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Asymmetries in facial actions

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Asymmetries in Facial Actions

by

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DISSERTATION

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ABSTRACT

Researchers have proposed several different models that invoke specialization of function of the right, the left, or both hemispheres to explain asymmetries in facial actions. Some models implicate specialization for emotion; others, for non-emotional processes such as perception of expressions. This study employed three major strategies for assessing the viability of these various models. First, asymmetry of individual muscular actions was measured to determine whether all show the same asymmetry, as some models imply. Second, several conditions elicited two major types of facial movement, deliberate and spontaneous, each subserved by different neural pathways. Differences between these two types of movement indicated whether models implicating emotional processes are tenable. Third, asymmetry of deliberate actions was measured in four ways: 1) which side of bilateral actions had stronger contractions, 2) which side could, on request, show a more unilateral action, 3) which side subjects preferred for unilateral actions, and 4) which side subjects rated easier for unilateral movement.

Laterality varied for different actions for measures 1 and 2. These results indicated that all asymmetry in facial actions is unlikely to be caused by specialization of a single hemisphere for one kind of process. Measures 3 and 4 showed only weak or no laterality.

Spontaneous actions involved in positive emotion and startle reflexes were generally more symmetrical than deliberate actions and rarely showed laterality. Lateralization

of deliberate actions, when observed, was mostly opposite to that predicted by theories of right hemispheric specialization for negative or avoidance emotions and left specialization for positive or approach emotions. These results indicated that asymmetry of deliberate actions is not caused by hypothesized laterality of emotion. Instead, evidence suggested that asymmetry was related to differentiated motor control on each side of the face.

Only half of the correlations between the four asymmetry measures for individual, deliberate actions were significantly positive and their magnitude was modest. These and other results suggested that although the measures tapped common variance, they did not always measure the same thing.

No single model fits all the results of this study, indicating the inadequacy of existing and the need for new conceptualizations.

INTRODUCTION

Researchers in various disciplines that study the face have found asymmetry in the action of facial muscles an important issue. Behavioral scientists have discussed whether asymmetry is one of the cues that send messages in social interaction (Darwin, 1872) and whether it is related to personality or constitution (Lynn & Lynn, 1938, 1943). In biology, researchers have considered whether asymmetry is related to genetic factors (Papadatos, Alexiou, Nicolopoulos, Mikropoulos, & Hadzigeorgiou, 1974) and the growth and development of the face (Thompson, 1943). Medical investigators have tried to use asymmetry in facial actions to locate the focus of brain lesions (Tschiassny, 1953; Remillard, Andermann, Rhi-sausi, & Robbins, 1977), and oral surgeons and dentists have included asymmetry as an objective of corrective treatments (Janzen, 1977).

Recently, this topic attracted considerable attention because it may be related to asymmetries in cerebral hemispheric function. Several studies have reported lateralized asymmetries in facial actions that were claimed to support this relationship. Some studies reported that asymmetries in facial action are lateralized so that the left side has greater electromyographic activity (Schwartz, Ahern, & Brown, 1979), has more intense expression (Sacheim, Gur, & Saucy, 1978), has stronger muscular contractions (Ekman, Hager, & Friesen, 1981), or has more frequent unilateral actions during conversation (Moscovitch & Olds, 1981). One explanation for these findings is that the nervous system functions asymmetrically to produce observable asymmetries in muscle action. Since neural connections between the cortex and the face are mostly crossed, the right hemisphere has been thought to play a special role involving the production of facial actions. Some researchers (Chaurasia & Goswami, 1975; Heller & Levy, 1981) theorized that the right hemisphere has this role because of its purportedly greater involvement in cognitive, non-verbal processes such as the recognition of faces or facial expressions (Benton, 1980). Others (Schwartz, et al., 1979; Sacheim et al., 1978) have pointed to the evidence that the right hemisphere has an important function in emotional processes (Ley & Bryden, in press). 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 researchers, however, did not clarify whether this role is limited to emotion expressions or applies to all facial actions, even though different types of movement have different neural pathways. This ambiguity was exacerbated by inadequately specifying what type of movements were studied, e.g., whether emotional or not (see below).

In apparent contradiction to left laterality in facial actions, other studies reported a greater facility in performing deliberate actions on the right side of the face (e.g., Alford & Alford, 1982; Kohara, Note 2) or that moving the right side of the face is subjectively more "natural" v

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(Alford, in press). These findings might indicate that the left hemisphere is specialized for producing facial actions.

Problems in Previous Asymmetry Research

These contradictory results may be due to serious problems in these studies (see Hager, 1982, for a review). First, most reports failed to distinguish adequately which of the many facial characteristics that manifest asymmetry, such as facial structure, permanent facial features, scars, blemishes, or muscular actions, were measured. This deficiency makes it difficult to know whether the results obtained can reasonably be attributed to nervous system activity, which has direct effects on the action of muscles, or to some other factor unrelated to muscle or neural activity. Second, the type of facial movement studied, such as deliberate imitative actions versus spontaneous emotional expressions, was often not adequately considered or specified. This issue is important because different types of facial movements have different neural substrates (e.g., Tschiassny, 1953). For example, deliberate facial actions are mediated by the classical pyramidal system or corticobulbar pathways. Spontaneous emotional movements, however, are mediated by other, non-pyramidal pathways. When discussing the implications of asymmetry for neural organization, as in hemispheric specialization, the types of movement and their associated neural pathways should be distinguished. Knowing which types of movement manifest asymmetry might also indicate whether a theory relating asymmetry to emotional processes or to processes which involve deliberative control of

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actions is more tenable.

To compound these problems, only one measure, unique to the researcher's program, was typically used to assess asymmetry. Thus, there is no evidence about the relation of different measures of asymmetry to each other. The discrepancy between reports in the literature of right versus left laterality could arise because each different measure tapped unrelated aspects of facial asymmetry. For example, the studies which showed right sided facial laterality examined unilateral muscular actions, but only one of the studies showing left sided laterality studied unilateral actions. Multiple measures of asymmetry are useful to weigh the validity of individual measures and to assess the degree to which asymmetry in facial function is a general characteristic or is a set of discrete, unrelated phenomena.

The study reported here attempted to clarify what factors are associated with asymmetry of facial actions by correcting the problems of previous studies. The major problems are: 1) lack of multiple measures of asymmetry, 2) failure to use well-defined, sensitive measures which can discriminate specific facial actions, 3) inadequate specification and isolation of the type of movement studied, such as spontaneous versus deliberate or emotional verses non-emotional.

Measures of Asymmetry

To remedy the lack of multiple measures of asymmetry, this study employed four measures of asymmetry in deliberate

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facial actions: which side of bilateral muscular actions had stronger contractions, which side was able to show a more purely unilateral action of the requested, specific muscles, which side subjects chose to use for unilateral actions when the side to move was not specified, and the side on which subjects rated unilateral actions easier to do. When discussing these measures, it is useful to distinguish between asymmetry and laterality. A particular measurement indicates whether an action is symmetrical or not. Laterality is indicated by a consistent, significant pattern of asymmetry across many measurements. Of course, there may be much asymmetry, but no consistent tendency for one side or the other, i.e., no laterality.

1. Bilateral Asymmetry

The first measure reflected asymmetry in the strength of contraction of bilateral actions. This measure was the basic measure of asymmetry used in this study. All the different types of movement examined in this study were scored with this measure, so comparisons of different types of actions were based on this measure. The other measures described below necessitated deliberate, requested unilateral facial actions and, thus, could not be applied to spontaneous actions or other expressions in the whole face. A problem with this measure is that the underlying processes it reflects are unclear. For example, previous researchers have assumed that a stronger contraction on one side of the face indicates that this side is better controlled, but there is little reason to assume this relation.

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2. Better Unilateral Control

The second measure assessed how much better one side could perform a unilateral action than the other. The better unilateral side was defined by whether the request for a right or a left unilateral movement showed greater asymmetry, i.e., was more nearly unilateral. Some researchers (Chaurasia and Goswami, 1975; Alford, in press) asked subjects to perform unilateral actions on each side of the face and rated how coordinated and controlled each movement was. These researchers attempted a more direct assessment of the control exerted over each side of the face rather than making inferences based on asymmetry in the intensity of actions, but their ratings were subjective, without explicit rules, and vulnerable to bias. Measurement of the better unilateral side was more objective in the study reported here. The better unilateral action was predicted to reflect better control over that side of the face. If so, the better unilateral action should be accompanied by fewer actions of unrequested muscles than a unilateral action on the poorer side. In addition, if the strength of contraction of actions is related to factors influencing their control, the better unilateral action should have a stronger contraction than the poorer unilateral.

3. Preferred Side

The third measure of asymmetry in facial function was identifying whether there was a side of the face that subjects preferred when making unilateral actions. This mea-

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sure is analogous to measures of hand, ear, eye, foot, or paw preference.

4. Side Rated Easier

The fourth measure was how much more difficult subjects rated making a unilateral action on one side than on the other. This measure can be interpreted as reflecting subjective estimation of control over unilateral actions, although subjects could have based their ratings on other criteria such as a preference or habit to use one side.

These four measures helped to show whether different aspects of asymmetry were part of a general pattern of asymmetry in facial function or whether there are different, unrelated aspects of asymmetry in facial action. The measures involving unilateral actions are likely to tap variance related to control of the action, so a strong relation of these measures to the measure of asymmetry in the strength of bilateral actions would indicate that this latter measure also reflects these control factors.

Facial Action Measurement

One of the most important features of this study was measuring the symmetry of each muscular action separately. This approach mitigated the problem, crippling in other techniques, of defining what features in the face are measured for asymmetry. Some studies of asymmetry in facial action (e.g., Sacheim et al., 1978; Campbell, 1978) had observers make judgments about the intensity of expressions on each side of the face, but whether observers were judging the intensity of muscular actions or some other asymmetrical

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characteristics was not clear, because physiognomic features, scars, hair style, lighting, blemishes, and many other characteristics could have made one side of the face different from the other and might have misled judges about the intensity of muscular action (see Hager, 1982, for a discussion). Even objective physical measurements of facial asymmetry are susceptible to this problem. EMG measurements, for example, are influenced by the amount and kind of tissue between the electrode and the muscle. The asymmetry scoring procedures used in this study minimized the influence of such extraneous factors on the measurement of actions and their intensity. A skilled facial scorer, trained to consider the effects of various characteristics on facial actions, can filter out these factors by comparing the appearances produced by the action to the inactive, baseline face.

The ability to distinguish individual muscular actions depended upon using Ekman and Friesen's Facial Action Coding System (FACS) (1976, 1978). FACS measures the visible action of facial muscles with "Action Units" (AUs) that indicate what muscles have contracted to produce the expression. Action units correspond to the anatomy of facial muscles, but rather than measuring every change in muscular action, they differentiate what skilled scorers can reliably discriminate when movements are inspected repeatedly in stopped and slowed motion. Using this technique, an expression can be decomposed into the elemental muscular actions that produced it. After identifying the particular AU to be scored with FACS, it is possible to determine whether or not there is asymmetry in the intensity of the action. Figure 1 (pg. 24-26) describes the Action Units (AUs) that were measured in this study and indicates the conditions in which they were typically elicited.

By enabling accurate measurement of individual muscular actions, FACS helps to alleviate other measurement problems. Some researchers have attempted to measure the symmetry of whole expressions (e.g., Borod & Caron, 1980), but this measure could be inaccurate or inefficient. For example, actions comprising an expression might manifest different degrees of asymmetry, as suggested by Ekman et al. (1981), or even have the greater intensity on opposite sides. These differences among actions might be masked by a summary score. Also, asymmetry of only one of several actions in the expression might not be detected when looking at the expression as a whole. If the actions that show more asymmetry were known, it could make scoring more efficient by concentrating on the more asymmetrical actions. Finally, researchers comparing asymmetry of different expressions, such as positive versus negative (Borod, Caron, & Koff, 1981), cannot determine whether differences obtained are due to the hedonic quality of expressions or simply to different muscles involved in them. Using surface electromyography (EMG) to measure the activity of facial actions also cannot precisely identify what muscles acted (see Ekman, 1982, and Hager & Ekman, 1983, for a discussion).

Deliberate versus Spontaneous or Emotional Actions

Finally, this study solved the remaining major problem of previous studies by carefully distinguishing different types of facial movements and comparing their asymmetry. Ekman (1980) hypothesized and Ekman et al. (1981) showed that the pattern of asymmetry in strength of contraction differed between spontaneous emotional and deliberate requested actions: deliberate smiling actions were more asymmetrical than spontaneous emotional smiles and deliberate actions were lateralized while spontaneous were not. This finding is important because these two types of movement correspond to different neural processes and bear on the two theories of the relation between asymmetry in facial actions and hemispheric specialization for emotion verses for deliberative, cognitive processes. In the present study, relatively pure samples of spontaneous and deliberate actions were obtained by using eliciting conditions that maximized the opportunity to observe only one type. In addition, samples of actions were obtained that mixed the types of actions. Previous studies used similar eliciting conditions so the inclusion of these actions allowed a point of comparison. These conditions were also included to test some ideas about the causes of asymmetry described below.

A relatively pure sample of deliberate actions was obtained by requesting the subject to perform specific facial actions. Performing some of these actions might have suggested an emotion expression, but making individual

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actions as requested is a task that minimizes the likelihood of producing an emotional experience. Requests for deliberate actions were made in two ways, verbally and visually. For verbal requests, the experimenter described each action with phrases such a "pull your upper lip up." For the visual requests, the subject saw each action performed on television and tried to imitate it without any verbal description or coaching. These two conditions were intended to maximize the differences in the kind of information processing that occurred with the facial actions. Translating the verbal requests into motor actions could have involved relatively more left hemispheric processing than imitating the visual, nonverbal stimuli. Examining actions in these two conditions checked the possibility that asymmetry might be affected by different processes that mediate the motor actions.

A relatively pure sample of spontaneous actions was obtained by creating conditions that would minimize the likelihood of reflection or deliberate control. One type of spontaneous action, the startle expression, was elicited by startling subjects with a loud noise. Another spontaneous action, smiling related to emotion, was elicited by a mildly amusing comment by the experimenter.

Conditions that attempted to produce a mixture of spontaneous and deliberate actions were created by two general strategies. First, subjects were asked to simulate six emotion expressions and a startle expression. The type of movement obtained in this task was more ambiguous because

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subjects could use at least two different strategies for producing the actions, one involving emotion and one not (Ekman, Roper, & Hager, 1980). Several previous studies of asymmetry have used such requests to elicit facial actions (e.g., Borod & Caron, 1980; Schwartz et al., 1979). A second approach was to manipulate the natural response to the startle noise. Subjects were told when two noises would occur and were asked to suppress their reaction to one of them. It was thought that the process of anticipating or inhibiting a startle reaction might introduce processes that would affect the symmetry of startle actions.

Hypotheses and Rationales

One hypothesis was that different muscular actions would show different patterns of lateralization. This prediction conflicts with models of the relation between hemispheric specialization and asymmetry of facial action that have implicated a single process and specialization of a single hemisphere as underlying asymmetry. Such models imply that all muscular actions have the same laterality. The methods researchers used to explore these ideas often reflected this assumption. For example, asymmetry of entire expressions was usually measured rather than that of individual muscular actions. Other models have hypothesized specialization of both hemispheres for different processes and predict that different actions might have varying laterality. This study attempted a partial test of these independent theories by measuring individual actions and compar-

ing the laterality observed. There were two empirical reasons for predicting laterality that depends upon the action. First, Ekman et al. (1981) found evidence that some actions showed less tendency to show laterality than others, but their samples were to small to be conclusive. Second, each of the studies that examined winking showed greater skill and/or preference for winking the right eye, and this result agrees with informal observation. Studies of other facial actions have usually found lateralization favoring the left side of the face.

Thus, a specific prediction was that deliberate facial actions that showed laterality would be lateralized left across subjects, except for actions related to blinking and winking, which should show right laterality. The preponderance of previous evidence, including the Ekman et al. (1981) study that used procedures similar to the present study's, suggested the prediction of left laterality (see Hager, 1982).

The second hypothesis was that the four measures of asymmetry would reflect the same underlying processes. If so, these measures should have significant positive intercorrelations and the same pattern of laterality for each action. Specifically, for all actions except winking and blinking, subjects should show greater strength of contraction on the left side of bilateral deliberate actions, prefer using the left side to make unilateral movements, rate the left side easier to move unilaterally, and show better unilateral actions on the left side.

The third hypothesis was that asymmetry in the strength of contraction of muscles would be related to measures of control over the action. This relation should be shown, in part, by the correlations between the bilateral asymmetry measure and the other measures of asymmetry, which more obviously tapped control factors. In addition, this relationship was predicted to be apparent in a more detailed analysis of better unilateral control scores. The unilateral action on the better unilateral side should be stronger than the unilateral action on the other side. Secondly, unilateral actions on the poorer unilateral side, as opposed to the better side, should be accompanied by stronger contractions on the side that is not supposed to move. Finally, the action on the better unilateral side should be accompanied by fewer unrequested actions than the action on the poorer unilateral side.

The fourth hypothesis was that the pattern of asymmetry would differ between spontaneous and deliberate actions in two ways. First, spontaneous actions would show less asymmetry than deliberate actions. Specifically, spontaneous smiles in response to the experimenter's humorous comment would be less asymmetrical than deliberate smiles, and actions in response to a startle noise would be less asymmetrical than when these same actions were deliberately performed individually. Second, spontaneous actions, unlike deliberate actions, were not expected to show laterality.

Related to the hypothesized differences in asymmetry between spontaneous and deliberate actions are predictions about conditions where these two types of actions were mixed, i.e., simulations of startle or emotions, and startle reactions where the subjects expected the noise. Since spontaneous and deliberate actions were thought to be mixed in simulations of startle and emotions, these actions were predicted to show fewer asymmetries and less laterality than deliberate actions, but more than spontaneous actions. Specifically, smiling actions in simulations were expected to be more asymmetrical than spontaneous smiles of amusement, but less asymmetrical than requested actions of individual muscles. Likewise, actions in simulations of startle were expected to be more asymmetrical than actions in genuine startle reactions, but less asymmetrical than the requested actions of individual muscles. Startle actions in the two conditions where subjects knew when the noise would occur were predicted to be more asymmetrical than actions in the unanticipated startle. This prediction bears on Ekman et al.'s (1981) proposition that more cognitive control and the involvement of higher nervous centers, rather than emotion, underlies asymmetry of facial actions.

The final hypothesis concerned the two modes of requesting individual deliberate actions, verbal and visual. Since viewing a model and imitating the action might have involved more right hemispheric activity than following the verbal instructions of the experimenter, visually requested actions were predicted to show more left-sided asymmetry.

The hypotheses described above are outlined below:

1. Different actions have different patterns of laterality.
   A. Some actions will be lateralized, others will not.
   B. Lateralized actions will usually favor the left, sometimes the right side.
      i. Actions involving winking or blinking will be lateralized favoring the right side.
      ii. All other lateralized actions will be lateralized left.
2. Different measures of asymmetry reflect common underlying processes.
   A. The measures will be positively correlated.
   B. Each measure will show the same pattern of laterality for each action.
3. Asymmetry in the strength of actions is related to control of the action.
   A. The unilateral action on the better side will contract more intensely than the unilateral action on the poorer side.
   B. The unilateral action on the poorer side will be accompanied by stronger contractions on the side that is supposed to remain still, as opposed to the better side.
   C. The unilateral action on the better side will be accompanied by fewer unrequested actions than the action on the poorer side.
4. The asymmetry of spontaneous versus deliberate actions will differ.

A. Deliberate actions will be more asymmetrical than spontaneous actions.

   i. Spontaneous smiles related to a humorous comment will be more symmetrical than requests for deliberate smiles.

   ii. Spontaneous actions elicited by a startling noise will be more symmetrical than requests for deliberate individual actions of these muscles.

B. Asymmetries of spontaneous actions will not be lateralized across subjects, unlike deliberate actions.

C. Asymmetry of actions in conditions that mixed spontaneous and deliberate types of movement will show asymmetry and laterality intermediate between actions from conditions that elicited relatively pure samples of these movement types.

   i. Actions in emotion and startle simulations will show less asymmetry than requests for deliberate, individual actions, but more asymmetry than spontaneous actions of these muscles.

   ii. Actions in startle conditions where subjects knew when the noise would occur would show more asymmetry than actions in the unanticipated startle.

5. Visually requested individual actions will show more left asymmetry than verbally requested actions.

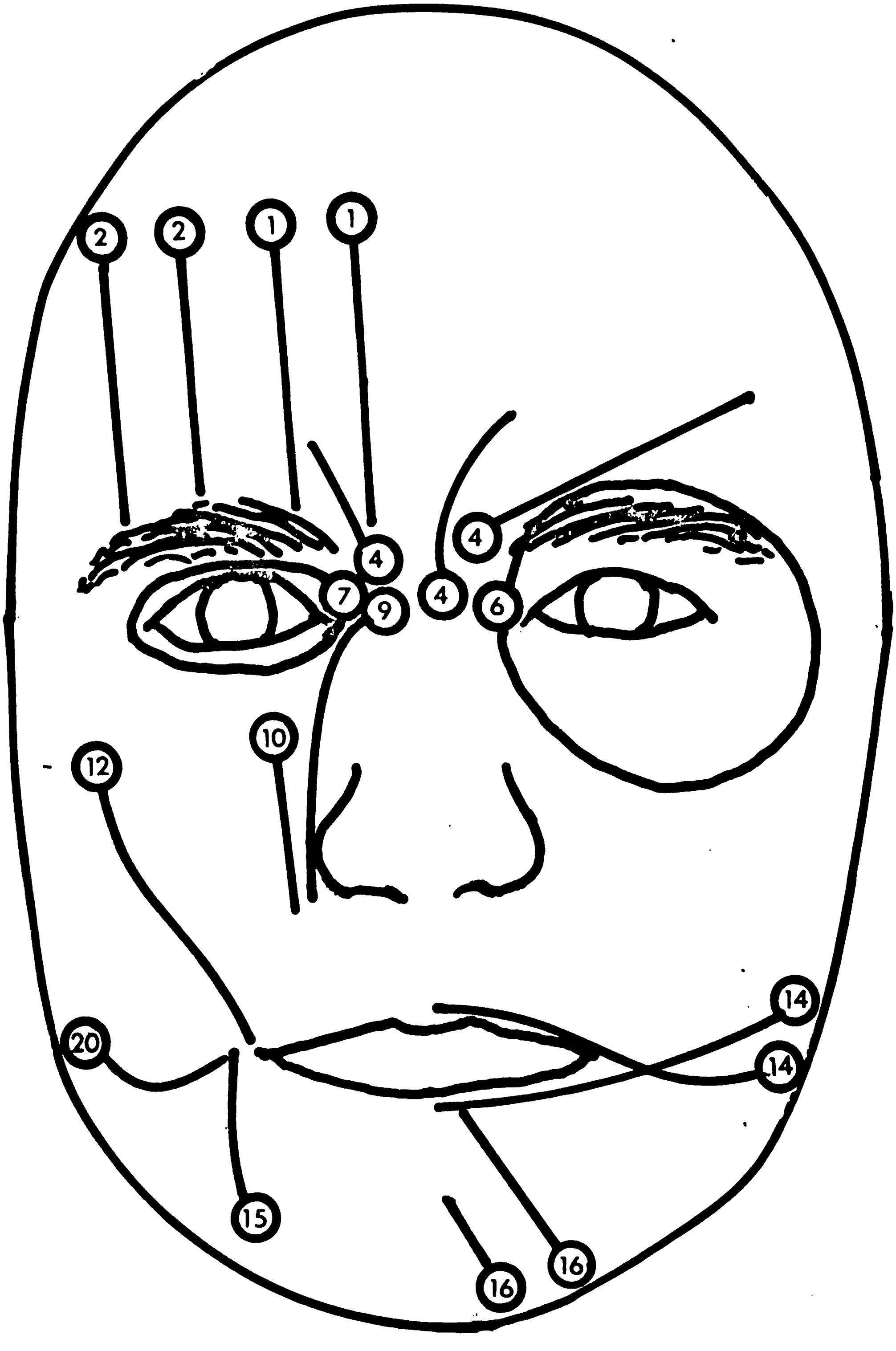
FIGURE 1

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 Unilateral actions
2	Outer frontalis	Raises outer corner of brow	Requested actions Startle simulations Emotion simulations Unilateral actions
1+2	Frontalis	Raises entire brow	Same as above
4	Corrugator Procerus	Lowers and pulls brows together	Requested actions Emotion simulations Unilateral actions
6	Orbicularis oculi, outer portion	Squints eyes, makes crowsfeet wrinkles	Requested actions Startle simulations Emotion simulations Startle actions Happy emotion action Unilateral actions
7	Orbicularis oculi, inner portion	Squints eyes, raises and straigh-tens lower lid	Requested actions Startle simulations Emotion simulations Startle actions Unilateral actions
9	Quadratus labii superioris, pars nasalis	Wrinkles nose	Requested actions Emotion simulations Unilateral actions
10	Quadratus labii superioris, pars labii	Raises upper lip	Requested actions Unilateral actions
12	Zygomatic major	Common smile	Requested actions Emotion simulations Happy emotion action Unilateral actions
14	Risorius	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 Unilateral actions
45	Orbicularis oculi	Blink or wink	Requested actions Startle simulations Startle actions Unilateral actions
80	Various neck and shoulder muscles	Shoulders up	Startle actions

FIGURE 1 (cont.)



NOTE: The diagram depicts schematically the actions of muscles measured in this study. Each circle identifies the actions and represents a relatively fixed point towards which the skin is pulled.

METHOD

Subjects

Although gender might be an important variable affecting symmetry of facial actions (e.g., Alford & Alford, 1981; Borod & Caron, 1980), only women were studied in order to keep the sample size managable. Previous studies (Ekman, et al., 1981) indicated that the size of laterality effects observed required about 30 subjects for significant trends to emerge. Because 30 subjects was a substantial number to score, the subject sample was restricted to one gender. Women were chosen because previous studies of facial laterality had focused on women (e.g., Ekman et al., 1981; Schwartz et al., 1979).

Participants were recruited for this study with bulletin board advertisements placed around campus. Of the 37 women who completed the final experimental procedure, only the 33 righthanded Caucasians were retained for scoring and analysis. This selection was intended to make the sample as homogeneous as possible because right- and left-handers differ on many measures of hemispheric activity. The sample ranged in age from 18 to 53 with a mean of 27.5 years. They were paid $15 for their hour of participation.

Equipment

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

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Friesen, & Simons, in press) have frequently used acoustic stimuli to elicit startles, in part because they are perhaps the most effective and reliable for eliciting the startle response, including facial expressions, and are relatively easy to administer. Although firing a starter's pistol has commonly been used, this stimulus was inappropriate for this study for two important reasons. First, the sound pressure level created by such shots in the laboratory varied widely and might have been a hazard to subjects' hearing (Simons, personal communication). Second, a pilot study suggested that asymmetry of facial actions might depend upon the direction of the noise from the subject. It would not have been easy to control the directional properties of a gunshot or other point source stimulus in a small experimental room where the subject could vary the position of her head.

To solve these problems, startle sounds were 80 msec bursts of white noise produced electronically, amplified, and transduced by headphones worn by the subject and an array of speakers stacked directly behind her (see Appendix S for details). Sound pressure level from the speaker and headphone combination was 125 dB and was balanced to within 1 dB on either side of the subjects head so that the sound appeared to come from the center of the head. This arrangement allowed the control of stimulus intensity and minimized the effects of slight differences in the position of the subject's head by creating a wide sound field and by using headphones that moved with the subject. The imposing speak-

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er arrays were hidden by a curtain in order to minimize any expectation about the magnitude of the stimulus.

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 questionaires. 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

Figure 2 (pg. 41) presents an outline of the experimental procedure that each subject completed individually. After a short, standard introduction, she gave consent and filled out the paper and pencil questionaires. These measures included a handedness questionaire (Johnstone, Galin, & Herron, 1979), an adjective self-rating scale (Veldman & Parker, 1970), the Social Desireability Scale (Crowne & Marlowe, 1964), and the Manifest Anxiety Scale (Taylor, 1953). The handedness questionaire was used to screen for right-handed subjects. The other measures were included to explore purported relations between asymmetry and personality and to check assertions that repression is the mediating variable in asymmetry (Schwartz, personal communication).

To summarize the startle part of the experiment, which was modeled after the procedure of Ekman et al. (in press), the subject simulated a startled expression twice and heard a loud noise in three different conditions. In the "unanticipated" condition the noise occurred unexpectedly. In the

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"anticipated" condition, the subject knew exactly when the noise would occur and reacted naturally. In the "inhibit" condition she knew exactly when the noise would occur and tried to act as though nothing had happened. Except for the "unanticipated" startle noise, each simulation or noise came after a countdown from ten to one. Between each noise was a five minute interview concerning her experience of the noise.

The first task was to make a startled expression at the tap of a pencil after the countdown. Ten seconds after making the simulated startle, she heard the unanticipated startle noise. During this interval, the experimenter attempted to shift her attention away from thinking about hearing a startle noise by asking her to help focus the camera by looking directly into the lens. This ploy not only minimized expectation of a noise, but also put her head in a good position for hearing the noise and for videotaping her response. No subject anticipated exactly when this noise would occur, even though all subjects knew that they would be startled sometime. The noise was completely unexpected for 24 subjects. The others thought the noise would occur sometime within the next few minutes of its actual occurrence. There were no differences between these two groups in the startle actions or their symmetry.

After the five minute interview, the subject heard the second noise, either in the anticipated or inhibit condition. These two conditions were counterbalanced across of

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subjects, but were not counterbalanced with the unanticipated startle because it became more difficult to elicit an unanticipated startle as the experiment proceded. After the interview following the third noise, the subject again simulated a startle expression at the tap of a pencil. By obtaining a simulated startle both before and after the startle noises, any changes consequent to a recent startle experience could be examined.

The next part of the experiment was a modified version of Ekman and Friesen's Requested Facial Action Test (REFACT) (Note 1). First, the subject simulated six emotions: happy, sad, fear, anger, surprise, and disgust. The experimenter then asked "Now that this is done, aren't you glad its over?" in order to elicit a more spontaneous smile. This comment played on the difference between pretending to show an emotion and actually feeling it, and it appeared when tension from the demands of the task was relieved, a condition conducive to eliciting happiness (Tomkins, 1963). Demand for a deliberate or social smile was minimized because the experimenter was behind a curtain and the subject was not in a face-to-face interaction. Afterwards, the subject filled out rating scales that assessed how the subject went about making these emotion expressions and how difficult the task was.

Next, eight facial movements were verbally requested: smile, raise eyebrows up, lower eyebrows and pull them together, blink, pull upper lip up, wrinkle nose, stretch lip corners straight to sides, and squint. After completing

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these verbally requested actions, the subject rated how difficult each was to do. Then, the subject imitated 17 facial movements shown on a television monitor. These movements had been recorded earlier and were performed by an expert in facial movement so that they precisely matched the Action Units (AUs) described in the Facial Action Coding System (Ekman & Friesen, 1978). These actions included: raise eyebrows (AU 1+2), wrinkle nose (AU 9), pull lower lip down (AU 16), raise lip corners up (AU 12), pull eyebrows down and together (AU 4), raise eyelids (AU 5), tighten eyelids (AU 7), push chin up (AU 17), press lips together (AU 24), raise upper lip (AU 10), lower lip corners (AU 15), tighten lip corners (AU 14), stretch lip corners to side (AU 20), raise inner corners of brow (AU 1), raise outer corners of brow (AU 2). No coaching or verbal descriptions of the actions were given in this visually requested action condition.

The final task was to make muscle actions on only one side of the face without moving the other side. The ten actions requested were the same eight as those verbally requested previously, plus raising the inner and outer corners of the eyebrow. No mention was made of which side should show the action, but if a subject asked, she was told it did not matter. In the final task, the subject performed the same unilateral actions again, except that she was instructed to do an action first on one side, then on the other. Which side was requested first was counterbalanced r

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Scoring Procedure

Scoring proceded in a series of steps, each completed before the next began. The first step was to score the five events in 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 AUs 6, 7, 20, 21, and 45, head movements, and shoulders and/or trunk up (see Figure 1). Following the scoring procedure of Ekman et al. (in press), any of these actions that began in the first 1/5th second after the noise were scored. Ekman et al. showed that this interval included the beginning of actions that comprise a characteristic startle response. In addition, idiosyncratic actions that were part of the startle response were also scored. Such actions were considered to be part of the startle if they onset before the end of the apex of AUs 6, 7, 20, or 21. In the simulate condition, AUs that began within 1/5th second of the onset of the first AU in the simulation were scored. Although actions in the simulation onset later than actions in the startle, the scoring interval included a distinct group of actions that onset at about the same time but excluded other actions that were apparently afterthoughts or signals to the experimenter. Each AU present in the simulation was identified and scored for asymmetry.

The second step in scoring was to score the verbally and visually requested facial actions in the same order as e

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requested. All eight verbal requests were scored, but only the visual requests for AUs 1, 2, 1+2, 4, 7, 9, 10, 12, 15, 16, and 20 were scored. AUs 5, 14, 17, 22, and 24 were requested but not scored because they were not scored in previous studies and omitting them saved scoring time. For both verbal and visual requests, each individual AU was scored separately. Sometimes, a subject performed a requested action many times, but only a maximum of four actions were scored. If the subject performed the requested action four or fewer times, all were scored. If the action was performed more than four times, the first, second, and the last two times were scored. Whether or not an unrequested action co-occurred with the requested action did not affect this selection procedure for scoring, but the co-occurance of unrequested AUs was noted. By scoring the first two and the last two times each requested AU appeared, a more reliable asymmetry score was obtained and any change with practice could be examined without scoring the many movements that sometimes were produced. Requested blinks were scored both for strength and timing as in the startle conditions.

The third step in the scoring procedure was to score the emotion simulations: Happy, Sad, Fear, Anger, Disgust, Surprise, and the response to the question: "Aren't you glad its done?" For each simulation, the subject said "Okay, I'm done" when she was finished. The expression scored for asymmetry was the one immediately prior to this statement because this expression was likely to be the one that the o

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subject thought was best and fulfilled the experimental instructions. To define the last expression, the scorer determined the AUs present just before the subject began to announce she was finished. Then, the onsets of these AUs were determined and the actions were scored for asymmetry as usual. Also scored for asymmetry were any actions that onset after the onset of the actions described above, but that offset before the end of the simulation.

The final step was to score the requests for unilateral actions. All requests were scored in the same order as requested in the experiment. Only the first action performed was included for analysis because this action was most likely to reveal the preferred side and the asymmetry present in actions that were not affected by recent practice. Only AUs that were correct actions for the AU requested were scored.

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 located the beginning and apex of the action and assessed how much appearances were changed by the action in this interval. These changes were the basis for assigning FACS intensity scores to each side of the face separately. Then, 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 of the action (a single video frame

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showing both sides at greatest intensity). A score was assigned to indicate whether the action was symmetrical or asymmetrical. If asymmetrical, the score indicated how great the difference in intensity was, guided by the FACS intensity scores previously assigned.

The asymmetry scores provided two levels of measurement that were used in the analysis of this study. One level was simply whether the action or subject was right, left, or symmetrical. The other was a continuous measure from extremely left to symmetrical to extremely right, similar to that of Lynn and Lynn (1943). Each of these measures were useful for describing different aspects of the results, and the continuous measure permitted more complex analyses than the categorical measure.

Reliability

Reliability of asymmetry scoring was given careful attention in this study even though the main coder was very experienced in scoring asymmetry of facial actions and had demonstrated reliability in a previous study (Ekman et al., 1981). The purpose of the reliability studies was to reconfirm reliability and to investigate the reliability of scores for different Action Units. A more detailed account of these studies is contained in Appendix R.

One important issue arising from the fact that the experimenter was also the main coder was whether knowledge of the hypotheses could have biased scoring. Several precautions were taken to avoid this problem. In many instances, the potential for bias was minimized by the scoring procedure. All the actions in one condition were scored separately from actions in other conditions rather than scoring all the actions of each subject at once. Conditions were scored at least a month apart, making it virtually impossible for the coder to remember how subjects had been scored in different conditions. Conditions with the most obvious and easily scored asymmetries, unilateral actions, were scored last so that obvious patterns of asymmetry would not influence other, more difficult scoring. Even when the opportunity for bias to influence results was present, many of these results were opposite to important hypotheses and other hypotheses were not confirmed. This fact, along with the reliability coefficients discussed below, indicates that bias was not an important factor in the results.

The other important issue in reliability was whether differences in the asymmetry of actions were accurately scored, i.e., could be discriminated by more than one coder. To summarize, reliability was established between the main coder and three other coders. The Pearson correlation for all the actions scored for reliability was 0.72 ($p < .0001$). This coefficient was for scoring by the main coder versus scoring by all three reliability coders. The actions were sampled from all conditions in the study and included a variety of representative AUs. Scoring reliability varied with the AU, ranging from modest (about .5) to high (about 0.8). Coders agreed that some AUs (e.g., AU 6) were harder to score than others (e.g., AU 12). Harder AUs generally had lower reliability. The difficulty in discriminating the asymmetry of some actions suggests that the measurement procedure might not have been sensitive enough to detect real differences in asymmetry for these actions, so results for these actions should be interpreted with appropriate caution.

Kappa was used to assess the reliability of category scores. Because hypotheses about categories concerned only the relative number of right and left asymmetries, a Kappa was calculated for only these two categories. Across all AUs and coders, this Kappa was .88 ($\underline{p}<.0001$) with 94 percent agreement. This coefficient indicates that when coders agreed that an action was asymmetrical, they almost always agreed about whether it was left or right. Reliability coders disagreed about whether an action was right or left on only two percent of all scores; almost all disagreements were about whether the action was symmetrical or not. The Kappa including the symmetrical category was .44 ($\underline{p}<.0001$) with 64 percent agreement.

In addition to reliability coefficients, the scores of different coders provided the opportunity to compare results of the experiment as seen by different people. There was virtually no difference in results based on scores of different coders. This analysis of reliability scoring duplicated many of the major analyses reported below and showed that reliability coders produced the same results as the main coder. This agreement about results indicates that disagreements among coders about scores did not affect the findings about the phenomena studied.

Measures in the Study

Once asymmetry had been measured for each individual action, scores used in the analysis were calculated. There were three different behavioral scores for deliberate, requested actions and a score based on subjects' ratings of unilateral movements. The "bilateral asymmetry" score reflects the asymmetry of bilateral requested actions and is simply the asymmetry score as described above or averages of these scores if there was more than one action in a given condition. This bilateral asymmetry score was also used to analyze movements in the simulated startle and emotion conditions and the spontaneous action conditions. The other scores were only applicable to deliberate movements.

"Better unilateral control" scores were derived by calculating the difference between asymmetry scores for unilateral actions requested first on one side, then on the other (see Appendix Y for details). Thus, better unilateral control scores tell how much more asymmetrical the unilateral action was on one side than on the other. "Preferred side" scores are simply the asymmetry scores for requests to move one side without moving the other. In these requests, the side moved was chosen by the subject, i.e., it was the side she preferred for making unilateral movements, and the asymmetry score indicated the side she chose. Sometimes, subjects could not perform the requested unilateral action d

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asymmetrically (i.e., the asymmetry score indicated symmetry). In such cases, preference could not be determined, and the subject was assigned to the "symmetrical" category. "Rated easier" scores were derived by calculating the difference between the subject's ratings of how easy it was to do the action unilaterally on each side of the face, providing a measure of how much easier one side was rated. Figure 3 (pg. 42) describes these four measures for easy reference.

FIGURE 2

OUTLINE OF STUDY

PROCEDURE:	TYPE OF MOVEMENT OBTAINED (ASYMMETRY MEASURE):
Paper and Pencil Questionaires	---
Startle Conditions:	
Simulate startle	Startle simulations
Unanticipated startle	Spontaneous Startle Actions
Anticipated startle	"
Counterbalanced	
Inhibit startle	"
Simulate startle	Startle simulations
Requested Facial Actions Test (REFACT) (modified)	
--Simulate Six Emotions	Emotion simulations
--Humorous Comment by Experimenter	Spontaneous positive emotion
--Questionaire about Performance of Simulations	---
--Verbal Request for Eight Facial Actions	Deliberate actions (Bilateral Asymmetry)
--Questionaire about Difficulty of Above Actions	---
--Imitate Videotape of 17 Facial Actions	Deliberate actions (Bilateral Asymmetry)
--Request for Ten Unilateral Actions	Deliberate Unilaterals (Preferred Side)
--Same Requests except on Each Side Separately with Ratings of Difficulty	Deliberate Unilaterals (Better Unilateral Control) (Rated Easier)

NOTE: Simulations of emotion and startle produce a mixture of types of movement.

FIGURE 3

ASYMMETRY MEASURES OF THIS STUDY

Measure	Derivation	Interpretation
Bilateral Asymmetry	Average of asymmetry scores for each AU elicited in specified condition.	Shows which side of bilateral actions had greater intensity of contraction and how much stronger it was.
Better Unilateral Control	Difference between the asymmetry scores for the right and left unilateral requested actions.	Defines the better unilateral action as the action that showed greater asymmetry and shows how much greater it was. (see Appendix Y)
Preferred Side	Asymmetry score for the requested unilateral action when subjects were free to choose which side to move.	Shows side which was preferred in making a unilateral action and how asymmetrical this action was.
Rated Easier	Difference between the ratings of how easy the right and left unilateral requested actions were to perform.	Shows how much easier it was to do a unilateral action on one side versus the other.

RESULTS

Deliberate Actions

Laterality of Deliberate Actions

Verbal versus Visual Tables 1 and 2 show the symmetry of subjects by category, right, left, and symmetrical, for each AU scored. Table 1 shows the symmetry of subjects for the verbally and visually requested actions separately and for these two conditions combined. Individual actions requested in both verbal and visual conditions (AUs 1+2, 4, 7, 9, 10, 12, 20) were combined and averaged together because there were no differences in asymmetry between these conditions. Correlations of asymmetry scores for the same AU in the two conditions were all significant. Patterns of correlations between either the verbal or the visual scores and the other scores described below were the same, although not necessarily at the same significance level. Combining scores for the same AU from the verbally and visually requested actions probably improved the sampling of bilateral requested actions to give a better estimate of the asymmetry of these actions. Table 2 shows the breakdown for these combined scores again and for the scores for "better unilateral control", "preferred side" and "rated easier" scores.

Laterality by AU Inspection of Tables 1 and 2 confirms the hypothesis that different muscle actions show different patterns of laterality. For three of the four measures in Table 2 (excepting the ratings), asymmetry of some actions was lateralized, while other actions showed little tendency for lateralization. For two of the asymmetry measures, bilateral asymmetry and better unilateral control, laterality of some AUs was opposite. For the bilateral asymmetry measure, nominally more AUs that were lateralized were stronger on the right than on the left, partially disconfirming the prediction of left lateralization for these actions. The asymmetry scores for requested bilateral movements in Table 1 indicate that AUs 4 (brow lowered) and 12 (smiling) were lateralized stronger on the left as predicted, but AUs 9 (nose wrinkle), 15 (lip corners down), and 20 (lip stretched to side) were lateralized right. The combination of 1+2 in the brow raise was also lateralized stronger on the right, although the separate scores for AUs 1 (inner) and 2 (outer) suggested that AU 2 was primarily responsible for this effect. The duration of eyes closed during the blink was also lateralized such that the right eye stayed closed longer, partially confirming the hypothesis of right laterality for actions related to blinking. Lateralization was not evident in bilateral asymmetry scores for AUs 1, 6, 7, 6+7, 10, 16, and 45 (strength of contraction during the blink).

Better unilateral control scores also showed laterality and, like bilateral asymmetry scores, laterality changed depending upon the action. Table 2 shows that the smile (AU 12) was lateralized with better actions on the left and the lip stretch (AU 20) tended in this direction. The brow raise (AUs 1+2) was lateralized with better actions on the right.

Table 2 shows that rated easier and preferred side scores are different from the other two measures in that no left laterality was observed. Nominally more subjects rated the right side easier than the left for nine of the ten actions, but none of these ratings for individual AUs showed significant laterality although AUs 2 (outer brow raise) and 4 (brow lowered) showed strong tendencies. Likewise, scores for the preferred unilateral movement showed that more subjects preferred moving their right than their left side for all AUs except for AUs 1 and 4 which showed a few more left than right subjects, but only two individual actions were significantly lateralized. Subjects preferred making brow raises (AUs 1+2) and winks (AU 45) significantly more often on the right and AU 2 tended in this direction.

To test the significance of AU as a variable in determining asymmetry scores, a one-way repeated measures analysis of variance with AU as the independent variable was performed four times, once for each asymmetry measure. The main effect of AU was was significant for the bilateral asymmetry scores, $\underline{F}(9,180)=3.61$, $\underline{p}<.001$, and better unilateral control scores, $\underline{F}(9,198)=2.41$, $\underline{p}<.02$, but not significant for the other two asymmetry scores.

The symmetry of actions did not change with repetitions of the requested actions. For each bilateral action requested by verbal or visual instruction, up to four occurrences (first and last two) were scored. All actions showed the same pattern as the totals in Table 3. Neither the ratio of left asymmetrical actions to total asymmetry or percentage asymmetry changed across repetitions of the action.

Relations among Asymmetry Measures

Evidence relevant to the hypothesis that the four measures of asymmetry reflect common underlying processes included: a) consistency about laterality between measures, b) correlations among measures, c) factor analysis of scores. First, the four measures generally showed the same pattern of laterality for any particular action in Table 2, as predicted. If there was a significant pattern of laterality for an AU for any measure, the other measures tended to show the same laterality, although this tendency may not have been significant. Table 4 summarizes the numbers of right versus left subjects for the actions measured by the four asymmetry measures. Inspection of Table 4 indicates possible inconsistency in laterality between two or more measures for AUs 4 (brow lowered), 9 (nose wrinkle), 12 (smiling), and 20 (lip stretch). To test the significance of these exceptions, McNemar tests showed the differences in the proportion of subjects who changed from left to right versus right to left. Table 5 lists the pairs of different asymmetry measures that had significant shifts in these proportions. For four of the five shifts, the direction was towards more right subjects in the ratings of difficulty or preferred side scores versus the other two measures.

Table 6 shows the Pearson correlations between continuous scores of the four asymmetry measures for each AU. Of the 60 correlations in Table 6, 31 are significant, and all significant correlations are positive. No single pattern of intercorrelations seems to apply to all the AUs in Table 6. Table 7 shows the number of significant correlations between each of the different asymmetry measures and the total number of significant correlations for each measure. Better unilateral scores have the largest number of significant intercorrelations with the other measures, and bilateral asymmetry scores have the fewest number of significant intercorrelations. Two possible explanation could account for this difference. It could be an artifact of the measures (e.g., unreliability, restricted ranges), or it could indicate differences between bilateral and unilateral movements since the measures of bilateral movements in Table 7 are the only measures that did not involve unilateral activity. This fact suggested that the unilateral measures tap specific variance different from the bilateral asymmetry measure. Factor analysis was used to examine this latter possibility.

With only 33 subjects, all 40 asymmetry scores for the individual actions could not be included in the factor analysis. Instead, scores were averaged across the ten AUs within each asymmetry measure to provide a score for total asymmetry as determined by each method. Since the combined bilateral asymmetry scores alone might not be expected to define a separate factor, the original verbal and visual scores were used in the first analysis. The principle components of these scores were extracted and factors with eigenvalues greater than 1 were rotated with the varimax technique. A second, similar analysis added the scores for actions during simulations of emotion (discussed below) to provide three scores for bilateral movements. Because different AUs have different patterns of asymmetry, only AUs that were scored with the four measures of asymmetry (the first ten actions listed in Table 4) were retained for the averages of the simulated scores.

Table 8 shows the loadings on rotated factors for the two analyses. In both cases, measures of unilateral actions and the ratings of unilateral difficulty loaded higher and together on a factor different from measures of bilateral actions. Notice that the preferred unilateral movements and the ratings were least related to the factors formed by the verbal and visual bilateral asymmetry scores, paralleling the low frequency of significant correlations between the respective variables. These analyses show that the three measures involving unilateral actions formed a large factor that accounted for about 40 percent of the variance in these measures which was distinct from the variance of bilateral measures, another 20 to 30 percent. Bilateral measures did not load on one factor when three scores for bilateral movements were included in the second analysis.

Relationship of Asymmetry for Different AUs

Different AUs, Same Measure Table 9 shows the significant correlations between scores for different AUs within each asymmetry measure. For each measure there were 45 correlations between different AUs, but only a small percenf

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tage of these were significant. In general, the asymmetry of particular AUs show a complex pattern of incorrelations. Significant intercorrelations were not random, but rather tended to occur predictably between certain groups of AUs. The groups of AUs generally were the same across the different asymmetry measures. These results and inspection of the correlation matrices suggested that there might be only a few factors contributing to the intercorrelations of asymmetry scores within each asymmetry measure. The principle components of scores were extracted for each set of asymmetry measures with mean substitution for missing values. The first three factors for each asymmetry measure were rotated with the varimax technique. Table 10 shows the loadings of scores on these rotated factors. These analyses showed that the three factors could account for about 60 percent of the variance of the ten individual scores for AUs. Although inspection of the factor loadings suggested good consistency between the factors for the preferred side and the rated easier scores, there was no apparent congruence between the factors for these two sets of scores and the factors for the other two sets.

Different AUs, Different Measures Table 11 shows the significant correlations between scores for different AUs as measured by each pair of the four asymmetry measures. For each pair of asymmetry measures, there were 90 different correlations between different AUs. The percentage of significant correlations was even less here than for the correlations within each asymmetry measure. Again, these inter-d

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correlations typically were predictable, occurring among certain groups of AUs that were the same groups that appeared within each asymmetry measure.

Unilateral Control and Strength of Contraction

More detailed examination of unilateral actions revealed that truly unilateral actions were infrequent (see Appendix Y); there was usually at least a trace of activity on the side of the face that was supposed to show no activity (the offside). For AUs in the lower face, the actions during unilateral requests were usually asymmetrical, with greater intensity on the side that was requested (the onside). For brow actions, however, most subjects could only make one side of their face have the greater intensity and could not reverse the asymmetry. Even so, these actions will continue to be called unilateral actions because they were elicited by requests for unilateral actions and this label will reduce confusion with the other kinds of actions obtained in this study.

In the discussion that follows, the "onside" of a unilateral action is the side that the subject was requested to make the action on. The "offside" is the other side, the one that the subject was not supposed to move (see Appendix Y for details). For example, in a request for a smile on the left side, the left side would be the onside, and the right side, the offside. Table 12 shows the relation between the better unilateral score for each AU and whether the right or left unilateral request had the greater onside r

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or offside intensity. An unequivocal pattern emerges from these figures. The side of the face that is better at making a unilateral action (defined by differences in asymmetry) contracts more intensely when that side is requested than the other side of the face contracts for a requested unilateral action on this poorer side. Conversely, during a unilateral action on the better side, the contraction on the other side is less intense than the contraction that occurs on the unrequested side during a request for unilateral action on the poorer side. To summarize, the onside contraction tends to be greater when unilateral actions are requested on the better side. The offside contraction tends to be greater when unilateral actions on the poorer side are requested.

Table 12 also shows the relation between the better unilateral action and the occurance of other, unrequested actions. For each AU requested, Table 12 shows whether unrequested actions occurred during the request for unilateral action on one side, but not for the request on the other. When no unrequested actions occurred for either unilateral requests or occurred for both unilateral requests, the events were dropped from further consideration. Although too few events remained for each AU singly, the totals show a clear pattern. As predicted, requested unilateral actions on the better side were more likely to be performed without unrequested actions than unilaterals on the poorer side.

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Laterality of Spontaneous Actions

Spontaneous Happy Expression

Most subjects smiled when hearing the question "Now that this is done, aren't you glad it's over?" at the end of the emotion simulations. Many of these smiles seemed to be genuine expressions of happiness or relief, but a few seemed tentative and forced as though to say "He's got to be kidding." Since there was no objective way to distinguish how emotional and spontaneous these smiles were, all were retained in the subsequent analysis. The problem of identifying spontaneous emotional movements is common to every eliciting circumstance, but any deliberate, controlled smiles retained would work against the hypothesis of a difference between spontaneous and deliberate actions. The distribution of asymmetry scores for these spontaneous smiles is given in Table 13. There were more AU 12s stronger on the left than the right, but not significantly more. AU 6 was largely symmetrical.

Spontaneous Startle Actions

Table 14 shows the distribution of symmetry scores for each AU and condition that had a startling noise. Two results are apparent: the incidence of asymmetry was low, and, second, the only AU to show lateralization was AU 6, which was stronger on the right.

Laterality of Mixed Deliberate and Spontaneous Actions

Startle Simulations

Table 15 shows the distribution of asymmetry scores for AUs that occurred frequently in the startle simulations.

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The incidence of asymmetry was low, and there was no significant lateralization. There were no differences in asymmetry between the two simulations.

Simulations of Emotions

Table 16 shows the symmetry categories of subjects for each emotion simulation (happy, sad, fear, anger, surprise, and disgust) and for each AU that was commonly observed in the simulated condition. Few AUs manifested significant laterality, but trends tended to be in the same direction as the asymmetry measures of deliberate actions in Tables 1, 2 and 4. Significant laterality in the number of left verses right subjects for AUs 2 and 12 was the same as the requested bilateral actions. Table 17 shows that the average asymmetry of actions in each emotion simulation was not significantly lateralized.

Table 18 shows the correlations between total scores for each AU in the simulate condition and the scores derived by the different asymmetry measures in Table 2. Simulations significantly correlated with the requested bilateral actions for AUs 1, 2 and 12 and with both better unilaterals and preferred side scores for AUs 9 and 10. This correlation is consistent with the expectation that deliberate actions are mixed with spontaneous actions in simulations.

The laterality of actions did not shift with increasing involvement of AUs in the simulated expression. It was possible that the more subjects involved themselves in simu-

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lating the expression, the more facial actions they would show. This involvement, perhaps indicating emotional processes, could be reflected in the symmetry of actions. For each simulation, Table 19 shows the frequency of right, left and symmetrical categories for certain AUs according to the number of other AUs in the simulation. The AUs tabulated in column 1 of Table 19 occurred frequently in different combinations with other AUs and showed variance in asymmetry. The table shows in column 2 what other actions were in the simulation and shows the number of other actions in column 3. The frequencies show no apparent change in the relative number of right versus left asymmetries with changes in the number of other AUs in the expression. However, the totals across these actions show that the proportion of asymmetrical actions apparently declined with increasing involvement of additional AUs. This result is consistent with the hypothesis that greater emotional involvement in simulations is associated with less asymmetry.

If asymmetry is related to emotional versus more deliberate processes as hypothesized by Ekman et al. (1981), then asymmetry of actions in simulations might be related to how much emotion was involved in producing them. Self-reported ratings of emotion experienced in each simulation were used as a measure of emotional involvement, although there was no reliability or validity data on them. These self reports were correlated with the total degree of asymmetry (ignoring whether right or left) summed across individual actions in each simulation. For happy simulations, the

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more asymmetrical the expression, the less emotion was experienced ($r = -.39$, $p < .03$), just as predicted. However, for fear simulations, the relationship was the opposite ($r = .54$, $p < .01$), and none of the other correlations were significant, clouding interpretation of these ambiguous results. These findings should be clarified by further research.

Differences in Asymmetry between Types of Movement

Table 20 shows significant differences in the degree of asymmetry for AUs that appeared in different conditions. Three different types of actions are represented in this experiment: spontaneous emotional or reflex actions, deliberate requested actions, and more ambiguous types of actions occurring when the subjects simulated expressions.

Spontaneous Actions versus Deliberate, Requested Actions

Absolute values of asymmetry scores were used as measures of degree of asymmetry, regardless of whether it was right or left. Wilcoxon signed-ranks tests showed that, as predicted, spontaneous actions were more symmetrical than deliberate actions. AU 12 in spontaneous happy expressions was more symmetrical than in requested actions ($z=4.53$, $p<.001$). AU 6 in spontaneous happy expressions was more symmetrical than the requested action of AU 6 ($z=2.42$, $p<.02$). AU 20 in the startle expressions was more symmetrical than requested actions of AU 20 ($z=3.19$, $p<.002$). AU 7 in startle expressions tended to be more symmetrical than requested actions of AU 7 ($z=1.69$, $p=.09$). The prediction

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was not confirmed for AUs 6, 45, and the eye closure measure between the startle and the requested actions, all showing no difference. AU 6 was unexpectedly more asymmetrical in the startle than in the spontaneous happy expression ($\underline{z}$=2.27, $\underline{p}$<.03).

These 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 since there was a range of intensity scores among the numerous deliberate actions. This analysis showed the same differences as the one based on averages of all actions shown.

Differences between Startle Conditions

Few differences between startle conditions where subjects heard a noise were found. Absolute values of asymmetry scores were used to explore differences in the degree of asymmetry regardless of whether the asymmetry was right or left. These values were averaged across AUs in each condition to provide a measure of total degree of asymmetry in each startle. Wilcoxon signed-ranks tests on these averages did not show any significantly different pairs of conditions. Signed-ranks tests on each AU separately showed a difference only for the eye closure measure between the unanticipated and anticipated condition ($\underline{p}$ < .05). Although the anticipated condition showed greater asymmetry as predicted, this difference could be attributed to chance since

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no other prediction about differences between conditions was confirmed.

Signed-ranks tests on the original asymmetry scores and on the averages of these scores were used to determine whether the amount of right or left asymmetry differed between conditions. No differences in the averages of asymmetry scores were found between conditions in Table 14. Looking at each AU individually showed that AU 7 shifted to the right in the inhibit condition from left in the unanticipated condition ($p < .05$). This result can easily be attributed to chance since there were 29 other comparisons that showed no significant differences.

Spontaneous Startle versus Startle Simulations

The same kinds of analyses as above were conducted for the two simulated startles versus the startles in response to a noise. The two simulations did not differ significantly in the actions that subjects produced, but the 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 real startles can be attributed to chance.

One reason why simulations did not differ from startles in asymmetry might be that the pencil tap was conducive to recruiting a partial startle. The sound pressure level of the tap was far too low to elicit a genuine startle, but the tap had some characteristics, such as a sharp onset, that

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might have helped subjects to simulate more than other alternatives, such as an experimenter's verbal prompt.

Mixed versus Spontaneous or Deliberate Actions

There were few significant differences in the degree of asymmetry between the mixed types of actions in the simulated expressions and either the spontaneous or deliberate actions. Spontaneous actions of AU 12 were more symmetrical than AU 12s in emotion simulations of happy (z=2.92, p<.004), which were, in turn, more symmetrical than deliberate actions of AU 12 (z = 6.66, p < .001). AU 20 in the startle tended to be more symmetrical than AU 20 in the emotion simulations (z=1.75, p<.08). As predicted, the degree of asymmetry of simulated actions was intermediate between spontaneous actions and the requested, deliberate actions, even when differences were not significant. Table 21 lists each subject's raw scores for AU 12 in three types of movement, deliberate (bilateral asymmetry), simulated, and spontaneous emotional.

Symmetry and Personality

Considerable effort was devoted to assessing the relation between asymmetry and personality. Some researchers have reported a relation between facial expression and repression (Notarius & Levenson, 1979), and Schwartz (personal communication) suggested that this variable may mediate lateralization of asymmetry in facial actions. Repressors were defined as subjects who scored below the median on the Taylor Manifest Anxiety Scale and above the median on the Social Desireablility Scale. True low anxious

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subjects were defined as those who scored below the median on the Anxiety Scale and below the median on social desireability (Weinberger, Schwartz, & Davidson, 1979). There were seven true low anxious subjects and eleven repressors so identified. The remaining subjects were classified as moderately anxious subjects. Many analyses were performed to detect differences between these groups, but they were virtually identical on all the asymmetry measures used in this study. Inspection of the distributions of left, right, and symmetrical categories of subjects showed no consistent differences. This lack of relation assures that the other findings of this study are not mediated by the repression variable.

The relations between personality variables and asymmetry were explored _post hoc_ with correlational techniques. These analyses produced little evidence that symmetry is related to any of the personality variables used in this study. Only about six percent of these correlations were significant, no more than might be expected by chance. Significant correlations that did occur were distributed equally across measures of asymmetry and personality with two isolated exceptions which, since they were not predicted, should not be interpreted until replicated. First, significant correlations between asymmetry scores and personality measures were disproportionately high for brow raises (AU 1+2) (Chi-Sq. = 12.7, $p < .001$). Second, the "ego-organization" scale of the Adjective Self-Rating Ques-

tionaire (Veldman & Parker, 1970) was related to asymmetry of brow raising (AU 1+2) for three of the four asymmetry measures (bilateral asymmetry, r = -.34, p = .05; better unilateral, r = -.35, p =.05; preferred side, r = -.37, p<.05). Further research on the relation between asymmetry and personality might profitably concentrate limited resources on measuring asymmetry in the brow area, ego-organization personality variables, and anxiety variables which were negatively related to ego-organization and showed scattered significant correlations with asymmetry.

Laterality within Subjects across AUs

Thus far, laterality has been examined in terms of the consistency in asymmetry across subjects for each Action Unit. Another way to look at the data from this study is to examine consistency within each subject across the actions measured. This approach addresses the issue of whether any particular subject has a bias for one side of her face, and, if so, is it the same side for different subjects. Table 22 shows the significant laterality manifested by individual subjects across AUs for each asymmetry measure. A maximum of eight actions was measured by the verbal bilateral asymmetry score, eleven by the visual bilateral asymmetry score, and ten by each of the other three measures. The cell entries indicate significant laterality for a given subject and score. Laterality was defined by a generous criterion of a difference between the number of right and left actions that had less than a one in ten chance of occurring randomly according to a two-tailed binomial test. A more stringent

criterion would have eliminated all but a few subjects from the analysis.

Inspection of Table 22 shows that few subjects manifested laterality. This result cannot be attributed merely to the criterion for laterality or to infrequent asymmetry because most subjects showed a mixture of left and right asymmetries for each measure. Except for the better unilateral control score, there is slightly more right laterality in Table 22, but not significantly more for any measure except preferred side which showed six right subjects and no left ($p < .05$, two-tailed binomial). In contrast to laterality across actions, the rated easier scores showed the most laterality while bilateral asymmetry scores showed the least.

DISCUSSION

Laterality of Different Action Units

Different actions showed different patterns of laterality and asymmetry. Analysis of variance on the continuous asymmetry scores showed a significant effect of AU for the bilateral asymmetry and better unilateral scores. Inspection of Tables 2 and 4 showed that AUs differed in the degree of asymmetry and the tendency to be lateralized. Some actions showed no tendency towards lateralization across subjects for any of the four measures. Laterality was evident ($p < .05$) for at least two of the individual actions in each of three of the asymmetry measures, excepting the ratings. For two of the measures, laterality of different AUs was opposite.

The prediction that laterality of deliberate actions, other than those related to blinking and winking, would be left was confirmed for some actions, disconfirmed for others. Bilateral asymmetry and better unilateral control scores showed that some actions were lateralized right while others manifested left laterality. The other two measures, preferred side and rated easier, showed a somewhat different pattern of laterality in that no individual Action Unit showed left laterality. These measures showed a weak tendency for right laterality, but they manifested less laterality than the bilateral asymmetry measure. Subjects significantly preferred moving the right side for two of the unilateral actions requested. Although nominally more subjects rated the right side easier to move for nine of ten actions f

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(except smiling, which was equal), no tendency for an individual action was significant.

The prediction that actions of winking and blinking would be lateralized right was partially confirmed in that the subjects preferred winking with their right eye, but the other measures showed little asymmetry for these actions. Similarly, in blinking bilaterally, subjects kept their right eye closed longer. The finding that the right eye is preferred for winking replicates the findings of two other studies (Kohara, Note 2; Alford & Alford, 1982), but the other three measures of winking and blinking in Table 5 showed little asymmetry.

The unexpected evidence for some right laterality in facial function apparently contradicts reports about only left laterality, such as that the left side showed more EMG activity (e.g., Schwartz et al., 1979), was better coordinated (Chaurasia & Goswami, 1975), or was more expressive (Sacheim et al., 1978; Borod & Caron, 1980). In most cases, these contradictions could be due to different measurements of asymmetry. The modest correlations between measures used in this study, which on their face seemed so similar, suggest that the disparate measures used in previous studies may be even less related. Also, most measures employed previously have had serious limitations. As discussed in the introduction, ratings of which unilateral movement is more coordinated have appeared vulnerable to bias, especially with no explicit scoring rules. Similarly, judges' ratings of the intensity of expressions may be spuriously influenced by cues besides muscle actions, and are unlikely to reflect accurately the intensity of actions.

As an example of how results might differ because of differences in measures, consider the findings of this study about the asymmetry of deliberate smiles versus those of a study that employed EMG measurements. AU 12 (smiling action of zygomatic major) was lateralized stronger on the left in this study, but Sirota and Schwartz (1982) reported that EMG activity from the "zygomatic placement" of electrodes was lateralized greater on the right. EMG cannot precisely identify what muscle has acted, and they admitted that other muscles in the same area might have contributed to the activity recorded from this placement. Much of the muscular activity in this area of the face either was not lateralized or tended to be stronger on the right as measured in this study . Thus, this apparent discrepancy between studies might be explained by the lack of precision about the muscles measured by EMG. Another difference is the practice of averaging EMG activity over many seconds while asymmetry was measured in this study at a particular moment (apex of action).

Although different measures might account for some contradictions between studies, Ekman et al. (1981) used the same bilateral asymmetry measure as in this study and reported left laterality for deliberate actions. Their subjects, however, were much younger and included males rather than only females. Alford (in press) reported that males had more facility with the left side of their face than females. Also, the actions measured in the Ekman et al. study were only a subset of those measured here and the sample of all but one action was too small to permit analysis of each individually. Ekman et al. had a large sample of zygomatic major actions (AU 12) which they reported as lateralized stronger on the left side. This finding was replicated strongly here.

This study partially supported claims that the right side of the face was preferred in unilateral actions. The finding that subjects preferred moving the right side for two unilateral actions corroborated Alford's report (in press) that subjects generally found moving the right side of their face "more natural." On the other hand, the lack of laterality in ratings and most of the preferred side scores indicates that this effect is weak or largely absent.

Relations among Measures of Asymmetry

Conceptually, scores indicating the side of the face with a more intense bilateral action, the side that performs a unilateral action better, the side that subjects prefer for making unilateral actions, and the side rated easier to move unilaterally each took a somewhat different view of asymmetry in facial function. Intercorrelation of these four measures of deliberate facial actions showed that the different conceptual aspects of asymmetry were partially related. All the significant correlations among these asymmetry measures were positive, indicating that the separate measurements reflected some common variance rather than isolated phenomena. On the other hand, only half the intercorrelations were significant, and the magnitudes of significant correlations were modest. Artifactual problems, such as weaknesses in the measurements and low score variance, could have limited their magnitude, but these results were indications that the four measures might tap different factors affecting asymmetry.

Ratings of the side easier to move and scores indicating the side subjects preferred for unilateral actions were similar measures. Averages of ratings and preferred side scores loaded highly on a factor with the average better unilateral score (Table 8). Factor analysis of scores for individual actions within each asymmetry measure showed that factors for ratings and the preferred side were similar to each other, but different from the other measures (Table 10). These results and the significant correlations between these two measures (Table 6) suggest that they tap the same set of variables.

Scores for the side with the better unilateral action were similar to rated easier and preferred side scores. The average better unilateral score loaded on the same factor as averages of ratings and preferred side scores (Table 8) and usually correlated significantly with these measures (Table 7). Better unilateral scores also measured some variance in common with the bilateral asymmetry scores as shown by the patterns of correlations (Table 6). Factors of individual scores within the better unilateral and bilateral asymmetry measures were different from each other and from the other two measures (Table 10). Disparity between measures was greatest for bilateral asymmetry scores compared with rated easier and preferred side scores because these measures had the fewest number of significant correlations and showed the least similarity in factor analysis. Like measures of facial asymmetry, measures of handedness also show varying degrees of intercorrelation (Johnstone et al., 1979).

Although preferred side and rated easier scores were very similar to each other, they have the most dubious value for assessing asymmetry in facial function. As discussed below, these two measures showed the least tendency towards laterality, and rated easier scores consistently showed the least asymmetry, as though subjects were not sensitive to differences in difficulty. On the other hand, the bilateral asymmetry score showed the most lateralized individual actions, and it is applicable to any facial behavior that can be adequately recorded, rather than only deliberate, requested actions. The better unilateral score appeared to tap variance that overlapped most with all three of the other measures, but it showed only modest laterality.

Asymmetry of Facial Actions and Hemispheric Specialization

The asymmetry of actions measured in this study highlights the inadequacies of several models of hemispheric specialization for explaining asymmetry and laterality of facial actions. One shortcoming is relying solely on the specialization of one process in a single hemisphere to

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explain asymmetry in facial actions. Another problem is attributing asymmetry to emotional processes. For both the bilateral asymmetry and better unilateral measures, asymmetries of some actions were lateralized left while others were lateralized right. This finding compels the conclusion that one kind of specialization in a single hemisphere cannot be the only factor that produces asymmetries in facial actions, given the assumption that such specialization would affect all actions the same way. Other evidence corroborates this conclusion. Specialization for one kind of process in a single hemisphere implies that a given individual subject would show the same asymmetry for all actions, but most subjects showed a mixture of left and right asymmetry that changed with the AU, and few subjects showed laterality except in self-report ratings. This pattern was evident for each of the four asymmetry measures.

Specialization for Emotion

Researchers who have found left lateralization of facial activity have speculated that specialization of the right hemisphere produced it. Some have hypothesized that the right hemisphere is specialized for emotion and that this asymmetry affects the symmetry of facial actions (Schwartz et al., 1979; Borod & Caron, 1980). Spontaneous emotional and reflex movements studied here were usually not lateralized, replicating the results of Ekman et al. (1981). Only action of orbicularis oculi in the startle showed lateralization, but the direction was opposite to that predicted by right hemispheric specialization for emotion. It is possible that this study did not measure enough spontaneous actions to detect significant tendencies for lateralization, but it did replicate the findings of Ekman et al. (1981) that there was generally less asymmetry in spontaneous than in deliberate actions. These findings suggest that at least some of the factors that produce asymmetry and laterality in deliberate movements are not related directly to emotional processes, at least for positive emotions involving smiling, nor to processes giving rise to negative, reflex-like startle reactions. Further research is needed to determine whether this pattern holds for negative emotions.

It might be possible to explain the opposite laterality of different actions with some type of dual specialization where some actions are affected by the activity of one hemisphere while other actions are affected by the other hemisphere. Some researchers who have proposed hemispheric specialization for emotion have argued that the right hemisphere is specialized only for negative emotions, but the left is specialized for positive emotions (Schwartz et al., 1979; Reuter-Lorenz & Davidson, 1981; Sacheim & Gur, 1978). This theory 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 significantly 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 non-significant tendency lends no support to this position. The asymmetry of some deliberate actions (AUs 9, 15, and 20) which are often found in negative emotion expressions were significantly stronger on the right rather than on the left as their theory predicts for negative facial expressions. The right stronger laterality of orbicularis oculis (AUs 6 and 7) in the startle also does not support this model. While there is some dispute about whether startle is an emotion, almost all subjects said it was an unpleasant experience whether or not they knew when the noise would occur. However, subjects might have reported their negative expressions based on subsequent reactions to the startle reflex rather than the startle itself so whether the startle expression is negative is not certain.

A variant of this dual specialization for emotion theory is that the right hemisphere is specialized for avoidance emotions while the left hemisphere is specialized for approach emotions (Davidson & Fox, 1982). In this study, deliberate actions often involved in approach emotions (e.g., AU 4 in anger; AU 12 in happiness) were lateralized stronger on the left, and those often involved in avoidance emotions (e.g., AU 9 in disgust; AU 20 in fear) were lateralized right stronger. These relations are the opposite to those predicted for facial expressions by this theory. Again, these results indicate that asymmetry in deliberate actions or spontaneous smiling is not produced directly by the processes described by these theories of emotion and facial expression.

Specialization for Control of Actions

Some researchers have argued that rather than reflecting emotion, left lateralization of facial activity indicates that the right hemisphere is specialized to direct facial actions (Chaurasia & Goswami, 1975; Heller & Levy, 1981). They assumed without evidence that greater intensity on one side of a facial action indicates greater neural motor control over that side and, therefore, contralateral hemispheric specialization for controlling actions. The study presented here established relationships between the control of actions and asymmetry in their intensity. First, asymmetries in intensities of bilateral actions were generally related to measures of control over actions, i.e., which side had a better unilateral action, was preferred in making a unilateral action, and was rated easier to move. Second, in making unilateral actions, subjects were required to control intensity to augment movement on the onside (side where movement was requested) and minimize movement on the offside (side where movement was not to appear). Onside intensity was greater when the side that performed the better unilateral action was requested than when the poorer side was requested. This finding supports the notion that better control of an action is associated with greater intensity, at least on the side where movement is requested in unilateral actions. Conversely, offside intensities were

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greater when the poorer side was requested. This finding indicates that poorer control of an action is associated with greater intensity where the action is not supposed to appear. The finding that fewer unrequested actions occur with better than with poorer unilateral actions corroborates the assertion that this measure reflects subjects' ability to control facial actions.

Although this study supported a relation between intensity and control of an action, it did not support the hypothesis that the right hemisphere is specialized to direct facial actions. Looking across all the measurements in Tables 1, 2, and 4, more lateralization of deliberate actions was right than left, suggesting that if any hemisphere specializes in controlling facial actions, it might well be the left.

Although specialization for controlling facial actions might be one factor influencing asymmetry, one model of hemispheric control is ruled out by the relation between the offside intensity and the better unilateral action. If one hemisphere simply is better at directing the action, then we would expect the offside intensity to be greater when the better side does a unilateral action because the nonspecialized hemisphere is less able to keep the offside still. The opposite relation was found, which suggests that the offside intensities are determined by which hemisphere can inhibit the other's activity better.

Geschwind (1965, 1975) proposed a model of hemispheric specialization for control of facial actions that comes b

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closest to fitting these findings. By studying facial apraxias, Geschwind inferred that a neural center in the left temporal lobe typically sends messages about making movements to the left precentral motor cortex, which controls facial movements on both sides. Geschwind 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. This model is compatible with the findings that laterality in this study was mostly right, but changed to the left depending upon the AU and the measurement. Geschwind did not indicate that hemispheric specialization could be observed in the normal actions of non-patients, nor did he indicate whether the left hemisphere typically inhibits any control the right hemisphere might attempt to exert.

Left hemispheric specialization for controlling deliberate facial actions can account for right facial laterality, but cannot obviously explain why actions of AUs 4 and 12 were lateralized left stronger. There are several possible explanations for the difference in laterality among actions. First, the right hemisphere could be specialized to control the actions that were lateralized left stronger. It is difficult to explain with this hypothesis why the rated easier and preferred side scores did not show the same differences among actions as the other two scores, unless the measures were insensitive. Second, the assumption that the specialization of one hemisphere affects 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 components. It is possible that control is different depending upon the action. For example, some actions might be inhibited more often and others might be put-on or intensified more often. Even if control were lateralized in one hemisphere, different actions might show different laterality depending upon how they were typically controlled.

Other explanations of the differences in laterality between actions were found to be inadequate. The area of the face was not a factor since both left and right laterality was 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. First, this explanation implies that spontaneous actions of smiling would be lateralized, but they were not. Second, many actions that were lateralized right are involved in emotions that are probably as common as those in which smiling and brow lowering are found. How common the action is for other functions besides emotion also seems inadequate. Although there are no norms available for the frequency of occurance of actions, brow raising, which was lateralized right, is probably as common as brow lowering and smiling, which were lateralized left. Galin has suggested (personal communication) that the right hemisphere is specialized for inhibiting or modulating emotion expression, rather than for emotion itself. Smiling (AU 12) and frowning (AU 4) are actions that appear in emotion expressions that are often controlled (e.g., feigning happiness or masking with a smile and anger, respectively). Whether these expressions and actions are more commonly controlled than others is an issue for further research.

The point of this speculation is that more sophisticated ideas about the causes of facial asymmetry are required to explain the difference in laterality between actions. The results do not support theories about right hemispheric specialization for emotion or controlling facial actions, nor more complex theories about one hemisphere specialized for positive or approach emotions and the other for negative or avoidance emotions. Geschwind's theory about typical left hemispheric control of facial movements is the model of hemispheric specialization most compatible with the results, but what conditions make control shift to the right hemisphere and how this switch is related to the actions of AUs 4 and 12 need to be clarified.

Other Possible Causes of Asymmetry in Facial Actions

Verbal vs. Visual Processes

There was no evidence in this study that asymmetries of actions were mediated differently by verbal versus visual processes. Evidence from brain-damaged patients suggests that neural organization for processing verbal requests is different from processing nonverbal information (Geschwind,

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1965). No difference in the laterality of actions that were verbally versus visually requested was detected, and these scores were significantly correlated. These results suggest that it does not make any difference in the asymmetry measured here whether actions are mediated by verbal or nonverbal requests.

Structural Asymmetry

Some evidence indicated that one of the factors affecting asymmetry might have been physical, structural characteristics. First, asymmetry scores for different actions tended to be unrelated except for certain clusters of actions which could be seen in correlation matrices and factor analyses. Many of these relationships reflected the anatomy of the muscles and nerves underlying different actions. For example, scores for AU 1, 2 and 1+2 tended to be related (Table 9 and 11) and to load on the same factor (Table 10). AUs 1 and 2 are the inner and outer strands of the same muscle (frontalis) and AU 1+2 is the brow raise action of both these strands. Likewise, the correlation of AUs 9 and 10 might be attributed to their being different heads of the same muscle (levator labii superioris).

Another finding suggesting a physical, structural basis for asymmetry was the analysis of the action's intensity on each side of the face during unilateral actions (Table 12). The onside intensity was greater when the side with the better unilateral was requested, and the offside intensity was greater for the request for the poorer side. In other words, when comparing either onside or offside intensities, m

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intensity was less on the poorer side of the face. The consistent tendency for one side to have weaker contractions might be attributed to a structural factor.

Unilateral movements also might have reflected known anatomical differences between the innervation of the brow versus the lower two thirds of the face (Thompson, 1982). As discussed in Appendix Y, most subjects could produce asymmetrical actions of lower face muscles with greater intensity on either side of the face (Table Y1). Few subjects could do the same for brow actions. This pattern might be related to the largely crossed corticobulbar pathways to the lower face, versus the greater bilateral innervation in the upper third of the face.

The possibility that peripheral factors influence asymmetry raises interesting questions about the antecedents of the asymmetry of structural components and why they are lateralized. Little is known about the causes of asymmetry in structural tissues, but the action of muscles is an important factor influencing their own size and strength as well as the growth and shape of bone. Asymmetries in the action of muscles might produce asymmetries in structural tissues. This relation could explain why there is more laterality in measures of normal, bilateral muscle action than in preferred side scores and ratings. The effects of weak laterality in the use of muscles could have accumulated over the years to yield a more marked laterality in structural tissue. Bilateral asymmetry scores would be influenced more by these factors than ratings of difficulty if the structural asymmetries do not affect a subject's evaluation. In other words, an observer who compares intensity on each side might see more asymmetry than the subject feels.

Peripheral factors such as structural asymmetries can not explain the entire pattern of results in this study. First, such factors alone do not explain why some actions are lateralized right, some left, although different structural factors might affect each separate action differently. Second, peripheral factors are likely to affect all types of movement equally, but asymmetry of spontaneous actions was different than deliberate actions. Exactly what structural properties are contributing to laterality and how well they can account for the laterality in preferred side and rated easier scores also need clarification.

Opposite laterality for different AUs might be explained by structural factors opposing the effect of specialization of one hemisphere and shifting laterality of some deliberate actions. This explanation, however, is inconsistent with the possibility that hemispheric specialization causes structural asymmetry. Also, structural asymmetries such as sizes of muscles, should be reflected in the symmetry of spontaneous actions, but they were not as spontaneous actions generally showed little asymmetry and no laterality. It is possible that spontaneous actions might, contrary to expectation, not reflect asymmetries in structural factors that affect deliberate actions. This could happen, for example, if there were differences between the neural impulses involved in spontaneous versus deliberate actions that interact with structural characteristics to reduce the asymmetry of spontaneous compared to deliberate actions. Although such interactions are hypothetical, spontaneous emotional actions have different neural substrates than deliberate actions. These differences might not be limited to neural pathways, but could include differences in the ratio of crossed versus uncrossed connections, rates or sequences of motor unit firing, etc. If so, asymmetries in the intensity of actions caused by structural asymmetries might be reduced in spontaneous actions by the effects of different neural activity.

Emotional vs. Cognitive Activity

The finding that spontaneous actions were generally more symmetrical than deliberate actions corroborated the results of Ekman et al. (1981) who found this relation for the smiling action (AU 12). They speculated that the greater involvement of cortical processes in deliberate actions as opposed to emotional actions could have induced a greater degree of asymmetry. This hypothesis was tested by seeing whether the average degree of asymmetry during simulations of each emotion was related to how much emotion the subject felt during the simulation. The hypothesis was confirmed for the happy simulation, but was the opposite for the fear simulation.

This same idea suggested the prediction that actions in the unanticipated startle might be more symmetrical than actions in the other startle conditions because anticipating the noise or trying to inhibit it might involve more cognitive processes. The finding that there were no differences among conditions indicates that whatever subjects thought or did during these startles did not affect the symmetry of their actions and suggests that the symmetry of the startle pattern is not very vulnerable to modification.

The disconfirmation of this prediction is not strong evidence against the hypothesis that cognitive processes account for the difference in asymmetry between emotional and deliberate actions for two reasons. First, Ekman et al. (in press) have presented evidence that the startle reaction is unlike emotional expression. Thus, startles may not have the same neural substrates nor reflect the same asymmetry patterns as emotion expression. Second, deliberately producing actions may involve different neural processes from reacting naturally to actions elicited by a reflex or trying to inhibit these actions, as subjects did in the anticipate and inhibit startle conditions. Further research is needed to clarify what factors underlie the difference in asymmetry between spontaneous and deliberate actions.

Need for Better Concepts

In summary, this study has shown that the asymmetry of certain deliberate actions is consistent across individuals in this sample of women subjects. This consistency implies that the subjects have in common some functional asymmetry related to differential use of the hemispheres or some structural, anatomical asymmetry or both kinds of asymmetry. Evidence from this study indicated that although the specialization of a single hemisphere for one kind of process might explain some asymmetry and laterality of facial actions, it cannot be the only factor. Laterality might differ among actions because both hemispheres are specialized, but too little evidence is available that can clarify how this dual specialization might work. There was no evidence that asymmetry is a mere by-product of whether the actions are mediated by verbal or visual requests.

Physical, structural asymmetries in nerves, muscles, or other tissues can account for some patterns of asymmetry and differences in laterality among actions, but the cause of such structural lateralization calls out for explanation. Differential use of the hemispheres in motor actions is one explanation. Structural asymmetries cannot be the whole story either because all types of movement should reflect this asymmetry, but spontaneous actions did not show the same pattern of asymmetry as deliberate actions. Why the pattern of asymmetry differs between spontaneous and deliberate actions is not yet clear.

With so many factors that could affect observed asymmetry in the face, it seems reasonable that the results are more complex than originally hypothesized. The asymmetry and laterality observed in this study might be a product of of different factors or a fluctuating combination of them. These factors could interact in complex ways with the action studied, the type of movement observed, and the specific measurement that is made. Clearly, more research is needed to clarify precisely how these factors influence facial asymmetry.

SUMMARY AND CONCLUSIONS

The hypothesis that lateralization of asymmetries across subjects would change with the action was confirmed. Analysis of variance revealed a main effect of different Action Units on bilateral asymmetry and better unilateral control scores. Bilateral asymmetry, better unilateral control, and preferred side scores showed that asymmetries of some actions were lateralized, but those of other actions showed no tendency towards laterality. Rated easier scores did not show laterality for any individual action. According to bilateral asymmetry and better unilateral control measures, laterality of some deliberate actions was opposite. Blinking and winking actions were sometimes lateralized right as predicted, but more often showed little asymmetry. Several actions predicted to have left laterality had right laterality instead. Two actions had left laterality as predicted.

The four different measures of laterality reflected common variance as predicted, but also appeared to measure some different variables. All the significant correlations between measures were positive, but the number of significant correlations was only slightly over half the total. Some measures correlated better with each other than with other measures. As predicted, the measures usually showed the same pattern of laterality for a given action, but not always.

There were two sources of evidence supporting the hypothesis that asymmetries in the strength of actions are related to factors involving the control of the actions. First were the significant, positive correlations between the measure of bilateral asymmetry in the strength of contraction and the other measures which more clearly reflected control over actions. The hypothesis that the unilateral action on the better side would be accompanied by fewer unrequested actions than the unilateral on the poorer side was confirmed, supporting the interpretation that this measure reflects control over facial actions. Second, a more detailed analysis of the strength of unilateral actions showed that the onside (requested side) contraction was stronger for the better unilateral than the poorer action. Conversely, the offside (unrequested side) contraction was stronger for the poorer unilateral action.

The hypothesis that spontaneous and deliberate actions would differ in asymmetry was confirmed. Deliberate actions were generally more asymmetrical than spontaneous actions. Deliberate individual actions of orbicularis oculi (crowsfeet wrinkles) and zygomatic major (smiling) were more asymmetrical than the spontaneous actions of these muscles in response to a humorous comment. Deliberate individual actions of orbicularis oculi (squinting) and risorius (lip stretching) were more asymmetrical than the spontaneous actions of these muscles in response to a startling noise. AUs 6, 45 (blinking), and the eye closure measure did not show a difference between deliberate and startle conditions.

A second difference between the asymmetry of spontaneous and deliberate actions was in lateralization across subjects. As predicted, the asymmetries that were observed in spontaneous actions were generally not lateralized, unlike asymmetries of deliberate actions. Only asymmetries in the action of orbicularis oculi in the startle reaction were lateralized.

Actions from conditions that mixed spontaneous and deliberate types of movement showed asymmetry and laterality intermediate between actions from conditions that elicited a purer sample of these two types of actions. Actions in emotion and startle simulations showed less asymmetry than requests for deliberate individual actions, but more asymmetry than spontaneous actions, but few of the differences were significant. Lateralization of asymmetries of simulated actions showed the same tendencies as deliberate actions, but these tendencies were not as pronounced.

The hypothesis that actions from startle conditions where the subject knew that the noise would occur would be more asymmetrical than actions from the unanticipated startle was not confirmed. The few differences in asymmetry between the startle conditions can easily be attributed to chance.

The asymmetry of individually requested actions did not depend upon whether they were requested verbally or visually. There were no significant differences between these conditions.

The major implication of these results is to call into question every explanation of laterality of facial actions that has been proposed previously. Laterality is specific to particular deliberate facial actions, and the pattern of laterality across actions does not entirely fit any theoretical model. Models of hemispheric specialization for emotional processes, whether specialization by only the right hemisphere or by dual specialization for positive or approach emotions versus negative or avoidance emotions, cannot account for the asymmetries and laterality observed here. Models that attribute asymmetry to processes involving the directed control of actions and to cognitive, deliberative processes appear to be more compatible with the evidence from this study, but they cannot explain all the findings. It may be that asymmetry is produced by a complex interaction of different processes and variables or by factors that await future conceptualization.

The findings of this study present a considerable challenge to researchers using asymmetries in facial muscle action as indices of hemispheric specialization. The four measures used in this study measured common variance but also tapped different variables affecting asymmetry. Only ratings and preferred side scores appeared to measure the same variable and showed any consistency of laterality across actions, but this laterality was weak. Although measures of asymmetry in bilateral movements and better unilateral actions showed more laterality, they also indicated that some other factor besides specialization of one process in a single hemisphere influenced asymmetry. More disparate measures from those used in this study could reflect other aspects of asymmetry in facial function. Researchers who use only one measure of asymmetry need to show how well it reflects hemispheric specialization. Multiple measures of asymmetry in facial function that carefully specify what aspect of asymmetry is being assessed could help to know what is being measured. Researchers who study only one muscle will not be able to generalize easily to other muscles. Likewise, measurements of the average activity of a group of muscles (e.g., with EMG) may not be applicable to particular muscles. Several representative muscle actions should be measured individually, carefully separating out the influence of other muscle actions or extraneous factors such as permanent facial features that could affect the measurement.

The results of this study, in combination with those of previous studies, indicate that the phenomenon of asymmetry in facial actions is one of considerable complexity demanding rigorous attention to control of many variables. Characteristics of the subject should be controlled, including gender, age, and handedness. An important variable to consider is the type of movement studied, whether the actions are spontaneous or deliberate, emotional, reflex, etc. This study has investigated asymmetry of deliberate actions thoroughly, and much evidence indicated that the asymmetry of these deliberate actions differs from reflex startle actions and positive emotional actions. The effort needed now is to better understand spontaneous emotional expressions, especially negative expressions. Such a study would face the difficult task of eliciting uncontrolled expressions of specific emotions, but it might resolve questions about the differential role of the hemispheres in emotion.

TABLE 1

DISTRIBUTION OF AYSMMETRY FOR EACH ACTION UNIT BY MODE OF REQUEST, VERBAL DESCRIPTION VERSUS IMITATING A MODEL

AU 1 - INNER BROW RAISE

	Verbal	Visual	Combined
Left	-	12	-
Right	-	10	-
Symmetrical	-	9	-
Total Ss	-	31	-
Lf vs. Rt Prob.	-	n.s.	-

AU 2 - OUTER BROW RAISE

	Verbal	Visual	Combined
Left	-	8	-
Right	-	17	-
Symmetrical	-	7	-
Total Ss	-	32	-
Lf vs. Rt Prob.	-	n.s.	-

AU 1+2 - BROW RAISE

	Verbal	Visual	Combined
Left	9	8	9
Right	20	20	22
Symmetrical	4	4	2
Total Ss	33	32	33
Lf vs. Rt Prob.	.06	.04	.03

AU 4 - LOWER BROW

	Verbal	Visual	Combined
Left	14	14	18
Right	6	6	7
Symmetrical	12	11	7
Total Ss	32	31	32
Lf vs. Rt Prob.	n.s.	n.s.	.04

AU 6 - SQUINT

	Verbal	Visual	Combined
Left	5	-	-
Right	11	-	-
Symmetrical	13	-	-
Total Ss	29	-	-
Lf vs. Rt Prob.	n.s.	-	-

AU 7 - SQUINT

	Verbal (in squint)	Visual	Combined
Left	7	14	16
Right	10	9	10
Symmetrical	16	8	7
Total Ss	33	31	33
Lf vs. Rt Prob.	n.s.	n.s.	n.s.

AU 6+7 - SQUINT

	Verbal	Visual	Combined
Left	10	-	-
Right	10	-	-
Symmetrical	13	-	-
Total Ss	33	-	-
Lf vs. Rt Prob.	n.s.	-	-

AU 9 - WRINKLE NOSE

	Verbal	Visual	Combined
Left	4	6	6
Right	15	15	20
Symmetrical	12	9	6
Total Ss	31	30	32
Lf vs. Rt Prob.	.02	.08	.01

AU 10 - RAISE UPPER LIP

	Verbal	Visual	Combined
Left	12	9	14
Right	6	6	9
Symmetrical	4	1	2
Total Ss	22	16	25
Lf vs. Rt Prob.	n.s.	n.s.	n.s.

AU 12 - SMILE

	Verbal	Visual	Combined
Left	17	24	23
Right	11	6	10
Symmetrical	5	2	0
Total Ss	33	32	33
Lf vs. Rt Prob.	n.s.	.001	.04

AU 15 - LOWER LIP CORNERS

	Verbal	Visual	Combined
Left	-	4	-
Right	-	13	-
Symmetrical	-	8	-
Total Ss	-	25	-
Lf vs. Rt Prob.	-	.05	-

AU 16 - LOWER LIP PULLED DOWN

	Verbal	Visual	Combined
Left	-	7	-
Right	-	9	-
Symmetrical	-	12	-
Total Ss	-	28	-
Lf vs. Rt Prob.	-	n.s.	-

AU 20 - LIP STRETCHED TO SIDES

	Verbal	Visual	Combined
Left	8	7	9
Right	10	19	20
Symmetrical	8	2	1
Total Ss	26	28	30
Lf vs. Rt Prob.	n.s.	.03	.06

AU 45 - WINK

	Verbal	Visual	Combined
Left	3	-	-
Right	4	-	-
Symmetrical	26	-	-
Total Ss	33	-	-
Lf vs. Rt Prob.	n.s.	-	-

Eyes Closed (during blink)

	Verbal	Visual	Combined
Left	7	-	-
Right	21	-	-
Symmetrical	5	-	-
Total Ss	33	-	-
Lf vs. Rt Prob.	.01	-	-

NOTE: All probabilities are two-tailed binomials, p=q, and are reported only if $< .1$. Combined scores were calculated by averaging scores for all the individual actions for both the verbal and visual requests, and are not totals or averages of the entries in the "Verbal" and "Visual" columns.

TABLE 2
DISTRIBUTION OF ASYMMETRY FOR EACH AU FOR FOUR MEASURES: BILATERAL ASYMMETRY, BETTER UNILATERAL CONTROL, FAVORED UNILATERAL SIDE, AND SIDE RATED EASIER

AU 1 - INNER BROW RAISE

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	12	8	8	6
Right	10	10	7	14
Symmetrical	9	13	13	13
Total Ss	31	31	28	33
Lf vs. Rt Prob.	n.s.	n.s.	n.s.	n.s.

AU 2 - OUTER BROW RAISE

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	8	8	7	4
Right	17	16	17	12
Symmetrical	7	6	4	17
Total Ss	32	30	28	33
Lf vs. Rt Prob.	n.s.	n.s.	.06	.08

AU 1+2 - BROW RAISE

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	9	7	6	7
Right	22	19	18	12
Symmetrical	2	5	8	14
Total Ss	33	31	32	33
Lf vs. Rt Prob.	.03	.03	.02	n.s.

AU 4 - LOWER BROW

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	18	8	6	6
Right	7	4	3	15
Symmetrical	7	17	20	12
Total Ss	32	29	29	33
Lf vs. Rt Prob.	.04	n.s.	n.s.	.08

AU 6/7 - SQUINT

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	10	15	15	7
Right	10	14	17	8
Symmetrical	13	4	1	18
Total Ss	33	33	33	33
Lf vs. Rt Prob.	n.s.	n.s.	n.s.	n.s.

AU 9 - NOSE WRINKLE

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	6	14	9	9
Right	20	9	17	11
Symmetrical	6	6	3	13
Total Ss	32	29	29	33
Lf vs. Rt Prob.	.01	n.s.	n.s.	n.s.

AU 10 - RAISE UPPER LIP

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	14	15	12	12
Right	9	9	15	13
Symmetrical	2	5	2	8
Total Ss	25	29	29	33
Lf vs. Rt Prob.	n.s.	n.s.	n.s.	n.s.

AU 12 - SMILE

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	23	17	12	6
Right	10	5	21	6
Symmetrical	0	11	0	21
Total Ss	33	33	33	33
Lf vs. Rt Prob.	.04	.02	n.s.	n.s.

AU 20 - LIP STRETCH TO SIDES

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	9	15	14	4
Right	20	6	17	5
Symmetrical	1	10	0	24
Total Ss	30	31	31	33
Lf vs. Rt Prob.	.06	.08	n.s.	n.s.

AU 45 - WINK/BLINK

	Bilateral Asymmetry	Better Unilateral	Favored Side	Rated Easier
Left	3	9	9	6
Right	4	9	24	9
Symmetrical	26	15	0	18
Total Ss	33	33	33	33
Lf vs. Rt Prob.	n.s.	n.s.	.01	n.s.

NOTE: Probability values are two-tailed binomials and are reported only when less than .1. See Figure 3 for definitions and discussion of scores.

TABLE 3

NUMBER OF REPETITIONS OF REQUESTED, BILATERAL ACTIONS RELATED TO THE PROPORTION OF ASYMMETRICAL ACTIONS AND THE PROPORTION OF ASYMMETRICAL ACTIONS THAT WERE LEFT STRONGER

	First	Second	Next to Last	Last
Left	150	147	123	83
Right	208	190	174	92
Symmetrical	320	316	273	164
Left/Left+Right	.42	.44	.41	.47
Asymmetrical/ Total	.53	.52	.52	.52

TABLE 4
SUMMARY OF LATERALITY BY ACTION
FOR EACH ASYMMETRY MEASURE

Action Unit (AU)	Bilateral Asymmetry			Better Unilateral			Favored Side			Rated Easier		
	Side	%L	%R	Side	%L	%R	Side	%L	%R	Side	%L	%R
1	l	39	32	r	26	32	l	28	25	r	18	42
2	r	25	53	r	27	53	R	25	61	R	12	36
1+2	R*	27	67	R*	22	61	R*	19	56	r	21	36
4	L*	56	22	l	28	14	l	21	10	r	18	45
6/7	nd	30	30	l	45	42	r	45	52	r	21	24
9	R*	19	62	l	48	31	r	31	59	r	27	33
10	l	56	36	l	52	31	r	41	52	r	36	39
12	L*	70	30	L*	51	15	r	36	64	nd	18	18
20	R+	30	67	L	48	19	r	45	55	r	12	15
45	r	09	12	nd	27	27	R*	27	73	r	18	27
15	R*	16	52	-			-			-		
16	r	25	32	-			-			-		
eyes closed	R*	21	63	-			-			-		

NOTE: In the column headed "Side", lower case denotes nominally more left (l) or right (r) subjects. Upper case denotes a difference with p<.1 (two-tailed binomial); nd denotes no difference in right vs left. In the columns headed "%L" and "%R" are the proportions of subjects who showed left and right asymmetry, respectively, of all subjects who showed the action. AUs 15, 16, and eye closure were not assessed in better unilateral, favored side, and ratings.

* $p < .05$ (two-tailed binomial)

+ AU 20 was significantly lateralized for the visual requests ($p < .05$), but not when combined with the verbal requests ($p < .06$).

TABLE 5

SIGNIFICANT CHANGES IN THE PROPORTION OF SUBJECTS WHO SHIFTED LATERALITY (RIGHT VS. LEFT) BETWEEN PAIRS OF ASYMMETRY MEASURES

Laterality Measures	AU	Net differences	Probability
Bilateral Asymmetry vs Rated Easier	4	More right in Ratings	<.05
Better Unilateral vs Favored Side	12	More right in Favored Side	<.05
Bilateral Asymmetry vs Favored Side	12	More right in Favored Side	<.01
Better Unilateral vs Bilateral Asymmetry	9	More right in Bilateral	<.05
Better Unilateral vs Favored Side	20	More right in Favored Side	<.05

TABLE 6
CORRELATIONS BETWEEN MEASURES OF ASYMMETRY

Raise Inner Corners of Brow (AU 1)

		Rated Easier	Favored Side	# Bilateral Asymmetry (Visual AU 1)
Better	r=	.429	.673	.498
Unilateral	p=	.016	.0001	.004
	N=	31	27	31
Side Rated	r=		.302	.122
Easier	p=		ns	ns
	N=		28	31
Favored	r=			.508
Side	p=			.007
	N=			27

Raise Outer Corners of Brow (AU 2)

		Rated Easier	Favored Side	Bilateral Asymmetry (Visual AU 2)
Better	r=	.571	.675	.667
Unilateral	p=	.001	.0001	.0001
	N=	30	27	30
Side Rated	r=		.484	.341
Easier	p=		.009	.056
	N=		28	32
Favored	r=			.568
Side	p=			.002
	N=			28

Brow Raise (AUs 1+2)

		Rated Easier	Favored Side	Bilateral Asymmetry
Better	r=	.275	.562	.463
Unilateral	p=	ns	.001	.009
	N=	31	31	31
Side Rated	r=		.732	.109
Easier	p=		.0001	ns
	N=		32	33
Favored	r=			.247
Side	p=			ns
	N=			32

Lower Brow (AU 4)

		Rated Easier	Favored Side #	Bilateral Asymmetry
Better Unilateral #	r=	.012	.367	.598
	p=	ns	.055	.001
	N=	29	28	29
Side Rated Easier	r=		.122	.371
	p=		ns	.036
	N=		29	32
Favored Side	r=			.312
	p=			.099
	N=			29

Squint (AUs 6+7)

		Rated Easier	Favored Side	Bilateral Asymmetry # (AU 7 in SQ & WK)
Better Unilateral	r=	.609	.438	.291
	p=	.002	.011	.099
	N=	33	33	33
Side Rated Easier	r=		.275	.424
	p=		ns	.014
	N=		33	33
Favored Side	r=			-.018
	p=			ns
	N=			33

Nose Wrinkle (AU 9)

		Rated Easier	Favored Side	Bilateral Asymmetry
Better Unilateral	r=	.604	.554	.307
	p=	.0005	.002	ns
	N=	29	28	28
Side Rated Easier	r=		.508	.266
	p=		.005	ns
	N=		29	32
Favored Side	r=			.245
	p=			ns
	N=			28

Lip Raise (AU 10)

		Rated Easier	Favored Side	Bilateral Asymmetry
Better Unilateral	r=	.492	.690	.570
	p=	.007	.0001	.003
	N=	29	28	25
Side Rated Easier	r=		.662	.152
	p=		.0001	ns
	N=		29	25
Favored Side	r=			.416
	p=			.043
	N=			24

Smile (AU 12)

		Rated Easier #	Favored Side	Bilateral Asymmetry
Better Unilateral #	r=	.324	.248	.430
	p=	.065	ns	.012
	N=	33	33	33
Side Rated Easier	r=		.150	.387
	p=		ns	.026
	N=		33	33
Favored Side	r=			.178
	p=			ns
	N=			33

Lip Stretch (AU 20)

		Rated Easier #	Favored Side	Bilateral Asymmetry
Better Unilateral	r=	.364	.135	.210
	p=	.044	ns	ns
	N=	31	29	28
Side Rated Easier	r=		.093	-.076
	p=		ns	ns
	N=		31	30
Favored Side	r=			.024
	p=			ns
	N=			28

Blink/Wink (AU 45)

		Rated Easier	Favored Side	Bilateral Asymmetry #
Better Unilateral	r=	.600	.425	-.004
	p=	.0002	.014	ns
	N=	33	33	33
Side Rated Easier	r=		.505	.113
	p=		.003	ns
	N=		33	33
Favored Side	r=			-.194
	p=			ns
	N=			33

Total Eyes Closed During Blink/Wink

		Rated Easier (for Wink)	Favored Side	Bilateral Asymmetry
Better Unilateral	r=	.621	.345	.061
	p=	.0001	.014	ns
	N=	33	33	33
Side Rated Easier (for Wink)	r=		.405	-.127
	p=		.019	ns
	N=		33	33
Favored Side	r=			.028
	p=			ns
	N=			33

The two actions requested which had the lowest variance in each condition are marked with #. This low variance could explain some of the low correlations, but not others.

NOTE: Probability values are reported only when less than .1. See Figure 3 for definitions of scores.

TABLE 7
NUMBER OF SIGNIFICANT CORRELATIONS BETWEEN DIFFERENT ASYMMETRY MEASURES IN TABLE 6, EXCLUDING TIMING OF EYELID CLOSURE (maximum 10 posible in each cell)

	Better Unilateral	Rated Easier	Favored Side	Bilateral Asymmetry
Better Unilateral	-	7	7	6
Rated Easier	7	-	5	3
Favored Side	7	5	-	3
Bilateral Asymmetry	6	3	3	-
Totals	20	15	15	12

TABLE 8

FACTORS AND LOADINGS FOR TWO ANALYSES REGARDING ASYMMETRY OF BILATERAL AND UNILATERAL ACTIONS

	Factor 1	Factor 2
Average Favored Side	<u>0.804</u>	-0.038
Average Better Unilateral	<u>0.773</u>	0.385
Average Rated Easier	<u>0.798</u>	0.054
Average Visual Asymmetry	0.252	<u>0.846</u>
Average Verbal Asymmetry	-0.059	<u>0.920</u>
Cumulative proportion of variance	.389	.732

	Factor 1	Factor 2	Factor 3
Average Favored Side	<u>0.797</u>	0.118	0.369
Average Better Unilateral	<u>0.778</u>	0.365	0.083
Average Rated Easier	<u>0.804</u>	0.103	-0.319
Average Visual Asymmetry	0.270	<u>0.840</u>	0.006
Average Verbal Asymmetry	0.047	<u>0.903</u>	0.200
Average Simulation Asymmetry	-0.035	0.180	<u>0.930</u>
Cumulative proportion of variance	.398	.636	.804

NOTE: Highest factor score is underlined for each variable.

TABLE 9
SIGNIFICANT CORRELATIONS BETWEEN DIFFERENT ACTION UNITS
WITHIN EACH SET OF ASYMMETRY MEASURES

Better Unilateral	Favored Side	Ratings	Bilateral Asymmetry
AU1 + AU2		AU1 + AU2	
AU1 + AU1+2	AU1 + AU1+2	AU1 + AU1+2	
		AU1 + AU4	
AU1 + AU12			AU1 + AU12
AU2 + AU1+2	AU2 + AU1+2	AU2 + AU1+2	AU2 + AU1+2
			AU1+2 + AU12
AU2 + AU9			
AU4 - AU9			
			AU4 - AU10
		AU4 + AU12	
			AU4 + AU45
	AU6/7 + AU9		
	AU6/7 + AU10	AU6/7 + AU10	
AU6/7 + AU20	AU6/7 + AU20	AU6/7 + AU20	
AU6/7 + AU45	AU6/7 + AU45	AU6/7 + AU45	
AU9 + AU10	AU9 + AU10	AU9 + AU10	AU9 + AU10
	AU9 + AU12		
	AU9 + AU20	AU9 + AU20	
	AU9 + AU45	AU9 + AU45	
		AU10 + AU20	
AU10 + AU45	AU10 + AU45	AU10 + AU45	AU10 - AU45
		AU20 + AU45	

NOTE: Table shows significant relations at $p \leq .05$ where a + between entries indicates a positive relation and a - between entries indicates a negative relation.

TABLE 10
FACTORS AND LOADINGS FOR EACH ACTION UNIT
WITHIN FOUR ASYMMETRY MEASURES

BETTER UNILATERAL

	Factor 1	Factor 2	Factor 3
AU 1	-0.062	<u>0.846</u>	0.021
AU 2	0.165	<u>0.762</u>	0.018
AU 1+2	0.075	<u>0.725</u>	0.188
AU 4	-<u>0.787</u>	0.349	0.187
AU 6/7	0.136	-0.057	<u>0.922</u>
AU 9	<u>0.740</u>	0.211	0.275
AU 10	<u>0.741</u>	0.213	0.159
AU 12	0.027	<u>0.552</u>	0.003
AU 20	-0.042	0.032	<u>0.634</u>
AU 45	0.341	0.295	<u>0.630</u>
Cumulative variance proportion	.189	.432	.614

FAVORED SIDE

	Factor 1	Factor 2	Factor 3
AU 1	-0.082	0.317	<u>0.679</u>
AU 2	0.202	<u>0.872</u>	0.054
AU 1+2	0.000	<u>0.889</u>	0.209
AU 4	0.036	0.035	<u>-0.801</u>
AU 6/7	<u>0.781</u>	-0.037	-0.270
AU 9	<u>0.823</u>	0.170	0.333
AU 10	<u>0.623</u>	0.328	-0.109
AU 12	<u>0.514</u>	-0.033	0.030
AU 20	<u>0.553</u>	-0.465	0.338
AU 45	<u>0.674</u>	0.060	-0.358
Cumulative variance proportion	.275	.476	.635

RATED EASIER

	Factor 1	Factor 2	Factor 3
AU 1	0.099	0.688	0.388
AU 2	0.103	0.854	-0.003
AU 1+2	-0.062	0.879	0.251
AU 4	0.205	0.178	0.769
AU 6/7	0.764	-0.175	0.160
AU 9	0.710	0.087	0.167
AU 10	0.742	0.263	0.031
AU 12	0.076	0.152	0.788
AU 20	0.720	0.336	0.006
AU 45	0.885	-0.204	0.122
Cumulative variance proportion	.301	.530	.680

BILATERAL ASYMMETRY

	Factor 1	Factor 2	Factor 3
AU 1	0.317	0.534	0.184
AU 2	0.060	0.081	0.850
AU 1+2	0.050	0.396	0.710
AU 4	0.898	-0.026	0.082
AU 6/7	0.035	0.567	-0.066
AU 9	-0.342	0.545	0.136
AU 10	-0.786	0.022	0.075
AU 12	0.009	0.770	0.108
AU 20	0.089	0.435	-0.552
AU 45	0.787	0.127	0.058
Cumulative variance proportion	.228	.414	.576

NOTE: Highest factor loading is underlined for each factor.

TABLE 11
SIGNIFICANT CORRELATIONS BETWEEN DIFFERENT ACTION UNITS
BETWEEN DIFFERENT SETS OF ASYMMETRY MEASURES

Better Unilateral	Favored Side	Better Unilateral	Ratings	Better Unilateral	Bilateral Asymmetry	Favored Side	Ratings	Favored Side	Bilateral Asymmetry	Ratings	Bilateral Asymmetry
AU1	+ AU1/2	AU2	+ AU1	AU2	+ AU1/2	AU1	+ AU1/2	AU9	- AU4	AU1	- AU20
AU2	+ AU1/2	AU2	+ AU1/2	AU1/2	+ AU1	AU2	+ AU1/2	AU10	- AU4	AU6/7	+ AU9
AU1/2	+ AU2	AU6/7	+ AU20	AU1/2	+ AU2	AU1/2	+ AU2	AU12	+ AU2	AU20	+ AU1/2
AU4	- AU9	AU6/7	+ AU45	AU10	- AU4	AU12	+ AU9	AU45	- AU4	AU20	+ AU9
AU6/7	+ AU4	AU9	+ AU10	AU12	+ AU2	AU20	+ AU9			AU45	+ AU9
AU10	+ AU6/7	AU9	+ AU20	AU12	+ AU1/2	AU20	+ AU45				
AU10	+ AU9	AU10	+ AU45	AU20	+ AU9	AU45	+ AU6/7				
AU20	+ AU45	AU12	+ AU1								
AU45	+ AU10	AU45	+ AU6/7								
		AU45	+ AU10								

NOTE: Significant correlations (p<= .05) are listed with a + indicating a positive relation and a - indicating a negative relation. Column heads show the laterality measures which were correlated, and cell entries show the AUs for each measure. Note that the original correlation matrices were not symmetrical.

TABLE 12
THE RELATION BETWEEN THE BETTER UNILATERAL ACTION AND THE ONSIDE, OFFSIDE INTENSITIES AND THE OCCURANCE OF OTHER AUS

Action Unit	Better Unilateral	Onside Intensity Lf>	Onside Intensity Rt>	Offside Intensity Lf>	Offside Intensity Rt>	Other Actions Lf>	Other Actions Rt>
1	Left	3	0	1	6	0	0
	Right	0	7	5	0	0	1
2	Left	4	3	2	5	1	1
	Right	0	9	11	2	1	1
1+2	Left	2	1	0	3	0	0
(for AU 1)	Right	6	5	9	4	3	2
1+2	Left	4	1	1	3	0	0
(for AU 2)	Right	3	11	11	2	3	3
4	Left	1	1	1	3	0	1
	Right	0	2	2	0	1	1
6	Left	4	0	2	1	0	0
	Right	1	7	3	2	1	0
7	Left	7	1	1	10	0	0
	Right	1	8	8	2	0	0
9	Left	6	1	0	11	2	4
	Right	1	4	6	0	0	0
10	Left	7	1	0	9	1	3
	Right	0	6	3	1	6	0
12	Left	11	1	3	9	0	9
	Right	0	2	4	0	1	0
20	Left	14	0	0	3	1	4
	Right	0	6	1	0	3	0

Action Unit	Better Unilateral	Onside Intensity Lf>	Onside Intensity Rt>	Offside Intensity Lf>	Offside Intensity Rt>	Other Actions Lf>	Other Actions Rt>
45	Left	6	0	0	3	2	0
(wink)	Right	0	8	4	0	0	0
eye	Left	3	0	0	4	2	0
closure	Right	0	4	4	0	0	0
Total	Left	69	10	11	66	7	22
(w/o eye	Right	12	75	67	13	19	8
closure)		ChiSq=86.72		ChiSq=72.98		ChiSq=10.23	
		p<.001		p<.001		p<.01	

NOTE: Totals exclude the eye closure measure because it is not an intensity measure and would count the wink twice.

TABLE 13
DISTRIBUTION OF SCORES FOR SPONTANEOUS HAPPY EXPRESSIONS

	AU 12	AU 6	Average
Left	5	2	5
Right	1	1	2
Symmetrical	26	23	25
Total Subjects	32	26	32

TABLE 14
LATERALITY OF SUBJECTS FOR EACH COMMON ACTION UNIT
IN THE THREE STARTLE CONDITIONS

		CONDITION			
AU	Category	Unanticipated	Anticipated	Inhibit	Total
6	Left	0	1	2	3*
	Right	4	6	4	12
	Symmetrical	14	19	16	12
7	Left	4	0	0	4
	Right	4	3	2	8
	Symmetrical	14	10	12	13
20	Left	3	3	3	7
	Right	4	4	4	8
	Symmetrical	18	14	7	14
21	Left	4	4	5	5
	Right	1	3	1	4
	Symmetrical	27	23	25	23
45	Left	2	1	0	2
	Right	2	4	2	6
	Symmetrical	27	28	29	25
80	Left	2	2	0	4
	Right	3	2	2	5
	Symmetrical	5	11	5	11
eye	Left	6	2	5	9
clo-	Right	14	8	13	19
sure	Symmetrical	11	23	13	5

*Number of left versus right is significant, $p < .05$, binomial.

TABLE 15
DISTRIBUTIONS OF ASYMMETRY SCORES FOR COMMON ACTIONS IN THE SIMULATED STARTLE

		First Try	Second Try	Total
AU 1	Left	2	1	3
	Right	2	1	3
	Symmetrical	10	6	11
AU 2	Left	3	2	3
	Right	6	2	8
	Symmetrical	6	6	8
AU 4	Left	0	0	0
	Right	0	0	0
	Symmetrical	2	2	3
AU 6	Left	0	1	1
	Right	2	2	2
	Symmetrical	1	4	4
AU 7	Left	1	0	1
	Right	0	0	0
	Symmetrical	2	4	5
AU 12	Left	0	3	3
	Right	0	2	2
	Symmetrical	3	0	0
AU 20	Left	0	1	1
	Right	1	0	1
	Symmetrical	1	1	2
AU 21	Left	4	5	7
	Right	2	2	3
	Symmetrical	20	22	20
AU 45	Left	0	3	3
	Right	1	3	4
	Symmetrical	22	22	24
AU 80	Left	2	2	3
	Right	3	3	5
	Symmetrical	17	19	18
eye	Left	4	6	8
clos-	Right	9	8	10
ure	Symmetrical	9	14	13

NOTE: In addition to the above actions, there were from 1 to 3 actions of AUs 9, 10, 15, 16, 17, and 18.

TABLE 16
SYMMETRY OF SUBJECTS FOR EACH FREQUENTLY OBSERVED ACTION UNIT IN THE EMOTION SIMULATION CONDITION

AU	Symmetry	HA	SA	FE	AN	SU	DI	TOTAL	%TOTAL
1	Left	0	2	3	1	2	0	4	13%
	Right	4	2	2	0	5	0	9	29%
	Symmetrical	2	5	6	1	21	1	18	58%
	Total Ss	6	9	11	2	28	1	31	
	L vs R Prob.	-	-	-	-	-	-	ns	
2	Left	0	0	3	1	3	0	6	20%
	Right	5	0	5	1	13	0	15	50%
	Symmetrical	1	2	2	0	13	0	9	30%
	Total Ss	6	2	10	2	28	0	30	
	L vs R Prob.	-	-	-	-	.05	-	.08	
4	Left	0	2	1	2	0	1	5	19%
	Right	0	1	2	2	0	0	4	15%
	Symmetrical	0	9	10	16	0	2	17	65%
	Total Ss	0	12	13	20	0	3	26	
	L vs R Prob.	-	-	-	-	-	-	ns	
6	Left	4	0	0	1	0	0	5	19%
	Right	5	0	1	1	0	1	5	19%
	Symmetrical	17	0	0	2	3	0	16	62%
	Total Ss	26	0	1	4	3	1	26	
	L vs R Prob.	-	-	-	-	-	-	ns	
7	Left	0	1	1	2	0	0	3	14%
	Right	0	0	1	4	0	0	4	19%
	Symmetrical	0	2	2	14	1	3	14	67%
	Total Ss	0	3	4	20	1	3	21	
	L vs R Prob.	-	-	-	-	-	-	ns	
9	Left	0	0	0	0	0	1	1	12%
	Right	0	0	0	0	0	3	3	38%
	Symmetrical	0	0	0	0	0	4	4	50%
	Total Ss	0	0	0	0	0	8	8	
	S vs R Prob.	-	-	-	-	-	-	ns	

AU	Symmetry	HA	SA	FE	AN	SU	DI	TOTAL	% TOTAL
10	Left	0	0	1	0	0	4	4	80%
	Right	0	0	0	0	0	0	0	0%
	Symmetrical	0	0	0	0	0	1	1	20%
	Total Ss	0	0	1	0	0	5	5	
	L vs R Prob.	-	-	-	-	-	-	ns	
12	Left	14	1	0	0	5	3	13	39%
	Right	1	0	1	0	2	0	2	06%
	Symmetrical	18	0	1	0	6	1	18	54%
	Total Ss	33	1	2	0	13	4	33	
	L vs R Prob.	.001	-	-	-	-	-	.01	
14	Left	0	2	0	5	1	9	13	54%
	Right	1	2	1	3	0	8	8	33%
	Symmetrical	0	0	1	4	0	3	3	12%
	Total Ss	1	4	2	12	1	20	24	
	L vs R Prob	-	-	-	-	-	-	ns	
15	Left	1	0	1	1	0	0	2	22%
	Right	0	1	1	1	0	0	2	22%
	Symmetical	0	6	0	1	1	0	5	55%
	Total Ss	1	7	2	3	1	0	9	
	L vs R Prob.	-	-	-	-	-	-	ns	
20	Left	0	0	2	0	0	1	3	38%
	Right	0	0	1	0	0	3	3	38%
	Symmetrical	0	0	0	0	0	2	2	25%
	Total Ss	0	0	3	0	0	6	8	
	L vs R Prob.	-	-	-	-	-	-	ns	

NOTE: Actions 17 and 23/24 appeared frequently during simulations, but these actions showed virtually no asymmetry. Probabilities are two-tailed binomials, p=q, and are reported only when < .1.

TABLE 17
AVERAGE ASYMMETRY OF ACTIONS IN THE SIMULATION OF EACH EMOTION EXPRESSION

	Left		Right		Symmetrical		Total
	N	%	N	%	N	%	
Happy	12	36%	7	21%	14	42%	33
Sad	5	17%	7	24%	17	59%	29
Anger	11	33%	8	24%	14	42%	33
Fear	5	23%	8	36%	9	41%	22
Disgust	14	42%	11	33%	8	24%	33
Surprise	6	19%	12	39%	13	42%	31

NOTE: All the actions performed by each subject were averaged for each simulation. Cell entries are the number of subjects whose average score was left, right or symmetrical. Percentages are row percents. Totals reflect the lack of any movements scored for asymmetry for some simulations by some subjects.

TABLE 18
CORRELATIONS OF ASYMMETRY SCORES IN THE SIMULATE EMOTION EXPRESSION CONDITION WITH EACH OF THE ASYMMETRY SCORES FROM THE REQUESTED INDIVIDUAL ACTION CONDITIONS BY AU

Action Unit	Better Unilateral	Rated Easier	Favored Side	Bilateral Asymmetry
1	-.085	-.148	.089	.364*
	ns	ns	ns	.044
	30	31	28	31
2	.011	-.138	.270	.399*
	ns	ns	ns	.029
	28	30	26	30
4	.291	-.107	-.064	.317
	ns	ns	ns	ns
	25	26	24	25
6(in squint)	-.196	-.242	.034	-.115
	ns	ns	ns	ns
	26	26	26	23
7	.251	.002	.291	.205
	ns	ns	ns	ns
	21	21	21	21
9	.743	.225	.756	.128
	.035	ns	.030	ns
	8	8	8	8
10	.938	.752	.901	.713
	.018	ns	.037	ns
	5	5	5	4
12	-.038	.225	.174	.409
	ns	ns	ns	.039
	33	33	33	33
15	none	none	none	-.352
				ns
				9
20	-.528	-.131	.235	.438
	ns	ns	ns	ns
	8	8	8	7

NOTE: Probabilities are shown only if < .1.
* AUs 1 and 2 in the verbal brow raise request were combined with the visual request for AUs1 and 2 for these correlations since there was no correlation for 1+2 together.

TABLE 19
ASYMMETRY OF ACTIONS FOR EACH SIMULATION
BY THE NUMBER OF CO-OCCURRING ACTIONS

AU	OTHER ACTIONS	NUMBER OTHER AUs	LEFT	SYM	RIGHT
	HAPPY SIMULATION				
12	----	0	3	1	0
12	AU 6	1	6	10	1
12	AUs 6, 1+2, 14, 15, 17 or 24	2 or 3	5	7	0
6	AU 12	1	3	10	3
6	AUs 12, 1+2,	2 or 3	1	7	2
	SAD SIMULATION				
1	AUs 2, 4, 15 or 17	1	1	2	1
1	2, 4, 7, 15, or 17	2, 3 or 4	1	3	1
4	----	0	1	2	1
4	AUs 1, 7+14 or 17	1 or 2	1	3	0
4	AUs 1+15+17, 1+2+17 & 7, 12	3 or 4	0	4	0
	ANGRY SIMULATION				
4	AUs 7 or 14	0 or 1	1	5	0
4	AUs 1, 2, 6, 7, 14, 16, 15, 17, 23, 24, 28	2, 3, 4, or 5	1	11	2
7	AUs 4 or 14	0 or 1	1	4	1
7	AUs 1, 4, 6, 13, 14, 16, 17, 23, 24, 28	2, 3, 4, or 5	1	10	3
14	AUs 4, 7, 11, 17	0 or 1	4	0	1
14	AUs 1, 4, 7, 16, 17, 23, 24,	2, 3, 4, or 5	1	4	2
	FEAR SIMULATION				
1	AUs 2, 4, 7, 20	1 or 2	2	3	1
1	AUs 2, 4, 7, 6, 10, 11, 14, 15, 17	3, 4, or 5	1	3	1
2	AUs 1, 4, 12, 20	0, 1, or 2	2	2	3
2	AUs 1, 4, 7, 12, 11, 15	3, 4, or 5	1	0	2
4	AU 24	0 or 1	1	3	2
4	AUs 1, 2, 6, 7, 10, 11, 15, 14, 17, 24	2, 3, 4, or 5	0	7	0

AU	OTHER ACTIONS	NUMBER OTHER AUs	LEFT	SYM	RIGHT
		DISGUST SIMULATION			
9	AUs 6, 17, 24	0, 1, or 2	1	1	2
9	AUs 4, 7, 9, 10, 12, 14, 17, 20, 21	3, 4, or 6	0	3	1
14	----	0	4	1	3
14	AUs 4, 7, 9, 10, 12, 17, 18, 20, 22, 24	1, 2, 3, or 6	5	2	5
		SURPRISE SIMULATION			
1	AU 2	1	1	8	5
1	AUs 2, 4, 6, 12, 14, 17, 21, 28	2, 3, or 4	1	13	0
2	AU 1	0 or 1	2	5	8
2	AUs 2, 4, 6, 12, 14, 17, 21, 28	2, 3, or 4	1	8	5
		TOTALS			
First row entry for each AU			27 (26%)	47 (45%)	31 (30%)
Remaining row entries			26 (18%)	95 (65%)	25 (17%)

TABLE 20
DIFFERENCES IN DEGREE OF BILATERAL ASYMMETRY
FOR ACTIONS APPEARING IN DIFFERENT CONDITIONS

Action:	Appearing in:	Showed more asymmetry than:
AU 1	Requested actions	
	Startle simulations	
	Emotion simulations	
AU 2	Requested actions	
	Startle simulations	
	Emotion simulations	
AU 4	Requested actions	
	Emotion simulations	
AU 6	Requested actions	emotion actions ($p<.02$)
	Startle simulations	
	Emotion simulations	
	Startle actions	emotion actions ($p<.03$)
	Emotion actions	
AU 7	Requested actions	
	Startle simulations	
	Emotion simulations	
	Startle actions	
AU 9	Requested actions	
	Emotion simulations	
AU 12	Requested actions	emotion actions ($p<.001$) & emotion simulations ($p<.001$)
	Emotion simulations	emotion actions ($p<.004$)
	Emotion actions	
AU 15	Requested actions	
	Emotion simulations	
AU 20	Requested actions	startle actions ($p<.005$)
	Emotion simulations	
	Startle actions	
AU 45	Requested actions	
	Startle simulations	
	Startle actions	
eye closure	Requested actions	
	Startle simulations	
	Startle actions	

NOTE: All tests are two-tailed. An N of 7 or greater was required before performing a test between conditions.

TABLE 21

BILATERAL ASYMMETRY SCORES FOR AU 12 FOR THE DELIBERATE, SIMULATED, AND EMOTIONAL CONDITIONS

Subject	Deliberate	Simulated	Emotional
1	-0.57	-1.0	0
2	-1.28	-1.2	m
3	-0.50	0	0
4	-0.87	0	0
5	-0.37	0	0
6	-1.17	0	0
7	0.25	0	0
8	0.33	0	0
9	0.43	-2.0	0
10	0.37	0	0
11	0.50	0	0
12	-1.00	-2.0	0
13	-1.25	-1.0	0
14	-1.88	0.5	-1
15	-1.50	-2.0	0
16	-0.28	-1.0	0
17	-1.20	0	0
18	1.33	0	0
19	-1.83	-1.5	0
20	-1.88	-1.0	0
21	-1.00	0	0
22	-1.88	-2.0	0
23	1.50	2.0	1
24	0.17	0	0
25	-0.14	-0.5	-1
26	-0.88	0	-1
27	1.00	-2.0	-1
28	-1.88	0	0
29	0.83	0	0
30	-0.28	0	0
31	-0.71	0	0
32	-1.28	0	0
33	-2.00	-2.0	-1
Mean	-0.574	-0.506	-0.156
s.d.	.999	.931	.369
N	33	33	32

TABLE 22

SUBJECTS WHO SHOWED SIGNIFICANT LATERALITY ACROSS ACTION UNITS FOR EACH OF THE FOUR ASYMMETRY MEASURES

Subject Number	Bilateral Asymmetry		Better Unilateral	Preferred Side	Rated Easier
	Verbal	Visual			
1					
2					
3			L		
4				R	
5	L				R
6				R	
7					
8				R	
9		R			
10					
11		R			R
12	R				
13					
14					R
15					
16					R
17			L		L
18					
19				R	
20					R
21			L		L
22					
23					
24	R	R			R
25				R	
26					
27					R
28			L		L
29					
30			R	R	
31					
32					
33					R

NOTE: The criterion for significant laterality was a difference between the number of right and left actions with a two-tailed binomial $\underline{p} < .1$.

APPENDIX R

RELIABILITY

An argument could be made that demonstrating reliability was not necessary in this study. A similar scoring technique was shown to be reliable in the Ekman et al. (1981) study, and the main coder (myself) had demonstrated reliability and was the same in both studies. The purpose of examining reliability was to affirm previously established reliability and to investigate the reliability for different AUs.

Table R1 shows the reliability coefficients for inter-coder agreement for each action scored. Pearson correlations were based on the actual numerical scores assigned by the coders, but percent correct and Kappas were based on the category (Left, Right, or Symmetrical) of asymmetry. This category was determined simply by whether the score was left, right, or symmetrical, regardless of numerical value. Actions were selected for reliability scoring from each of condition in the study except the simulations of emotion.

In general, coefficients for in Table R1 were high enough to establish asymmetry scoring as a reliable method. This reliability is reflected in Tables R2 and R3 which show that coders agreed about the results of the scoring. Evidence for validity beyond the reliability coefficients was clear because the results obtained by different coders are similar. Table R2 shows that coders agreed on the relative proportions of left, right, and symmetrical subjects for each requested AU. Table R3 shows consistent agreement between the two coders on the results of the experiment involving spontaneous actions. Table R3 Part 1 shows the distribution of left, right, and symmetrical subjects for three spontaneous movements. Both coders scored roughly equal proportions of asymmetrical subjects, and they agreed on the ratio of right to left subjects for each movement. There were more right than left subjects for AU 6/7, roughly equal numbers of left and right subjects for AU 20, and slightly more left than right subjects for AU 12.

Table R3 Part 2 looks at the distribution of left, right and asymmetrical scores within the startle conditions (a breakdown of the "startle" entries in Part 1). For AU 20, coders agreed about the proportion of asymmetries and that there were roughly equal numbers of right and left asymmetries in all three conditions and in total (slightly, but not significantly, more right). For AU 6/7 they agreed on the tendency for more right than left asymmetries in each condition and in total (significantly more for both coders). This tendency was stronger in Jim's than in Joe's scores, perhaps because Jim also scored relatively more asymmetries than Joe. That Jim scored more asymmetries of spontaneous AU 6/7 than Joe is the only point of disagreement in these results, but as explained below, both coders agreed about the degree of asymmetry in the spontaneous conditions versus the requested conditions.

The most cogent comparisons for assessing whether coders validly scored the degree of asymmetry are comparisons of how the two coders scored different conditions. Table R3 Part 3 compares the degree of asymmetry observed between pairs of startle conditions. Both coders agreed that there were no differences between conditions for either AUs 6/7 or 20. Of course the failure to find differences could be due to weaknesses in the experiment, but the agreement of coders about these results does not implicate invalidity as would disagreement about results.

Table R4 compares the degree of asymmetry in deliberate versus spontaneous actions based on the scores of two different coders. For all three AUs, the coders agreed on the results of this comparison. AUs 12 and 20 were significantly more asymmetrical in the deliberate condition, but AU 6/7 did not differ. Thus, even though Jim scored more asymmetries of AU 6/7 within the spontaneous condition than Joe, they agreed on the more important issue of the comparison between conditions.

Coder Bias

The influence of coder bias was possible in this study because the main coder was the experimenter and knew the hypotheses. However, the scoring procedure eliminated most of the opportunity for bias to occur. Important hypotheses of the study involved comparison of different conditions that were scored at least one month apart. This interval, combined with the large number of subjects, precluded remembering how subjects had been scored. The coder did not know how to score consistent with hypotheses about relations between conditions. Other important hypotheses involved relations between the facial scores and questionaire variables which the scorer also did not know. This ignorance not only minimized bias, but also strengthened the scorer's motivation to record asymmetry as accurately as possible in order to maximize the opportunity to test these hypotheses.

In cases where the main coder's knowledge could have biased scoring, the reliability of scoring is evidence that that bias could not have been significant. Three secondary coders who were naive to the hypotheses all attained acceptable reliability. In the one comparison between two naive coders, reliability was at the same level as between the main and secondary coders. Also important is that coders agreed about the results.

Finally, many of the results of the experiment either did not confirm the hypotheses or they contradicted them. This is true even for scoring that was most susceptible to bias. For example, the hypothesis that deliberate requested actions would be lateralized left was contradicted for many AUs that were lateralized right. Such inconsistencies between hypotheses and findings indicate that coder bias could not have been an important factor in this study.

Another possible source of bias could have been a perceptual bias to look at one side of the face more than the other. Since coders saw the face only in its normal orientation, laterality might be an artifact of this bias. This bias could not have been significant in this study because the laterality of AUs changed between conditions and differed with AU.

TABLE R1
RELIABILITY COEFFICIENTS BY ACTION UNIT

AU scored	N	Pearson r	Kappa	% correct
1	83	.45	.29	54
2	82	.81	.56	77
12	67	.83	.55	72
20	155	.55	.28	53
6	141	.65	.30	56
7	141	.85	.62	77

NOTE: N = number of events involved in coefficients. Pearson r's are based on continuous scores (-5 to 5) as assigned by the coders; percent correct and Kappas are based on "Left, Symmetrical, or Right" categories.

All probabilities for coefficients $p < .0001$

TABLE R2
COMPARISON OF RESULTS BASED ON DIFFERENT CODERS' SCORES
Classification of Subjects based on Requested Actions

AU	Category	Joe N	Joe %	Jim N	Jim %	AU	Category	Joe N	Joe %	Bob N	Bob %
12	Left	8	47	12	70	1	Left	4	25	0	0
	Right	5	29	5	30		Right	8	50	12	75
	Symm.	4	24	0	0		Symm.	4	25	4	25
6	Left	7	25	8	33	2	Left	2	13	1	07
	Right	9	32	4	17		Right	12	80	13	87
	Symm.	12	43	12	50		Symm.	1	07	1	07
7	Left	5	15	8	24	1+2	Left	4	25	2	12
	Right	12	36	11	33	Total	Right	12	75	13	81
	Symm.	15	45	14	42		Symm.	0	0	1	06
6+7	Left	10	30	13	39						
Total	Right	10	30	10	30						
Squint	Symm.	13	39	10	30						
20	Left	8	31	11	35	20	Left	3	25	3	25
	Right	10	38	13	42		Right	5	41	6	50
	Symm.	8	31	7	22		Symm.	4	33	3	25

TABLE R3
COMPARISON OF RESULTS BASED ON DIFFERENT CODERS' SCORES
Part 1--Classification of Subjects during Spontaneous Actions

AU	Category	Joe N	Joe %	Jim N	Jim %	Condition
6+7	Left	6	18	4	09	Startle
Total	Right	15	45	21	64	
	Symm.	12	36	9	27	
20	Left	7	24	12	38	Startle
	Right	8	28	11	34	
	Symm.	14	48	9	28	
12	Left	4	27	5	33	Aren't you happy?
	Right	1	07	1	07	
	Symm.	10	67	9	60	

For startle conditions, scores are across all 3 startle noise conditions.

TABLE R3

Part 2--Distribution of Asymmetry Scores in Startle Conditions

		Unanticipated			Anticipated			Inhibit			Total		
		Left	Right	Symm.	Left	Right	Symm.	Left	Right	Symm.	Left	Right	Sym.
20 Jim	N	7	7	15	2	8	16	3	5	12	12	20	43
	%	24	24	52	08	31	62	15	25	60	16	27	57
20 Joe	N	3	4	18	3	4	14	3	4	7	9	12	39
	%	12	16	72	14	19	67	21	28	50	15	20	65
6/7Jim	N	2	14	17	2	14	16	0	13	20	4	41	53
	%	06	42	52	06	44	50	0	39	61	04	42	54
6/7Joe	N	4	7	20	1	9	21	2	6	22	7	22	63
	%	13	22	64	03	29	68	07	20	73	08	24	68

NOTE: Across conditions, the coders agreed that more right than left asymmetries of AUs6/7 occurred ($p<.05$), but no laterality for AU 20. The number of subjects was not equal for each coder in situations where the coders did not agree on the number of actions to score.

TABLE R3

Part 3--Differences between startle conditions

AU	Coder	#Ss with Greater Asymmetry in each Condition								
		Unant. vs. Ant.			Unant. vs. Inhibit			Ant. vs Inhibit		
		Unant.>	Ant.>	Eq.	Unant.>	Inhib.>	Eq.	Ant.>	Inhib.>	Eq.
		N %	N %	N %	N %	N %	N %	N %	N %	N %
20	Jim	8(33)	6(25)	10(42)	4(20)	5(25)	11(55)	2(12)	3(18)	12(70)
20	Joe	3(17)	2(11)	13(72)	3(23)	5(38)	5(38)	4(33)	4(33)	4(33)
6/7	Jim	7(22)	9(28)	16(50)	7(21)	6(18)	20(61)	7(22)	5(16)	20(62)
6/7	Joe	8(28)	7(24)	14(50)	8(28)	7(24)	14(50)	6(20)	6(20)	17(60)

TABLE R4
DIFFERENCES BETWEEN SPONTANEOUS AND DELIBERATE ACTIONS

AU	Coder	Conditions	Deliberate >	Spontaneous >	Equal
20	Jim	Startle vs Request	19	7	4
20	Joe	" "	13	7	3
6/7	Jim	" "	13	17	3
6/7	Joe	" "	15	11	7
12	Jim	Happy Qs vs Smile Req	13	1	2
12	Joe	" "	11	2	2

NOTE: Scores for the spontaneous startle actions were averages of the three startle noise conditions. Scores for the deliberate requested actions were averages of the several actions performed. Only one spontaneous happy action was scored for each subject. Wilcoxon signed-ranks tests showed that deliberate actions were more asymmetrical than spontaneous actions of AU 20 (Joe, $p < .05$; Jim, $p < .001$), but there was no difference for AUs 6/7.

APPENDIX S

PRODUCTION OF STARTLE NOISE

Equipment

The startle stimulus used in this study was a white noise generated by a 5837 integrated circuit. The signal from this chip was switched electronically and fed to two stereo high fidelity amplifiers that drove the headphones and speakers. Choice of amplifiers was based on the ability to amplify signal pulses quickly (slew rate) and the amount of power available for amplifying transients (dynamic headroom). The headphones were chosen because they could deliver high sound pressure levels, fit comfortably, and allowed the subject to hear the experimenter. Four high fidelity speaker units and two PA speakers were stacked directly behind the subject's seat, about six inches from her head. The sound field from this array was wide, rather than from a single point, minimizing the effects of room boundaries and head position on intensity.

Speakers were used in addition to the headphones because during pretesting, it was clear that they markedly increased the capacity of the noise to startle. This increase was out of proportion to the increase in actual sound pressure level which was marginal (see below). Subjectively, this effect was compelling, and subjects clearly appeared to have greater responses to the combination of speakers and headphones than to headphones alone. The sound seemed to have a more palpable form and was more noxious. Perhaps this effect was due to sound waves hitting the face or body rather than being confined to the place where the headphones rested. Also, the speakers provided heavier, felt low frequencies that may have resonated with body organs.

Measurement of Sound Pressure Level

Measurement of sound pressure levels (SPL) produced by the audio equipment used in this study was made to provide guidance for replication by other researchers. SPL is, of course, only one factor that contributes to the perceived loudness of a sound, and loudness is only one factor contributing to he capacity of a sound to startle. SPL was measured using a Bruel and Kaejr Precision Sound Level Meter Type 2203 and its associated 4134 microphone element. The "A" weighting, fast response scale was used. To measure the output from the headphones or headphone/speaker combination, a non-standard headphone coupler was used. This coupler was a plexiglass cylinder 1 1/2 inches in inner diameter and 7/8 inches deep fitting around the B & K's microphone which was 3/4 inches from the diaphram of the microphone. The microphone was placed in the approximate center of an imaginary subject's head sitting in the chair, 11 inches from the speaker's front panels. The microphone diaphram was perpendicular to the wavefront of the speakers's sound, but parallel to the headphone's sound. The headphones were placed on top of the coupler.

The background SPL before the subject received the startling noise was 49 dB. The continuous output of the headphones alone was 116 dB, and of the speakers alone (without coupler) was 119 dB. Together, headphones and speakers produced a continuous output of 121 dB. Balance of the speaker stack was assessed by moving the microphone (without coupler) to he centerline of each speaker stack which was 7 inches from the center of the two speaker stacks. Channel balance was within 1 dB. Measurements of headphone balance showed equal output from each cup. Combined SPL from the speaker/headphone combination was also balanced within 1 dB. The variability in SPL of 80 msec pulses was no greater than 1 dB as read from the B & K's "fast" measuring scale. Although the headphone coupler used to make the measurements above was not standard, an audio consultant measured headphone output alone using a standard B & K coupler to assure its balance and output. Comparison of the measurements above with these measurements indicated that the nonstandard measurements were as much as 4 dB lower than the standard measurements.

APPENDIX Y

DERIVATION OF SCORES FOR UNILATERAL ACTIONS

An appropriate score was needed to analyze unilateral actions. One alternative was to consider simply the intensity of the action on the side the action was requested. This score does not give any information about the asymmetry of the action or whether the action was unilateral. For example, two subjects might both have produced an intensity of 4 on the requested side, but one might have made a symmetrical action and the other a unilateral action. A better score should tell something about the symmetry or unilaterality of the action because there are no hypotheses about how the simple intensity scores are related to other variables.

Another alternative was to use the separate asymmetry scores for the right and left unilateral requests. The information these scores provide about an action that the subject was asked to make asymmetrical is minimal and depended upon the action requested. When a unilateral action is requested on the right, the asymmetry score should be right; when on the left, the score should be left. Table Y1 shows that this pattern was generally obtained. Only for brow actions did a large proportion of subjects seem unable to perform actions as requested. Over all the requests for unilateral actions in Table Y1, 69 percent had an asymmetry score consistent with the request. Of the brow actions alone (AUs 1,2, and 4), only 36 percent followed this pattern while 90 percent of the other actions followed it. A score was needed that could discriminate among the subjects who performed the action as requested.

Another reason for rejecting these separate asymmetry scores was that there were no hypotheses regarding them. For example, there was no hypothesis about how the asymmetry of a unilateral action requested for the left side would be related to the side subjects favored in making a unilateral request or the side they rated as easier to make it on. (There were only chance correlations between the separate asymmetry scores and other measures in this study.) There were hypotheses about which side subjects could do a better unilateral action on and which side they would rate easier or favor. What was needed was a score that would reveal the relative asymmetry of the two requests. This score would reflect how much better a unilateral action was performed when requested for one side than for the other. The score needed to be analogous to other scores that indicated how much stronger an action was on one side, how much easier an action was on one side, etc.

It will be helpful for discussing the derivation of such a score to introduce some terminology that describes unilateral actions. The subjects were asked to perform a unilateral action on one side, and, afterwards, on the other. The side on which the action was requested will be called here the "onside" because this is the side where the action should occur. The other side will be called the "offside" because no action should occur here. These distinctions were reflected in the instructions to subjects which explicitly stated that they should show the action on only one side and not on the other. Thus, for every requested unilateral action there was an offside intensity score and an onside intensity score, regardless of whether the request was for an action on the right or the left side.

The simplest score that might be considered is whether the subject could do a unilateral action on one side but not on the other. The separate asymmetry scores for each unilateral request reflect how well a subject could do the action on one side, but they do not indicate anything about how the well the request for the other side was performed. Again, in order to determine whether the subject could do an action on only one side of the face, one needs to know the scores for both sides. Using the asymmetry scores for each request separately will not suffice.

Table Y2 looks at asymmetry scores for both the right and left unilateral requests considered together. It shows how many subjects had asymmetry consisent with both requests or had only left, only right, or only symmetrical scores. Agreeing with Table Y1, most subjects could produce asymmetry that was consistent with both requests for most of the actions except the brow actions. Only for the brow actions did a large proportion of the subjects have difficulty producing asymmetry consistent with one or both requests. A better score would differentiate among subjects who had asymmetry consistent with both requests and thus retain more subjects in the analysis.

One approach would be to use only true unilateral actions as the criterion for whether a subject can do a unilateral action on the requested side of the face. A true unilateral action should have an intensity of zero on the offside, but movement could often be detected on the offside of both the right and left unilateral requests. Table Y3 shows for each action requested how many subjects did a right or a left unilateral action with an offside of zero intensity. For many of the actions, only a few subjects could do a true unilateral action on either side. This lack of actual unilateral movements would mean an unacceptable loss of subjects from the analysis of these actions if this criterion were used.

Table Y3 also shows that some subjects could do a truly unilateral action for both the right and the left unilateral requests. For example, the total of subjects who did a right unilateral plus those who did a left unilateral AU 20 exceeds the number of subjects, indicating that some subjects must have done both. For most of the AUs, it was obvious during scoring that some subjects could do a true unilateral for both requests. Some way was needed to decide which of the two unilateral actions was better.

One solution might be to chose the unilateral action that had a greater onside intensity. Suppose the request for a right action showed an onside intensity of 4 while the onside intensity for the left action was 3 with the offside intensities zero in both requests. The right unilateral ac

bc

r

t

s

action might be considered a more or better unilateral because more of the action could be shown or isolated on the right side than the left.

This solution suggests that using the onside intensities alone might provide the basis for determining which side showed the better unilateral, regardless of whether the actions were truly unilateral or not. If there was a greater onside intensity for either the right or left request, that would be the better unilateral. For example, suppose the score for a right unilateral request had an onside intensity of 4 and an offside intensity of 1, while the request for a left action had the corresponding intensities of 3 and 1. The right requested action would be called the better unilateral, and this is sensible because it is the more asymmetrical.

This formula works well when the offside intensities are constant (e.g., both 0 or both 1, etc.), but there are problems when the offside intensities vary as they do in this study. For example, suppose the request for a right unilateral produced an onside intensity of 5 and an offside intensity of 5, while the request for a left unilateral produced an onside intensity of 4 and an offside intensity of 1. Simply considering the onside intensities would select the right performance as the better unilateral , but this would be misleading because this action was not only bilateral, it could have been symmetrical while the requested left unilateral was quite asymmetrical. Consider also the case where both onside intensities are the same, but the offside intensities vary. It would be useful to use the offside intensities to decide which was the better try for the unilateral action, but using the offside intensities alone would result in the same kinds of difficulty as using the onside alone.

The examples above illustrate a host of problems that result from considering only the onside intensity and ignoring the offside intensity (or vice-versa) when deriving a score for unilateral actions. It suggests that a better approach would be to consider the difference between the onside and offside intensities. If the right or left requested performance had a bigger difference, that would be the better unilateral. However, there is a more refined measure of the difference between these intensities: the asymmetry score. Thus, in this study, the better unilateral action is defined as the requested unilateral performance which showed the greater asymmetry. Furthermore, a scalar value was calculated to reflect how much better one request was by taking the difference between the asymmetry scores for the two requests. This method of calculating a score for unilateral movements allowed all of the subjects who showed an action to be included in the analysis. All the subjects who showed only a right or only a left asymmetry in Table Y2 were assigned this score, and all the subjects who showed asymmetry consistent with both requests were assigned a score based on the difference in scores for the two sides. Subjects who showed only symmetrical actions were assigned a

better unilateral score of zero.

Some difficult conceptual issues are handled better by defining the better unilateral as the more asymmetrical action. For example, consider the request for a right unilateral as having an onside intensity of 1 and an offside intensity of 0 and the left request having a 5 and 1, respectively. Even though the right request was a true unilateral, it would be misleading to call it the better unilateral because the left performance showed a greater ability to isolate much action on one side and little action on the other. When scoring these rare events, it seemed clear that the subject could easily turn on the one side that was scored as a big asymmetrical action (left in this example), but could not do the same when the other side was requested, as though the offside would move if too much were attempted on the onside.

Having defined the better unilateral as the more asymmetrical attempt to perform a unilateral action, it is instructive to compare relative intensities for the onside and offside between the better and poorer attempt. The strong relationship between these measures is reported in the results (Table 11), and should provide confidence in the final definition because it is highly related to the other scores that were rejected above.

TABLE Y1

NUMBERS OF UNILATERAL ACTIONS WHICH WERE RIGHT, LEFT, AND SYMMETRICAL FOR BOTH THE RIGHT AND LEFT REQUESTS

Action	For the Right Request the action was:			For the Left Request the action was:		
	Left	Symmetrical	Right	Left	Symmetrical	Right
AU 1	6	13	11	10	12	8
AU 2	6	16	18	7	11	11
AU 1+2	4	9	18	10	7	14
AU 4	6	20	3	8	17	3
AU 6/7	1	1	31	29	1	3
AU 9	2	5	22	23	3	2
AU 10	3	3	21	26	2	0
AU 12	0	2	31	32	1	0
AU 20	1	0	29	28	1	2
AU 45	1	1	31	30	2	1
Total	30	60	215	203	57	44

TABLE Y2

COMPARISON OF ASYMMETRY SCORES FOR THE RIGHT AND THE LEFT UNILATERAL REQUESTS SHOWING HOW MANY SUBJECTS PRODUCED ACTIONS CONSISTENT WITH BOTH REQUESTS OR HAD ONLY LEFT OR ONLY RIGHT OR NO ASYMMETRICAL SCORES FOR EITHER REQUEST

Action	Asymmetry Consistent With Both Requests	Only Showed Left Asymmetry	Only Showed Right Asymmetry	Showed No Asymmetrical Actions	Total
AU 1	2	8	9	9	28*
AU 2	3	7	16	4	30
AU 1+2	4	7	17	3	31
AU 4	0	8	4	16	28*
AU 6/7	27	2	4	0	33
AU 9	16	7	6	0	29
AU 10	19	7	2	1	29
AU 12	30	2	1	0	33
AU 20	27	1	2	0	30*
AU 45	28	2	3	0	33

* A total of 5 events across 3 AUs did not fit into the categories of this table.

TABLE Y3

NUMBER OF SUBJECTS WHO PERFORMED TRUE UNILATERAL ACTIONS WITH AN OFFSIDE OF ZERO INTENSITY FOR THE RIGHT AND LEFT UNILATERAL REQUESTS

		Number of Subjects who Performed:		
		Right Unilateral	Left Unilateral	Total N
Request	Action			
Right	AU 1	4	0	30
Left	AU 1	2	2	30
Right	AU 2	9	2	30
Left	AU 2	4	4	14
Right	AU 1 (in 1+2)	3	0	29
Left	AU 1 (in 1+2)	2	2	31
Right	AU 2 (in 1+2)	6	1	31
Left	AU 2 (in 1+2)	3	4	31
Right	AU 4	0	1	29
Left	AU 4	1	0	28
Right	AU 6 (in 6/7)	14	0	22
Left	AU 6 (in 6/7)	0	16	23
Right	AU 7 (in 6/7)	1	0	33
Left	AU 7 (in 6/7)	0	1	33
Right	AU 9	9	1	29
Left	AU 9	0	12	28
Right	AU 10	14	1	27
Left	AU 10	0	18	28
Right	AU 12	7	0	33
Left	AU 12	0	9	33
Right	AU 20	21	0	30
Left	AU 20	0	22	31
Right	AU 45	21	0	33
Left	AU 45	0	22	33

Reference Notes

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