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Identification of familiar and unfamiliar faces from internal and external features: some implications for theories of face recognition

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Abstract. Three experiments are reported in which recognition of faces from whole faces or internal or external features was compared. In the first experiment, where the faces were of famous people, an advantage was found for identification from internal features. In the second experiment involving unfamiliar faces, however, no difference was found in recognition rates when subjects were given the internal or the external features. In a third experiment famous faces were presented and mixed with other famous faces for a recognition test. As in experiment 1, better recognition occurred from internal as compared with external features. It is argued that the internal representation for familiar faces may be qualitatively different from that for faces seen just once. In particular some advantage in feature saliency may accrue to the internal or 'expressive' features of familiar faces. The implications of these results are considered in relation to general theories of face perception and recognition.

1 Introduction

The human face is an increasingly popular stimulus for use in perceptual and cognitive research. It is a familiar type of pattern with which we have a tremendous amount of experience and perhaps represents the ultimate in our capacity to discriminate and store different exemplars within a class of objects.

One of the questions to which some of this research has been addressed concerns the saliency of different facial features. The face is a multidimensional pattern which can be scanned and encoded by an infinite variety of perceptual strategies. The search for universal encoding techniques has led to the establishment of certain principles that appear to govern the manner in which Western observers perceive and remember Western faces.

In general, it would appear that we adopt a top-to-bottom perceptual scan (Smith and Nielsen 1970), paying particular attention to upper face features compared with lower face features (Goldstein and Mackenberg 1966; Ellis et al 1975; McKelvie 1976; Fisher and Cox 1975; Davies et al 1977). This pattern has been demonstrated by a variety of techniques that include masking particular features, changing features to see which alterations subjects notice, and observing the order and accuracy with which people describe and reconstruct faces.

Where research has been undertaken into the distribution of eye movements made by people when examining a face, however, the picture is less clear. If feature saliency follows a top-to-bottom order, one would expect the order and frequency of eye movements to follow a similar path. According to Luria and Strauss (1978), however, the eyes and nose attract most visual attention. Admittedly they used pictures of military personnel as inspection stimuli and these wore caps obscuring most hair and brow details, but in an eye-movement study by Walker-Smith et al (1977), hair details were available for inspection and yet subjects appeared not to scan them. The latter authors were unable to find consistent patterns across subjects' eye movements although individuals tended to repeat their individual patterns upon testing with other faces. Nevertheless in all cases it would appear that the central region of the face attracted most visual interest.

The central region contains the eyes and the mouth, both supremely involved in acts of communication and therefore likely to command attention. Developmental studies have shown how young infants pay regard first to the outer contours of a face and as they grow older switch attention to the inner, expressive features (Maurer and Salapatek 1976).

The masking studies mentioned earlier have not examined specifically the distinction between inner and outer facial features but have tended to concentrate on individual facial features or broad regions such as top half and bottom half or left half and right half. Goldstein and Mackenberg (1966) included a condition in which inner features were masked but did not have a condition in which outer features were masked. By contrast, the present experiment involves a comparison of identification accuracy given either the inner or outer features of a face.

Previous workers have used faces drawn from a variety of sources. Goldstein and Mackenberg (1966) employed pictures of children, which they masked in a number of different ways (including, as mentioned above, obscuring the inner features) and presented to their classmates for identification. Fisher and Cox (1975) presented their subjects with larger and larger segments of celebrities' faces; Davies et al (1977) made up faces from the Photofit Kit; McKelvie (1976) gave his subjects pictures of strangers to memorise and later recognise with certain features masked. A face is a face regardless of its familiarity, but it is possible that we process familiar faces in a manner somewhat different from that adopted for novel faces. Some indirect support for this idea is given by the observation made by Warrington and James (1967) that memory for famous faces and memory for unfamiliar faces are not correlated. Clearly, familiar faces may be encoded in a fairly elaborate way involving examples of, or rules for, various transformations of pose and knowledge of the individual's name, status, and history. By comparison the information available about a novel face is restricted and this may determine that the manner in which it is perceived and stored be different from that involved in processing familiar faces.

In the present study three experiments were conducted to examine the question as to whether photographed faces are easier to identify from inner or from outer features. Experiment 1 examined the ability of subjects to identify well-known faces on the basis of either their inner or their outer features. Performance in these two part-face conditions was compared with a condition in which whole faces were presented. In the second experiment subjects were presented with the photographed faces of strangers and subsequently were asked to identify them on the basis of either their inner or their outer features. In the third experiment the procedure employed in the second experiment was used with famous faces as stimuli.

2 Experiment 1: identification of famous faces

2.1 *Method*

2.1.1 *Faces.* Thirty black-and-white photographs of well-known people alive or dead from the worlds of royalty, stage, screen, television, politics, and sports were selected from a newspaper file. The criteria for selection were that they were male, fairly familiar to the authors, and that the pose was at or near full-face. The names of the selected celebrities appear in table 1.

The area of each face was measured and masks made to enable the centremost 50% or outermost 50% of the face to be excluded. Figure 1 illustrates the results obtained by masking and rephotographing the faces. The area covered by the masks slightly deviated at times from 50% in order that all of the inner features (i.e. eyes, nose, and mouth) could be either included or excluded.

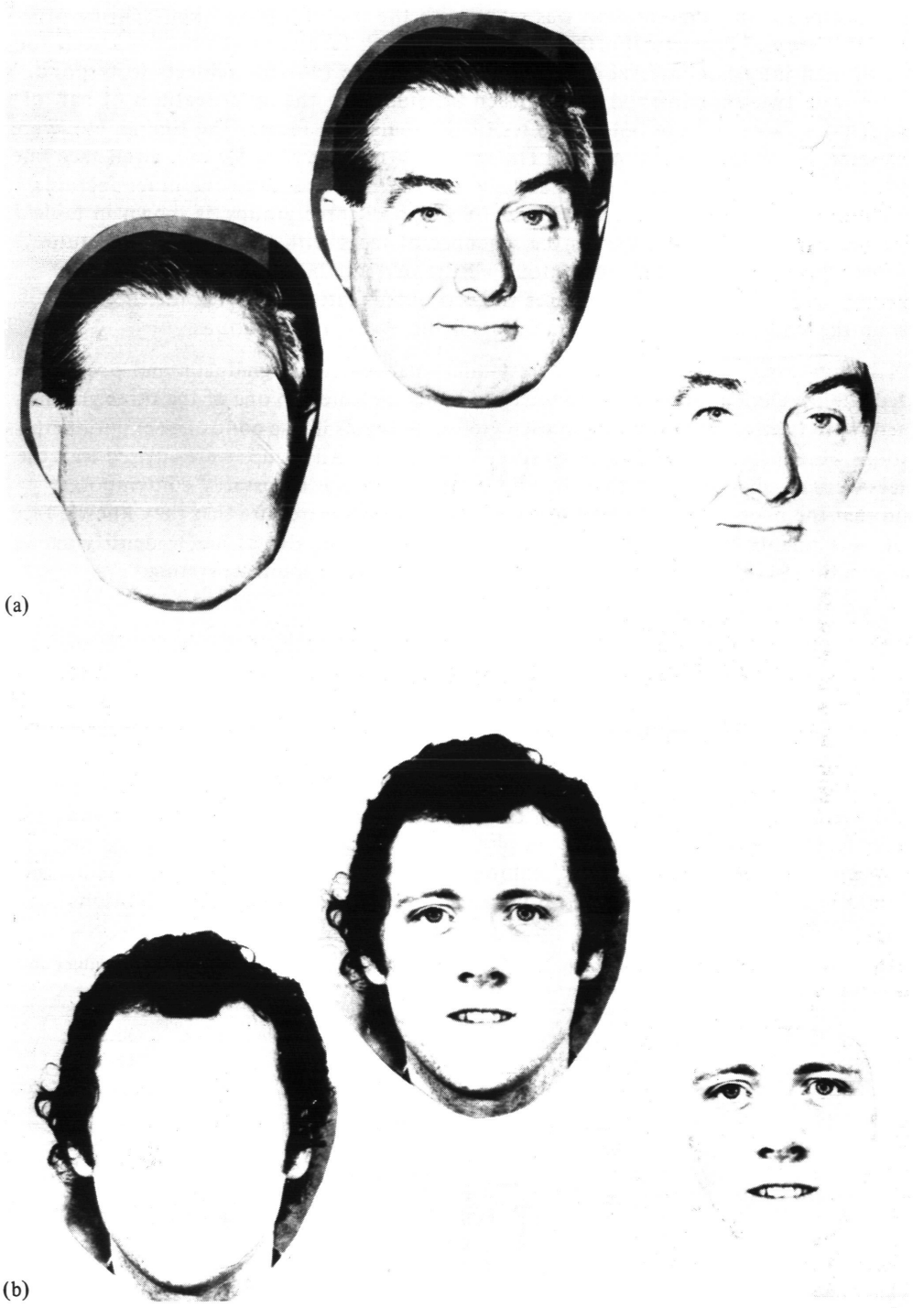

Figure 1. Examples of the faces used in the two experiments: (a) a familiar celebrity (James Callaghan); (b) an example of the unfamiliar face used in experiment 2.

2.1.2 *Design and procedure.* There were three slides of each face: the whole face, the outer features, and the inner features. The thirty whole faces were presented to a control group of subjects who simply had to write the name of the face on a

response protocol. Presentation was made with the use of a projection tachistoscope (Kodak Carousal Projector/Forth Instruments). Each face appeared on the screen for 9 s with an interslide interval of 6 s, which gave ample time for subjects to respond. There were two experimental groups, each of which saw the inner features of half of the famous faces and the outer features of the remaining faces. The timing, etc, were the same as for the control group. The groups differed in that for any given face one group was given the inner features and the other group was given the outer features.

The order of presentation, which was fixed for all three groups, is shown in table 1. For the two experimental groups the sequence of faces with inner or outer features visible alternated, so that for one group all the odd-numbered faces showed inner features and the even-numbered faces showed outer features whereas for the other group the odds contained outer features and the evens inner features.

2.1.3 *Subjects.* The subjects were sixty-nine final-year undergraduate, and post-graduate psychology students who were randomly allocated to one of the three groups; there were twenty-three subjects in each group. Subjects in the control or experimental groups were informed of the type of stimuli to expect. All groups were advised that the faces were of celebrities but that the photographs were not necessarily contemporary and that the people involved might be deceased. If they were sure that they knew a face but were unable to supply the name they were invited to give as much identifying information about the person as was possible in the time limits operating.

2.2 *Results and discussion*

Table 1 presents the number of subjects who identified each of the celebrities under the three viewing conditions. It is clear that, compared with seeing the whole face, it is fairly difficult to identify a face from just the inner or outer features. The comparison of greatest interest, however, is between the mean identification score from inner features compared with the mean score for outer features. On average, subjects identified roughly 80% of the whole faces, 50% when given the inner features, and 30% when given the outer features. The difference between scores for inner and outer features was analysed by a split-plot analysis of variance with groups as the between factor and inner vs outer features as the within factor. The only significant F ratio occurred for the comparison between inner- and outer-feature conditions ($F_{1,44} = 48{\cdot}6$; $p < 0{\cdot}001$).

Table 1. Number of subjects (maximum 23) correctly identifying the thirty celebrities from inner and outer features compared with whole-face recognition.

Celebrity	Whole face	Inner features	Outer features	Celebrity	Whole face	Inner features	Outer features
James Callaghan	9	14	9	Cliff Richard	22	16	8
Prince Philip	23	9	18	Michael Parkinson	20	11	6
Jo Grimond	15	1	14	Bill Simpson	20	10	3
Michael Barrett	20	16	0	Tony Benn	8	7	1
Tony Greig	14	1	3	John Wayne	19	17	0
Harold Wilson	23	23	5	Andy Stewart	14	19	0
Richard Burton	22	17	1	Richard Baker	12	2	5
Ronnie Barker	18	6	4	Jimmy Connors	12	6	0
John Lennon	17	10	1	Jeremy Thorpe	18	5	12
Steve McQueen	14	10	0	Prince Charles	23	15	23
Frank Sinatra	17	16	0	Jimmy Carter	23	14	14
Tommy Steele	20	16	8	Sid James	22	21	15
Ian Paisley	14	3	9	Hughie Green	22	9	6
Bruce Forsyth	23	21	19	David Steel	16	1	15
John Kennedy	22	9	11	Paul Newman	20	10	5

It is also evident from table 1 that there is a fairly wide difference among identification rates for different faces. These differences, however, need not concern us here. The result of note is that the inner half of a face provides significantly more information than the outer half for identifying a well-known face. We shall postpone further discussion of this result until later.

Table 1 also shows that some faces do not obey the average rule that they are more easily identified from inner features than from outer features. This reversal in general trend is more noticeable for the faces of Prince Philip, Jo Grimond, Prince Charles and David Steel. We should not forget, of course, that the experiment involved a single photograph of each celebrity which may not have been a truly representative picture of the individual.

3 Experiment 2: unknown faces

3.1 *Method*

3.1.1 *Faces.* Thirty black-and-white full-face portraits of University students and staff were used. As with the famous faces, two extra prints were made, one with the inner 50% and one with the outer 50% masked (see figure 1b).

3.1.2 *Design.* The design of this experiment was based upon the typical method for studying recognition memory. Subjects were presented with half of the faces (target set) and then tested for their recognition of them when mixed with the other half of the faces (distractor set). The difference between the present experiment and the usual case lay in the fact that some groups of subjects were required to recognise the target from the distractor faces on the basis of either the outer face features or the inner face features.

Six groups of subjects were employed, each of which experienced one of the conditions shown in table 2. As the table shows, the thirty faces were randomly divided into two equal-sized groups—set A and set B. Subjects were assigned to one of six groups and thus received one of the treatments indicated.

Table 2. Allocation of groups to treatments in experiment 2.

Group	Presentation set	Nature of stimuli at recognition
1	A	outer features
2	A	inner features
3	A	whole faces
4	B	outer features
5	B	inner features
6	B	whole faces

3.1.3 *Procedure.* Subjects were simply told to look at the screen and try to remember the fifteen faces that would be shown to them. They were not told the form of the recognition test to expect. Each face was presented for 6 s with a 3 s interstimulus interval. A 15 min interval occurred between presentation and testing during which all subjects completed an unrelated paper-and-pencil test.

Just prior to the recognition test, subjects were informed as to the manner in which the faces would be presented (whole faces, inner features, or outer features). They were allowed a 6 s view of each slide followed by a 3 s interstimulus interval. Subjects were instructed first to make a decision as to whether they believed the particular face in front of them had or had not been shown earlier (by writing 'y' or 'n' on their response protocols) and second, the groups tested with inner or outer faces were asked to give an indication of the confidence they placed in their decision using the following scale: 1 = not at all confident in my decision; 2 = slightly confident in my decision; 3 = fairly confident in my decision; 4 = confident in my decision.

3.1.4 *Subjects.* Fifty-four subjects drawn from a panel comprising a cross-section of Aberdeen citizens were paid to participate in the experiment. There were thirty-eight women and sixteen men, who were randomly assigned to one of the six groups, with the constraint that each group contained approximately two-thirds women and one-third men.

3.2 *Results*

It should be noted that the most critical comparison, that between recognition of faces from outer features and recognition from inner features is a between-groups comparison. Since we were not interested in any differences between set A and set B faces the results of groups 1 and 4, 2 and 5, and 3 and 6 were combined.

3.2.1 *Recognition scores.* In order to make some compensation for guessing strategies, the hit and false-identification scores for each subject were used to compute A', which is a nonparametric statistical decision parameter (Rae 1976). This technique does not make any assumptions concerning the normality of the underlying distributions of likelihood ratios for familiar and unfamiliar faces as parametric statistical decision theory does. This procedure yielded the following A' scores (standard deviations are given in brackets):

	whole faces	outer features	inner features
Mean A'	0·909 (0·044)	0·731 (0·173)	0·707 (0·183)

An analysis of variance applied to these scores indicated a significant difference among the groups ($F_{2,51} = 10{\cdot}06$; $p < 0{\cdot}001$). This overall difference is entirely due to the high scores of the group presented with whole faces upon testing. Paired comparison tests revealed that scores of the whole-face group differed significantly from the groups given just the outer features and the groups given the inner features during the recognition test ($t_{34} = 4{\cdot}34$ and $4{\cdot}56$, respectively; $p < 0{\cdot}01$). The two part-face groups, however, did not differ significantly from one another in their recognition of faces ($t = 0{\cdot}40$). Thus it would seem that for relatively unknown faces inner and outer features are equally informative.

3.2.2 *Confidence scores.* Table 3 shows the mean confidence ratings given by subjects in the partial-information groups for the different categories of answer, namely correct identification, incorrect identification, correct rejection and incorrect rejection. In none of the comparisons were confidence ratings from outer-feature groups significantly different from ratings given by inner-feature groups.

Table 3. Mean confidence ratings for groups presented with either inner or outer face features at testing in experiment 2.

Correct identifications		Incorrect identifications		Correct rejections		Incorrect rejections	
outer	inner	outer	inner	outer	inner	outer	inner
3·27	2·92	2·35	2·09	2·28	2·40	2·61	2·42

4 Experiment 3: recognition of famous faces

The results of experiments 1 and 2 point to a possible distinction between the processing of well-known and unknown faces: for the former type of faces the central part of the face is more likely to lead to recognition, for the latter there is no difference in the ease with which faces are recognised from inner and outer features. There was, however, a marked difference in the procedures used in the two

experiments and it would be as well, perhaps, to eliminate the possibility that the different pattern of results was due simply to procedural variation. The first experiment involved an identification paradigm in which different groups of subjects attempted to identify the faces of celebrities from photographs showing the whole face or masked to show only the inner or outer features. In the second experiment, however, a study-test procedure was used with faces of unknown individuals masked in the same manner.

In the following experiment the faces of famous people were shown and then the faces were masked and mixed with an equal number of similarly masked faces of other celebrities. As in experiment 2, subjects were required to recognise the faces shown initially from among an equal number of distractor faces.

4.1 *Method*

4.1.1 *Faces.* The thirty faces of celebrities used in experiment 1 served as stimuli. Half were randomly chosen and designated as target stimuli and the other half comprised the distractor set at the recognition stage.

4.1.2 *Design and procedure.* The design and procedure were similar to those in experiment 2. There were three versions of each face: a whole face, the inner features, and the outer features. Subjects saw the fifteen whole target faces each shown for 6 s with a 3 s interstimulus interval via a Kodak Carousel/Forth instruments projection tachistoscope. Subjects were not required to name the faces. The order of presentation of the target faces was randomly determined and fixed for all groups.

Three groups of subjects were employed. One group (the control group) was required to recognise the fifteen target faces when randomly mixed with fifteen distractor famous faces. At the recognition stage, a second group saw these same thirty faces with the outer features masked. A third group saw the faces with the inner features masked. In all cases there was an interval of approximately 15 min between presentation and recognition stages. Each face in this recognition stage was shown for 6 s with an interstimulus interval of 3 s.

4.1.3 *Subjects.* Sixteen volunteer subjects were assigned to each of the three conditions. The two experimental groups comprised psychology students; the control group was made up of members of the general public. The reason for this difference in subject samples is that there is no great interest in comparing scores for subjects in the control conditions with scores for subjects in the partial-face conditions. There is, however interest in comparing the control-condition scores for this experiment, involving famous faces, with the control-condition scores from experiment 2—derived from a sample of individuals from the general public.

4.2 *Results*

Each subject's hit and false-alarm rate was calculated and combined in the non-parametric statistical decision parameter A':

	whole faces	outer features	inner features
Mean A'	0·952 (0·043)	0·833 (0·122)	0·948 (0·068)

An analysis of variance revealed an overall difference among the recognition accuracy scores for the whole face, inner features, and outer features ($F_{2,45} = 10{\cdot}93$; $p < 0{\cdot}001$). Paired comparisons by t tests revealed that the recognition rate in the inner-features condition was significantly higher than for the outer-face condition ($t_{30} = 3{\cdot}61$; $p < 0{\cdot}02$). Indeed, the inner-face conditions led to recognition rates insignificantly different from those for the whole-face condition ($t = 0{\cdot}02$, n.s.).

Thus it would seem that there is a genuine difference in the way the faces of well-known and unknown people are recognised from partial information.

5 Discussion

The results of these three experiments quite clearly indicate the possible dangers of treating familiar and unfamiliar faces as being equivalent stimulus materials. It would seem that memory for pictures of faces seen just once may be assessed equally well by the presentation of the internal features and the external or outline features. This result implies that the internal and external features of a face are of roughly the same degree of importance in determining its identity. This does not mean, of course, that all facial features are equally discriminable and memorable. The hairline is likely to attract more attention than the jawline, and eyes will receive more scrutiny than nose and mouth. When, however, the face is split into the inner and outer features the various feature saliencies balance one another.

The picture is quite different for familiar faces. The internal features are more likely to lead to recognition than are the external features. At the moment it is only possible to speculate on the reason for this result. The explanation which seems most plausible is that in seeing famous people in magazines, on television, and in films we have the opportunity to examine their faces from a variety of angles and are likely to attend to their internal features in order to discover the message and mood the individuals are trying to convey. This attention deployment would, over time, lead to a better memory representation for the internal as compared with the external features of a face. Presumably, such a process would occur when we repeatedly encounter the faces of relatives, friends, colleagues, etc. It should be noted, however, that the data shown in table 1 indicate that not all of the thirty famous faces produced the pattern of inner features leading to better recognition than outer features. One third of the faces were either better identified from the outer features than the inner features or were identified equally well in each of the part-face conditions. These deviations may restrict the generality of the results but, for the present, we will offer some theoretical speculations to account for the findings.

Recently Anderson and Paulson (1978) have outlined a theory of how faces may be represented in memory, which is able to cope with the present results. Basically, they argue that the internal representation of a face involves an abstract, propositional code which is contained within a node that is itself related in a network to other nodes. They further argue that the development of such a face node takes time and that the representation of a face over a relatively short time may be in some more literal gestalt form. Thus, it may be conjectured, the laws governing the perception and retention of familiar faces may not be the same as those typically studied in laboratory experiments employing unfamiliar faces presented just once.

The results of the three experiments outlined in this paper are consistent with such a notion. In particular they serve to illustrate the danger of generalising about the differential saliency of facial features from data obtained in experiments using unfamiliar faces as stimulus material. That is not to dismiss such studies: there is a certain applied interest, particularly from forensic sources, in how well people can perceive and remember unfamiliar faces.

It is also noteworthy that the recognition scores in experiment 3, where famous faces were stimuli, are somewhat higher than in experiment 2, where the faces of complete strangers were presented to subjects. A comparison of scores for the whole-face conditions in each experiment reveals that recognition memory for famous faces is significantly better than that for unknown faces ($t_{32} = 2{\cdot}32$; $p < 0{\cdot}05$). Half of the subjects in experiment 3 obtained perfect scores (100% hits and no false identifications) whereas none of the eighteen subjects in experiment 2 obtained a perfect score. The famous faces lend themselves to verbal as well as visual coding, which may increase the likelihood of correct recognition and correct rejection.

Theories of face recognition, however, will probably have to recognise the distinction between familiar and unfamiliar faces and theories of pattern recognition in general should likewise pay heed to the apparently different ways in which familiar and unfamiliar patterns are handled by our perceptual and memory systems.

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