	
		Left	Equal	Right	Yes[a]	No	Yes	No[b]
A	Yes	9	6	1	10	6	9	7
B	Somewhat[c]	4	2	2	6	2	4	4
C	No	7	4	1	8	4	7	5

[a] "Left" and "Right" categories combined.
[b] "Equal" and "Right" categories combined.
[c] "Yes" for one of the two criteria (subject alone; camera/observer concealed).

and the other two nor between the most conceptually disparate categories (i.e., A vs. C).

Discussion

This review of 82 observations culled from 35 different sources suggests that the left hemiface (which presumably has greater connectivity to the right cerebral hemisphere) is more involved than the right hemiface during the facial expression of emotion. This was generally the case regardless of facial part, elicitation condition, and the operation of social display rules. It also appeared that left-sided facial asymmetries were more frequent for negative than for positive emotions and that equal and right-sided facial asymmetries were more frequent for positive than for negative emotions. The results of this review are generally consistent with earlier reviews (Borod and Koff, 1984; Borod and Van Gelder, 1990; Campbell, 1986; Hager, 1982; Rinn, 1984; Sackeim and Gur, 1983) and with the results of a meta-analysis of the facial asymmetry literature (Skinner and Mullen, 1991).

In terms of the theoretical models regarding hemispheric specialization for emotion, the overall findings of greater left- than right-sided asymmetries suggest that the right hemisphere is dominant for the expression of facial emotion. However, when valence is factored in, these findings are stronger for negative than for positive emotions. In fact, in the case of positive emotions, especially for the spontaneous condition, there is evidence for left as well as right hemisphere involvement. Weaker left-sided asymmetries, presumably reflecting weaker right-hemisphere mediation for positive emotions, could be consistent with the valence hypothesis. Although there were no instances of right-sided asymmetries for negative emotions, there was a 15% incidence for positive emotions. These findings for positive emotions are suggestive of some degree of left hemisphere involvement in positive emotion.

The possibility that positive emotion might be mediated by both hemispheres has been raised by a number of investigators (e.g., Borod, Koff, and Buck, 1986; Ehrlichman, 1987). There are several reasons that the left hemisphere might be involved in the expression of positive emotions. For example, Borod, Koff, and Buck (1986) have noted that positive emotions tend to be more communicative and linguistic than negative emotions, which could reflect more left-hemisphere involvement in their execution. In a similar vein, it has been suggested that smiles, the most frequently studied expression of positive emotion, differ from negative facial expressions in their ease of intentional production and frequency of use during social communication (Etcoff, 1986; Gainotti *et al.,* 1993). In fact, Ross *et al.* (1994) have provided some evidence that social emotions (as opposed to primary emotions) may actually be modulated by the left hemisphere. Ross *et al.*'s findings are in keeping with Wolff's earlier speculations (1933) that the right hemiface (i.e., left hemisphere) projects an individual's social facade.

Of note is the fact that the dimensions of pleasantness and communicativeness can be related to yet another dimension, that of approach/withdrawal. This dimension of motoric direction has received much attention in the emotion laterality literature in recent years. Several writers (e.g., Davidson, 1984, 1993; Fox, 1991; Kinsbourne, 1982) have suggested that the expression/experience of approach emotions is mediated by the left hemisphere and that the expression/experience of withdrawal emotions is mediated by the right hemisphere. In light of these speculations, we reexamined the discrete emotions in the studies reviewed in this paper according to this distinction. Of the emotions considered, anger is the only one that would shift categories (i.e., from negative to approach). Among the posed studies, there were nine instances in which anger was examined. In eight cases, anger was expressed more strongly on the left than the right hemiface; in one case, there were no significant facial asymmetries. There were no spontaneous studies in which anger was purposefully elicited. Thus, the data examined in the present review do not provide support for the motoric direction hypothesis.

When elicitation condition was considered, there were no significant differences between facial asymmetry distributions for posed vs. spontaneous conditions, across valences and facial parts. Thus, this review does not implicate differential innervation for these two conditions. However, it was the case that for one spontaneous condition (i.e., positive whole face), there was relatively less asymmetry than for its analogue posed condition (see Table VI). This effect seems to be more a function of emotional valence, however, than of elicitation condition, since the least left-lateralized distribution occurred for positive posed lower face expressions. Thus, although spontaneous facial expression is thought to be subcortically mediated through bilateral facial innervation, our examination of the facial asymmetry literature provides no support for this notion.

Condition differences might actually have been obscured by the degree to which social display rules were operating. It could be argued that fewer facial asymmetries should have occurred in spontaneous conditions when social display rules were not operating. To address this issue, we analyzed the data for the spontaneous studies in terms of three levels of social display rules, and found no significant differences in direction (left, equal, right), presence (yes, no) of facial asymmetries, or presence of left-sided asymmetries (yes, no) across the three levels.

Another factor that bears mention pertains to the instructions used to elicit posed/deliberate facial expressions. Both verbal and visual elicitation procedures can be used to determine whether the right hemisphere's dominance for visuospatial processing and the left hemisphere's dominance for verbal processing affect the direction of facial asymmetry. Based on the literature review conducted in this paper, there appear to be two studies that considered this issue. In one study, posed expressions were elicited separately to verbal command or visual imitation in 16 right-handed adult males (Borod *et al.*, 1988), with the result that the left hemiface was rated as more intense than the right hemiface in both conditions. In another study (Borod, Koff, and White, 1983), facial expressions of positive and negative emotions were elicited in two posed, as well as a spontaneous, conditions. For the spontaneous condition, 37 right-handed male and female subjects were videotaped unobtrusively as they viewed emotionally provocative slides (Buck, 1978); for the posed conditions, subjects were requested to pose expressions to "verbal command" and to pose expressions appropriate for each of the slides ("visual command"). The left hemiface was judged as moving significantly more extensively than the right hemiface, regardless of condition (i.e., spontaneous, posed verbal, or posed visual). Further study of this issue appears warranted.

In light of possible differences in the neuroanatomical innervation of facial expression, we examined patterns of asymmetries in whole vs. lower faces. In three of four comparisons (see Table V), there were no significant differences in patterns of asymmetry. When we looked at the set of experiments (posed positive) where significant face part differences occurred, it turned out that several of these experiments used methodologies very different from those used in the majority of the experiments reviewed. These experiments (Kop *et al.*, 1991; Schiff and Lamon, 1989) involved deliberate unilateral muscle movement and analysis of the subsequent emotion experienced. When the data from these experiments were removed from this face-part analysis, as well as from all analyses reported above, the patterns of results vis-à-vis significance were the same. In order to directly address the effect of face part on patterns of asymmetry, research will need to evaluate facial asymmetry in upper, lower, and whole faces within the same set of subjects.

The finding of left-sided facial asymmetry in normal subjects has generally been attributed to central (i.e., right hemispheric), as opposed to peripheral, brain mechanisms. However, the effects of nonemotional peripheral factors on such asymmetries must be assessed for several reasons. First, if the two hemifaces differed in the degree of muscular activity, the hemiface with greater mobility might be perceived as more emotionally intense (Koff *et al.*, 1981). Second, if the two hemifaces differed in size, the expression mapped on the wider side could appear diluted and be perceived as less extensive (Koff *et al.*, 1981). Third, morphological characteristics of the resting face could affect raters' perceptions of the emoting face (Ekman, 1980; Fridlund *et al.*, 1987).

In a number of studies, attempts have been made to rule out such confounding factors. Studies have demonstrated that nonemotional hemiface mobility (Borod and Koff, 1983) and hemiface width (Jaeger, 1984; Sackeim and Gur, 1980) were not significantly correlated with measures of hemiface intensity during posed and/or spontaneous emotional facial expression. In addition, morphological asymmetries in the resting face were not correlated with facial asymmetry during posed emotional expression (Borod *et al.*, 1988; Moreno *et al.*, 1990). In these two studies, the left side of the resting face displayed more morphological asymmetries (i.e., was perceived as more intense) than the right side (Borod *et al.*, 1988; Moreno *et al.*, 1990). This finding of greater left-sided emotional intensity in the resting or neutral face has been widely corroborated (Campbell, 1978; Kowner, 1995; Mandal *et al.*, 1992; Sackeim and Gur, 1978; Schwartz *et al.*, 1979; cf. Cacioppo and Petty, 1981).

Using a somewhat different approach, hemiface mobility and hemiface size were examined and compared in normal adult subjects (Koff *et al.*, 1981). Hemiface mobility was assessed from videotapes of nonemotional unilateral facial movements, and hemiface size was measured from frontal-view photographs of the whole face. The left hemiface was judged as more mobile/facile and the right hemiface was measured as larger, but these two asymmetry ratings were not significantly related to one another.

Studies of facial asymmetry during emotion also need to control for the phenomenon of perceiver bias or the tendency to focus on the left side of space in judgments of facial stimuli (Borod *et al.*, 1990). This hemispace bias for free-field evaluation of emotional intensity has been demonstrated using schematic (Carlson and Harris, 1986) and photographic (e.g., Heller and Levy, 1981; Jaeger *et al.*, 1987; Levy *et al.*, 1983; Moreno *et al.*, 1990) chimeric facial stimuli. Two other studies also found a left hemispace bias during free-field ratings of facial asymmetry in whole faces expressing emotion (Borod *et al.*, 1990; Sackeim and Grega, 1987). Based on these reports, studies involving whole-face judgments of facial symmetry should control for orientation by presenting the facial stimuli to the raters in both original and mirror-reversed orientations.

Finally, these facial asymmetry data suggest that more attention should be paid to the demographic characteristics of the posers. First, in terms of *handedness*, most experiments used only right-handed posers. In experiments where left-handers were included, in most cases (Borod and Caron, 1980; Campbell, 1978, 1979; Heller and Levy, 1981; Lynn and Lynn, 1938; Wylie and Goodale, 1988), there were no significant overall differences in facial asymmetry between right-handed and left-handed posers. However, in two experiments (Chaurasia and Goswami, 1975; Moscovitch and Olds [Experiment 4], 1982), left-handers were significantly less left-faced than right-handers.

Second, in terms of the *age* of the posers, though it would be interesting to look systematically at its effect on facial asymmetry, the majority of studies reviewed used college-aged subjects and, where there was an age range, no age subgroup statistics were reported. One of the studies from our laboratory (Moreno *et al.*, 1990) explored the hypothesis that there is a decline in functions mediated by the right hemisphere as a function of age (Albert and Kaplan, 1980; Borod and Goodglass, 1980; Brown and Jaffe, 1975; Ellis and Oscar-Berman, 1989) by looking at whether there were changes in facial asymmetry as a function of age. Composite faces were created from photographs of posed facial expressions. Posers were 30 young (ages 21–39), 30 middle-aged (ages 40–59), and 30 elderly (ages 60–81) right-handed neurologically and psychiatrically normal adult females who were photographed while posing positive and negative emotional expressions to verbal command. Overall, regardless of age and valence, left hemiface composites were rated as significantly more intense than right hemiface composites. To determine whether there was a decline with age, laterality ratios for the intensity ratings for each expression ([left composite - right composite]/[left composite + right composite]) were correlated with age. Consistent with the overall lack of an age effect, the correlation coefficient ($r = -0.08$) was not significant. In light of the importance of the question of whether there is differential decline in hemispheric function with age, this is an area in need of further research.

Third, in terms of *gender*, this review offered an opportunity to examine hypotheses in the literature regarding more bilateral hemispheric representation of function for females than males (e.g., McGlone, 1980) and greater valence by hemisphere effects for females than for males (e.g., Borod, Koff, and Buck, 1986). When gender of the posers was examined, out of 49 experiments, 3 did not specify gender while 16 used only one gender. See Table VIII. Among the 30 experiments that included both genders, 9 did not present results separately for males and females. Where data were described or could be analyzed with respect to gender, 14 experiments did not demonstrate significant differences in facial asymmetry. Of the 7 experiments where significant overall gender differences were reported, no systematic patterns emerged.

CONCLUSIONS

This review strongly supports the notion that the left hemiface is more involved than the right hemiface in the expression of facial emotion, regardless of valence, face part, elicitation condition, or the operation of social display rules. Furthermore, studies controlling for peripheral confounds have shown these left-sided findings for facial asymmetry to be unaffected by nonemotional facial factors. Because of the predominantly contralateral innervation of the face, the finding of significant left-sidedness is consistent with the hypothesis that the right cerebral hemisphere is dominant for the facial expression of emotion.

These findings in normal adults have been underscored by studies of stroke patients with focal right or left brain damage (e.g., Blonder *et al.,* 1993; Borod, Koff, Lorch, and Nicholas, 1986; Buck and Duffy, 1980; Kent *et al.,* 1988). When stroke patients were videotaped producing posed and/or spontaneous facial emotional expressions, overall, patients with focal right-sided brain damage were significantly less accurate than patients with left-sided brain damage or normal controls. For a comprehensive review of the literature about facial emotional expression in brain-damaged subjects, see Borod (1993).

From a theoretical perspective, there are a number of factors that help explain why the right cerebral hemisphere might be more involved in emotional processing than the left hemisphere. It has been long known that the two hemispheres have different processing styles and capabilities (e.g., Goldberg and Costa, 1981; Levy, 1974; Sperry, 1966). Further, there seems to be a consensus that the neuroanatomical organization of the right hemisphere may be particularly suited for the integrative multimodal nature of emotional processing. For a discussion of these theories and issues, see Borod (1992), Gainotti *et al.* (1993), Tucker (1981), and Tucker and Frederick (1989).

In spite of strong evidence for right-hemisphere specialization for emotional expression, some of the data raise the possibility of differential hemispheric involvement as a function of emotional valence, or pleasantness/unpleasantness. The availability of neuroimaging techniques, permitting online recordings, will undoubtedly provide a way to better understand neural mechanisms underlying cerebral asymmetries with respect to valence and other emotional dimensions. Although the work is in its infancy, investigators have begun to examine where faces are processed (e.g., Egan *et al.,* 1996; Erwin *et al.,* 1992; George *et al.,* 1993; Sergent *et al.,* 1992). The next obvious step would be to look at emotional expression and facial asymmetry with imaging techniques. Whether such in vivo studies will continue to support overall right hemisphere dominance for emotional processing or whether further complexities will be revealed, remains to be seen.

Table VIII. Gender of Posers in the 49 Experiments

				Both Genders Included		
		One Gender Only			Analysis by Gender	
	No Information Regarding Gender	Males	Females	No Analysis By Gender	No Significant Difference	Significant Difference
No. of Studies	3	7	9	9	14	7
Percent of Total	6.1%	14.3%	18.4%	18.4%	28.6%	14.3%

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REFERENCES

Albert, M. S., and Kaplan, E. (1980). Organic implications of neuropsychological deficits in the elderly. In Poon, L. W., Fozard, J. L., Cermak, L. S., Ahrenberg, D., and Thompson, L. W. (eds.), *New Directions in Memory and Aging: Proceedings of the George A. Talland Memorial Conference,* Lawrence Erlbaum, Hillsdale, NJ, pp. 403-432.

Alford, R. (1983). Sex differences in lateral facial facility: The effects of habitual emotional concealment. *Neuropsychologia* 21: 567-570.

Alford, R., and Alford, K. (1981). Sex differences in asymmetry in the facial expression of emotion. *Neuropsychologia* 19: 605-608.

Allport, G. W. (1961). *Pattern and Growth in Personality,* Holt, Rinehart, and Winston, New York.

Baribeau, J., Guérette, R., and Braun, C. (1987). *Hemifacial production of posed emotional expression in normal men and women.* Paper presented at the meeting of the International Neuropsychological Society, Washington, DC.

Blonder, L., Burns, A., Bowers, D., Moore, R., and Heilman, K. M. (1993). Right-hemisphere facial expressivity during natural conversation. *Brain and Cognition* 21: 44-56.

Borod, J. (1992). Interhemispheric and intrahemispheric control of emotion: A focus on unilateral brain damage. *Journal of Consulting and Clinical Psychology* 60: 339-348.

Borod, J. (1993). Cerebral mechanisms underlying facial, prosodic, and lexical emotional expression: A review of neuropsychological studies and methodological issues. *Neuropsychology* 7: 445-463.

Borod, J., and Caron, H. S. (1976, March). *Facial expression and cognitive control.* Invited paper presented at the Cortical Functions Laboratory, Johns Hopkins Medical Center, Baltimore, MD.

Borod, J., and Caron, H. S. (1979, February). *Facial asymmetry during emotional expression.* Paper presented at the International Neuropsychological Society, New York City, NY.

Borod, J., and Caron, H. (1980). Facedness and emotion related to lateral dominance, sex, and expression type. *Neuropsychologia* 18: 237-242.

Borod, J., and Goodglass, H. (1980). Lateralization of linguistic and melodic processing with age. *Neuropsychologia* 18: 79-83.

Borod, J., and Koff, E. (1983). Hemiface mobility and facial expression asymmetry. *Cortex* 19: 335-361.

Borod, J., and Koff, E. (1984). Asymmetries in affective facial expression: Anatomy and behavior. In Fox, N., and Davidson, R. (eds.), *The Psychobiology of Affective Development,* Lawrence Erlbaum Associates, Hillsdale, NJ, pp. 293-323.

Borod, J., and Koff, E. (1990). Lateralization for facial emotional behavior: A methodological perspective. *International Journal of Psychology* 25: 157-177.

Borod, J., and Koff, E. (1991). Facial asymmetry during posed and spontaneous expression in stroke patients with unilateral lesions. *Pharmacopsychoecologia* 4: 15-21.

Borod, J., and Van Gelder, R. S. (1990). Facial asymmetry: Expression and paralysis [Special Issue]. *International Journal of Psychology* 25: 2.

Borod, J., Caron, H., and Koff, E. (1981). Asymmetry of facial expression related to handedness, footedness, and eyedness: A quantitative study. *Cortex* 17: 381-390.

Borod, J., Kent, J., Koff, E., Martin, C., and Alpert, M. (1988). Facial asymmetry while posing positive and negative emotions: Support for the right hemisphere hypothesis. *Neuropsychologia* 26: 759-764.

Borod, J., Koff, E., and Buck, R. (1986). The neuropsychology of facial expression in normal and brain-damaged subjects. In Blanck, P., Buck, R., and Rosenthal, R. (eds.), *Nonverbal Communication in the Clinical Context,* Pennsylvania State University Press, University Park, PA, pp. 196-222.

Borod, J., Koff, E., and Caron, H. (1983). Right hemispheric specialization for the expression and appreciation of emotion: A focus on the face. In Perecman, E. (ed.), *Cognitive Functions in the Right Hemisphere,* Academic Press, New York, pp. 83-110.

Borod, J., Koff, E., Lorch, M., and Nicholas, M. (1986). The expression and perception of facial emotion in brain-damaged patients. *Neuropsychologia* 24: 169-180.

Borod, J., Koff, E., and White, B. (1983). Facial asymmetry in spontaneous and posed expressions of emotion. *Brain and Cognition,* 2: 165-175.

Borod, J., St. Clair, J., Koff, E., and Alpert, M. (1990). Perceiver and poser asymmetries in processing facial emotion. *Brain and Cognition* 13: 167-177.

Brockmeier, B., and Ulrich, G. (1993). Asymmetries of expressive facial movements during experimentally induced positive versus negative mood states: A video-analytic study. *Cognition and Emotion* 7: 393-405.

Brown, J., and Jaffe, J. (1975). Hypothesis on cerebral dominance. *Neuropsychologia* 3: 107-110.

Buck, R. (1978). The slide-viewing techniques for measuring nonverbal sending accuracy: A guide for replication. *Catalog of Selected Documents in Psychology* 8: 63.

Buck, R. (1984). *The Communication of Emotion,* Guilford, New York.

Buck, R., and Duffy, R. J. (1980). Nonverbal communication of affect in brain-damaged subjects. *Cortex* 16: 351-362.

Cacioppo, J. T., and Petty, R. E. (1981). Lateral asymmetry in the expression of cognition and emotion. *Journal of Experimental Psychology: Human Perception and Performance* 7: 333-341.

Campbell, R. (1978). Asymmetries in interpreting and expressing a posed facial expression. *Cortex* 14: 327-342.

Campbell, R. (1979). Left-handers' smiles: Asymmetries in the projection of a posed expression. *Cortex* 14: 571-579.

Campbell, R. (1982). Asymmetries in moving faces. *British Journal of Psychology* 73: 95-103.

Campbell, R. (1986). Asymmetries of facial action: Some facts and fancy of normal face movement. In Bruyer, R. (ed.), *The Neuropsychology of Face Perception and Facial Expression,* Erlbaum, Hillsdale, NJ, pp. 247-267.

Carlson, D. F., and Harris, L. J. (1986, February). *Perception of happiness and sadness in free-viewing of chimeric faces.* Paper presented at the meeting of the International Neuropsychological Society, Denver, CO.

Chaurasia, B. D., and Goswami, H. K. (1975). Functional asymmetry in the face. *Acta Anatomica* 91: 154-160.

Chusid, J. G., and McDonald, J. F. (1976). *Correlative Neuroanatomy and Functional Neurology* (17th ed.), Lange Medical Publications, Los Altos, CA.

Crosby, E. G., and De Jonge, B. R. (1963). Experimental and clinical studies of the central connections and central relations of the facial nerve. *Annals of Otology, Rhinology, and Laryngology* 72: 735-755.

Damasio, A. R., and Maurer, R. G. (1978). A neurological model for childhood autism. *Archives of Neurology* 35: 777-786.

Darwin, C. (1890). *The Expression of the Emotions in Man and Animals,* D. Appleton and Co., New York.

Davidson, R. (1984). Affect, cognition, and hemispheric specialization. In Izard, C. E., Kagan, J., and Zajonc, R. (eds.), *Emotions, Cognition, and Behavior,* Cambridge Press, Cambridge, England, pp. 320-365.

Davidson, R. (1993). Parsing affective space: Perspectives from neuropsychology and psychophysiology. *Neuropsychology* 7: 464-475.

Davidson, R., Ekman, P., Saron, C. D., Senulis, J. A., and Friesen, W. V. (1990). Approach-withdrawal and cerebral asymmetry: Emotion expression and brain physiology I. *Journal of Personality and Social Psychology* 58: 330-341.

DeJong, R. N. (1979). *The Neurologic Examination,* Harper and Row, New York.

Diamond, C., and Frew, I. (1979). *The Facial Nerve,* Oxford University Press, New York.

Dopson, W. G., Beckwith, B. E., Tucker, D. M., and Bullard-Bates, P. C. (1984). Asymmetry of facial expression in spontaneous emotion. *Cortex* 20: 243-251.

Dyken, P., and Miller, M. D. (1980). *Facial Features of Neurologic Syndromes,* C. V. Mosby, St. Louis, MO.

Egan, G. J., Kilts, C. D., Gideon, D. A., Hoffman, J. M., and Faber, T. (1996, August). *PET analysis of hemispheric involvement in human face perception.* Paper presented at the annual meeting of the American Psychological Association, Toronto, Ontario.

Ehrlichman, H. (1987). Hemispheric asymmetry and positive-negative affect. In Ottoson, D. (ed.), *Duality and Unity of the Brain,* Macmillan, Hampshire, England, pp. 194-206.

Ekman, P. (1980). Asymmetry in facial expression. *Science* 209: 833-834.

Ekman, P., and Friesen, W. V. (1969). The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Semiotics* 1: 49-98.

Ekman, P., and Friesen, W. V. (1978). *Facial Action Coding System,* Consulting Psychologists Press, Palo Alto, CA.

Ekman, P., Hager, J. C., and Friesen, W. V. (1981). The symmetry of emotional and deliberate facial actions. *Psychophysiology* 18: 101-105.

Ellis, R., and Oscar-Berman, M. (1989). Alcoholism, aging, and functional cerebral asymmetries. *Psychological Bulletin* 106: 128-147.

Erwin, R. J., Gur, R. C., Gur, R. E., Skolnick, B., Mawhinney-Hee, M., and Smailis, J. (1992). Facial emotion discrimination: I. Task construction and behavioral findings in normal subjects. *Psychiatry Research* 42: 231-240.

Etcoff, N. (1986). The neuropsychology of emotional expression. In Goldstein, G., and Tarter, R. E. (eds.), *Advances in Clinical Neuropsychology,* Plenum Press, New York, pp. 127-175.

Fox, N. A. (1991). If it's not left, it's right. *American Psychologist,* 46: 863-872.

Fridlund, A., Ekman, P., and Oster, H. (1987). Facial expressions of emotion: Review of the literature 1970-1983. In Siegman, A., and Feldstein, S. (eds.), *Nonverbal Behavior and Communication,* Erlbaum, Hillsdale, NJ, pp. 143-224.

Gainotti, G. (1972). Emotional behavior and hemispheric side of lesion. *Cortex* 8: 41-55.

Gainotti, G., Caltagirone, C., and Zoccolotti, P. (1993). Left-right and cortical/subcortical dichotomies in the neuropsychological study of human emotions. *Cognition and Emotion* 7: 71-93.

Gardner, H. (1975). *The Shattered Mind: The Person after Brain Damage,* A. A. Knopf, New York.

George, M., Ketter, T. A., Gill, D. S., Haxby, J. V., Ungerleider, L. G., Herscovitch, P., and Post, R. M. (1993). Brain regions involved in recognizing facial emotion or identity: An Oxygen-15 PET study. *Journal of Neuropsychiatry* 5: 385-394.

Geschwind, N. (1979). Specializations of the human brain. *Scientific American* 241: 180-199.

Goffman, E. (1958). *The Presentation of Self in Everyday Life,* Doubleday, New York.

Goldberg, E., and Costa, L. (1981). Hemisphere differences in the acquisition and use of descriptive systems. *Brain and Language* 14: 144-173.

Güntürkün, O. (1991). The Venus of Milo and the dawn of facial asymmetry research. *Brain and Cognition* 16: 147-150.

Hager, J. C. (1982). Asymmetries in facial expression. In Ekman P. (ed.), *Emotion in the Human Face,* Cambridge University Press, Cambridge, England, pp. 318-352.

Hager, J. C., and Ekman, P. (1985). The asymmetry of facial actions is inconsistent with models of hemispheric specialization. *Psychophysiology* 22: 307-318.

Hallervorden, J. (1902). Eine neue methode experimenteller physiognomik. [A new method of experimental physiognomy.] *Psychiatrisch-Neurologische Wochenschrift* 28: 309-311.

Hallervorden J. (1929). Rechts-und Linkshandig-keit und Gesichtausdruck. [Right- and left-handedness and facial expression.] *Zentralbatt fur die gesamte Neurologie und Psychiatrie* 53: 560.

Heilman, K. M., Scholes, R., and Watson, R. T. (1975). Auditory affective agnosia: Disturbed comprehension of affective speech. *Journal of Neurology, Neurosurgery, and Psychiatry* 38: 69-72.

Heller, W., and Levy, J. (1981). Perception and expression of emotion in right-handers and left-handers. *Neuropsychologia* 19: 263-272.

Izard, C. E. (1983). *The Maximally Discriminative Facial Movement Coding System,* Instructional Resources Center, University of Delaware, Newark, DE.

Jaeger, J. (1984). *The neuropsychology of emotion in major depressive disorder.* Unpublished doctoral dissertation, Yeshiva University, New York.

Jaeger, J., Borod, J., and Peselow, E. (1987). Depressed patients have atypical hemispace biases in the perception of emotional chimeric faces. *Journal of Abnormal Psychology* 96: 321-324.

Kahn, E. A. (1964). Facial expression. *Clinical Neurosurgery* 12: 9-22.

Karch, G. R., and Grant, C. W. (1978). Asymmetry in perception of the sides of the human face. *Perceptual and Motor Skills* 47: 727-734.

Kent, J., Borod, J., Koff, E., Welkowitz, J., and Alpert, M. (1988). Posed facial emotional expression in brain-damaged patients. *International Journal of Neuroscience* 43: 81-87.

Kinsbourne, M. (1982). Hemispheric specialization and the growth of human understanding. *American Psychologist* 37: 411-420.

Kinsbourne, M., and Bemporad, B. (1984). Lateralization of emotion: A model and the evidence. In Fox, N., and Davidson, R. (eds.), *The Psychobiology of Affective Development,* Erlbaum Press, Hillsdale, NJ, pp. 259-291.

Koff, E., Borod, J., and White, B. (1981). Asymmetries for hemiface size and mobility. *Neuropsychologia* 19: 825-830.

Kop, W. J., Merckelbach, H., and Muris, P. (1991). Unilateral contraction of facial muscles and emotion: A failed replication. *Cortex* 27: 101-104.

Kowner, R. (1995). Laterality in facial expressions and its effect on attributions of emotion and personality: A reconsideration. *Neuropsychologia* 33: 539-559.

Kuypers, H. G. J. M. (1958). Corticobulbar connections to the pons and lower brainstem in man. *Brain* 81: 364-390.

Levy, J. (1974). Psychobiological implications of bilateral asymmetry. In Dimond, S. J., and Beaumont, J. G. (eds.), *Hemisphere Function in the Human Brain,* John Wiley & Sons, New York, pp. 121-183.

Levy, J., Heller, W., Banich, M. T., and Burton, L. A. (1983). Asymmetry of perception in free viewing of chimeric faces. *Brain and Cognition* 2: 404-419.

Libby, W. L., and Yaklevich, D. (1973). Personality determinents of eye contact and direction of gaze aversion. *Journal of Personality and Social Psychology* 27: 197-206.

Lindzey, G., Prince, B., and Wright, H. K. (1952). A study of facial asymmetry. *Journal of Personality* 21: 68-84.

Lynn, J. G. (1940). An apparatus and method for stimulating, recording and measuring facial expression. *Journal of Experimental Psychology* 27: 81-88.

Lynn, J. G., and Lynn, D. R. (1938). Face-hand laterality in relation to personality. *Journal of Abnormal and Social Psychology* 83: 291-322.

Lynn, J. G., and Lynn, D. R. (1943). Smile and hand dominance in relation to basic modes of adaptation. *Journal of Abnormal and Social Psychology* 38: 250-276.

Mandal, M. K., Asthana, H. S., Madan, S. K., and Pandey, R. (1992). Hemifacial display of emotion in the resting face. *Behavioral Neurology* 5: 169-171.

Mandal, M. K., Asthana, H. S., and Tandon, S. C. (1993). Judgment of facial expression of emotion in unilateral brain-damaged patients. *Archives of Clinical Neuropsychology* 8: 171-183.

Mandal, M. K., and Singh, S. K. (1990). Lateral asymmetry in identification and expression of facial emotions. *Cognition and Emotion* 4: 61-70.

McGlone, J. (1980). Sex differences in human brain asymmetry: A critical survey. *The Behavioral and Brain Sciences* 3: 215-263.

Miehlke, A. (1973). *Surgery of the Facial Nerve,* W. B. Saunders, Philadelphia, PA.

Monserrat, L. (1984). *Facial asymmetry in the spontaneous expression of emotion: An index of the role of functional brain asymmetry in the regulation of emotional expression.* Unpublished doctoral dissertation, New York University, New York.

Moreno, C. R., Borod, J., Welkowitz, J., and Alpert, M. (1990). Lateralization for the expression and perception of facial emotion as a function of age. *Neuropsychologia* 28: 199-209.

Moscovitch, M., and Olds, J. (1979, June). *Asymmetries in spontaneous facial expressions and their possible relation to hemispheric specialization.* Paper presented at the European International Neuropsychological Society, Amsterdam, The Netherlands.

Moscovitch, M., and Olds, J. (1982). Asymmetries in spontaneous facial expressions and their possible relation to hemispheric specialization. *Neuropsychologia* 20: 71-81.

Myers, R. F. (1976). Comparative neurology of vocalization and speech: Proof of a dichotomy. *Annals of the New York Academy of Sciences* 51: 112-129.

Rappeport, M., and Friendly, M. (1978). *Facial asymmetry in emotion: Observer and stimulus differences.* Paper presented at the Canadian Psychological Association, Ottawa, Canada.

Remillard, G. M., Andermann, F., Rhi-Sausi, A., and Robbins, N. M. (1977). Facial asymmetry in patients with temporal lobe epilepsy. *Neurology* 27: 109-114.

Rinn, W. B. (1984). The neuropsychology of facial expression: A review of the neurological and psychological mechanisms for producing facial expression. *Psychological Bulletin* 95: 52-77.

Rinn, W. E., Friedman, C., and Meller, P. (1982, February). *An investigation of personality correlates of lateral gaze preference and facial asymmetry.* A paper presented at the meeting of the International Neuropsychological Society, Pittsburgh, PA.

Roberts, L. (1966). Central brain mechanisms in speech. In Carterette, E. C. (ed.), *Brain Function: Speech, Language and Communication,* University of California Press, Berkeley, CA, pp. 17-36.

Ross, E. D., Homan, R. W., and Buck, R. (1994). Differential hemispheric lateralization of primary and social emotions. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology* 7: 1-19.

Rozhe, A., Voronin, L. G., and Sokolov, Ye. N. (1960). Electroencephalographic research on temporary association with dampening of the orientation reflex in man. In Brazier, M. A. B. (ed.), *The Central Nervous System and Behavior: Translations from the Russian Literature,* The Josiah Macy, Jr., Foundation, Bethesda, MD, pp. 841-859.

Sackeim, H. A., and Grega, D. M. (1987). Perceiver bias in the processing of deliberately asymmetric emotional expressions. *Brain and Cognition* 6: 464-473.

Sackeim, H. A., and Gur, R. C. (1978). Lateral asymmetry in intensity of emotional expression. *Neuropsychologia* 16: 473-481.

Sackeim, H. A., and Gur, R. C. (1980). Asymmetry in facial expression. *Science* 209: 834-836.

Sackeim, H. A., and Gur, R. C. (1983). Facial asymmetry and the communication of emotion. In Cacioppo, J. T., and Petty, R. E. (eds.), *Social Psychophysiology,* Guilford, New York, pp. 307-352.

Sackeim, H. A., Weiman, A. L., and Forman, B. D. (1984). Asymmetry of the face at rest: Size, area and emotional expression. *Cortex* 20: 165-178.

Schiff, B. B., and Lamon, M. (1989). Inducing emotion by unilateral contraction of facial muscles: A new look at hemispheric specialization and the experience of emotion. *Neuropsychologia* 27: 923-935.

Schiff, B. B., and MacDonald, B. (1990). Facial asymmetries in the spontaneous response to positive and negative emotional arousal. *Neuropsychologia* 28: 777-785.

Schnierla, T. (1959). An evolutionary and developmental theory of motivation underlying approach and withdrawal. *Nebraska Symposium on Motivation* 7: 1-42.

Schwartz, G. E., Ahern, G. L., and Brown, S. (1979). Lateralized facial muscle response to positive and negative emotional stimuli. *Psychophysiology* 16: 561-571.

Seinen, M., and Van Der Werff, J. J. (1969). The perception of asymmetry in the face. *Nederlands Tijdschrift voor de Psychologie en Haar Grensgebieden* 24: 551-558.

Sergent, J., Ohta, S., and MacDonald, B. (1992). Functional neuroanatomy of face and object processing. *Brain* 115: 15-36.

Silberman, E. K., and Weingartner, H. (1986). Hemispheric lateralization of functions related to emotion. *Brain and Cognition* 5: 322-353.

Sirota, A. D., and Schwartz, G. E. (1982). Facial muscle patterning and lateralization during elation and depression imagery. *Journal of Abnormal Psychology* 91: 25-34.

Skinner, M., and Mullen, B. (1991). Facial asymmetry in emotional expression: A meta-analysis of research. *British Journal of Social Psychology,* 30: 113-124.

Sperry, R. W. (1966). Brain bisection and consciousness. In Eccles, J. C. (ed.), *Brain and Conscious Experience,* Springer-Verlag, New York, pp. 298-313.

Strauss, E., and Kaplan, E. (1979). *Lateralized asymmetries in self-perception.* Paper presented at the Canadian Psychological Association, Quebec, Canada.

Strauss, E., and Kaplan, E. (1980). Lateralized asymmetries in self-perception. *Cortex* 16: 289-293.

Strauss, E., Moscovitch, M., and Olds, J. (1980). *Children's production of facial expression.* Paper presented at the convention of the American Psychological Association, Montreal.

Stringer, P., and May, P. (1981). Attributional asymmetries in the perception of moving, static, chimeric and hemisected faces. *Journal of Nonverbal Behavior* 5: 238-252.

Thompson, J. K. (1985). Right brain, left brain; left face, right face: Hemisphericity and the expression of facial emotion. *Cortex* 21: 281-299.

Tschiassny, K. (1953). Eight syndromes of facial paralysis and their significance in locating the lesion. *Annals of Otology, Rhinology and Laryngology* 62: 677-691.

Tucker, D. M. (1981). Lateral brain function, emotion, and conceptualization. *Psychological Bulletin* 89: 19-46.

Tucker, D. M. (1986). Neural control of emotional communication. In Blanck, P. D., Buck, R., and Rosenthal, R. (eds.), *Nonverbal Communication in the Clinical Context,* The Pennsylvania State University Press, University Park, PA, pp. 258-307.

Tucker, D. M., and Frederick, S. L. (1989). Emotion and brain lateralization. In Wagner, H. L., and Manstead, A. S. R. (eds.), *Handbook of Social Psychophysiology,* Wiley, New York, pp. 27-70.

Tucker, D. M., and Williamson, P. A. (1984). Asymmetric neural control systems in human self-regulation. *Psychological Review* 91: 185-215.

Van Gelder, R. S., and Van Gelder, L. (1990). Facial expression and speech: Neuroanatomical considerations. *International Journal of Psychology* 25: 141-155.

Wemple, C. Y., Safer, M. A., and Notarius, C. T. (1986, August). *Display rules and facial expression: Intensity, asymmetry and type.* Paper presented at the convention of the American Psychological Association, Washington, DC.

Wolff, W. (1933). The experimental study of forms of expression. *Character and Personality* 2: 168-173.

Wolff, W. (1943). *The Expression of Personality: Experimental Depth Psychology,* Harper and Row, New York.

Woodworth, R. S., and Schlosberg, H. (1954). *Experimental Psychology,* Holt, Rhinehart, and Winston, New York.

Wyler, F., Graves, R., and Landis, T. (1987). Cognitive task influence on relative hemispheric motor control: Mouth asymmetry and lateral eye movements. *Journal of Clinical and Experimental Neuropsychology* 9: 105-116.

Wylie, D. R., and Goodale, M. A. (1988). Left-sided oral asymmetries in spontaneous but not posed smiles. *Neuropsychologia* 26: 823-832.