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Right Hemisphere Superiority in the Recognition of Famous Faces

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Words and famous faces were tachistoscopically presented in bilateral view to normal right-handed subjects. A left visual field advantage was obtained for famous faces whether naming or recognition from an array was required and a right visual field advantage was obtained for words. While the finding of a left visual field advantage for the recognition of famous faces is consistent with studies of face recognition deficits in brain-damaged patients, a right visual field advantage for the recognition of famous faces has recently been reported in normal subjects. Possible explanations for this discrepancy are discussed.

Differential right hemisphere involvement in the recognition of unfamiliar faces is supported by studies of unilaterally brain-damaged patients (Milner, 1960, 1968; Warrington & James, 1967a; Benton & Van Allen, 1968; De Renzi, Faglioni & Spinnler, 1968; Yin, 1970) and commissurotomy patients (Levy, Trevarthen, & Sperry, 1972; Sperry, 1974), as well as by tachistoscopic studies with normal right-handed adults (Geffen, Bradshaw, & Wallace, 1971; Rizzolatti, Umiltà, & Berlucchi, 1971; Hilliard, 1973; Klein, Moscovitch, & Vigna, 1976; Marcel & Rajan, 1975; Leehey, Carey, Diamond, & Cahn, 1978). Much less information is available on the recognition of known faces. Recently, Leehey and Cahn (1979) have reported a left visual field (LVF)–right hemisphere advantage for the recognition of familiar colleagues' faces. In contrast, a right visual field (RVF)–left hemisphere advantage has been reported by Marzi and Berlucchi (1977) for the recognition of famous faces and by Umiltà, Brizzolara, Tabossi, and Fairweather (1978) for the recognition of faces familiarized through photographs prior to laterality testing.

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These apparently conflicting findings on visual field asymmetries for the recognition of *known* faces may be attributable to methodological differences among the studies. It should be noted that under comparable experimental conditions, the LVF advantage obtained for the recognition of familiar colleagues' faces did not significantly differ from the LVF advantage found for the recognition of these same faces by subjects who were completely unfamiliar with them (Leehey & Cahn, 1979). In contrast, the other studies investigating lateral asymmetries for the recognition of known faces (Marzi & Berlucchi, 1977; Umiltà et al., 1978) have used methods which differ from those typically employed in laterality research with unfamiliar faces (Geffen et al., 1971; Hilliard, 1973; Klein et al., 1976; Marcel & Rajan, 1975; Leehey et al., 1978). In the study investigating recognition of faces familiarized through photographs (Umiltà et al., 1978), a small set of four faces was used. Small set size has been shown to increase left hemisphere involvement in a letter recognition task (Miller & Butler, 1980) and may have a similar effect on hemispheric involvement in face recognition. It is also possible that subjects applied verbal encoding strategies while studying the four face stimuli (e.g., "John has bushy eyebrows"). Such a strategy might also have contributed to the obtained RVF advantage since research with commissurotomy patients has shown that the isolated left hemisphere recognizes faces by verbally encoding salient features (Levy et al., 1972). In the study investigating recognition of famous faces, Marzi and Berlucchi (1977) presented the faces to unilateral view for 400 msec, well above eye movement latency. In addition, trials were blocked such that all LVF trials preceded all RVF trials or vice versa. Either or both of these methodological factors may have contributed to the finding of a RVF advantage.

Alternatively, the RVF advantage obtained for the recognition of famous faces may be attributable to differences in the manner in which famous faces are recognized. A RVF advantage would be expected if famous faces are recognized in terms of isolated verbalizable features since previous studies suggest that the left hemisphere is differentially involved when faces are recognized in these terms (Levy et al., 1972; Patterson & Bradshaw, 1975).

Further, although recognition of both famous faces and colleagues' faces involves matching current input to an already stored representation of that face, several considerations suggest that one's knowledge of these two classes of faces may differ. First, famous faces are seen only occasionally through photographs, films, or television, while colleagues' faces are seen quite frequently, in real life, across a variety of transformations in angle of view, mood, etc. Thus, famous faces may be encoded in terms of more static information than colleagues' faces. Second, we typically know more about the lives, personalities, feelings, etc., of colleagues than of famous people. Such differences in perceptual and/or semantic information about famous and familiar colleagues' faces may result in different patterns of hemispheric involvement in the recognition of these classes of faces.

The present study investigates hemispheric involvement in the recognition of famous faces using the same procedure as that used by Leehey and Cahn (1979) to study hemispheric specialization for the recognition of familiar colleagues' faces and unfamiliar faces. If a different pattern of hemispheric involvement is found for the recognition of famous faces than was previously found for unfamiliar faces and colleagues' faces under comparable experimental conditions, it is most likely attributable to differences in the manner in which famous faces are encoded and/or subsequently recognized. Alternatively, if a LVF advantage is found for the recognition of famous faces, comparable to that found for unfamiliar faces and colleagues' faces, then the previous finding of a RVF advantage for the recognition of famous faces (Marzi & Berlucchi, 1977) is most likely an artifact of the particular methods used.

Each subject was tested on the recognition of laterally presented words as well as on the recognition of laterally presented famous faces. The finding of a RVF–left hemisphere advantage for word recognition would preclude explaining a LVF advantage for faces on the basis of a left-to-right directional scanning preference. Such a scanning preference would seem more likely to affect word recognition than face recognition because of the involvement of left-to-right scanning in reading.

METHODS

Subjects. Sixty-four university students served as subjects. All subjects were right-handed with right-handed parents, and were right-eyed (sighting dominance), with normal or fully corrected vision. Half of the subjects participated in the Naming condition of the experiment and half in the Pointing condition. There were 16 males and 16 females in each condition.

Stimuli and apparatus. A pool of 120 full-face photographs of well-known people (from politics, entertainment, sports, and science) was assembled. The pictures did not contain paraphernalia such as crowns or uniforms which might aid in their identification. In order to select highly recognizable famous faces, 10 subjects who did not participate in the main experiment were asked to rate the familiarity of these faces on a scale from 1 (completely unfamiliar) to 7 (extremely familiar, instantly recognized). Another 10 subjects were asked to name the faces. The faces selected for use in the experiment were rated at least 5/7 on the familiarity scale by all judges (mean rating: 6.0) and were named correctly by at least 7 out of 10 judges (average naming frequency: 8.9/10).

There were 24 male faces and 12 female faces among those chosen. Three choice arrays containing 12 pictures each were formed by grouping the female faces together and by randomly dividing the males into two groups. The three arrays were balanced in terms of average familiarity of the faces. Eighteen face pairs, six constructed from each array, were mounted on stimulus cards. The near point of each face appeared 55′ to the left or right of fixation, and each face subtended 3°33′ of horizontal visual angle. A fixation digit ranging from 2 to 9 appeared at the center of each card. An additional 12 faces (all male) were used to form six practice pairs and one choice array. These faces averaged 7.8/10 in naming frequency and 5.9/7 in familiarity.

Word stimuli were the same as those used by Leehey and Cahn (1979), and consisted of high-frequency four-letter nouns taken from Kucera and Francis (1967). Eighteen test pairs and nine practice pairs were aligned vertically on the stimulus cards. The near point of each word appeared 1°36′ to the left or right of fixation and each word subtended 1°32′ of vertical visual angle. As for the face stimuli, a fixation digit appeared at the center of each stimulus card.

Word and face stimuli were bilaterally presented to binocular view in a Gerbrands two-channel tachistoscope (Model T-2B1).

Procedure. Subjects began each trial by viewing a preexposure field consisting of six lines radiating from an open space in the center of the field. This space was just large enough to be filled by the fixation digit. Two trials with cards having only a fixation digit were shown in order to accustom the subjects to this procedure. Prior to each trial, the experimenter said "Focus" to alert the subject to fixate the center space. The stimulus card was then flashed, followed immediately by the return of the preexposure field. In order to maintain positive control over fixation, subjects were first required to report the digit, and any trials on which the digit was reported incorrectly were excluded. On face recognition trials, following digit report, the Naming Group verbally reported the names of the faces and the Pointing Group made a forced choice of 2 faces from an array of 12 which was presented by the experimenter. On word recognition trials, following digit report, subjects in both groups verbally reported whatever word or words they recognized. A pointing response was not used for word stimuli because a previous study (Klein, Moscovitch & Vigna, 1976) showed that a naming vs. pointing response had no effect on visual field asymmetries for words.

Additional control over fixation was provided by presenting word and face stimuli at exposure durations below eye movement latency. In order to adjust for intersubject variability in word recognition skill, subjects viewed word stimuli for 80, 100, or 120 msec, depending on performance on practice trials which were shown for 100 msec. In an attempt to equate performance level on the face recognition task for the Naming and Pointing Groups, faces were presented to the Pointing Group for 80 msec and to the Naming Group for 120 msec.

Materials were blocked such that half of the subjects in each group were presented with words before faces and half were presented faces before words. Each word and face pair was shown only once during an experimental session, resulting in a total of 18 bilateral face trials and 18 bilateral word trials. Side of presentation of the two members of each pair was counterbalanced across subjects. Four random stimulus presentation orders, balanced across conditions, were used.

At the conclusion of the experiment, subjects attempted to name the face stimuli. In order to ensure that all subjects were highly familiar with the majority of the faces, only those subjects who could name at least 31 of the 36 test faces (86%) were included.

RESULTS

Results of the present study are in general agreement with those reported by Leehey and Cahn (1979) using familiar faces. That is, we find evidence for differential right hemisphere involvement in both the matching and verbal identification of famous faces.

The average numbers of words and faces recognized in the left and right visual fields by the Naming and Pointing Groups are shown in Fig. 1. Face and word scores in each visual field were significantly greater

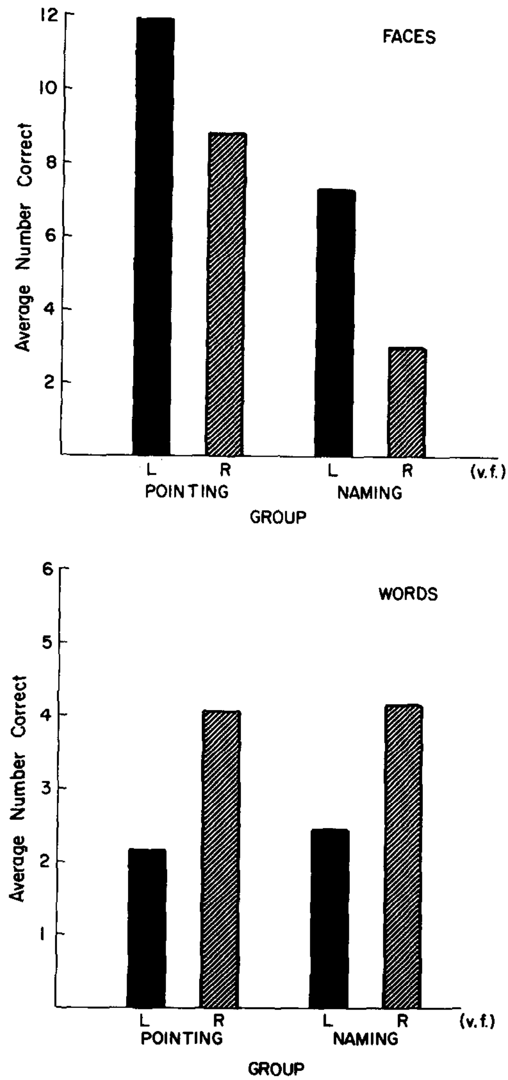

FIG. 1. The average numbers of faces and words recognized (out of 18) in the left and right visual fields (v.f.) by the Pointing and Naming groups.

than zero (t tests, $p < .001$) for both groups. Since guessing was possible on the face recognition task for the Pointing Group, a guessing correction was applied to each subject's visual field scores before testing whether performance level was significantly greater than zero. As in a previous study (Leehey & Cahn, 1979) each subject was treated as a random guesser which would result in an average of 3 correct responses over 18 test trials in each visual field.

All subsequent analyses were performed on scores uncorrected for guessing. A repeated-measures analysis of variance was performed with Stimulus Type (faces, words) and Visual Field (left, right) as within-subject factors and Group (Pointing, Naming), Task Order, Sex, and Item Position as between-subject factors. Main effects of Stimulus Type ($F(1, 48) = 167.19$, $p < .001$), in favor of faces, and Group ($F(1, 48) = 22.64$, $p < .001$), in favor of the Pointing Group, were significant. Examination of the significant Group × Stimulus Type interaction ($F(1, 48) = 50.72$, $p < .0001$) shows that the Group main effect is attributable to better performance by the Pointing Group on the face recognition task (post hoc Scheffé test, $p < .001$) and no group difference on the word recognition task ($p > .10$).

The two-way interaction of Stimulus Type × Visual Field was also significant ($F(1, 48) = 56.84$, $p < .001$). Post hoc Scheffé tests reveal a significant LVF advantage for face recognition ($F(1, 48) = 380.94$, $p < .001$) and a significant RVF advantage for word recognition ($F(1, 48) = 91.16$, $p < .001$). The opposite visual field advantages obtained for faces and words suggest that the LVF advantage for famous faces is not attributable to a left-to-right scanning preference. Neither the Group × Visual Field interaction ($F(1, 48) = 1.84$, $p > .10$) nor the Group × Stimulus Type × Visual Field interaction ($F(1, 48) = 1.21$, $p > .20$) approached significance. An unexpected interaction of Sex × Task Order was found ($F(1, 48) = 8.02$, $p < .01$). Post hoc Scheffé tests show that the males who saw words first had higher overall performance (on words and faces combined) than all other groups ($p < .001$) and that females who saw faces first performed better than both females who saw words first and males who saw faces first ($p < .001$). We have no explanation for this interaction.

Of 64 subjects in the Naming and Pointing Groups, 49 showed a LVF advantage and only 13 showed a RVF advantage for face recognition (2 showed no visual field asymmetry). In contrast, 43 subjects showed a RVF advantage and only 15 showed a LVF advantage for word recognition (6 showed no visual field asymmetry).

Finally, we performed another repeated-measures analysis of variance on the data of the Pointing Group from this study and the data from the groups who were familiar and unfamiliar with the face stimuli used in the study by Leehey & Cahn (1979). It should be noted that these three groups were equivalent in terms of subject characteristics (e.g., sex, handedness, sample size). Stimulus Type (faces, words) and Visual Field (left, right) were within-subject factors and Group (Famous, Familiar, and Unfamiliar) was a between-subject factor. The interaction of Stimulus Type × Visual Field was highly significant ($F(1, 93) = 115.19$, $p < .001$), indicating opposite visual field advantages for faces and words. The interaction of Group × Stimulus Type × Visual Field was not

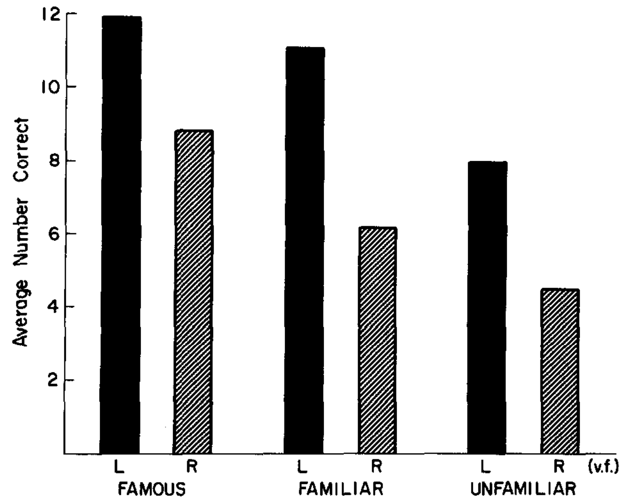

FIG. 2. The average numbers of faces recognized (out of 18) in the left and right visual fields (v.f.) by the Pointing Group (Famous) and two groups of subjects from Leehey and Cahn's study (1979), the group familiar with colleagues' faces (Familiar) and the group unfamiliar with these faces (Unfamiliar).

significant ($F(2, 93) = 1.76$, $p > .10$), indicating comparable visual field effects for all three groups for both words and faces. The average numbers of faces recognized in each visual field by each of the three groups are shown in Fig. 2.

DISCUSSION

The main finding of the present study is a significant LVF–right hemisphere advantage for the recognition of famous faces. Consistent with previous studies which suggest that requiring a naming response has no effect on the magnitude or direction of visual field asymmetries for visuospatial stimuli in normal subjects (Umiltà et al., 1978; Leehey & Cahn, 1979; Berlucchi, Brizzolara, Marzi, Rizzolatti, & Umiltà, 1979), a LVF advantage of comparable magnitude was obtained for naming and pointing response conditions. Of particular importance, the LVF advantage obtained for famous faces is comparable in magnitude to that found for the recognition of familiar colleagues' faces and unfamiliar faces under equivalent experimental conditions (Leehey & Cahn, 1979). This pattern of results suggests that the right hemisphere is differentially involved in face recognition regardless of whether the face to be recognized is unfamiliar, highly familiar, or even famous.

In general, the present finding of differential right hemisphere involvement in the recognition of famous faces is compatible with reports of face recognition deficits in brain-damaged patients. Face recognition abilities have been assessed in two different clinical populations—unilaterally brain-damaged patients who do not present with prosopagnosia (agnosia for familiar faces) (Hécaen & Angelergues, 1962) and prosopagnosic patients who present with the relatively rare and striking symptom of inability to recognize previously familiar faces, including celebrities, relatives, and in extreme cases, even their own mirror images (e.g., Hécaen & Angelergues, 1962; Whiteley & Warrington, 1977; Assal, 1969; Cole & Perez-Cruet, 1964; Rondot, Tzavaras, & Garcin, 1967).

Most studies examining face recognition abilities in unilaterally brain-damaged patients have used tasks that involve recognition of previously unfamiliar faces (Milner, 1960, 1968; Warrington & James, 1967a; Benton & Van Allen, 1968; De Renzi et al., 1968; Yin, 1970). These studies generally reveal that patients with damage to the posterior sector of the right hemisphere are significantly impaired in the recognition of faces. This pattern of results is certainly consistent with tachistoscopic studies with normal adults which typically report a LVF–right hemisphere advantage for the recognition of previously unfamiliar faces (e.g., Geffen et al., 1971; Rizzolatti et al., 1971; Hilliard, 1973; Klein et al., 1976; Marcel & Rajan, 1975; Leehey et al., 1978).

Recently, however, Benton (1980) has reported that patients with left hemisphere damage and receptive aphasia as well as patients with right posterior damage are significantly impaired on tasks involving perceptual matching of previously unfamiliar faces. Although Benton interprets this result as support for the role of left hemisphere linguistic coding in face recognition, there is an alternative explanation. Consider the possibility that the damaged left hemisphere of receptive aphasics interferes with the normal face recognition abilities of the intact right hemisphere. It has recently been reported that left brain-damaged receptive aphasics are frequently unable to point to the typical color of common objects (e.g., apple–red), even though the isolated right hemisphere of commissurotomy patients is better at this task than the isolated left hemisphere (Levy & Trevarthen, 1981). This finding strongly suggests that at least some of the normal abilities of the right hemisphere are suppressed in left brain-damaged patients with receptive aphasia, and these abilities may well include face recognition. A similar hypothesis has been proposed to explain why language comprehension deficits in left brain-damaged receptive aphasics are more severe than one would expect on the basis of right hemisphere language comprehension abilities in commissurotomy patients (Goodglass & Kaplan, 1976; Zaidel, 1978; Moscovitch, 1976; Levy & Trevarthen, 1977).

Only one study (Warrington & James, 1967a) has investigated the ability of unilaterally brain-damaged patients to recognize known as well as previously unfamiliar faces. Results of this study show that patients with right parietal lesions are most impaired on a task requiring perceptual matching of unfamiliar faces while patients with right temporal lesions are most impaired on a task requiring naming of famous faces. Moreover, deficits on these two types of face recognition tasks do not usually co-occur. Consistent with the finding that right temporal lesions interfere with the recognition of famous faces, Milner (1968) reports that patients with right temporal lesions are markedly impaired on a test of delayed memory for an array of unfamiliar faces but are only minimally impaired on a test of immediate memory for these faces. Although suggestive of a dissociation between the ability to recognize known and previously unfamiliar faces, even these results would predict differential right hemisphere involvement in the recognition of known as well as unfamiliar faces in normal subjects. It should be noted that our finding of comparable LVF advantages for the recognition of famous, familiar, and unfamiliar faces in normal subjects does not imply that deficits in the recognition of these different types of faces would always co-occur in brain-damaged patients.

Because of the rarity of clinical prosopagnosia, most of the available information on this syndrome is based on single case reports or reports on small numbers of cases (Whiteley & Warrington, 1977; Assal, 1969; Cole & Perez-Cruet, 1964; Rondot et al., 1967; Benton, 1980; Meadows, 1974). In general, clinical observations (e.g., the preponderance of left upper quadrantic field defects) and radiological evidence suggest that unilateral right hemisphere damage underlies prosopagnosia. However, bilateral lesions have been reported in all nine cases of prosopagnosia which have come to autopsy (Benton, 1980; Meadows, 1974). The location of the right hemisphere lesion is consistently occipitotemporal while the location of the left hemisphere lesion is somewhat more variable. Perhaps a bilateral lesion is a prerequisite for prosopagnosia because patients with unilateral right hemisphere lesions may be able to recognize highly familiar faces by relying on the face recognition abilities of the intact left hemisphere. Studies of commissurotomy patients clearly show that the isolated left hemisphere can recognize faces, although less efficiently than the isolated right hemisphere (Levy et al., 1972; Sperry, 1974). In any case, even the autopsy results on prosopagnosic patients would not predict a RVF–left hemisphere advantage for the recognition of known faces, famous or familiar, in normal adults.

We are left with the problem of explaining Marzi and Berlucchi's (1977) finding of a RVF–left hemisphere advantage for the recognition of famous faces. As previously discussed, it is possible that the discrepant results in their study and the present study are attributable to methodological differences. One salient difference involves exposure durations of the face stimuli. A 400-msec exposure duration, which is well above eye movement latency, was used by Marzi and Berlucchi, calling into question whether their face stimuli were actually confined to unilateral view.

Mean overall performance level in this study for laterally presented faces was 23%. The authors state that such a long exposure duration was necessitated by task difficulty. In contrast, Chi (1977) reports that the 50% threshold for identification of familiar faces presented to central vision and followed by a mask is only 26 msec. Review of Marzi and Berlucchi's procedure suggests that task difficulty was increased by positioning face stimuli between 5 and 10° from central fixation. In the present study we avoided the use of a stimulus exposure duration above eye movement latency, but achieved an overall performance level at least as high as that in Marzi and Berlucchi's study. By positioning stimuli between 1 and 3.5° from central fixation it was possible to use a 120-msec exposure duration and still achieve an overall performance level of 28% in our naming condition. Thus, despite the fact that we used an exposure duration much shorter than that used by Marzi and Berlucchi, overall performance level in the present study was higher, making it unlikely that our finding of a LVF–right hemisphere advantage for the recognition of famous faces was induced by greater right hemisphere involvement in the recognition of "degraded" stimuli (Hellige, 1976; Warrington & James, 1967b).

Another methodological difference between the two studies was the use of a central digit to monitor fixation. However, it is also unlikely that the requirement of central digit report in the present study can account for the opposite visual field advantages obtained in the two studies since the direction of lateral asymmetries for both verbal and nonverbal stimuli is reported to be unaffected by the requirement of central digit report (MacKavey, Curcio, & Rosen, 1975; Hines, 1978).

An alternative hypothesis is that the discrepant results of the two studies are attributable to differences in subjects' familiarity with the famous face stimuli. Retrieving the name of a moderately familiar face may involve the activation of a series of verbal associations, thereby increasing left hemisphere involvement in the task of face recognition. For example, a particular photograph might elicit such verbal associations as "movie star in the '50's, hero-type, starred in *High Noon*," before the identification of "Gary Cooper" is made. Since Marzi and Berlucchi accepted verbal descriptions as well as identifications by name as correct responses, left hemisphere involvement in their face recognition task may have been increased. Further, on post-test naming, Marzi and Berlucchi's subjects varied widely in the number of famous faces they were able to name, ranging from 24 to 95%, suggesting that some of the subjects may have been only moderately familiar with the faces. In contrast, on our post-test all subjects were able to name at least 86% of our face stimuli.

The possibility that subjects' familiarity with famous faces affects hemispheric involvement is also supported by results of an unpublished study which came to our attention during the preparation of this paper. Young and Bion (in press) used face stimuli which may also have been only moderately familiar to subjects as they were taken from another study in which the criterion for selection of the faces was "male, fairly familiar to the authors" (Ellis, Shepherd, & Davies, 1979). They report a LVF advantage for the naming of famous faces when subjects were informed of the names of the faces they would be shown prior to the presentation of stimuli, but no visual field advantage when they were not so informed. Perhaps a LVF–right hemisphere advantage was obtained in the informed condition because the names served to activate subjects' representations of these faces, thereby making them more familiar. We are currently investigating the effect of variations in the degree of familiarity of famous faces on visual field asymmetries.

In conclusion, results of the present study suggest that the LVF advantage for recognition of famous faces does not significantly differ from that for unfamiliar and familiar colleagues' faces under comparable experimental conditions. Although the left hemisphere may be differentially involved in face recognition tasks under certain conditions, e.g., when schematic faces which differ by only a single feature are used (Patterson & Bradshaw, 1975; also see Sergent & Bindra, 1981, for a review), the left hemisphere does not appear to be differentially involved in the recognition of famous faces. Results of recent studies suggesting that the left hemisphere is more involved in the recognition of famous faces than other types of faces may be attributable to methodological differences, or to the use of famous faces which were only moderately familiar.

REFERENCES

Assal, G. 1969. Régression des troubles de la reconnaissance des physiognomies et de la mémoire topographique chez un malade opéré d'un hématome intracérébral parieto-temporal droite. *Revue Neurologique*, **121**, 184–185.

Benton, A. L. 1980. The neuropsychology of face recognition. *American Psychologist*, **35**, 176–186.

Benton, A. L., & Van Allen, M. W. 1968. Impairment in facial recognition in patients with cerebral disease. *Cortex*, **4**, 344–358.

Berlucchi, G., Brizzolara, D., Marzi, C. A., Rizzolatti, G., & Umiltà, D. 1979. The role of stimulus descriminability and verbal codability in hemispheric specialization for visuospatial tasks. *Neuropsychologia*, **17**, 195–202.

Chi, M. 1977. Age differences in memory span. *Journal of Experimental Child Psychology*, **23**, 266–281.

Cole, M., & Perez-Cruet, J. 1964. Prosopagnosia. *Neuropsychologia*, **2**, 237–246.

De Renzi, E., Faglioni, P., & Spinnler, H. 1968. Performance of patients with unilateral brain damage on face recognition tasks. *Cortex*, **4**, 17–34.

Ellis, H. D., Shepherd, J. W., & Davies, G. M. 1979. Identification of familiar and unfamiliar faces from internal and external features: Some implications for theories of face recognition. *Perception*, **8**, 431–439.

Geffen, G., Bradshaw, J. L., & Wallace, G. 1971. Interhemispheric effects on reaction times to verbal and non-verbal stimuli. *Journal of Experimental Psychology*, **87**, 415–422.

Goodglass, H., & Kaplan, E. 1972. *The assessment of aphasia and related disorders.* Philadelphia: Lea & Febiger.

Hécaen, H., & Angelergues, R. 1962. Agnosia for faces (prosopagnosia). *Archives of Neurology*, **7**, 92–100.

Hellige, J. B. 1976. Changes in same–different laterality patterns as a function of practice and stimulus quality. *Perception and Psychophysics*, **20**, 267–273.

Hilliard, R. D. 1973. Hemispheric laterality effects on a facial recognition task in normal subjects. *Cortex*, **9**, 246–258.

Hines, D. 1978. Visual information processing in the left and right hemispheres. *Neuropsychologia*, **16**, 593–600.

Klein, D., Moscovitch, M., & Vigna, C. 1976. Perceptual asymmetries and attentional mechanisms in tachistoscopic recognition of words and faces. *Neuropsychologia*, **14**, 44–66.

Kucera, H., & Francis, W. N. 1967. *Computational analysis of present day American English*. Providence, RI: Brown Univ. Press.

Leehey, S. C., & Cahn, A. 1979. Lateral asymmetries in the recognition of words, familiar faces and unfamiliar faces. *Neuropsychologia*, **17**, 619–628.

Leehey, S. C., Carey, S., Diamond, R., & Cahn, A. 1978. Upright and inverted faces: The right hemisphere knows the difference. *Cortex*, **14**, 411–419.

Levy, J., & Trevarthen, C. 1977. Perceptual, semantic and phonetic aspects of elementary language processes in split-brain patients. *Brain*, **100**, 105–118.

Levy, J., & Trevarthen, C. 1981. Color-matching, color-naming and color-memory in split-brain patients. *Neuropsychologia*, **19**, 523–541.

Levy, J., Trevarthen, C., & Sperry, R. 1972. Perception of bilateral chimeric figures following hemisphere deconnexion. *Brain*, **95**, 61–68.

MacKavey, W., Curcio, F., & Rosen, J. 1975. Tachistoscopic word recognition performance under conditions of simultaneous bilateral presentation. *Neuropsychologia*, **13**, 27–33.

Marcel, T., & Rajan, P. 1975. Lateral specialization for recognition of words and faces in good and poor readers. *Neuropsychologia*, **13**, 489–497.

Marzi, C., & Berlucchi, G. 1977. Right visual field superiority for accuracy of recognition of famous faces in normals. *Neuropsychologia*, **15**, 751–756.

Meadows, J. C. 1974. The anatomical basis of prosopagnosia. *Journal of Neurology, Neurosurgery and Psychiatry*, **37**, 489–501.

Miller, L. K., & Butler, D. 1980. The effect of set size on hemifield asymmetries in letter recognition. *Brain and Language*, **9**, 307–314.

Milner, B. 1960. *Impairment of visual recognition and recall after right temporal lobectomy in man.* Paper presented at Psychonomic Society Meeting, Chicago.

Milner, B. 1968. Visual recognition and recall after right temporal lobe excision in man. *Neuropsychologia*, **6**, 191–209.

Moscovitch, M. 1976. On the representation of language in the right hemisphere of right-handed people. *Brain and Language*, **3**, 47–71.

Patterson, K., & Bradshaw, J. 1975. Differential hemispheric mediation of non-verbal visual stimuli. *Journal of Experimental Psychology: Human Perception and Performance*, **1**, 246–252.

Rizzolatti, G., Umiltà, C., & Berlucchi, G. 1971. Opposite superiorities of the right and left cerebral hemispheres in discriminative reaction time to physiognomic and alphabetical material. *Brain*, **94**, 431–442.

Rondot, P., Tzavaras, A., & Garcin, R. 1967. Sur un cas de prosopagnosie persistant depuis quinze ans. *Revue Neurologique*, **117**, 424–428.

Sergent, J., & Bindra, D. 1981. Differential hemispheric processing of faces: Methodological considerations and reinterpretation. *Psychological Bulletin*, **89**, 541–554.

Sperry, R. W. 1974. Lateral specialization in the surgically separated hemispheres. *In* F. Schmitt & F. Worden (Eds.), *The neurosciences: Third study program*. Cambridge, MA: MIT Press.

Umiltà, C., Brizzolara, D., Tabossi, P., & Fairweather, H. 1978. Factors affecting face recognition in the cerebral hemispheres: Familiarity and naming. *In* J. Requin (Ed.), *Attention and performance*. Hillsdale, NJ: Erlbaum. Vol. VII.

Warrington, E. K., & James, M. 1967. An experimental investigation of facial recognition in patients with unilateral cerebral lesions. *Cortex*, **3**, 317–326. (a)

Warrington, E. K., & James, M. 1967. Disorders of visual perception in patients with localized cerebral lesions. *Neuropsychologia*, **5**, 253–266. (b)

Whiteley, A. M., & Warrington, E. K. 1977. Prosopagnosia: A clinical, psychological, and anatomical study of three patients. *Journal of Neurology, Neurosurgery and Psychiatry*, **40**, 395–403.

Yin, R. 1970. Face recognition by brain injured patients: A dissociable ability? *Neuropsychologia*, **8**, 395–402.

Young, A. W., & Bion, P. J. Accuracy of naming laterally presented known faces by children and adults. *Cortex*, in press.

Zaidel, E. 1978. Auditory language comprehension in the right hemisphere following cerebral commissurotomy and hemispherectomy: A comparison with child language and aphasia. *In* A. Caramazza and E. Zurif (Eds.), *Language acquisition and language breakdown: Parallels and divergences*. Baltimore: Johns Hopkins Press.