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The Asymmetry of Facial Actions is Inconsistent with Models of Hemispheric Specialization

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ABSTRACT

Several models of hemispheric specialization have been used to explain asymmetries in facial actions. This study measured the asymmetry of several different muscular actions individually, alone and in combination, and under different eliciting conditions. The findings did not fit any of the theoretical models. In the deliberate actions, some of the asymmetries were lateralized with greater intensity on the left side; others, on the right side. Spontaneous actions were more symmetrical than the deliberate, requested actions. We rejected specialization for emotion as a cause of the facial asymmetry observed, and discussed the weaknesses of other models.

DESCRIPTORS: Facial expressions, Facial muscles, Facial asymmetry, Hemispheric specialization, Emotion, Startle.

Recent reports have suggested that asymmetries in facial expressions result from cerebral hemispheric specialization. A summary of these theoretical models is contained in Table 1. These models differ in two important respects: whether emotional or nonemotional neural processes are involved, and whether specialization of the right, the left, or both hemispheres underlies asymmetry. This report evaluates these issues.

Facial Asymmetry and Specialization

Facial asymmetry has been attributed to both emotional and nonemotional neural processes. Some researchers (Chaurasia & Goswami, 1975; Heller & Levy, 1981) theorized that specialization in right-handers of the right hemisphere for cognitive, non-verbal processes such as the recognition of faces (see Benton, 1980) produced asymmetry. Others (Sackeim, Gur, & Saucy, 1978; Schwartz, Ahern, & Brown, 1979) referred to the evidence that the right hemisphere has an important function in emotional processes (Ley & Bryden, 1981). They speculated that since facial expressions are an integral part of emotion, it is reasonable to expect the right hemisphere to have a special role in the production of facial expressions. These theories of right hemispheric specialization predict that asymmetries of facial actions should be lateralized with the left side stronger or more active.

Still others have hypothesized that each hemisphere is specialized for different emotions. One model is right hemispheric specialization only for negative emotions, and left specialization for positive emotions (Schwartz et al., 1979; Reuter-Lorenz & Davidson, 1981; Sackeim & Gur, 1978). A variant of this theory, mentioned by Davidson and Fox (1982), is right hemispheric specialization for avoidance emotions and left specialization for approach emotions. These theories explicitly predict or suggest that positive or approach expressions would be stronger or show more activity on the right side of the face, but negative or avoidance expressions would show the opposite.

Geschwind (1965, 1975) argued that bilateral facial movements are typically integrated by the left hemisphere, particularly in response to verbal requests for movements, but that the right hemisphere can control movements in certain conditions, such as when the request is non-verbal. Geschwind did not indicate that hemispheric special-

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Table 1

Summary of hemispheric specialization models for facial asymmetry

Brief Statement of Models for Neural Basis of Facial Asymmetry	Illustrative Citations	Predictions or Implications for Facial Asymmetry	
		Emotional Facial Actions	Nonemotional Facial Actions
Emotional Processes			
Emotion in Right Hemisphere	Sackeim et al. (1978), Moscovitch & Olds (1981)	left stronger	left stronger
Positive Emotion in Left, Negative Emotion in Right Hemisphere	Schwartz et al. (1979), Sackeim & Gur (1978)	positive: right stronger; negative: left stronger	possibly same pattern?
Approach Emotion in Left, Avoidance Emotion in Right Hemisphere	Davidson & Fox (1982)	approach: right stronger; avoidance: left stronger	possibly same pattern?
Nonemotional Processes			
Recognition of Facial Identity and Emotion Expression in Right Hemisphere	Chaurasia & Goswami (1975), Heller & Levy (1981)	left stronger	left stronger
Integration of Bilateral Facial Actions by the Left Hemisphere	Geschwind (1965, 1975)	no prediction	right stronger; possibility for left stronger

ization would be observed in the expressions of nonpatients, but his model allows for both left and right asymmetry.

These models of hemispheric specialization do not make explicit the neural mechanisms that explain why specialization would cause asymmetrical facial actions. There are two theoretical bases for this relationship. First is an analogy to the direction of lateral eye movements that was hypothesized to reflect the differential activation of the cerebral hemispheres (Bakan, 1969; see Ehrlichman & Weinberger, 1978, for a critical review). Kinsbourne (1972) theorized that increased activation of the left hemisphere during language processing "overflows" to left hemispheric orientation and motor centers to shift gaze to the right. Kimura (1973) used a similar explanation to account for her findings that free right-hand movements were more frequent during speech than nonspeech but frequencies of left-hand movements did not differ. A second possible explanation disregards hemispheric activation and instead implicates other consequences of hemispheric specialization. For example, messages created in one hemisphere for integrating bilateral facial movements (e.g., Geschwind, 1965) might be degraded crossing to the contralateral hemisphere, thus inducing motor asymmetry. What mechanism produced facial asymmetry was not clearly specified by models of either emotional or nonemotional hemispheric specialization.

These models also failed to specify whether lateralization was the same for emotional expressions as for deliberate and other types of facial actions. Ekman (1980) pointed out that many experiments did not adequately distinguish emotional from nonemotional movements and hypothesized greater asymmetry for nonemotional movements. Ekman, Hager, and Friesen (1981) confirmed this hypothesis, finding that stronger muscular actions tended to occur more often on the left side of the face, but only for deliberate, requested actions, not for actions related to emotion. They also found smiles more symmetrical when children responded to an experimenter's joke or praise than when they smiled deliberately on request.

Other studies found either left or right laterality in facial expression. In some, asymmetries were lateralized so that the left side had greater electromyographic (EMG) activity (Schwartz et al., 1979), more intense expression (Borod & Caron, 1980; Campbell, 1978; Sackeim et al., 1978), stronger muscular contractions (Ekman et al., 1981), and more frequent unilateral actions during conversation (Moscovitch & Olds, 1982). Other reports showed greater facility in performing deliberate actions on the right side of the face (e.g., Alford & Alford, 1981; Kohara, 1975), or that moving the right side of the face is subjectively more "natural" (Alford, 1983), or that the right side of the mouth is more motile during speech (Graves, Goodglass, & Landis, 1982; Hager & van Gelder, in press).

The implications of these different asymmetries for the models described above are unclear, in part, because of three methodological problems: 1) Some studies did not clearly distinguish whether the asymmetry was temporarily produced by muscular actions or was a more permanent physiognomic cue. Among those which measured muscular action, 2)

some failed to specify whether emotional or non-emotional processes generated the expressions, and, 3) most did not employ a sufficiently refined measure which could distinguish exactly which muscles acted.

Considerations for Research on Facial Asymmetry

Relevant Facial Cues. A serious shortcoming of many previous reports is the failure to distinguish adequately which characteristics, such as permanent facial features or muscular actions, were measured. Thus, one cannot know whether the results are due to nervous system activity or to some other factor unrelated to neuromuscular activity. This problem is especially severe when asymmetry is measured by observers' judgments about the intensity of expression in the whole face. It is not possible to ascertain whether observers judged the intensity of muscular actions or some other asymmetrical characteristic (Hager, 1982). Even objective physical measurements of facial asymmetry are vulnerable. EMG measurements, for example, are influenced by the tissue between the electrode and the muscle, tissues that might be asymmetrical and cause measurement problems (Fridlund, 1984).

Here, we measured the symmetry of each muscular action separately to assess differences between the two sides of the face in the strength of contraction of individual muscles. This approach defined the features measured and minimized the influence of extraneous factors on measurements. Distinguishing individual facial actions depended upon Ekman and Friesen's *Facial Action Coding System* (FACS) (1976, 1968). FACS measures the visible action of facial muscles with Action Units (AUs) that indicate which muscles contract to produce expressions. Action Units correspond to the anatomy of facial muscles, but rather than measuring every change in muscular action, they differentiate what scorers can reliably discriminate. After identifying an AU with FACS, asymmetry is determined. Table 2 describes the Action Units that were measured in this study.

Table 2

Action units measured in this study

Action Unit (AU)	Muscles Involved	Description of Action	Conditions Where Elicited
1	Inner frontalis	Raises inner corner of brow	Requested actions Startle simulations Emotion simulations
2	Outer frontalis	Raises outer corner of brow	Same as above
1+2	Frontalis	Raises entire brow	Same as above
4	Corrugator Procerus	Lowers and pulls brows together	Requested actions Emotion simulations
6	Orbicularis oculi, outer portion	Squints eyes, makes crowsfeet wrinkles	Requested actions Startle simulations Emotion simulations Startle actions Happy emotion action
7	Orbicularis oculi, inner portion	Squints eyes, raises and straightens lower lid	Requested actions Startle simulations Emotion simulations Startle actions
9	Levator labii superioris, alaque nasi	Wrinkles nose	Requested actions Emotion simulations
10	Levator labii superioris	Raises upper lip	Requested actions
12	Zygomatic major	Common smile	Requested actions Emotion simulations Happy emotion action
14	Buccinator	Dimples cheeks	Emotion simulations
15	Triangularis	Lowers corners of lips	Requested actions Emotion simulations
16	Depressor labii inferioris	Pulls lower lip down	Requested actions
20	Risorius	Stretches lip corners straight to the side	Requested actions Emotion simulations Startle actions
45	Orbicularis oculi	Blink or wink	Requested actions Startle simulations Startle actions

Like EMG, FACS scoring measures the activity of muscles, but it is based on the visible changes in facial tissues produced by the action of muscles rather than the electrical potentials generated by contractions. Both FACS and EMG can locate the beginning, apex, and end of muscular action and variations in the intensity of contraction, but EMG has a much finer, continuous scale. FACS and EMG measures of the intensity of contraction are highly correlated (Ekman, 1982).

EMG may be more sensitive to low level changes in muscular activity and is often used to compute integrated measures of activity over time. FACS, however, is more sensitive to the action of individual muscles than surface EMG, which picks up activity of any muscle in the area of the electrode. Needle EMG can measure the action of individual muscles more precisely than surface EMG, but inserting fine wires into subjects' faces is usually impractical. Because surface EMG is imprecise about what muscles are measured, it is probably not possible for it to discriminate the range of facial expressions that FACS can distinguish.

EMG cannot be used to measure facial action when unobtrusive methods are an important consideration. Attaching electrodes heightens the subject's awareness of what is being measured. Subjects may inhibit large expressions in order not to detach the EMG electrodes. EMG is a more automated method for collecting records and extracting data, whereas FACS scoring relies on the trained discrimination of experts aided by high quality video equipment. Compared to EMG, FACS takes a relatively long time to derive usable data from the record. (For a more complete comparison of facial measurement techniques see Ekman, 1982.)

When measuring asymmetry in the intensity of muscular action, however, both measures may be affected by anatomical factors independent of the strength of muscular contraction (e.g., thickness, mass, and elasticity of skin). Fridlund (1984) suggests that if these anatomical factors are not the same on the two sides of the face, measurements of symmetry based on either visual observation (FACS) or electrical activity (EMG) may be misleading. Unequal muscular contractions may appear to be symmetrical if compensated by anatomical differences. Conversely, equal muscular contractions may appear asymmetrical because of anatomical asymmetries. Fridlund argued that these anatomical confounds are most problematic when comparing asymmetry between conditions that show large differences in the intensity of muscular contractions. In this study, analyses were performed to control for differences in the intensity of actions across conditions whenever possible.

Deliberate versus Spontaneous Movements. This study distinguished deliberate from spontaneous facial movements and compared their asymmetry. These types of facial movements have neural substrates that are at least partially different (e.g., Tschiassny, 1953; Rinn, 1984). Deliberate facial actions probably have their neural origins in the motor strip of the neocortex, but spontaneous emotional movements are probably initiated in subcortical motor centers of the prosencephalon, such as the basal ganglia.[1] The startle actions measured in this study are another type of spontaneous facial movement having neural pathways different from either deliberate or emotional movements. The reflexes involved in the startle are probably mediated by centers in the brainstem reticular formation (Hoffman & Ison, 1980).

The description of types of facial movements is complicated further by the independence of the spontaneous-deliberate and emotional-nonemotional dimension. Ekman et al. (1981) in a previous study of asymmetry explained that:

> The voluntary (or deliberate) versus involuntary (or spontaneous) dichotomy is far too simple, glossing over many diverse behaviors which might depend upon different neural pathways. For example, involuntary facial expressions might include actions which are over-learned habits and unlearned reflexes [such as the startle], actions which are modulated by choice or habit and those which cannot be so controlled, and actions which are reported into awareness and those which are not.
>
> Even among expressions which refer only to emotion, the voluntary-involuntary distinction does not capture all of the different types of behavior. *Spontaneous* emotional expressions appear quickly, seemingly without choice, although they may be modulated by choice or habit. Some of these expressions are considered to be innate because of similarities across cultures and among some primates. A *simulated* emotional expression is a deliberate attempt to appear as if an emotion is being experienced. . . . A *gestural* emotional expression resembles actual emotional expression but it differs sufficiently in appearance to make it evident to the beholder that the person does not feel that emotion at this moment; he is just mentioning it.
>
> . . . It is important that those interested in the differential role of the two cerebral hemispheres in the production of emotional expressions specify which type of facial expression they have studied (pp. 101–102).

In our study, a relatively pure sample of spontaneous facial actions was obtained in circumstan-

[1]Historically, deliberate movement has been associated with the pyramidal motor system, and emotional movement with the extrapyramidal system. Recent anatomical viewpoints no longer maintain this division of the motor system (e.g., Barr & Kiernan, 1983), but the distinction between two different neural pathways for deliberate and emotional movements is pronounced for the face and has an established clinical basis (Rinn, 1984).

ces in which the likelihood of attempts to control the expression, by habit or choice, would be minimal: 1) The startle expression was elicited by a sudden, loud noise. 2) An enjoyment expression was elicited by a comment presumed to be amusing, without any element of embarassment.

A relatively pure sample of deliberate actions was obtained by requesting the subject to perform specific facial actions without referring to emotion (e.g., raise your eyebrows up). By asking the subjects to perform these actions singly one at a time, the likelihood of inadvertently obtaining emotional behavior was minimized. Ekman, Levenson, and Friesen (1983) found that voluntarily making facial expressions did *not* generate the autonomic nervous system activity associated with emotion unless the entire facial expression was performed.

A mixture of spontaneous and deliberate actions was produced by requesting subjects to simulate six emotional expressions and a startle expression. Subjects could solve this task by either remembering an emotional experience, attempting to let the expression flow from the remembered experience, or by remembering a picture of a face which they attempt to imitate (Ekman, Roper, & Hager, 1980). The findings from Ekman et al. (1983) suggest that by either method, autonomic nervous system activity may be generated.

Hypotheses

This report distinguishes *asymmetry*, which denotes a difference between the two sides of the face, from *laterality*, which indicates consistent asymmetry or a bias for one side. Spontaneous and deliberate actions were predicted to differ in two ways. First, deliberate actions would show more asymmetry than spontaneous actions. Second, deliberate actions, unlike spontaneous actions, were expected to show lateralization of asymmetries. In conditions where spontaneous and deliberate actions were mixed, actions were predicted to show fewer asymmetries and less laterality than deliberate actions, but more than spontaneous actions.

For deliberate actions, the preponderance of evidence suggested the prediction of left laterality (Hager, 1982) with two exceptions. Evidence from Ekman et al. (1981) suggested that the tendency for asymmetries to manifest laterality varied with the action, but their samples were too small to be conclusive on this point. Some actions may not be lateralized. Second, each of the studies that examined winking (Alford & Alford, 1981; Kohara, 1975) showed greater skill and/or preference for winking the right eye. Actions related to blinking and winking were predicted to show right laterality.

Method

Subjects

Gender might be an important variable affecting the symmetry of facial actions (e.g., Alford & Alford, 1981; Borod & Caron, 1980), but the facial scoring required for this study was too time-consuming to factorially vary subject variables. To make the sample more homogeneous, 33 right-handed Caucasian women, aged 18–53 ($\bar{X}$ = 27.5) yrs, were recruited as subjects. A handedness questionnaire (Johnstone, Galin, & Herron, 1979) screened for right-handed subjects.

Equipment

All of the subjects' facial actions were recorded on videotape for later analysis. The subject always faced directly into the camera lens, producing straight ahead shots that were ideal for asymmetry scoring.

Previous researchers (e.g., Landis & Hunt, 1939; Ekman, Friesen, & Simons, in press) have frequently used acoustic stimuli to elicit startles because they reliably elicit the startle response and are relatively easy to administer. The commonly used starter's pistol was inappropriate for this study because, first, the sound pressure level of shots varied widely and might have endangered subjects' hearing. Second, a pilot study suggested that asymmetry depended upon the direction of the noise, and directional properties of shots could not be controlled easily.

To solve these problems, startle sounds were 80-ms bursts of white noise produced electronically, amplified, and transduced by headphones worn by the subject and an array of six speaker cabinets stacked directly behind her. Sound pressure level was 125dB and was balanced to within 1dB on either side of the subject's head. This arrangement controlled stimulus intensity and minimized directional variation.

All of the equipment for controlling the experiment was placed behind a partition so that the experimenter was hidden from view except when giving general instructions and questionnaires. Thus, the subject could not see any subtle cues that the experimenter might have shown about how to do movements, when the unanticipated startle noise was to occur, etc.

Experimental Procedure

Each subject completed the procedure individually. There were two main parts to the study. The startle part of the experiment was modeled after the procedure of Ekman et al. (in press). The subject simulated a startled expression twice, before and after hearing three separate loud noises.[2] The next part of the ex-

[2]There was no difference between the two startle simulations so their scores were averaged. As in the Ekman et al. study, the three noises were elicited under different conditions. In the first, the noise was unexpected, but in the other two, the subject knew exactly when the noise would occur. To one expected noise, the subject reacted naturally; to the other, the subject tried to act as though nothing happened. Asymmetry of actions in the startles did not differ so their scores were averaged for analysis.

periment was a modified version of Ekman and Friesen's Requested Facial Action Test (REFACT) (1982). For simulations of six emotions, the subject was asked to look happy, sad, angry, fearful, disgusted, and surprised, in this order for every subject. The experimenter then asked "Now that this is done, aren't you glad it's over?" in order to elicit a more spontaneous smile. This comment was expected to produce amusement or enjoyment because it acknowledged the strangeness of having to make expressions devoid of feeling on request and it came when relief at completing this task might be a stimulus for enjoyment (Tomkins, 1962). Demand for deliberate or unfelt social smiles was minimized because the experimenter was behind a curtain and the subject was not in a face-to-face interaction.

Subjects in this study knew they were being videotaped, and this knowledge could have heightened self awareness and altered natural spontaneous expressions (see Hager, 1982). Ideally, videotaping should be as unobtrusive as possible. Only the lens of the camera was in view, but we did not hide the videotaping. Evidence suggests that the startle pattern is relatively invulnerable to attempts at control and alteration (Landis & Hunt, 1939). The spontaneous smile was elicited when the subject's attention shifted away from the task and recording. If any subjects did control or alter their spontaneous actions, in either the startle or smile samples, it would work against our hypothesis, diminishing the differences between the spontaneous and deliberate actions.

Next, the subject deliberately made individual facial actions. Requests for some of the deliberate actions were made in two ways, verbally and visually, to check the possibility that asymmetry might be affected by verbal vs. visual mediation. First, the experimenter verbally instructed the subject to perform eight actions (AUs 12, 1+2, 4, 45, 10, 9, 20, 6+7, in this order; see Table 2). Then, the subject viewed an expert in facial movement on videotape and imitated the 17 individual actions shown by the expert with no coaching or comments. Eleven of these actions that were measured in previous studies or in other conditions of this study were scored (AUs 1+2, 9, 16, 12, 4, 7, 10, 15, 20, 1, 2, requested and scored in this order). Sometimes a subject could not perform the requested action, and at other times performed the action many times for a given request. A maximum of four repetitions of the action were scored (the first and last two). There was no difference in asymmetry between the seven requests common to both verbal and visual conditions so they were averaged for analysis.[3]

Facial Scoring Procedures

A series of scoring steps began with the startle part of the study. Only actions that were part of the startle response were scored. According to Ekman et al. (in press), startle actions that are either common or universal are tightening the muscles around the eye (AUs 6 and 7), stretching the lips horizontally (AU 20), tightening neck muscles (AU 21), closing the eyes (AU 45), and moving the head and shoulders upwards. Following their scoring procedure, any of these actions that began in the first ⅓ second after the noise were scored because this interval includes the beginning of actions that comprise a characteristic startle response. Other, idiosyncratic actions were also scored if they began before the end of the apex of AUs 6, 7, 20, or 21. In the simulate conditions, every AU that began within ⅓ second of the onset of the first AU in the simulation was scored.

The second scoring step was to score the requested facial actions. Eleven different requested actions were selected for scoring because they appeared in other conditions and were included in previous studies. Subjects typically performed each requested action several times so the scores were averaged.

The third step was scoring the emotion simulations and the spontaneous response to the question: "Aren't you glad it's done?" For simulations, the scorer determined the AUs just before the subject began to announce she was finished and scored them all.

Measurement of Asymmetry

Measurement of asymmetry was similar to the procedure used by Ekman et al. (1981). Each individual muscular action was identified using Ekman and Friesen's Facial Action Coding System (FACS) (1978). The scorer assessed the changes in facial appearance between the action's beginning and apex (a single video frame showing both sides at greatest intensity). The intensity of contraction was measured on a six-point scale separately for each side of the face by blocking off the other side from view. The scorer used a video disk to look repeatedly in slow motion and real time for any differences in intensity between the two sides at the apex. A score between −5 (extreme left asymmetry) and +5 (extreme right asymmetry) was assigned to indicate whether the action was symmetrical or asymmetrical. If asymmetrical, the score provided a categorical measure of right vs. left and a continuous measure of how great the difference in intensity was. Determining a facial midline is not as important with this procedure as it is when cutting and pasting still photographs (Sackeim et al., 1978). The changing appearances due to a contracting muscle are gauged from their beginning and ending positions, not their relationship to a midline.

Reliabilty

Asymmetry scoring was based on the FACS technique, which has substantial reliability evidence (Ekman & Friesen, 1978). Similar asymmetry scoring was shown to be reliable in a previous study (Ekman et al., 1981). The experimenter was the main scorer in this study because of his expertise and ability to spend five man-months scoring. One important issue was whether knowledge of the hypotheses biased scoring because of the experimenter's role as scorer. The potential for bias was minimized by the scoring proce-

[3]Wilcoxon signed-ranks tests on the asymmetry scores for separate AUs showed no significant differences for any of the seven AUs.

dure which, for example, spread the scoring over time so that scores in different conditions were hard to remember. The reliability coefficients indicate that bias was not an important factor. The Pearson correlation between the main coder (who knew the hypotheses) and three reliability coders (who did not know the hypotheses) was .72 ($p<.001$). A Kappa used to assess the reliability of the right vs. left category scores was .88 ($p<.0001$) with 94 percent agreement, indicating that when coders agreed an action was asymmetrical, they usually agreed about whether it was left or right.

Results

Differences in Asymmetry between Types of Movement

Spontaneous versus Deliberate Actions. Absolute values of asymmetry scores were used to index the degree of asymmetry, disregarding whether the right or left side was more intense. Wilcoxon signed-ranks tests on these scores showed that, as predicted, spontaneous actions were more symmetrical than deliberate actions. As shown in Table 3, smiling (AU 12) in spontaneous happy expressions was more symmetrical than in requested actions. Squinting (AU 6) in spontaneous happy expressions was more symmetrical than in requested actions. Lip stretching (AU 20) in the startle expressions was more symmetrical than in requested actions. The prediction was not confirmed for squinting (AUs 6 and 7) and blinking (AU 45) between the startle and the requested actions, which showed no difference.

These significant differences in asymmetry between conditions cannot be attributed to differences in the intensity of actions between conditions. In a separate analysis to eliminate intensity differences, each action in the spontaneous conditions was matched for intensity with a deliberate action with rules to eliminate biased selection. As Table 4 shows, the matching produced an average intensity difference between conditions that was less than one scoring interval. The results of this analysis showed the same significant differences except for AU 6, which had too many ties but still showed the same tendency.

Table 3

Differences in asymmetry of deliberate versus spontaneous action units in the spontaneous smile and startle conditions

Condition	Action Unit	Mean Score		Greater Rank		Ties	z
		Del.	Spon.	Del.	Spon.		
Happy vs. Deliberate	6	.540	.174	13	1	9	2.42*
	12	.971	.188	29	2	1	4.53**
Startle vs. Deliberate	6	.341	.409	9	8	6	0.07
	20	1.068	.417	20	6	0	3.19**
	45	.111	.091	7	4	22	0.80

Note.—Analyses are Wilcoxon signed-ranks tests on the absolute values of asymmetry scores.
*$p < .02$. **$p < .001$.

Table 4

Differences in asymmetry in Table 3 controlled for intensity

Action Unit	Mean Intensity		Mean Score		Greater Rank			z
	Del.	Spon.	Del.	Spon.	Del.	Spon.	Ties	
6	2.7	3.3	.500	.182	7	1	14	1.59
12	3.5	3.9	.969	.188	19	2	11	3.63**
20	2.8	1.9	1.182	.409	15	4	3	2.27*

Note.—Analyses are Wilcoxon signed-ranks tests on absolute values of asymmetry scores for actions matched on intensity. Intensity scale ranges from 0 to 5.
*$p < .05$. **$p < .001$.

Spontaneous Startle versus Startle Simulations. Simulations had more actions that were not common in startles (e.g., AUs 1, 2, 12) and fewer actions that were common in startles (e.g., AUs 6, 7, 20). The only difference in asymmetry between simulations and the real startle can be attributed to chance.

Emotion Simulations versus Spontaneous or Deliberate Actions. All but one subject smiled to the question "Now that this is done, aren't you glad it's over?" at the end of the emotion simulations. We could not eliminate the possibility that some of these actions were deliberate or controlled rather than spontaneous emotional smiles. This possibility, however, worked against the hypothesis of a difference between spontaneous and deliberate actions. As shown in Table 5, spontaneous smiles (AU 12) were more symmetrical than these AUs in emotion simulations of happy, which were, in turn, more symmetrical than in deliberate actions. There were no other significant differences between actions in emotion simulations and either spontaneous or deliberate actions.

Table 5

Differences in asymmetry for AU 12 between the simulated happy condition and the spontaneous and deliberate conditions

Condition	Mean Score	Greater Rank	Ties	z
Simul.	.658	9	1	5.66**
Del.	.981	23		
Simul.	.641	12	17	2.92*
Spon.	.188	3		

Note.—Analyses are Wilcoxon signed-ranks tests on absolute values of asymmetry scores.
*$p < .01$. **$p < .001$.

Table 6

Summary of laterality by action

Action Unit (AU)	Deliberate Actions	Startles	Spontaneous Smiles	Simulated Startles	Emotion Simulations
1	S	–	–	S	S
2	S	–	–	S	S
1+2	R	–	–	–	–
4	L	–	–	S	S
6	S	R	S	S	S
7	S	S	–	S	S
9	R	–	–	–	S
10	S	–	–	–	S
12	L	–	S	S	L
15	R	–	–	–	S
16	S	–	–	–	–
20	S[a]	S	–	S	S
21	–	S	–	S	–
45	S	S	–	S	–

Note.—Letters "R" and "L" denote right and left laterality $p<.05$ (two-tailed binomial). The letter "S" denotes no significant laterality.

[a]The AU in this condition showed a tendency ($p=.06$) for the right.

Laterality of Actions

Different Deliberate Actions. Table 6 summarizes laterality by individual AUs showing that asymmetries of some actions were lateralized, but others were not. AUs 4 (brow lowered) and 12 (smiling) were lateralized stronger on the left as predicted, but AUs 9 (nose wrinkle), and 15 (lip corners down), were lateralized right, disconfirming the prediction of left laterality for these actions. The combination of AUs 1+2 in the brow raise was also lateralized right, although the separate scores for AUs 1 (inner) and 2 (outer) suggested that AU 2 was primarily responsible for this effect. Lateralization was not evident for AUs 1, 6, 7, 6+7, 10, 16, and 45 (all tests were exact binomial, two-tailed).

To test the significance of AU as a variable in determining asymmetry scores, one-way repeated measures analysis of variance with AU as the independent variable was performed on the continuous asymmetry scores. Several ANOVAs of this design were calculated by changing the AUs included because missing data for some difficult to perform AUs lowered the valid N, sometimes to less than half the total N. All analyses included a Greenhouse-Geisser correction using the estimated Epsilon (Winer, 1971). The worst case analysis included all 12 different deliberate actions (AUs 1, 2, 1+2, 4, 6+7, 9, 10, 12, 15, 16, 20, 45) and was significant, $F(11/154) = 2.55$, $p<.05$ ($N = 15$). The other analyses showed stronger effects with smaller p levels, confirming that the variation of asymmetry scores across AUs was not chance.

Spontaneous Expressions. More smiles (AU 12) were stronger on the left than the right, but not significantly more, and squinting (AU 6) was largely symmetrical. The startles showed little asymmetry, and the only AU to show laterality was squinting (AU 6), which was stronger on the right.

Simulations. For startle simulations, the incidence of asymmetry was low, and there was no significant laterality. For actions in the six emotion simulations, the laterality of smiling (AU 12) was in the same direction as requested actions.

Laterality within Subjects across AUs

In addition to examining consistency in asymmetry across subjects for each Action Unit, we looked at the consistency within each subject across the actions measured. This approach addressed the issue of whether any particular subject had a bias for one side of her face. Only 5 of the 33 subjects showed such a consistent tendency, and it was not the same side across subjects.

Discussion

Does Specialization for Emotion Produce Facial Asymmetry?

The results of this study were not entirely consistent with any model of hemispheric specialization. Left lateralization of facial activity has been attributed to specialization of the right hemisphere for emotion (Borod & Caron, 1980; Schwartz et al., 1979). Spontaneous emotional and reflex movements as measured here were generally not found to be lateralized. Only action of orbicularis oculi in the startle showed lateralization, but the direction was opposite to that predicted by right hemispheric specialization for emotion.

This study might not have employed a measure sensitive enough to low levels of asymmetry or measured enough actions to detect significant tendencies for lateralization in the happy, startle, and simulation conditions. The study did, however, replicate the findings of Ekman et al. (1981) that there was less asymmetry in spontaneous than in deliberate actions. These findings indicate that factors producing asymmetry in deliberate movements are not related directly to positive emotional processes involving smiling, nor to processes giving rise to negative, reflex-like startle reactions. The finding that the asymmetry of smiles in simulated happy expressions was intermediate between spontaneous and deliberate smiles supports the hypothesis that asymmetry is a function of the extent to which movements are emotional vs. deliberate. Further research is needed on negative emotional expressions.

Dual specialization for emotion does not account for the opposite laterality of different actions. One dual specialization model is that the right hem-

isphere is specialized only for negative emotions, and the left, for positive emotions (Reuter-Lorenz & Davidson, 1981; Sackeim & Gur, 1978; Schwartz et al., 1979). It predicts that actions related to positive emotion would be lateralized stronger on the right while actions related to negative emotion would be lateralized left. The finding that deliberate actions of AU 12 (the smile involved in positive emotion) are lateralized stronger on the left is opposite to this theory's prediction for positive expressions, and the finding that spontaneous actions of AU 12 show only the same slight tendency lends no support to this position. The asymmetries of some deliberate actions (AUs 9 and 15), which are elements of negative emotion expressions (disgust and sadness), were significantly stronger on the right, not the left. The right stronger laterality of orbicularis oculis (AUs 6 and 7) in the startle also does not support this model because almost all subjects said it was an unpleasant experience.

Another model of dual specialization for emotion is that the right hemisphere is specialized for avoidance emotions and the left hemisphere, for approach emotions (see Davidson & Fox, 1982). Some deliberate actions often involved in approach emotions (e.g., AU 4 in anger; AU 12 in happiness) were lateralized stronger on the left, and others often involved in avoidance emotions (e.g., AU 9 in disgust) were lateralized right stronger. These relationships are the opposite to those suggested by this theory.

Because the pattern of asymmetry for both the spontaneous and deliberate facial actions studied here does not conform to predictions based on models of cerebral specialization for emotion, we reject hypotheses that attribute such asymmetry to lateralization of emotion. We cannot, however, reject models of cerebral specialization for emotion based on this evidence alone. Many of those concerned with emotional lateralization will not consider these findings a challenge because they have not considered the issue of asymmetry of facial expressions of emotion.

Do Facial Actions Show Right or Left Laterality?

Using a detailed visual measurement procedure, laterality was observed to depend upon the muscle measured. This evidence apparently contradicts reports about only left or only right laterality (e.g., Alford & Alford, 1981; Borod & Caron, 1980; Sackeim et al., 1978). These contradictions could be due to different measurements of asymmetry. For example, Sirota and Schwartz (1982) reported that EMG activity from the "zygomatic placement" of electrodes was greater on the right, but they pointed out that other muscles in the same area might have contributed to the activity recorded from this placement. In the study reported here, the action of the zygomatic major (AU 12) was lateralized stronger on the left, but other actions in this area of the face either were not lateralized or tended to be stronger on the right. Thus, this apparent discrepancy between studies might be explained by the relative imprecision of EMG for measuring specific muscles. Another difference is the practice of averaging EMG activity over many seconds while asymmetry was measured in this study at a particular moment. Despite measurement differences, the finding that deliberate actions of AU 4 (corrugator) were lateralized stronger on the left is consistent with Schwartz et al.'s (1979) finding that EMG from a corrugator placement was greater on the left during voluntary facial expression.

Different measurements might account for some inconsistencies between studies, but Ekman et al. (1981) used the same measure as this study and reported left laterality for deliberate actions. Their subjects, however, were much younger and included males. Alford (1983) reported that males had more facility moving the left side of their face than females. Also, Ekman et al. measured only a subset of the actions measured here, and their sample was too small to permit analysis of each action individually, except for zygomatic major actions (AU 12) which were lateralized stronger on the left. This finding was replicated strongly here.

What Can Explain Asymmetry of Facial Actions?

This study indicates inadequacies in models of hemispheric specialization for explaining asymmetry in facial actions. As discussed above, specialization for emotion cannot explain the results of this study. Since deliberate actions showed more asymmetry than spontaneous actions, the neural processes involved in the directed control of actions might be implicated. This study does not support the hypothesis that one hemisphere alone is specialized to direct facial actions, but Geschwind mentioned the possibility that the hemispheres might sometimes share control. No one neural process specialized in a single hemisphere can explain all asymmetry in facial actions if we assume that this specialization affects all actions the same way. Such specialization predicts consistent laterality, but in this study asymmetries of some actions were lateralized left and others, right. In addition, this specialization implies that individual subjects show consistent asymmetry for all actions, but few subjects did: most showed a mixture of left and right asymmetry.

There are several possible explanations for different laterality among actions. First, the assumption that the specialization of one hemisphere af-

fects the symmetry of all actions equally might be incorrect, perhaps because some actions are subject to different kinds of control. Ekman and Friesen (1975) have pointed out that the control of facial actions has several aspects. Even if control functions were lateralized in one hemisphere, different actions might show different laterality depending upon how they were typically controlled. For example, some actions might be inhibited more often and others might be put-on or intensified more often. Galin suggested (Ekman et al., 1981) that the right hemisphere is specialized for inhibiting or modulating emotional expression, rather than for emotion itself, and indeed, smiling and frowning are actions that appear in emotional expressions that are often controlled (e.g., feigning happiness and suppressing anger). Whether these actions, which showed left laterality, are controlled differently or more frequently than right lateralized actions is an issue for further research.

Other explanations of the differences in laterality between actions were found to be inadequate. The area of the face was not a factor because both left laterality and right laterality were found in the upper and the lower face. The possibility that some kind of emotional process entered into the process of deliberately making actions of smiling and brow lowering was rejected. This explanation implies that spontaneous actions of smiling would be lateralized, but they were not. Different frequencies of actions cannot explain different lateralities. Although there are no norms for the frequency of occurrence of actions, brow raising, which was lateralized right, is probably as common as brow lowering and smiling, which were lateralized left.

Sackeim and Gur (1983) suggested that a perceptual bias to favor one side of the face might influence our asymmetry scoring. Typically, such biases are small and are observed when stimulus presentation is restricted. Our scoring procedure emphasized repeated, intensive viewing of both sides of the face. If perceptual bias were a problem for our scoring, it would be difficult to explain why some actions showed left laterality, and others, right laterality. During training of coders, we used both normal and mirror-reversed video monitors without the scorer's knowledge. Comparisons of scores for normal and mirror-reversed faces did not reveal a perceptual bias effect.

Physical, structural characteristics that were not measured in this study might have affected asymmetry, but this possibility raises questions about the antecedents of lateralized structures. Little is known about the causes of asymmetry in structural tissues, but the action of nerves and muscles is an important factor influencing their size and strength and the growth and shape of bone. Hemispheric specialization might produce asymmetries in structural tissues. Peripheral asymmetries cannot entirely explain the results of this study because they are likely to affect all types of movement equally, but asymmetry of spontaneous actions was different from deliberate actions. These differences remained when intensity of contraction was controlled, one of Fridlund's (1984) "acceptance criteria."

Interpreting this study and others might be easier if we knew more about the neural pathways to facial muscles (see Rinn, 1984, for a review). Models relating hemispheric specialization to facial asymmetry often assume contralateral innervation, but the situation is more complicated for upper face muscles and, perhaps, for non-voluntary movements. How facial motor neurons are related to neural centers for activities that can co-occur with facial movements, such as speech, imagery, or body movements, is unknown; and the effects of alternative processes, such as inhibition, are unexplored. Likewise, the models of hemispheric specialization described here may be too crude to accurately predict facial asymmetry. Evidence for intra-hemispheric inhibition would add complexity to predicting facial asymmetry if, for example, motor centers are inhibited by specialized processes in other parts of the same hemisphere.

In summary, this study has shown that asymmetries of certain individual deliberate actions are lateralized, implying that the subjects have in common some functional asymmetry related to differential use of the hemispheres or some structural, anatomical asymmetry, or both asymmetries. The results, however, are inconsistent, at least in part, with all existing models that attempt to explain laterality in facial actions. Future research should explore the possibility that different methods measure different aspects of facial asymmetry, such as the more extreme excursion vs. the more electrically active. Second, the action of each muscle must be considered separately because muscles may typically serve different functions, such as talking vs. emotional expression, or be controlled in different ways, such as inhibition vs. intensification, or have different neural innervations, such as the brow vs. the lower face. Finally, the type of facial movement, such as spontaneous emotional vs. deliberate nonemotional, needs to be carefully specified and matched to the neural processes hypothesized to underlie asymmetry. Eliciting conditions that produce ambiguous types of actions will produce inconclusive results. It may be that asymmetry is produced by a complex interaction of different processes and variables or by factors that await discovery.

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Announcements

Assistant Professorship For Research in Psychophysiology

A faculty position is available in the Department of Psychology at Hiroshima-Shudo University, Hiroshima, Japan. The characteristics for the position are somewhat flexible, but a commitment for at least two years should be made. It is possible that the successful applicant could be tenured. Research would concentrate on electrical brain measures, but other psychophysiological variables are also studied. The position is planned to start in September 1985. Applicants should write to: F. J. McGuigan; P.O. Box 1153, Encinitas, CA 92024.

New Investigator Research Awards From NIAAA

The National Institute on Alcohol Abuse and Alcoholism (NIAAA) is soliciting applications from new investigators to perform basic and applied research on all biomedical and psychosocial apsects of alcoholism and alcohol-related health problems. The NIRA program is designed to help researchers develop their alcohol research interests and capabilities and also to help them bridge the transition from training to work as independent investigators. Some areas of NIAAA interest are: 1) biomedical and genetic research including the study of alcohol metabolism; 2) epidemiologic research including studies of drinking patterns and derived health consequences among different groups; 3) neuropharmacological research on the cellular and molecular basis of alcohol actions, 4) pathology-related research on the nature of alcohol-associated disorders, 5) prevention research including the study of prevention interventions and study of the influence of law and policy on the incidence and prevalence of alcohol problems, 6) psychosocial research including the social and cultural differences in alcohol consumption, and 7) treatment research such as the assessment of treatment outcome. An NIRA award is restricted to an individual who has not been a principal investigator on an NIAAA research project. The principal investigator must have finished his/her formal professional training and have had no more than 5 years of research experience since completion of training. Investigators new to alcohol research need meet only the criterion of no prior NIAAA support.

The program is continually open. Submission dates are July 1, November 1, and March 1, of each year. Further information may be obtained by requesting a full NIRA program announcement from the National Clearinghouse for Alcohol Information (NCALI), Box 2345, Rockville, MD 20852. Inquiries should be made to Dr. Helen Chao, Chief of the Biomedical Research Branch, or Dr. Ernestine Vanderveen, Chief of the Clinical and Psychosocial Research Branch, at the following address: Room 14C-17, Parklawn Building, 5600 Fishers Lane, Rockville, MD 20857 (301/443–4223).