Excerpt from : Steele Russell,I.,Van Hof,M.W. & Berlucchi,G. (Eds)Structure and Function of cerebral Commissures
London : Mc Millan,1979.

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LEFT HEMIFIELD SUPERIORITY AND THE EXTRACTION OF PHYSIOGNOMIC INFORMATION

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INTRODUCTION

Data have accumulated in recent years which strongly suggest that the process of identifying human faces is critically dependent on functions for which the minor cerebral hemisphere is specialised. The notion is, in fact, supported by the now familiar pattern of neuropsychological evidence for hemispheric specialisation, which consists of (a) the existence of a specific pathological syndrome, (b) a correlation in brain-damaged patients between measures of the relevant capacity and side of injury, and (c) a perceptual asymmetry demonstrable in normal subjects. In the present case the syndrome is *prosopagnosia*, a rare condition involving the specific loss of the ability to recognise people from their faces, which is found mainly in patients with damage to the right hemisphere (Bodamer, 1947; Hecaen and Angelergues, 1962; Rondot and Tzavaras, 1969), although some lesion in a so-far unspecified region of the left hemisphere may also be necessary (Meadows, 1974).

When populations of non-prosopagnosic brain-damaged patients are submitted to tests involving recognition or comparisons of pictures of human faces, patients with right hemisphere lesions do more poorly (e.g. Benton and Van Allen, 1968; De Renzi *et al.*, 1968). The difference seems to be specific of a material picturing normally oriented human faces, since it is not found with pictures of other mono-oriented objects (Tzavaras *et al.*, 1970) nor with pictures of faces presented upside-down (Yin, 1970). Finally, faces presented in one visual hemifield of normal subjects are identified more accurately (Hilliard, 1973; Klein *et al.*, 1976; Marcel and Rajan, 1975) or faster (Geffen *et al.*, 1971; Rizzolati *et al.*, 1971) when presented in the left hemifield. This left side superiority is probably the reason behind the old finding (Wolff, 1933) that a composite picture made up by assembling two right halves of a face resembles the whole face more than one made up of two left halves (Gilbert and Bakan, 1973). There are however some conditions, not yet fully elucidated, under which the effect vanishes or gives way to right side superiority. One of these conditions is the use of names, another is familiarity with the pictures used in the test (Berlucchi *et al.*, 1976). We shall go back to that question

later : understanding the apparent lability of left side superiority in face recognition was one of the motives of the present study.

Independently of data on lateralisation, the idea that the perception of the human face may involve specialised processes, sometimes called physiognomic, different from those involved in identifying other kinds of objects, has been entertained by many students of perception (e.g. Hochberg, 1972). The physiognomic mode of perception can however be applied to non-face stimuli, as when we see faces in clouds, Rorschach inkblots, etc., and can then lead to better recognition performance (Gibson, 1969). Consideration of the role played by the face in social interaction as a source of both non-verbal communicative displays and of speech-accompanying signals on one hand, and as the main basis of individual recognition on the other, makes the emergence of specialised perceptual mechanisms plausible. There are also a number of remarkable features which appear to be specific of facial perception. One aspect, which has been well documented by Yin (1969), is the fact that recognition performance is affected by upside-down inversion in the case of faces much more than in the case of other mono-oriented objects such as houses or human figures. On the other hand, we can identify a person from his face across changes of viewing angle, of expression, of age, of health state and often in spite of the addition or elimination of paraphernalia such as moustache, beard, hair, glasses, etc. Physiognomic perception seems to imply the extraction of high order relational properties which are invariant across such changes.

The evidence regarding lateralisation undoubtedly fits in well with the notion of specialised processing facilities : some critical components of physiognomic perception would be based in the minor hemisphere. From that point of view, the sheer registration of lateral asymmetry is however unsatisfactory, and one is led to ask which are the critical operations, for which the right hemisphere is specialised, and which are essential to facial recognition (Teuber, 1972). An attractive proposition is that they consist of the extraction of those high order physiognomic invariants we have just been considering.

If this assumption is correct, left hemifield superiority will only be detected reliably in a task which requires the extraction of properly physiognomic information. Now, this is not necessarily the case of any face-identification task. For instance, if the task is to decide if two simultaneously presented pictures are of the same person, but if one person is always represented by the same picture, so that the decision 'same' is made on the basis of two physically identical pictures, the extraction of physiognomic information is not necessary. In that situation, any aspect of the material can be valid for doing the task, so that the pictures can well be processed in a non-physiognomic mode. But if the decision 'same' must be made on the basis of two different pictures of a person, it becomes much less likely that low level routines be valid.

In the experiment to be described, subjects were asked to give speeded same-different reactions to successive pairs of photographs, the first member of each pair being presented at the fixation point and the second unpredictably in the left or right hemifield. In one condition, called 'physical identity' condition, a trial involved

either two identical photographs or the photographs of two different people. In the other condition, called 'facial identity' condition, each trial involved two different photographs of the same person, taken from different viewing angles, or two photographs of two different persons. From the physiognomic invariant hypothesis, it was predicted that a larger left visual field superiority would be observed in condition 'facial identity'.

METHOD

Material and apparatus

The material consists of two photographs, one full-face and one three-quarter face, of 15 young men, aged ≈ 20 years. All models had dark hair, about the same hair-cut, were clean-shaven and wore no glasses. All were photographed wearing the same dark tee-shirt. Their expression was neutral. From each negative, two prints 24 mm × 35 mm were prepared with two opposite orientations.

The material was presented in an Electronic Developments 3-channel tachistoscope. In channel 1, a single small black cross, serving as fixation point, was presented in a central position. In channel 2, one photograph appeared in central position. In channel 3, a photograph was present either to the right or left of the centre. At the subject's eye, each face subtended a horizontal angle of about 1°50′. Those presented in lateral position extended from about 20′ to about 2° 10′.

The subject started each trial by pressing a push button held in the left hand. He responded by operating with his right hand a vertical two-way joystick, located in a median position, which he had to move either away from or towards his body.

A digital timer (Advance Instruments TC-12) was used to measure the reaction time.

Procedure

The subject was instructed to fixate the fixation cross before starting the trial. Channel 2, with a photograph in the centre, was then lit for 300 ms (phase 1). One hundred millisec after its offset, channel 3 (with a photograph left or right of centre) came on for 100 ms (phase 2).

The subject was told to move the joystick in one direction if the second picture represented the same person as the first one, and in the other direction if it represented a different person. The two directions of movement were given opposite meanings for half the subjects (two males and two females) of each group. The timer was started at the beginning of phase 2 and stopped when the joystick was activated.

At the completion of each trial, the subject was told whether his response had been correct and, if 'yes', whether it had been fast or slow – 'fast' meaning faster than the mean of the previous session, for sessions 2–5, or the mean of a group of preliminary trials, on session 1.

Each subject participated in five sessions, a practice session of 120 trials and four experimental sessions of 180 trials each.

Eight subjects, four of either sex, were allocated to one of two groups. The subjects of one group worked under one of two conditions throughout.

In both conditions, the photograph appearing in phase 2, i.e. the one to which the reaction had to be given, was a three-quarter face, either left or right. In condition 'physical identity' the photograph appearing (in the centre) in phase 1 was also a three-quarter face one, in the same orientation. In group 'facial identity' the photograph appearing in phase 1 was full-face. In both groups a 'same' pair was presented on half the trials, a 'different' pair on the other half. From the preceding description, it follows that on 'same face' trials, the two successive photographs were identical in group 'physical identity' but differed by the angle of view in group 'facial identity'.

On experimental sessions 2–5 the order of presentation of the pictures was balanced in such a way that all faces appeared an equal number of times (6), in both phase 1 and phase 2, in each half-session.

Subjects

Sixteen students, all naive regarding the aim of the study, volunteered to participate. They were paid a fixed amount, plus a premium depending on both speed and accuracy.

RESULTS AND DISCUSSION

Mean correct reaction times per condition, side of presentation and judgement category appears in table 33.1, together with error percentages. Individual reaction times are given in figures 33.1 and 33.2

The main result is that a systematic difference in reaction time favouring the left hemifield appears in condition 'facial identity', not in condition 'physical identity'. Individual reaction times were submitted to a three-way analysis of variance, with hemifield and judgement category (same versus different) as within-subjects factors, and condition as between-subjects factor. It revealed a significant condition × hemifield interaction: $F(1;14) = 7.0; P < 0.025$. This outcome thus supports our main prediction: left hemifield superiority is at any rate weaker in condition 'physical identity'.

Since the finding of a significant interaction between systematic factors made the interpretation of main effects impossible, separate analyses were carried out on the data of the two groups of subjects. The effect of side of presentation is found significant in group 'facial identity', $F(1;7) = 18.4; P < 0.005$, not in group 'physical identity', $F(1;7) = 1.2$. In other words, left hemifield superiority is demonstrated in condition 'facial identity' only.

Table 33.1
Mean reaction times, (in ms) per group, hemifield and response category, with percent errors (in parentheses)

Group	*Response category*	*Hemifield* Left	Right	*Difference* left–right
Facial identity	Same	369 (5%)	375 (5%)	6
	Different	414 (8%)	437 (14%)	23
	Mean	391 (6.5%)	406 (9.5%)	14
Physical identity	Same	331 (4%)	330 (3%)	−1
	Different	370 (6%)	377 (8%)	7
	Mean	350 (5%)	353 (5.5%)	3

Left hemifield superiority occurs at the level of percent errors also. It can be seen in table 33.1 that the subjects of group 'facial identity' made more errors on right- than on left-side presentations. Seven subjects out of eight exhibited that pattern, the eighth showing no difference (7 out of 7 is significant at $P = 0.011$ by a unilateral sign-test). The effect of side of presentation on reaction time appears thus to reflect a genuine change in performance level, and is not obtained by trading off accuracy for speed. Presumably, had the subjects maintained the same accuracy level on right and left hemifield presentations, the difference at the level of reaction times would have been amplified.

So far, we have only considered mean data across the two judgement categories. It appears in the two figures that 'same' responses are systematically faster than 'different' responses. Variance analyses show that the difference is significant in both facial identity, $F(1;7) = 35.4$; $P < 0.005$, and physical identity, $F(1;7) = 80.7$; $P < 0.001$, groups. Shorter reaction times for choosing 'same' rather than 'different' responses are a constant feature of comparison tasks, and should thus come as no surprise. A more interesting feature of the data is the fact that in group 'facial identity', hemifield differences tend to be larger for 'different' responses than for 'same' responses: mean left field superiority is 23 ms for 'different' and only 6 ms for 'same' responses. The effect falls short of the 0.05 significance level in the variance analysis (hemifield × type of response interaction: $F(1;7) = 4.07$; $0.05 < P < 0.10$). But the corresponding effect is observed at the level of percentage errors, which is larger for the right than for the left visual field in the case of 'different' responses, not for 'same' responses. Following the reasoning of the last paragraph, had the subjects adopted a strategy giving the same error rate for left and right visual fields on 'different' trials, the hemifield × judgement category interaction would presumably have been larger.

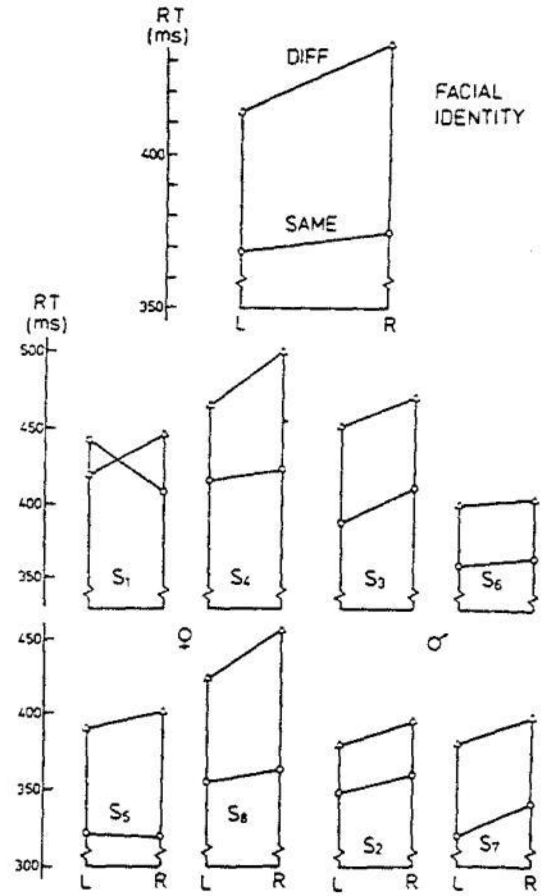

Figure 33.1. Group 'facial identity'. Mean correct reaction times as functions of hemifield (abscissa) and of type of judgement (parameter) for the group as a whole (above) and for each individual subject (below). Female subjects on the left and males on the right

Examination of figure 33.1 shows that there are rather large individual differences in pattern. One subject, S_1, is different from all others in that she exhibits right hemifield superiority for 'same' responses together with left hemifield superiority for 'different' responses. The data were examined for an effect of sex, since Rizzolati and Buchtel (1977) have reported data suggesting that women show lower laterality for faces than men. At the level of mean reaction time, only a small, non-significant, tendency is observed (mean left hemifield superiority = 15.5 ms for men, 10.5 for women). But the main difference is found at the level of the hemifield × type of judgement interaction. The four men give a mean left side superiority of 18 ms for 'different' response against 17 ms for 'same' responses. The corresponding figures for the women are 28 ms and −5 ms. Women appear thus to

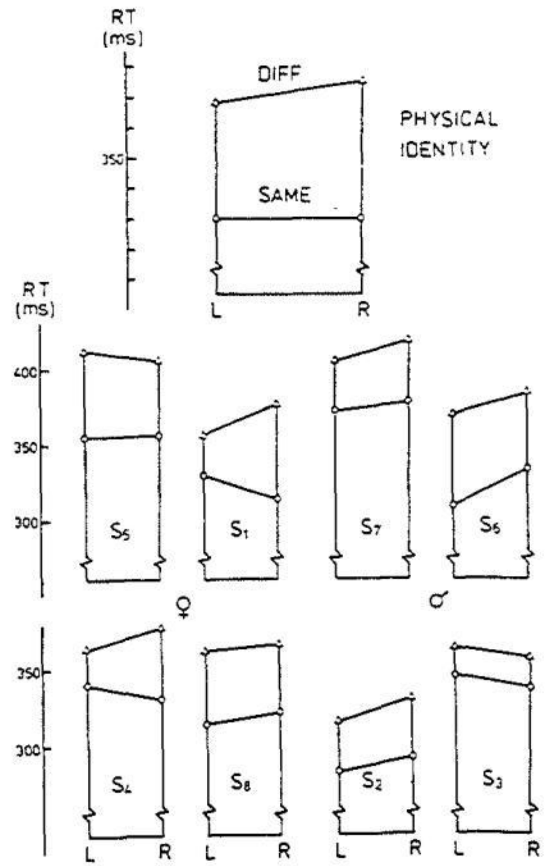

Figure 33.2. Group 'physical identity'. Mean correct reaction times as functions of hemifield (abscissa) and of type of judgement (parameter) for the group as a whole (above) and for each individual subject (below)

be responsible for the interaction observed at the level of mean reaction times. Even if we eliminate subject S_1, who exhibits the crossed interaction which has already been commented on, we find 30 ms and 5 ms for the three remaining female subjects. These observations can, of course, be considered as suggestive only and should be confirmed on a fresh sample of subjects before any interpretation is attempted.

CONCLUSION

The main prediction formulated in the introduction has been supported: left visual hemifield superiority was obtained in the task where the photographs to be compared were always physically different, and not when one of the possible

situations was physical identity. The results are thus consistent with the notion that the operations which are performed better in the right hemisphere are concerned with the extraction of physiognomic invariants. Of course, only one of the changes considered in the introduction, change in viewing angle, has been manipulated. The study should obviously be extended to other cases such as change of expression, or as ageing. Such developments may help specify the critical cues and bring us beyond the very abstract 'physiognomic versus non-physiognomic' dichotomy, which is one of the most unsatisfactory aspects of the present attempt.

The observation that, in some subjects at least, lateralisation manifests itself mainly in decisions of difference may however constitute a difficulty for the conclusion. Given that the pictures involved in decisions of sameness were equivalent at the level of physiognomic invariants only, one would have expected left hemifield superiority for these decisions also.

There are two alternative interpretations for the absence of asymmetry on 'same' decisions. One is that the specialisation of the lateralised mechanism does not consist of the extraction of physiognomic invariants, but in a still more narrowly defined operation, involved in 'different' decisions only. The other interpretation is that the present material did not make the extraction of physiognomic invariants really imperative. Some non-physiognomic cues might still have been valid bases of judgement, in spite of the change of viewing angle, and would have been used as such by some of the subjects. It is impossible to specify which these cues would be, but possible examples are details of haircut such as the presence of a flock or quiff on one side of the forehead. (It is here assumed that these non-physiognomic cues are used for decisions of sameness, but are not considered sufficient for decisions of difference. One may argue that, in this situation, the resistance of these cues to changes in viewing angle is only probabilistic, so that their presence in the second picture is a valid basis for deciding same, while their absence remains equivocal. In the 'physical identity' condition, on the contrary, absence and presence of a cue is equally informative, so that both 'different' and 'same' decisions can be made on the basis of low level visual data.)

While the first interpretation involves a qualification of the main conclusion, the second one keeps the conclusion and blames the material. It is of course impossible to choose between them on the basis of the present data. Further experiments, with more stringent obstacles to the use of non-physiognomic cues, are necessary before a decision can be reached. In the meantime, it is worth noting that Morais and Darwin (1974), in a task involving same–different reactions to lateralised CV syllables, observed right ear advantage for 'different' responses, not for 'same' responses, in spite of the fact that the two successive stimuli to be compared always differed in pitch, and were thus equivalent at a more abstract linguistic level only. A higher sensitivity of 'different' judgements to lateral specialisation might thus not be restricted to the present situation. (It must be noted however that in a same-different task with simultaneously presented schematic faces, Patterson and Bradshaw (1975) found right hemifield superiority for 'different' and left hemifield superiority for 'same' judgements—the opposite from the present interaction.)

After the present data had been gathered, a paper appeared whose results point to the same general conclusion (Moscovitch *et al.*, 1976). In same–different reactions to simultaneously presented 'identikit' pictures which were either identical or very different, no hemifield effect was obtained. But in another same–different task involving comparisons of photographs and caricatures, a clear left field superiority was obtained. This result clearly supports the notion that left hemifield superiority is connected with the extraction of physiognomic invariants. In the same study, it is shown also that left side superiority can be obtained in a 'physical identity' condition if delayed comparisons, imposing the retention of facial information, are used: with successive comparisons of either identical or different pictures, left hemifield superiority was observed with interstimuli intervals of 100 ms or more but not with shorter ones; it was also obtained whatever the interval where the first picture was pattern-masked. The results are in agreement with previous findings of Patterson and Bradshaw (1975). A possible interpretation is that faces are normally memorised in terms of physiognomic features.

With the idea that the lateralised physiognomic mechanism is best observed in tasks which involve either comparisons of different pictures of a same face, or comparisons of a picture to a memorised trace, we are in a position to understand several apparent difficulties in the literature. (The results showed by Rizzolatti, chapter 32 herein, reveal a third condition: asymmetry can be enhanced by shortening stimulus presentation. This manipulation may play a role similar to masking, by making low level visual cues unavailable for the decision.) Left side superiority has been found by authors who used a small constant set of pictures (Geffen *et al.*, 1971; Klein *et al.*, 1976; Moscovitch *et al.*, 1976; Rizzolatti *et al.*, 1971) because the presented picture had to be compared with a memorised face. Familiarity eliminated the effect (Berlucchi *et al.*, 1976) possibly because it made possible the discovery of valid non-physiognomic cues.

Another difficulty which can now be explained is the result of Milner (1968) who found that right temporal lobe-excised patients were inferior to left ones in a task involving recognition of pictures of faces after a filled or unfilled 90 s interval, not if the recognition test was carried out immediately after presenting the target pictures. She concluded that the difficulty encountered by right temporal patients lies in retaining facial information, not in extracting it. On the other hand, Benton and van Allen (1968), De Renzi *et al.* (1968) and Tzavaras *et al.* (1970) all found right hemisphere patients inferior in tasks involving the matching of simultaneously presented pictures. But the tasks used by these authors involved the matching of different photographs of the same models, whereas in Milner's recognition task the target pictures were identical with those presented immediately before.

ACKNOWLEDGEMENTS

The present work has been partially subsidised by the Belgian 'Fonds de la Recherche fondamentale collective' under convention No. 2.4522.76. The ~~illustrations~~ [photographs] were

kindly supplied by Dr Tony Marcel of the MRC Applied Psychology Unit in Cambridge. Very useful suggestions were made by Dr Daniel Holender.

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