



0028-3932(94)00137-5

LATERALITY IN FACIAL EXPRESSIONS AND ITS EFFECT ON ATTRIBUTIONS OF EMOTION AND PERSONALITY: A RECONSIDERATION*

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(Received 11 May 1994; accepted 21 November 1994)

Abstract—Are there consistent differences between the emotions attributed to the right and left hemiface? Six studies investigated this old question, using a new technique of computerized image reconstruction that eliminates several confounding factors common in previous studies. Findings suggest that there are no consistent differences between the emotions and personality attributed to the right and the left hemiface. Nevertheless, when the two hemifaces were simultaneously compared on intensity, the left hemiface showed greater intensity in posed smiles. As a whole, the present study suggests the possibility of a slight inference of brain laterality in posed expressions, but not in resting faces.

Key Words: facial laterality; facial asymmetry; emotional expression; brain function; judgment of personality; facial attribution.

INTRODUCTION

More than 90 years have passed since the publication of the first psychological study on facial asymmetry and its attribution, and the issue remains as controversial as it was then. Although the initial interest in facial asymmetry dates back to the second half of the nineteenth century [36], it was J. Hallervorden, who, in 1902, first examined the possibility of divergent emotional expressions on the right and left hemifaces [38, 39]. Hallervorden's conclusion was thought-provoking: the right side of the face is apperceptive and active, whereas the left side is affective and "having dark unformed content" [38, p. 310] (cited in [6]). In 1933, Werner Wolff [81] introduced the photographic technique used by Hallervorden to the English speaking world of psychology, and his name has subsequently become synonymous with this methodology ("Wolff's split-face technique"). As with his predecessor, Wolff found that the right hemiface shows vitality and power, representing the public and the individualistic aspects of personality, whereas the more passive left side shows features representing the unconscious and collective characteristics.

Since the publications of these psychoanalytical oriented insights, much research has been conducted within the medical and psychological domains on facial asymmetry. The most unequivocal finding is that the two sides of the face, either resting or expressive, along with the two sides of the skull are indeed somewhat asymmetric. This conclusion is based on popular and experimental observations [22, 23, 50], as well as numerous anatomical

*Portions of Experiments 1–3 were presented at the annual meeting of the Japanese Psychological Association, Tokorozawa, August 1993.

measurements [15, 69, 79, 83]. Furthermore, many studies supported Wolff's insights by pointing out that both hemifaces and their expressions are not only anatomically different, but also have a different impact on observers.

The majority of the psychological studies on facial asymmetry have dealt with attribution differences observers make to the left and right hemiface. While the question of which hemiface better represents the whole was elegantly resolved years later by Gilbert and Bakan [35] as a *left bias* of the perceiver, several issues concerning the right-left lateral dichotomy remain unclear:

Representation of personality

One legacy of the studies of Hallervorden and Wolff has been the interest in differential representation of personality in each hemiface. However, sporadic research has yielded only inconsistent results. Wolff [81, 82] found the left hemiface passive and dead like, and Lindzey *et al.* [49], in more systematic research, obtained similar results: the left hemiface is more passive and the right one is more vital (see also [68]). In contrast, Karch and Grant [44] found subjects to rate men's left side (neutral expression) as stronger, harder, and more masculine. Finally, Stringer and May [72] (cited in [37]) failed to replicate previous findings. Nonetheless, they did find the left hemiface to be more receptive and intuitive, whereas the right hemiface was not attributed with the opposing traits.

Emotional expression

Researchers dealing with facial asymmetry have shifted their efforts in the last two decades into the arena of asymmetry in emotional expression. Their principal objective has been the exploration of brain mechanism in general and hemispheric specialization in particular. Many studies have focused on the proposition that each hemiface, constantly or temporarily, exhibits emotion of different valence, or the same ones but in different magnitudes. Their basic hypothesis maintains that the face reflects brain activity. In other words, stronger expressions in one hemiface indicate a greater involvement of the opposite cerebral hemisphere due to the crossover of pathways from the motor cortex to the facial nucleus. The extensive research on brain specialization for emotion has yielded two "grand" theories. The first one, called the *valence hypothesis*, postulates that the left brain hemisphere is specialized for positive emotions and the right hemisphere for negative emotions [1, 70]. One variant of this theory maintains that there is less hemispheric asymmetry for positive emotions [4, 27], while a second variant maintains that there is a differential specialization for expression based on valence, but not for perception of emotions [24]. The second theory, the *right-hemisphere hypothesis*, postulates that the right hemisphere dominates overall in perception and expression of emotion, regardless of their valence [34, 40].

Several studies have suggested that a primary distinction should be made between neutral expressions found in resting faces and emotional expressions. It has been argued that whereas the former expressions are easily and naturally generated without cortical inference, the latter expressions stem from various often difficult to determine sources [21, 74]. Dealing with the face at rest, Karch and Grant [44] and Campbell [17] found right-handers' left and left-handers' right composites to be more expressive (miserable). In a subsequent larger sample, Campbell [18] (cited in [37, 65]) obtained these results only for females. Still, in another study, Campbell [19] found left-handers' right-side composites to be more expressive (happier or more miserable). Several studies found the left hemiface to show greater "intensity". Borod *et al.* [10] reported the neutral expression of elderly male subjects

to be “significantly left-sided” (p. 763), and similar results were obtained by Moreno *et al.* [53] for adult, elderly, and old women. McGee and Skinner [51] also reported more frequent attributions of emotion adjectives to the left hemiface, and likewise, Bennett *et al.* [3] found the left hemiface to be rated as more happy (cheerful, excitable). Finally, Rhodes and Lynskey [59], did not find any differences.

Compared with resting faces, the situation revealed in studies dealing with expressive faces is more complex, yet, the findings are somewhat less perplexing. Lynn [50] found natural smiles to be mostly symmetric, and when asymmetric, to be evenly divided between left and right dominance. Nonetheless, later studies demonstrated various degrees of greater left-side intensity (especially in negative affect) in right-handers [7, 9, 14, 17, 26, 54, 63, 64]. Among left-handers, however, Campbell [19] obtained more complicated patterns: left hemifaces looked happier in posed smiles, and right hemifaces sadder in posed sad expressions.

An additional reason for the equivocal results of some studies dealing with asymmetry in facial emotions is the lack of distinction between posed (deliberate) expressions and spontaneous expressions. In fact, there is growing evidence that different pathways serve for spontaneous and deliberately posed expressions [21, 25, 28, 60, 76]. On the other hand, several studies, which attempted to clarify this distinction yielded rather contradicting results. Ekman *et al.* [31] revealed more frequent asymmetry for posed expressions, although both spontaneous and posed expressions were found to be rather symmetric, while Cacioppo and Petty's [16] results generally indicated the opposite: posed expressions were judged intensive on the right side and spontaneous expressions intensive on the left side. Borod *et al.* [13] found left-sided asymmetry for both types of expression, whereas Dopson *et al.* [26] offered a fourth alternative: spontaneous expressions on the left hemiface were judged the most intense of all four possibilities, and left-side composites regardless of the condition were more expressive than right-side composites. Finally, a recent meta-analysis of 14 studies found posed emotional expressions to be more intense than spontaneous ones [71], while the latest review of this topic covering 47 studies did not reveal an effect of the elicitation condition [6].

The methodological setback

Notwithstanding the large number of studies, the research in this field as a whole has been “. . . characterized by profound contradictions in the empirical findings reported” [29] (p. 176). Indeed, many of the above studies suffered from methodological faults such as insufficiently systematized manipulation of various mediating factors (emotion type, sex, handedness, etc.), lack of consideration of anatomical differences in the hemifacial size of stimuli presented, unreliable generation of “spontaneous” and “posed” emotions, and samples with too few stimuli (for review see [20, 37, 75]).

While searching for confounding factors, we noticed that the majority of the psychological studies on facial asymmetry have employed the same technique (the “split-face” photographic technique) to create facial composites for stimuli presentation. Researchers took still photos of faces, made one normal print and one print by turning the negative over, and cutting the final image and the mirror image in the mid-line. Then, they rejoined the corresponding halves to produce two composite photos, one made solely of the left side of the face, and the other of the right side. Although some methodological advancements have been made over the years, the basic technique has not changed since the first study. The success of this method is simply because it has been the only method to allow thorough examination of the whole face in static and carefully arranged poses. In addition, it distinctly separates the

two hemifaces during evaluation and eliminates the effect of the left bias, that occurs when examining ordinary faces [35, 52].

The present study challenges Wolff's technique and hence the validity of some of the findings presented above. It is contended here that virtually all the researchers who used the above technique used somewhat inadequate stimuli (photographs), due to one or more of the following drawbacks:

- *Hair*. Duplicating the hair contour tends to create ridiculous and divergent hair forms in each composite.
- *Shadows and light*. Unilateral shadows on the face, cast by inappropriate lighting, cause the shadowy side to look unnaturally "darker" and thinner after duplication. Inadequate lighting may lead to repeated bias in a series of pictures.
 - *Blemishes*. Natural and unnatural blemishes are asymmetrically duplicated.
 - *Facial deflection*. Faces not positioned straight forward (in the camera direction), as a result of habitual or personal inclination of the model, lead to an ostensibly different facial width and shape following duplication. Inadequate frontal lighting causes such deflections to cast larger shadows on the side that is further from the camera.
 - *Uneven background*. Uneven background, clothes, or accessories tend to add an uneven subliminal effect.
 - *Manipulation cue*. The visible mid-line of the constructed pictures may indicate the experimenters' underlying intentions.

It is suggested that these factors, separate or combined, led to perceived differences, related to neither the anatomical nor the emotional reality, between the two hemifaces.

An improved technique for creating and presenting chimeric faces

In order to avoid the above faults, a new technique of hemifacial duplication was devised. Instead of the manual assembling of two pictures, photographs are scanned into a computer (Apple Macintosh), and manipulated on the computer screen using a graphics program (SuperPaint 3.0 graphics software, Silicon Beach Software, Inc.). Each portrait is halved, and the resulting two hemifaces are separately duplicated, so that the duplicated half is flipped vertically to form two new facial composites: left and right (Fig. 1). The vertical midline is determined by connecting the midpoints between the eyes, nose, upper lip, and chin (adapted from [65]), and the original hairline is copied from the original face and pasted on each composite. In addition, minor light differences were balanced, blemishes eliminated, and further information (background, clothes, earrings, etc.) erased.

Using these composites, we reexamined the existence of attribution differences between the right and left hemifaces, expecting no consistent differences between the right and left hemifaces at rest. The presumed similarity, regardless of stimuli's handedness, sex, or ethnicity, is based on the absence of any conclusive evidence for either consistent anatomical differences between the two hemifaces, or any lateralization effect. In contrast, in the case of expressive faces (posed smiles), previous findings lead to the expectation of a laterality effect: that is, the left hemiface is assumed to be somewhat more expressive.

EXPERIMENT 1: ATTRIBUTIONS TO RIGHT-HANDERS' NEUTRAL FACE

Overview

As with the majority of studies that have made a distinction of handedness, this experiment examined attributions to right-handers' resting faces. The rationale behind the expectation of

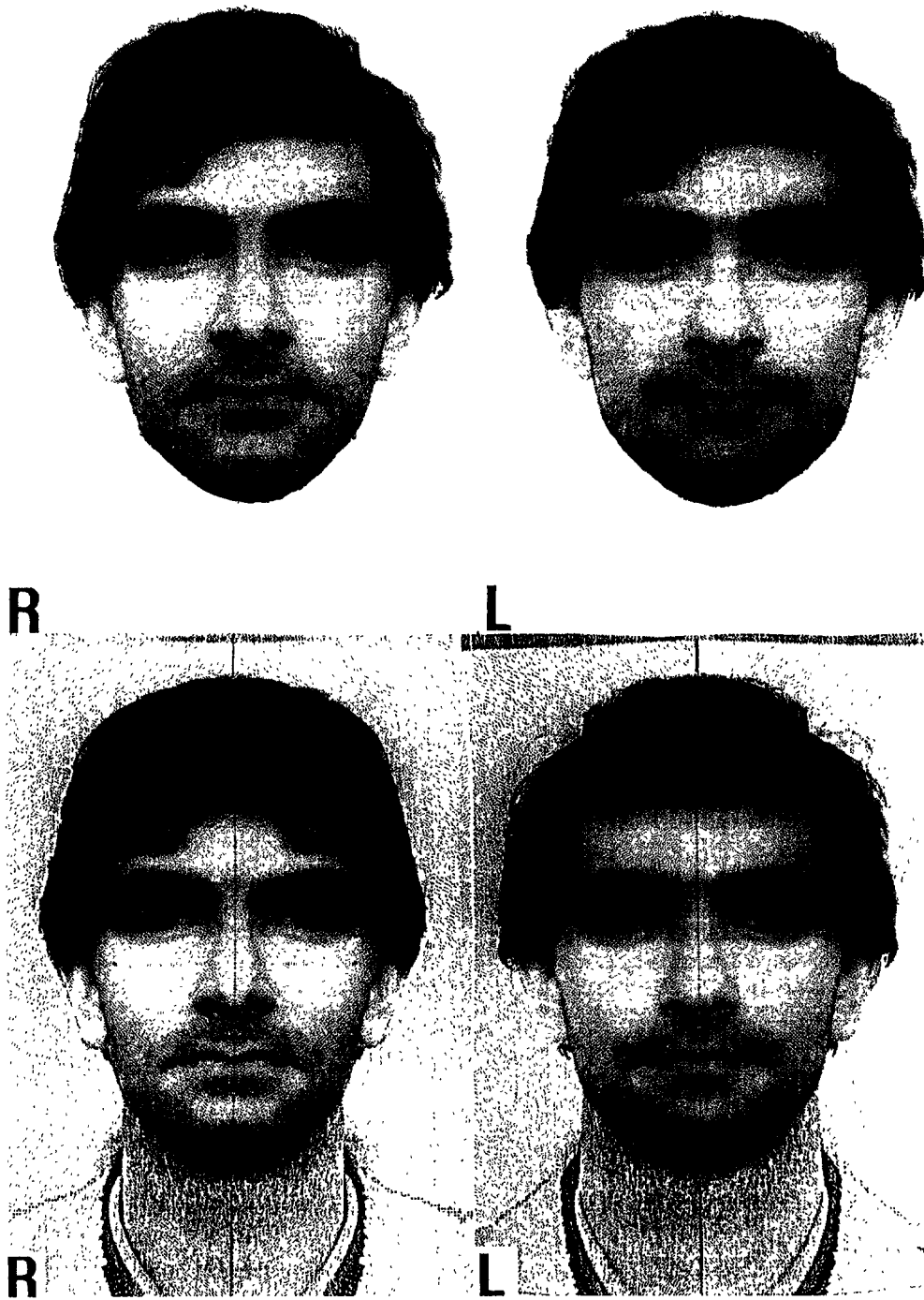


Fig. 1. Right hemifacial composite (R), and left hemifacial composite (L), using the new technique (upper row) and Wolff's technique (lower row).



Fig. 2. Right hemifacial composite (R), vs left hemifacial composite (L). The left hemifacial composite was judged as more intensive in 70% of the observations.

a laterality effect in right-handers is that they might have greater control over their face, for the same reason they have better control over other motoric acts. Using two groups of judges with two different procedures, nine bipolar attributions to resting faces of right-handed stimuli were examined. In the first group each subject rated only one set of stimuli made from either right or left hemifacial composites, whereas the second group of subjects first rated one of the two sets, and a week later rated the complementary set.

Methods

Subjects. Group 1—Sixty-one undergraduates (45 males and 16 female, mean age of 22.0 ± 4.4). Group 2—Thirty-two undergraduates (19 males and 13 females, mean age of 22.3 ± 5.0). All the subjects were Japanese enrolled in Meikai University. They were naive to the task, and participated as a part of their fulfilment of a course requirement.

Testing material. Stimulus materials—Twenty black-and-white pictures of right-handed people (handedness was determined according to self-report) were used: 10 pictures of males (mean age 29.3 ± 10.7), and 10 pictures of females (mean age 24.5 ± 8.2), all Japanese. Stimulus persons were photographed with a 35 mm camera (135 mm lens F2.5 on a tripod at a fixed distance of 2.0 m) with fixed, frontal illumination. They were instructed to look directly at the lens of the camera, and to present a neutral expression, devoid of any emotion. They were not forewarned when photographs would be taken. These pictures, as well as those of the following experiments, were selected from a large pool, according to their clarity, scarcity of uneven shadows, lack of horizontal and vertical deflections, and regardless of their facial asymmetry. The pictures were arranged in two sets: left hemifacial composites and right hemifacial composites. Each set was presented in a form of a booklet containing a distinct color cover and 20 pages with a single 25×18 cm photo on each page.

Dependent measure—Each photo was rated using eight scales of 7-point bipolar impression-related adjective pairs. The bipolar adjectives were selected on the basis of previous research indicating relevance to personality and emotion [44, 49, 65]. Seven of the adjectives were chosen after Karch and Grant [44] who isolated them from nine bipolar adjective scales selected for the evaluative, potency, and activity dimension of the *semantic differential* [56]. An additional reason for the choice of these scales, beside the fact that they yielded significant results, was the intention to compare this study with studies that employed the Wolff-style stimuli. The scales measure the following attributions: situational disposition and emotions (happy–sad, relaxed–nervous, sick–healthy, rich–poor expression), as well as personality and character (good–evil, passive–aggressive, hard–soft, feminine–masculine). In addition, age evaluation was performed using a 45-point scale (ranging from 15 to 60 years old). The inclusion of this dimension was based on the hypothesis that more expressive and intense faces would be perceived as older [53].

Procedure. Group 1 (between-subjects investigation)—The session was presented as a research on face perception, and took about 15 min. Subjects randomly rated a set of 20 photographs of either right-hemiface composites or left-hemiface composites.

Group 2 (within-subjects investigation)—This experiment was conducted in two phases. In the first phase, subjects randomly rated a set of 20 photographs of either right-hemiface composites or left-hemiface composites. In the second phase, a week later, those subjects who had previously rated the set of left-hemiface composites rated the set of right-hemiface composites and vice versa. In this manner we obtained ratings of each subject for both hemifacial composites.

Results and discussion

Group 1. A preliminary analysis of the stimuli's right and left hemifacial size using the Wilcoxon Signed-rank test indicated no significant difference. Subsequently, a 2 (right–left hemifacial attribution) \times 2 (sex) between subjects analysis of variance (ANOVA) was conducted to examine the differences between each attribution rating of the right and left hemifaces as well as the effect of the subject's sex. As expected, the analysis of subjects' mean ratings across the 20 stimuli persons for each attribution did not yield any significant difference (see Table 1). The same analysis was performed separately on the male and female stimuli and similar results were obtained.

Group 2. A 2 (sex) \times 2 (right–left hemiface attribution), and within subjects repeated measures ANOVA was conducted to examine the differences between attributions to right and left hemifaces as well as subject's sex. Only one difference approached significance: the left hemiface was attributed as healthier than the right one, $F(1, 31) = 6.8$, $P < 0.02$ (see Table 1).

Table 1. Mean (and S.D.) scores of attribution ratings of right-handed stimuli—left vs right composites of resting faces

Comparison type	N	Group 1 (Between subjects)		Group 2 (Within subjects)	
		Left (34)	Right (27)	Left (32)	Right
Attribution					
Happy-sad		3.89 (0.40)	3.90 (0.39)	38.2 (0.40)	3.89 (0.39)
Passive-active		4.11 (0.49)	4.12 (0.56)	4.18 (0.61)	4.13 (0.51)
Hard-soft		3.61 (0.52)	3.59 (0.45)	3.73 (0.55)	3.64 (0.47)
Good-evil		3.49 (0.65)	3.69 (0.65)	3.48 (0.64)	3.49 (0.69)
Healthy-sick		3.24 (0.61)	3.31 (0.63)	3.07 (0.55)	3.27 (0.57)*
Feminine-masculine		4.57 (0.49)	4.68 (0.45)	4.48 (0.33)	4.47 (0.44)
Rich-poor expression		4.37 (0.63)	4.46 (0.48)	4.27 (0.59)	4.35 (0.51)
Relaxed-tensed		4.09 (0.63)	4.12 (0.58)	3.87 (0.62)	4.07 (0.65)
Age (years)		26.0 (2.39)	25.6 (1.47)	26.4 (2.38)	25.6 (1.75)

* < 0.05.

The results confirmed this study's first hypothesis regarding attribution similarity between the resting right and left hemiface of right-handers. Given the possibility of type I error due to the large number of analyses, the one effect found in the second group was not interpreted. Separate analyses of males and females' stimuli did not yield a sex difference in lateralization. The lack of evidence for sex difference is in contrast to Stringer and May [72] (cited in [37]), who found that the trait "tired" was attributed to men's right side and women's left side, and Campbell, ([18] cited in [37, 65]), who obtained greater facial intensity only for females. Likewise, Alford and Alford [2] found males to display greater left-side asymmetry, using preferred eye winking and eyebrow raising facility as their criteria. Similarly, the absence of sex differences, which has been found to affect perceptual asymmetries in the processing of facial expressions [72], corroborates our first assumption that there is no lateral inference in the face at rest, regardless of sex.

EXPERIMENT 2: ATTRIBUTIONS TO LEFT-HANDERS' NEUTRAL FACE

Overview

In view of the "negative" evidence of the first study (acceptance of the null hypothesis), a control group was added to the second study in order to examine the specific variables that may have been responsible for the previously reported effects. The control group was presented with stimuli prepared with Wolff's "split-face technique". As a whole, the second experiment examined attributions to resting faces of left-handed stimuli.

Left-handedness has been associated in a number of studies with marked neurological differences [42, 79]. One hypothesized difference in some previous studies, was a smaller cerebral lateralization in left-handers; a notion that led to the assumption concerning hypothesized relations between facial dominance with handedness. Chaurasia and Goswami [22] found right-handers to have more left facial dominance in (supposedly) spontaneous expressions (59 vs 39%), and left-handers to have right facial dominance (73 vs 23%). Likewise, Rubin and Rubin [61], using 20 children posing various expressions, found most of the right-handed subjects had left-side dominance, whereas the left-handed subjects showed right dominance or none. Campbell [19], however, found posed smiling left-handed subjects to have left dominance, while Rapoport and Friendly [57] (cited in [65]) as well as Borod

and Caron [7] obtained more left dominance (or pronounced pleasantness) among posing left-handers which was similar to the results for right-handers. Borod *et al.* [8] also demonstrated greater intensity on the left hemiface, however, the results were unrelated to either hand or foot preference (except for “toughness”). Heller and Levy [41] tachistoscopically presented facial composites, half the face smiling and the other half resting, of right- and left-handed posers. The pictures were perceived as happier when it was the left side of the poser’s face that was smiling, and this held for both right- and left-handers. Finally, Moscovitch and Old [54], who videotaped subjects telling various experiences (supposedly spontaneous expressions), found right-handers to show left-side intensity, but no consistent asymmetry among left-handers.

The only study examining attributions to facial asymmetry of left-handers’ resting faces was conducted by Campbell [18] (cited in [37, 65]), who found again the right hemiface to be more intense. We hypothesized that the findings of the first experiment would be replicated, as we ruled out the effect lateralization of brain function (cortical inference) in resting faces.

Methods

Subjects. Group 1—Forty-seven undergraduates (30 males and 17 females, mean age of 20.1 ± 0.8). Group 2—Twenty-nine undergraduates (17 males and 12 females, mean age of 20.0 ± 0.9). Group 3—60 undergraduates (32 males and 28 females, mean age of 20.4 ± 2.0). All the subjects were Japanese enrolled in Meikai University or the University of Tsukuba.

Testing material. Stimulus materials—10 black-and-white pictures of left-handers were selected: five pictures of males (mean age 20.3 ± 1.3), and five pictures of females (mean age 24.3 ± 7.7), all Japanese. The selection procedure and the arrangement were identical to Experiment 1. The composites shown to group 3 were created according to Wolff’s “split-face technique” (see the Introduction).

Dependent measure—this used the same questionnaire as in Experiment 1.

Procedure. Groups 1 and 3 underwent the same procedure as that of Group 1 in Experiment 1, and Group 2 as that of Group 2 in Experiment 1.

Results and discussion

Group 1. A preliminary analysis indicated that the stimuli’s right and left hemifacial size did not differ significantly. Subsequently, a 2 (right–left hemiface attribution) \times 2 (sex) between subjects ANOVA was conducted to examine the differences in attributions between the right and left hemifaces. The analysis of subjects’ mean ratings across the 10 stimuli did not yield any significant difference between attributions to the left and right hemifaces.

Group 2. A 2 (sex) \times 2 (right–left hemiface attribution) within subjects repeated measures ANOVA was conducted to examine the differences between attributions to right and left hemifaces as well as the subject’s sex. No significant differences were found within the subjects (see Table 2).

Group 3. A 2 (sex) \times 2 (right–left hemiface attribution) between subjects ANOVA revealed that the left hemifaces were perceived as younger [$F(1, 57) = 7.1, P = 0.01$], and tended to be attributed as having richer expression and being more relaxed, $F(1, 57) = 3.4, P < 0.8$; $F(1, 57) = 2.8, P = 0.1$, respectively.

The results of the first two groups that judged the composites corroborated the findings of Experiment 1, and support the assumption of similarity between the two hemifaces in resting faces. In the third group, we have used the same stimuli, however they were manipulated using the traditional technique. The finding of few marginal differences in attribution in this group seems to indicate its potential for random attributional error. Moreover, subjects thought, when presented with both composites in a follow-up interview, that some of the pairs belonged to different people. This misattribution did not occur with composites created by the improved technique.

Table 2. Mean (and S.D.) scores of attribution ratings of left-handed stimuli—left vs right composites of resting faces

Comparison type	N	Group 1 (Between subjects)		Group 2 (Within subjects)		Group 3 (Between subjects)	
		Left (25)	Right (22)	Left (29)	Right (29)	Left (30)	Right (30)
Attribution							
Happy-sad		4.16 (0.54)	4.27 (0.66)	4.31 (0.61)	4.37 (0.77)	4.02 (0.40)	4.10 (0.38)
Passive-active		3.85 (0.57)	3.75 (0.60)	3.59 (0.62)	3.53 (0.76)	4.06 (0.48)	4.11 (0.45)
Hard-soft		3.62 (0.67)	3.69 (0.71)	3.51 (0.60)	3.59 (0.55)	3.66 (0.34)	3.78 (0.48)
Good-evil		3.72 (0.80)	3.40 (0.95)	3.57 (0.90)	3.55 (1.02)	3.49 (0.56)	3.62 (0.51)
Healthy-sick		3.67 (0.97)	3.65 (0.72)	3.82 (0.92)	3.72 (0.91)	3.50 (0.40)	3.30 (0.50)*
Feminine-masculine		3.95 (0.53)	4.08 (0.45)	3.97 (0.55)	4.08 (0.54)	4.13 (0.41)	4.24 (0.40)
Rich-poor expression		4.35 (0.65)	4.53 (0.51)	4.54 (0.63)	4.52 (0.70)	4.10 (0.56)	4.31 (0.53)
Relaxed-tensed		4.36 (0.83)	4.32 (0.53)	4.37 (0.85)	4.35 (0.73)	3.94 (0.51)	4.15 (0.49)*
Age (years)		23.0 (2.48)	22.8 (2.46)	23.3 (3.73)	22.6 (1.75)	21.3 (1.83)	22.3 (1.61)†

* ≤ 0.1 .† < 0.05 .

Campbell's [19] findings regarding face at rest may be due to inadequate stimuli. For final support for our results we lean on the findings of Heller and Levy [41] who found, in a different although illuminating setting, no handedness differences among posers of emotional expression. Experiments 1 and 2 also reconfirmed earlier findings that handedness does not predict facedness, that is left-handed people are not likely to be right-faced and vice versa [46]. The fact that hand preference is a poor predictor of cerebral laterality may lend additional support to an alternative explanation for the absence of cortical inference in resting faces (for review [20]).

EXPERIMENT 3: ATTRIBUTIONS TO NON-JAPANESE RIGHT-HANDERS' NEUTRAL FACE

Overview

The interest in the universality of facial expressions has recently penetrated the field of facial asymmetry as well. Rhodes and Lynskey who examined the likelihood of ethnic or racial differences in facial asymmetry, compared Chinese and Caucasians faces. In their first study [58] they found Chinese stimuli's faces to show more intense emotion on the left hemiface, whereas their Caucasian sample did not. In their second study [59], they found both groups showed more positive attributions (happiness and excitement) on the left hemifaces, but more negative attributions (cruel, cold) on the right hemiface of the Caucasians only. Nevertheless, several studies examining the universality of facial expressions have not revealed any substantial differences across cultures [30]. Our third experiment examined attributions to resting faces of right-handed Caucasian stimuli, to determine whether they differ from the attributions pattern found with Japanese faces used in Experiments 1 and 2. We hypothesized that the previous findings of the first experiment would be replicated, as the possibility of cortical inference in the resting faces, regardless of the stimuli's ethnicity, is ruled out.

Methods

Subjects Group 1—Fifty-nine undergraduates (33 males and 26 females, mean age of 20.4 ± 1.1). Group 2—The subjects were 29 undergraduate students of psychology (17 males and 12 females, mean age of 20.0 ± 0.9). All the subjects were Japanese enrolled in Meikai University or the University of Tsukuba.

Testing material. Stimulus materials—Ten black-and-white pictures of right-handers were selected: five pictures of males (mean age 28.6 ± 6.0), and five pictures of females (mean age 30.4 ± 2.5), all Caucasians. The selection procedure and the arrangement were identical to Experiment 1.

Dependent measure—This used the same questionnaire as that of Experiment 1.

Procedure. The same procedure as in Experiment 1 was used.

Results and discussion

Group 1. A preliminary analysis indicated that the stimuli's right and left hemifacial size did not differ significantly. Subsequently, a 2 (right–left hemiface attribution) \times 2 (sex) between subjects ANOVA was conducted to examine the differences between attributions to the right and left hemifaces as well as the subject's sex. The analysis of all subjects' mean 7-points ratings across the 10 stimuli for each attribution yielded one significant difference between the attributions to the left and right hemifaces: right hemifacial composites were on average rated as more masculine than the left composites, $F(1, 55) = 7.5$, $P < 0.01$.

Group 2. A 2 (sex) \times 2 (right–left hemiface attribution) within subjects repeated measures ANOVA was conducted to examine the differences between attributions to the right and left hemifaces as well as the subject's sex. One significant difference was revealed within subjects:

Table 3. Mean (and S.D.) scores of attribution ratings of Non-Japanese (Caucasians) right-handed stimuli—left vs right composites of resting faces

Comparison type	N	Group 1 (Between subjects)		Group 2 (Within subjects)	
		Left (32)	Right (27)	Left (29)	Right
Attribution					
Happy-sad		3.94 (0.44)	4.06 (0.39)	4.08 (0.61)	4.11 (0.43)
Passive-active		4.16 (0.55)	4.03 (0.50)	3.98 (0.52)	3.85 (0.47)
Hard-soft		3.94 (0.71)	3.86 (0.58)	3.80 (0.61)	3.82 (0.46)
Good-evil		3.90 (0.55)	3.88 (0.69)	3.91 (0.74)	4.02 (0.68)
Healthy-sick		3.74 (0.65)	3.78 (0.63)	3.84 (0.64)	3.76 (0.62)
Feminine-masculine		4.02 (0.53)	4.35 (0.39)**	4.04 (0.55)	4.32 (0.42)**
Rich-poor expression		4.10 (0.59)	4.24 (0.60)	4.29 (0.64)	4.16 (0.59)
Relaxed-tensed		3.70 (0.63)	4.02 (0.69)	3.92 (0.58)	3.95 (0.58)
Age (years)		27.5 (3.15)	27.7 (3.29)	27.7 (3.72)	27.7 (3.52)

** < 0.01.

the right face was attributed, as with Group 1, as more masculine than the left one, $F(1, 28) = 9.1$, $P < 0.01$ (see Table 3).

The results did not reveal substantial differences in attributions between the right and left hemifaces of right-handed Caucasians' resting face. The one difference found is probably due to the small sample used (10 faces). Obviously, the smaller the sample, the greater the probability that individual inconsistent asymmetries would effect the group average. As a whole, findings provide a cross-cultural support to our findings in Experiment 1. Following their own admission, Rhodes and Lynskey's [58] cross-cultural differences seem to stem from different expressions posed in each group, which were further enhanced by the low quality of the photographs in the Chinese sample.

Overall, the results of the first three experiments indicated the existence of very limited differences between the two hemifaces. To control for spurious significant findings due to the large number of univariate tests, new probabilities of Type I errors were calculated using Neher's [55] formula. Using this formula for eight variables (Age was excluded because it was measured on a different scale), a univariate F -test would need to have a $P = 0.006$ in order to have a Type I error probability level less than 5%. Such an error eliminates the few haphazard differences found. Taking an additional approach, the scores of the nine scales of three studies (Experiments 1-3, between-subjects groups) were subjected to a principal components analysis using varimax rotation, which indicated that 63% of the variance was accounted for by four factors. The items for the four factors were selected on the basis of their loading (minimum 0.5). The first factor *Emotional intensity* accounted for 30% of the variance and included the following five dimensions: Happy-sad, Passive-active, Hard-soft, Rich-poor expression, Relaxed-tensed; The second factor *Facial goodness* included two dimensions: Good-evil and Healthy-sick; The third factor *Gender orientation* included the Feminine-masculine dimension; and the fourth factor *Age* include the Age dimension.

Subsequently, a meta-analysis was conducted, using the scores of the first three studies ($n = 167$). We examined the effect of laterality and handedness on each factor, using 2 (Laterality) \times 2 (Handedness) between-subjects ANOVAs. The analyses revealed main effect of handedness in the first, third, and fourth factor; $F(1, 163) = 16.3$, $P < 0.001$, $F(1, 163) = 20.5$, $P < 0.0001$, $F(1, 163) = 61.2$, $P < 0.0001$, respectively. Right-handed stimuli were rated as more intensive, masculine and older. These differences may reflect

individual differences because of the small size of the samples rather than effect of handedness (e.g. age). There was no main effect of laterality, and only a tendency for interaction between laterality and handedness in the second factor, $F(1, 104) = 3.2, P < 0.08$. Right-handers' left hemiface was rated more positively than the right hemiface, while among left-handers the opposite ratings were revealed. Separate analyses were also conducted to examine the effect of laterality on the rating of the four factors within the left-handers and within the two samples of right-handers ($n = 120$). These analyses did not reveal any significant effect.

EXPERIMENT 4: ATTRIBUTIONS TO RIGHT-HANDERS' POSED SMILING FACE

Overview

The fourth experiment examined attributions to posed expressive faces of right-handers. In contrast to the limited perceived asymmetry found in the resting faces, the more prominent asymmetry in expressive faces has been associated with lateralization of brain function in expressing emotions. It is well-established that the cerebral hemispheres differ in their processing of emotions (for review see [80]). Although most of the studies have indicated that the left hemiface shows greater intensity, some of them have failed to distinguish between spontaneous and posed emotions (for review [28, 31]). This distinction seems indispensable, as neurological studies of patients with various brain lesions have indicated that some of them could not move their facial muscles voluntarily, but retained their involuntary emotional expressions (pyramidal tract lesion). On the other hand, certain patients displayed abnormal expressions, however their muscle movement remained intact [11, 60, 76, 78].

The choice of posed smiles in this experiment follows the conviction that it is impossible to take adequate still photos of genuine enjoyment-smiles in settings which demand fixed faces (similar to the ones in this experiment).

Methods

Subjects. Seventy-two undergraduates (36 males and 36 females, mean age of 20.4 ± 5.1 years old) enrolled in the University of Tsukuba. All were Japanese who participated as a part of course requirement.

Testing material. Stimulus materials—24 black-and-white pictures of right-handed Caucasians and Japanese were selected: 12 pictures of male stimuli and 12 pictures of female stimuli (mean age 25.7 ± 5.0). Models were instructed to present a controlled and moderate smile without any reflection, and to avoid moving their head during the photography session. Their smiles were obviously *non enjoyment-smiles* (deliberate and voluntary facial expression), which are assumed to be physically different from enjoyment ones [33].

Dependent measure—the same questionnaire as in Experiment 1 was used.

Procedure. The experiment was presented as research on face perception. The 24 pictures were arranged in two sets of 12 composites, half of them right-hemifacial composites and half left-hemifacial composites. The assignment of the sets and their laterality order were counterbalanced across subjects and gender.

Results and discussion

An analysis of all stimuli's hemifacial size indicated no significant difference between the right- and left-hemifacial composites ($P > 0.3$). A 2 (sex) \times 2 (attributions to each hemiface) within subjects ANOVA was conducted to examine the differences between the attributions to the right and the left hemifaces as well as the subject's sex. The analysis of all subjects' mean 7-points ratings across the 24 stimuli for each attribution revealed that the left hemiface was attributed as being more active (intense), $F(1, 576) = 4.0, P < 0.05$, and having a tendency for a richer expression than the right hemiface ($P = 0.1$). The targets' age also seemed to be effected by hemifacial differences: left hemifaces tended to be evaluated as older than the right ones ($P < 0.1$). Due to the large number of univariate tests, new probabilities of Type I errors

Table 4. Mean (and S.D.) scores of attribution ratings of right-handed stimuli—left vs right composites of expressive faces

Comparison type	N	Group 1 (Within subjects)	
		Left hemiface	Right hemiface
		(72)	
Attribution			
Happy-sad		2.95 (1.31)	3.11 (1.24)
Passive-active		4.44 (1.55)	4.17 (1.61)†
Hard-soft		4.14 (1.56)	4.12 (1.63)
Good-evil		3.14 (1.29)	3.19 (1.22)
Healthy-sick		3.05 (1.45)	3.06 (1.45)
Feminine-masculine		4.05 (1.74)	4.21 (1.70)
Rich-poor expression		3.67 (1.69)	3.90 (1.66)*
Relaxed-tensed		3.53 (1.57)	3.62 (1.66)
Age (years)		24.2 (6.86)	23.2 (6.43)*

* ≤ 0.1 .† < 0.05 .

were calculated using Neher's [55] formula. Using this formula for eight variables (Age was excluded because it was measured on a different scale), a univariate F -test would need to have a $P=0.006$ in order to have a Type I error probability level less than 5%. Such error eliminates the limited tendency found for the greater intensity on the left hemiface. Subsequently, the scores were subjected to a principal components analysis using varimax rotation, which indicated that 79.5% of the variance was accounted for by four factors. The items for the four factors were selected on the basis of their loading (minimum 0.05). The first factor *Emotional intensity* accounting for 48.5% of the variance and included the following six dimensions: Happy-sad, Passive-active, Hard-soft, Rich-poor expression, Relaxed-tensed. The second factor *Age* comprised the Age dimension, the third largest factor *Gender orientation* included the Feminine-masculine dimension, and the fourth factor *Goodness* included one dimension: Good-evil. Subsequently, we examined the effect of laterality on each factor, using one way between-subjects ANOVA for the first factor (the others were of a single dimension examined beforehand). The analysis did not yield any significant result ($P < 0.20$).

These findings indicate that only slight tendency for difference in lateral intensity could be observed. Although the differences appear to be greater than those observed among resting faces in Experiments 1-3, they are not conspicuous.

EXPERIMENT 5: LATERAL INTENSITY IN POSED SMILING FACES

Overview

The four experiments above did not reveal any salient or consistent differences between the attributions made to the right and the left hemifaces of either neutral or expressive faces. These results may stem from the great similarities between the two hemifaces, as we predicted for neutral faces, or alternatively because we used measures insufficiently sensitive to detect subtle hemifacial differences. Due to the extensive evidence for the greater intensity seen on the left hemiface of expressive faces, we sought to reexamine the issue of intensity using presumably more discriminative method. In the following experiment, left and right composites of (posed) expressive faces were simultaneously displayed and subjects were required to judge which of them shows greater emotional intensity.

Method

Subjects. Thirty-eight undergraduates participated in this experiment (21 females, 17 males, mean age = 21.3 ± 4.0 years old). All were volunteers enrolled in the University of Tsukuba.

Testing material. Stimulus materials—Twenty-two stimulus persons were used. They were identical to those used in Experiment 4 (two stimulus persons were deleted because their portraits could not be adequately reproduced). Two sets of stimuli were used. The first set comprised of 22 OHP sheets each with two portraits of the same stimulus person: a left-hemifacial composite on one side, and a right-hemifacial composite on the other side (see Fig. 2). The portraits were randomly arranged on either side of the OHP sheet, and their number was counter balanced. The second set comprised the same portraits, yet each pair was arranged in opposite (complementary) order to that presented in the first set. This procedure was used to increase reliability and to avoid the effect of the left-field perceptual bias of the observer [35].

Dependent measure.—Subjects were asked to select one portrait from the two presented on each OHP sheet, using the intensity of the stimuli's facial expression as a criterion ("which one of the two portraits seems to have more intensive expression?"). The independent measure was the selection ratio of the left-hemifacial composites.

Procedure. The subjects were divided into two groups and were given an evaluation sheet comprising of two columns (left portrait and right portrait) and 22 rows. The experiment was presented as a research on face perception, and following a short trial, the OHP sheets were displayed one by one on a 2×2 m screen for 5 sec each. After completing the first set, the subjects inserted the score sheet into an envelope, and following a short break, they were presented with the second set.

Results and discussion

Analysis of the mean selection ratio of the two hemifacial composites (left hemiface = 58.7% vs right hemiface = 41.3%) indicated that the left hemiface was selected significantly above the chance level, $t(37) 8.2$, $P < 0.0001$, two-tailed. The total selection ratio of the left-hemifacial composites in the first and the second set were identical (first set = 58.7% vs second set = 58.7%), and likewise, there was a high congruity between the total score of the male and female subjects (males = 59.1% vs females = 58.4%), and the male and female stimuli (males = 59.8% vs females = 57.7%). In addition, we examined the intensity ratings for each stimulus person. Seven stimuli were judged as more intensive on the left hemiface (31.8%); one stimulus person was more intensive on the right hemiface (4.6%), and the remaining 14 stimuli did not show any lateral inclination (63.6%). Significant scores were all at least $t(75) 2.0$, $P < 0.05$.

The results confirmed earlier evidence that right-handers' left hemiface is somewhat more intensive during emotional expression [6, 71]. Our findings regarding the prevalence of lateral intensity within individuals are similar to those of Lynn and Lynn [50] and Moscovitch and Olds [54]. In the former study, conducted more than five decades ago, it was reported that 73% of the observed involuntarily smiles were symmetric, while the remaining asymmetric smiles fell evenly into the two groups. In the latter study, 72% of the observed involuntarily smiles were symmetric, 19% were left-sided and 9% were right-sided.

EXPERIMENT 6: LATERAL INTENSITY IN NEUTRAL FACES

Overview

In the final experiment, we employed the procedure used in Experiment 5 to examine intensity difference between right and left hemifacial composites of faces with neutral expression. Intensity ratings for either hemiface were expected not to differ from chance level, as brain inference on neutral expressions was ruled out.

Method

Subjects. Thirty undergraduates participated in this experiment (18 females, 12 males, mean age = 19.8 ± 0.8 years old). All were volunteers enrolled in the University of Tsukuba.

Testing material. Stimulus materials—Forty stimuli were used. They were identical to those used in Experiments 1–3. The construction of the sets was identical to the one in Experiment 5.

Dependent measure—This used the same measure as described in Experiment 5.

Procedure. The subjects were divided into two groups and were given an evaluation sheet, which had two columns (left portrait and right portrait) and 40 rows. The experiment was presented as a research on face perception, and following a short trial, the OHP sheets were displayed one by one on a 2×2 m screen for 5 sec each. Each group rated a separate set of right-handed stimuli, while the 10 left-handed stimuli were rated only by the second group.

Results and discussion

Analysis of the mean selection ratio of the two hemifacial composites of the right-handed stimuli (left hemiface = 53.4% vs right hemiface = 46.6%) indicated that the left hemiface was selected significantly above chance level, $t(29) 2.2$, $P < 0.04$, two-tailed. Analysis of the mean selection ratio of the two hemifacial composites of the left-handed stimuli (left hemiface = 38.7% vs right hemiface = 61.3%) indicated that the left hemiface was selected significantly below chance level, $t(14) 2.2$, $P < 0.05$, two-tailed. In addition, we examined the intensity ratings for each stimulus person. Among the right-handed stimuli, eight stimuli were rated as more intensive on the left side (26.7%); two stimuli were more intensive on the right side (6.7%), and the remaining 20 stimuli did not show any lateral inclination (66.7%) (significant scores were all at least $t(29) 2.1$, $P < 0.05$). Among the left-handed stimuli, two stimuli were significantly more intensive on the right side (20%); one stimulus person was more intensive on the left side (10%), and the remaining seven stimuli did not show any inclination (70%) (significant scores were all at least $t(14) 2.1$, $P < 0.05$).

The results suggest that expression intensity perceived in neutral faces tends to be related to laterality. Neutral faces of right-handers showed somewhat greater intensity on the left side—a similar pattern to the one found in expressive faces of right-handers yet lower in magnitude. The opposite pattern revealed in neutral faces of left-handers is of considerable interest. Although Chaurasia and Goswami [22] found similar tendency (see Experiment 2), our sample is rather small and further research is required before conclusions can be made.

GENERAL DISCUSSION

This study attempted to reexamine lateral differences between the left and right hemiface in neutral and posed expressions, using properly constructed sets of stimuli.

Attributions to neutral faces

In the first three studies concerning attributions to neutral expressions, only three statistically significant main effects of left–right hemifacial distinction (between and within subjects) were found, out of a possible 54. These differences were not in the same direction or variables, and appeared in a tiny range of less than 0.3 point on a 7-point scale. Given the possibility of type I errors due to the large number of analyses, this effect would be expected on the basis of chance only. These findings were corroborated by analyses of four factors yielded by a factor analysis of the nine scales, which also did not reveal any laterality differences.

These results imply that although people may perceive some differences in personality and emotion between the two hemifaces of various individuals, consistent lateral differences do not exist in this situation. Several studies support this conclusion: Knox [45] (cited in Ref. [37]) demonstrated that asymmetry was common but not consistent across people, and likewise Sackeim *et al.* [65] did not find any consistency in emotional attribution to resting faces. The absence of hemifacial differences shown in the present study also correspond to the

anatomical reality: most of the anthropometric and radiographic comparisons of the right and the left hemifacial size, have revealed on average very small, or else contradictory differences [15, 32, 62]. Measuring the soft tissue thickness in cadavers' noses, Sutton [73], for example, did find marked differences but not in any consistent direction. Furthermore, even when anatomical differences were found, there was no significant correlation between the size of the hemiface and the degree of emotional intensity [43] (cited in Ref. [11]).

The accumulated evidence above suggests that various differences in attribution, revealed in previous studies, originated mainly from confounding factors in the process of making the stimulus material, as can be clearly observed in the imperfect composites of still photographs provided hitherto (some examples can be observed in Refs [47, 53, 64, 81]), as well as in the control group in Experiment 2.

Attributions to expressive faces

The differences in attributions made to the stimuli with posed smiles, were also very limited and hardly differed from neutral faces. Only when the composites were simultaneously compared on intensity, a greater intensity on the left hemiface was revealed. Several earlier studies support the latter finding by showing that deliberate smiles were usually stronger on the left side of the face [10, 26, 31, 53, 61, 64]. The greater intensity of the left hemiface is also consistent with the assertion that the right cerebral hemisphere of normal people has a dominant role in emotions [63] (for additional support see studies of brain lesions [5, 12, 14]). Nevertheless, the present study indicates that the majority of the people show greater intensity neither on the left hemiface nor on the right hemiface [50, 54]. Research on this individual difference may shed further light on individual differences in (brain) hemispheric asymmetry [42].

The slightly greater intensity found in right-handers' neutral left hemiface was not predicted. Kowner's [48] findings that symmetric composites of old people, but not of young adults or children, were rated as younger and more attractive than their original (somewhat asymmetric) face, may account for the results of Experiment 6. One reason for the role of asymmetry in old age may be related to morphological development throughout life, particularly the asymmetric development of slow signs. It is possible that in the long run the tendency for differential intensity of the two hemifaces (muscle activity) affects facial expression at rest (rather than the opposite), and leads to greater morphological asymmetries starting already in early adulthood.

Final words on methodological issues

The differences between the findings of the Experiments 1–4 and Experiments 5–6 reveal that the type of attribution examined and the method of presentation used may greatly affect the outcomes. Best *et al.* [4] suggested that previous inconsistencies occurred because studies favoring the the valence hypothesis assessed judgments about stimulus emotionality (such as Experiments 1–4), while studies favoring the right hemiface hypothesis have usually assessed discrimination or recognition of facial expression (such as in Experiments 5–6). Another source of error is related to the confusion or lack of distinction between posed (deliberate) expressions and spontaneous expressions (see the Introduction). Despite the growing awareness to this issue, various problems remain. Attempting to generate spontaneous expressions in the laboratory is a very delicate task, often ending in “semi-spontaneous” expressions. The misuse of the photographic technique for supposedly “spontaneous emotions” is reflected in Thompson's [75] suggestion that “. . . many ‘spontaneous’

manipulations actually produced posed responses . . ." (p. 297). This notion is especially applicable to smiles, that serve, although with somewhat different characteristics, various ends even when people are not observed [33]. In fact, it is likely that "adequate" still photos may never completely reflect a "spontaneous" emotion, because the basic idea of spontaneity contradicts the way adequate stimuli are produced for analysis in the split-half technique (for recent example see [67]). Our experience with this technique, both modified and original, shows that only photos that had been taken very carefully and slowly were suitable as stimuli for lateral comparison. Future studies may exploit available techniques that input video data directly into the computer.

In conclusion, the present study indicates that although the left hemiface may show slightly greater intensity, hemifacial differences even in posed emotions are minute and usually not perceived by observers. The existence of greater intensity on the left hemiface notwithstanding, findings show that about two-thirds of the stimuli did not exhibit any laterality difference in either expressive or neutral faces. The reason for these individual differences, their relation to differences in brain hemispheric asymmetry, and the role of handedness in laterality should be further examined. The question arises, however, as to how much can be inferred about brain activity from these negligible hemifacial differences, and whether future efforts should not be directed into more intrusive and probably more promising techniques, such as Positron Emission Tomography (PET) and Functional Magnetic Resonance Imaging (MRI). Despite this pessimistic view, the present study may clear up part of the confusion by offering more reliable method to examine hemifacial composites. Using appropriate stimuli and keeping in mind the methodological limitations, future studies may re-address unresolved issues such as difference between spontaneous vs deliberate expressions and negative vs positive emotions. Therefore, it seems that Hager's [37] statement that ". . . research in this area appears barely to have begun" (p. 351) is still valid.

Acknowledgements—The author would like to thank Toshiki Ogawa, Roberto Cabeza, Israel Broner, Ian Penna and several anonymous reviewers for their comments on earlier drafts, as well as Tadashi Kikuchi, Haruhiko Shobo, Joel Boudierlique, Hiroshi Kato, Hideo Shimomura, and seven members of two study groups at the Faculty of Social Science at the University of Tsukuba for their assistance in conducting the experiments. This work was supported by the Japanese Ministry of Education, Science and Culture.

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