

## LATERAL ASYMMETRIES IN THE RECOGNITION OF WORDS, FAMILIAR FACES AND UNFAMILIAR FACES

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**Abstract**—Words, familiar faces and unfamiliar faces were tachistoscopically presented in lateral view to normal right-handed adult subjects. A RVF advantage was obtained for word recognition and a LVF advantage was obtained for the recognition of both familiar and unfamiliar faces. Moreover, the LVF advantage for familiar faces was obtained when the required response was recognition from an array as well as when it was naming. This pattern of results is consistent with results of recent studies that indicate right-hemisphere involvement in the recognition of complex visuo-spatial stimuli, whether or not these stimuli have verbal labels.

DIFFERENTIAL involvement of the right cerebral hemisphere in the recognition of previously unfamiliar faces is perhaps more firmly established than differential right-hemisphere involvement in any other visuo-perceptual task [1–13]. Evidence from studies of patients with unilateral cortical lesions [1–6], from studies of commissurotomy patients [7, 8] and from tachistoscopic studies with normal adults and children [9–13] all supports the leading role of the right hemisphere in the recognition of unfamiliar faces.

In contrast to these results, RVF (i.e. left-hemisphere) advantages have recently been reported for tachistoscopic recognition of photographs of “famous” faces (i.e. well-known personalities from politics, science, entertainment, sports, etc.) [14, 15] and for photographs of previously anonymous faces which subjects had studied prior to the experiment [16, 17]. Since the RVF advantages were obtained in experiments measuring manual discriminative reaction time as well as naming accuracy [14–17], these lateral asymmetries are unlikely to be a function of overt naming of the flashed faces. Moreover, attaching a verbal label to a perceptually complex stimulus does not switch the hemispheric advantage. Perceptual complexity rather than verbalizability of stimulus material seems to be the critical determinant of differential right-hemisphere involvement. For example, in a tachistoscopic task requiring recognition of the time on a clock face, a LVF advantage was obtained, even though the response was verbal [18]. Similarly, a left-hand advantage has been found for Braille reading, suggesting that the difficulty of the tactual configuration outweighs the language requirement of this task [19, 20]. In addition, patients with unilateral right-hemisphere lesions have been shown to be more impaired than patients with unilateral left-hemisphere lesions on the Street Completion Test and the Poppelreuter Overlapping Figures Test, both of which involve the perception of realistic figures that are highly verbalizable [21]. WARRINGTON and JAMES [22] obtained similar results not only with the Gollin pictures and an incomplete-shapes test, but also with an incomplete-letters test.

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This line of evidence suggests that the RVF advantage for the recognition of familiar faces [14–17] may not be related to their having verbal labels but to their familiarity *per se*. That is, the right hemisphere may be specialized for the recognition of unfamiliar faces, the left for the recognition of familiar faces. The recognition of familiar and unfamiliar faces certainly differ in information-processing terms. Whereas recognition of a familiar face merely involves matching current input to an already stored representation of that face, recognition of a previously unfamiliar face involves first encoding a representation of that face for use in subsequent recognitions. One might hypothesize that the encoding stage of the recognition process is critical to the differential right-hemisphere advantage. However, two recent studies, one using schematic faces differing on three possible features [23] and the other using photographs of faces [24], have demonstrated a LVF advantage in reaction time when the task involves deciding whether an input face matches a previously memorized face. This task is somewhat similar to the task of recognizing a familiar face.

Additional evidence suggests that the anatomical substrate underlying the recognition of familiar and unfamiliar faces may differ. WARRINGTON and JAMES [3] found patients with right parietal lesions to be maximally impaired in the recognition of unfamiliar faces and patients with right temporal lesions to be maximally impaired in the recognition of well-known faces. Although suggestive of a dissociation, differences between the recognition tasks using the unfamiliar and well-known faces make these results difficult to interpret. Moreover, Warrington's results would not predict a RVF advantage for the recognition of well-known faces by normal adults.

Thus previous experimental work with brain damaged patients [3] does not predict differential left-hemisphere involvement in the recognition of familiar faces. Nevertheless, a RVF advantage for tachistoscopic recognition of well-known faces and for a small set of previously anonymous photographs with which Ss had become familiar has been obtained in normal adults [14–17]. In the present experiment, lateralized tachistoscopic recognition of previously unfamiliar faces is compared to recognition of familiar faces (Ss' colleagues), under equivalent experimental conditions. The stimulus faces used are objectively the same, familiar to one group of subjects and unfamiliar to another group. Results of the present study should further elucidate the role of the right hemisphere in face recognition.

## METHOD—EXPERIMENT 1

### *Subjects*

Two groups of 32 adult subjects (16 males and 16 females in each group) were tested. All subjects were right-handed with right-handed parents and had vision correctable to 20/20. For one group of subjects the face stimuli were highly familiar (Group F). These subjects were members of a graduate department at MIT from which the stimulus faces were photographed. For the other group of subjects, also drawn from the MIT community, but from other departments, the face stimuli were unfamiliar (Group UF).

### *Stimuli and apparatus*

Following the design of MCKEEVER and HULING [25], stimuli were bilaterally presented to binocular view. A Gerbrands two-channel tachistoscope (Model T-2 B1) was used to present the stimuli. Word stimuli consisted of high-frequency four-letter nouns taken from KUCERA and FRANCIS [26]. The words were aligned vertically on the stimulus cards, rather than horizontally, in order to avoid the possible interaction of differential informativeness of beginning vs end of a word with distance from the fixation-point. The face stimuli consisted of black and white photographs, half male faces and half female faces. These faces were familiar to one group of subjects, Group F and unfamiliar to the other, Group UF.

The near point of each word was located 1° 36' to the left or right of fixation and each word subtended 1° 32' of vertical visual angle. The near point of each face was located 55.5' to the left or right of fixation, and each face subtended 3° 33' of horizontal visual angle. A digit, ranging from 2 to 9, was chosen at random to appear at the fixation point of each stimulus card.

## PROCEDURE AND DESIGN

Subjects began each trial by viewing a pre-exposure field consisting of 6 lines radiating from an open space at the center of the field. This space was just large enough to be filled by the fixation-point digit on each stimulus card. Two trials with cards having only a digit at the fixation point were shown in order to accustom S to the procedure. Both the word-recognition and face-recognition portions of the experiment began with 8 practice trials. Prior to each trial E said "Focus" to alert S to fixate the center space. The stimulus card was then flashed, followed immediately by the return of the pre-exposure field. The digit provided positive control over fixation, since data from trials on which the digit was reported incorrectly were excluded. As a further precaution, both words and faces were presented at durations below eye-movement latency; familiar faces at 60 msec, unfamiliar faces at 120 msec, and words at 80, 100 or 120 msec. Different exposure-durations were used for familiar and unfamiliar faces in an attempt to equate the performance levels of Group F and Group UF. It was necessary to use a variable exposure-duration in the word recognition task to control for inter-subject variability in ability to recognize words. Exposure-duration for the word pairs was chosen on the basis of performance on 8 practice trials. Once chosen, this duration was used for the 18 test trials.

On the word-recognition task, after reporting the digit, if possible, S reported the words which he had seen. On the face-recognition task, after reporting the digit, S made a forced-choice of 2 faces from an array of 12, 2 of which were identical to those that had been flashed. Two arrays of 12 faces were used throughout the experiment, one consisting of photographs of 12 males and the other of 12 females. Within each array, 8 faces were presented twice each, 2 were presented once each and 2 were never presented. When a face was repeated, it was presented in the visual field opposite to that of its first presentation and paired with a different face than on its first presentation. In order to discourage the use of a "process of elimination" strategy for faces shown late in the series, Ss were informed in the instructions that not all faces in the array would be presented and that some would be repeated.

Materials were blocked such that half the subjects in each group were presented with words before faces and half were presented with faces before words. Eight random presentation orders, balanced across conditions, were used in the experiment. Each word and face pair was shown only once during an experimental session. Side of presentation of the two members of each pair was counterbalanced across Ss.

At the conclusion of the experimental session, subjects rated the face stimuli for "familiarity" on a scale from 1 to 10, a 1 corresponding to a face never seen before the experimental session, a 10 corresponding to a face one would recognize anywhere, even after a 5 yr interval. Subjects were also asked to name the persons in the photographs, if possible.

## RESULTS

The average numbers of words and faces recognized in the left and right visual fields are shown in Figs. 1(a) and (b). Significances of predicted Materials (faces, words) by Positions (left, right) interactions were tested by using  $F'$ , the so-called quasi  $F$ -ratio [27, 28]. For the purposes of this analysis, an item was considered to be a pair of faces or words, and for each pair, an L-R score was computed. Thus, we were able to compute L-R scores across items for each subject and L-R scores across subjects for each item. Analysis of variance [27, 28] revealed a significant Materials (words, faces) by Positions (left, right) interaction ( $F' = 49.79$ ,  $df = 1, 97$ ,  $P < 0.001$ ). However, the Groups (F, UF) by Materials (words, faces) by Positions (left, right) interaction was not significant ( $F' = 2.174$ ,  $df = 1, 96$ ,  $P > 0.10$ ). There were no significant main effects or interactions for sex or for order of presentation of words and faces.

The number of words recognized in each visual field was above chance level for both groups ( $P < 0.05$ ). A  $t$ -test for correlated means revealed the difference between words recognized in the left and right visual fields to be significantly greater than zero for both groups, in favor of the RVF (Group F:  $t = 2.837$ ,  $df = 31$ ,  $P < 0.01$ ; Group UF:  $t = 2.142$ ,  $df = 31$ ,  $P < 0.025$ , one-tailed tests). Moreover, there was no significant difference between the RVF advantages of Group F and Group UF on the word-recognition task ( $t = 0.899$ ,  $df = 62$ ,  $P > 0.10$ ).

All analyses of the results on faces were performed on scores corrected for guessing. A simplified and conservative guessing correction, which treats all subjects as random guessers,

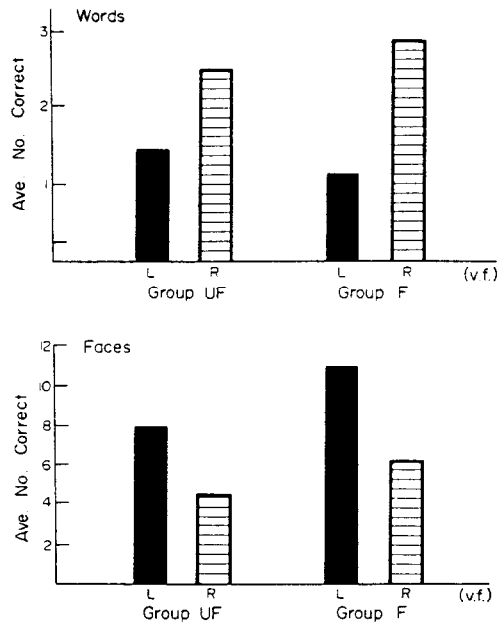


FIG. 1. (a) The average number of words recognized in the left and right visual fields (v.f.), respectively, by Group F and Group UF.  
 (b) The average number of faces recognized in the left and right visual fields (v.f.), respectively, by Group F and Group UF. Required response was recognition from an array.

was applied. Over 18 test trials, random guessing would have produced an average of 3 correct responses in each visual field; therefore, this amount was subtracted from individual accuracy scores for each visual field prior to further analysis. It should be pointed out that this guessing correction in no way affects the results of our analyses of variance or *t*-tests comparing the means of our samples. The guessing correction was applied only to check that subjects were performing significantly better than chance.

After the guessing correction had been applied, both familiar and unfamiliar faces were found to be recognized at better than chance level in each visual field ( $P < 0.001$  in all 4 cases). A *t*-test for correlated means revealed the difference between faces recognized in the left and right visual fields to be significantly greater than zero for both groups, in favor of the LVF (Group F:  $t = 7.071$ ,  $df = 31$ ,  $P < 0.001$ ; Group UF:  $t = 4.950$ ,  $df = 31$ ,  $P < 0.001$ ). As on the word recognition task, there was no significant difference between the visual field advantages of Group F and Group UF ( $t = 1.392$ ,  $df = 62$ ,  $P > 0.10$ ). In fact, Group F and Group UF differed only in the total number of faces recognized, Group F recognizing significantly more faces overall ( $t = 4.813$ ,  $df = 62$ ,  $P < 0.001$ ), even though exposure duration for the faces was 120 msec for Group UF and only 60 msec for Group F. The two groups did not differ in the total number of words recognized ( $t = 0.030$ ,  $df = 62$ ,  $P > 0.10$ ).

Of 64 subjects in Groups F and UF, 54 showed a LVF advantage and only 8 a RVF advantage for faces (2 showed no visual field difference). In contrast, 36 showed a RVF advantage and only 12 showed a LVF advantage for words (16 showed no visual field difference). On the word recognition task, most subjects showing no visual field advantage were performing at "floor" level, i.e. recognizing no words in either visual field. Subjects failing

to show expected visual field advantages were equally divided between Groups F and UF.

Subjects in Groups F and UF had a left-to-right order of report bias for both words and faces (73 and 90% of the double correct responses were left-to-right for faces and words, respectively). This bias cannot easily account for the opposite visual field advantages obtained for words and faces. Since reading is a left-to-right scanning task par excellence, and the report bias was greater for words than faces, it would seem more likely for the report bias to have produced a left visual field advantage for words. The finding of a significant right visual field advantage for words suggests that the report bias did not significantly affect the pattern of results.

The average familiarity rating given to the faces by Group F was 7.7/10 and by Group UF was 1.8/10. Group F was able to name an average of 79% of the faces; Group UF, an average of 1.4%.

## METHOD—EXPERIMENT 2

### *Subjects*

An additional group of 10 subjects, all highly familiar with the face stimuli, was recruited. Again, these subjects were members of the MIT graduate department from which the faces were photographed. All subjects were right-handed with right-handed parents and had vision correctable to 20/20.

### *Stimuli and apparatus*

Subjects were shown only the face stimuli from Experiment 1.

## PROCEDURE AND DESIGN

The procedure used in Experiment 2 was identical to that in Experiment 1 with the following exception. In Experiment 2, after reporting the fixation digit, subjects were required to name the stimulus faces and were not shown choice arrays.

## RESULTS

The results are shown in Fig. 2. The average number of faces named correctly in each visual field was significantly greater than zero ( $P < 0.001$ ). A *t*-test for correlated means revealed the difference between faces named correctly in the two visual fields to be significant ( $P < 0.025$ ) in favor of the LVF.

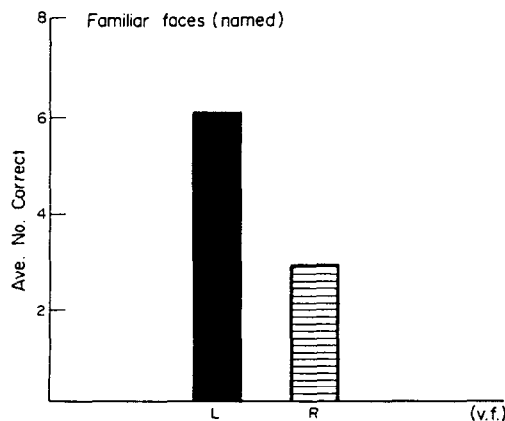


FIG. 2. The average number of familiar faces named in the left and right visual fields (v.f.), respectively, by subjects in Experiment 2.

A comparison of the LVF advantages obtained by the present group of subjects to that obtained by the subjects in Experiment 1 who viewed familiar faces before words, revealed no significant difference ( $t = 1.71$ ,  $df = 34$ ,  $P > 0.10$ , two-tailed test). The decrease in mean number of faces recognized in this experiment compared to Group F in Experiment 1 (9 vs 17) reflects the differential difficulty of identifying the faces by name compared to recognizing them in the distractor arrays.

The 10 subjects in Experiment 2 were able to name an average of 73% of the stimulus faces, as compared to 79% for Group F and 1.4% for Group UF in Experiment 1.

## DISCUSSION

The principal result of Experiment 1, a significant LVF advantage for the recognition of *both* familiar and unfamiliar faces, presumably reflects differential right hemisphere involvement in face recognition. Moreover, Experiment 2 demonstrates a LVF advantage of equal magnitude for the identification of familiar faces by name. The obtained pattern of results is consistent with those studies which suggest that perceptual complexity, rather than verbalizability of stimuli, determines the degree of right hemisphere involvement [18–22] in a particular task. Of course, faces are labeled with proper nouns. From the present study, it is not possible to ascertain what effect, for example, a common-noun label would have on the visual-field advantage for a complex visuo-spatial stimulus such as a face.

The present finding of a LVF advantage for the recognition of familiar faces (i.e. colleagues) contrasts with the RVF advantages reported for the recognition of famous faces [14, 15] and previously anonymous faces studied by subjects prior to the experimental session through photographs [16, 17]. Since all these faces are in a sense “familiar”, the discrepancy in obtained visual-field advantages is puzzling. Perhaps differences in the manner in which we typically encounter colleagues’ faces such as those used in the present study and the famous and familiar faces used in previous studies [15–17] account for the opposite visual-field advantages obtained. Whilst famous faces are seen mainly or exclusively in photographs or perhaps on television, and then only occasionally, the familiar faces used in the present study are encountered frequently, in real life, and therefore across a variety of transformations such as mood, lighting and paraphernalia. Thus, experiences with familiar colleagues’ faces and famous faces differ both quantitatively and qualitatively. The differences between colleagues’ faces and faces familiarized through single photographs are even more striking. UMLTÀ *et al.* [17] gave subjects a single photograph of each of four faces several days prior to the experimental session, instructing them to consult the photographs daily in order to learn to recognize them. Certainly this situation is markedly different from the situation in which we typically become familiar with a face. Such experiential factors raise the possibility of encoding differences which might, in turn, account for differential right hemisphere involvement in the recognition of familiar colleagues’ faces and differential left hemisphere involvement in the recognition of faces seen mainly or exclusively in photographs.

This possibility is supported by LEVY *et al.*’s [7] study of face recognition by split-brain patients. Results of this experiment suggest that both hemispheres have face recognition capabilities. Levy *et al.* presented chimeric faces tachistoscopically to commissurotomed patients. The patients showed a LVF recognition advantage when the response involved pointing to the target face from an array of choice faces with either the left or the right hand, but a RVF advantage when a verbal naming response was required. These results indicate

that faces can be recognized by either hemisphere. However, the results also suggest that the two hemispheres recognize faces in qualitatively different manners. First of all, recognition of faces presented in the RVF when a naming response was required was significantly less accurate than recognition of faces in the LVF when a pointing response was required. Moreover, in contrast to normals, all four commissurotomy patients tested had difficulty learning the names associated with the face stimuli involved. Levy *et al.* suggest that the right hemisphere processes faces as *Gestalten*, and the left hemisphere processes them in terms of salient, verbalizable features. In agreement, testing normal adults, PATTERSON and BRADSHAW [23] found a LVF reaction time advantage on a task which involved deciding whether a tachistoscopically-presented schematic face matched a previously studied schematic face when distractors differed on all three possible features, but a RVF advantage when they differed on only one feature. As in the Levy *et al.* study, these results were interpreted as reflecting analytic/gestalt processing modes of the left and right hemispheres, respectively.

Evidence from studies of patients with unilateral cortical lesions [6], as well as developmental studies [29, 30], suggests that the analytic processing mode, characteristic of the left hemisphere, is relatively inefficient for face recognition. Despite this, normal adults may rely on this mode of processing under certain circumstances, for example, for faces which become familiar through photographs (e.g. famous faces). While familiar colleagues' faces may be encoded as *Gestalten*, differentially involving the right-hemisphere in processing, famous faces and faces familiarized through photographs may be encoded in terms of salient verbalizable features (e.g. big nose, Jimmy Durante; big ears, Lyndon Johnson; cleft chin, Kirk Douglas), differentially involving the left-hemisphere in processing.

Differences in overt response requirements in experiments using various types of "familiar" faces cannot account for the discrepant visual-field advantages obtained, since a LVF advantage was obtained in the present experiment whether a pointing or naming response was required, and a RVF advantage was obtained in the previous experiments [14-17] whether a manual key press or a naming response was required. However, differential involvement of the left hemisphere in covert naming of famous vs familiar faces may explain the opposite visual-field advantages obtained. Independent of task requirements (e.g. naming, pointing, key-press), name-accessing of faces one sees several times each day is usually not difficult, nor do we necessarily access the names of people we see on a day-to-day basis. In contrast, it may be impossible to "recognize" a famous face without engaging the left hemisphere in the relatively difficult task of accessing the name, even when an overt naming response is not required. KINSBOURNE's [31] attentional model of hemispheric asymmetries predicts that attention will be biased toward the visual field contralateral to the more active or primed hemisphere. Naming, either overt or covert, may prime the left hemisphere during the recognition of famous, but not familiar faces, and thus account for the divergent visual-field advantages obtained.

Finally, the opposite visual-field advantages obtained for familiar faces in the present and previous studies [14-17] may be due to procedural differences. For example, the famous faces in MARZI *et al.*'s [15] experiment were presented unilaterally for 400 msec, while the familiar faces in the present experiment were presented bilaterally for 60 msec. An experiment using the same procedure as the present study with famous faces is now being carried out in our laboratory and should help resolve this question.

Results of the present study show LVF advantages of equal magnitude for the recognition of photographs of previously unfamiliar faces and highly familiar faces encountered on a day-to-day basis, even when an overt naming response is required. The obtained LVF

advantage for recognition of familiar faces agrees with results which indicate differential right-hemisphere involvement in the recognition of complex visuo-spatial stimuli, whether or not these stimuli have verbal labels [18–22]. Although previous studies with normal adults reveal a RVF advantage for the recognition of familiar faces encountered mainly through photographs (e.g. famous faces) [14–17], and support the finding that the left hemisphere has some capacity for recognizing faces [7, 28], the present results indicate that recognition of both familiar and unfamiliar faces, encountered in real life situations, differentially involves the right cerebral hemisphere.

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Résumé :

On a présenté tachistoscopiquement en vision latérale des mots, des visages familiers et des visages non familiers à des sujets adultes droitiers. Un avantage dans le champ visuel droit (CVD) était obtenu pour la reconnaissance des mots et un avantage du champ visuel gauche (CVG) pour la reconnaissance des visages aussi bien familiers que non familiers. En outre, il y avait toujours un avantage du CVG pour les visages familiers lorsque la réponse réclamée était aussi bien une reconnaissance sur un choix multiple qu'une réponse de dénomination. Ce type de résultats est en accord avec ceux d'études récentes qui indiquent que l'hémisphère droit est impliqué dans la reconnaissance des stimulus complexes visuo-spatiaux, que ces stimulus aient ou non des étiquettes verbales.

Deutschsprachige Zusammenfassung

Wörter, vertraute und unvertraute Gesichter wurden gesunden, rechts-händigen erwachsenen Personen tachistoskopisch in beiden Gesichtsfeldern getrennt angeboten. Eine Rechtsfeld-Überlegenheit wurde für das Erfassen der Wörter erzielt, eine Linksfeld-Überlegenheit für das Erkennen von vertrauten und von unvertrauten Gesichtern. Die Linksfeld-Überlegenheit für vertraute Gesichter fand sich übrigens sowohl beim Antworten durch Auswählen aus einer Anzahl von Gesichtern wie beim Antworten durch Benennen. Dieses Ergebnismuster paßt zu Ergebnissen von früheren Studien, die anzeigen, daß die rechte Hemisphäre beim Erfassen komplexer visuo-spatialer Stimuli involviert ist, gleichgültig, ob diese Namen haben oder nicht.