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Recognition of upright and inverted faces: a correlational study

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Abstract. An investigation of ninety-five university admission candidates failed to replicate the finding by Yin of a negative correlation between the ability to recognise upright and inverted faces. A zero correlation was obtained when unknown faces were both learned and recognised upside down, but when well-known faces were presented normally and upside down for identification, a significant positive correlation appeared. Rock has suggested that inverted faces are difficult to recognise because they overtax a mechanism for correcting disoriented stimuli. This explanation satisfactorily accounts for the data with the proviso that, when inverted faces are to be remembered, the best strategy is not to attempt to correct their orientation, but to learn isolated features of the face. This describes the data more parsimoniously than Yin's face-specific mechanism.

1 Introduction

Kohler (1940), and a number of more recent authors, have demonstrated that faces are exceptionally difficult to recognise upside down. This paper is concerned with individual differences in the ability to recognise upright and inverted faces. We follow up the finding of a negative correlation by Yin (1969), and also investigate whether mental rotation could aid the recognition of inverted faces.

Yin (1969) compared people's ability to recognise photographs of faces presented normally and upside down. He also measured recognition memory for a number of other common groups of objects: houses, aeroplanes, and cartoon figures of men in motion. In the upright condition faces were easiest to recognise, whereas with inverted presentation they were hardest. It made little difference to performance whether the faces were presented upright and tested upside down, or presented upside down and tested upright, or both presented and tested upside down: in all three conditions performance dropped substantially. This disproportionate difficulty in recognising inverted faces has been confirmed by Scapinello and Yarmey (1970) and Yarmey (1971).

The observation that inverted faces lose their expressions has frequently been made (e.g. Kohler 1940; Howard and Templeton 1966, Hochberg 1968). Facial expression emanates from the centre of the face and Phillips (1977) has shown that inverting the centre (eyes, nose, mouth) is more disruptive than inverting the periphery (hair, ears, chin). Although this link between inversion and facial expression is interesting, it provides no real explanation, as the nature of facial expression itself is so little understood.

Rock (1973, 1974) has found one class of stimuli which are more disrupted by inversion than faces—handwritten words: 71% of well-known faces were identified upright and 12% when they were upside down. For handwritten words (e.g. 'untimely', 'quiescent') the corresponding scores were 86% and 9%. It is possible that entirely different processes disrupt inverted faces and inverted handwriting. Turning a stimulus upside down also reverses it from left to right, and this lateral reversal may affect the perception of handwriting more strongly than it does faces. However, Rock proposes a common explanation for both types of stimuli. He suggests that handwritten words and faces both overtax a corrective mechanism for inverted objects. While attention is focused on correcting one feature, other features remain uncorrected, and so it is impossible to recognise the whole. Rock has suggested that the mechanism used to correct retinally disoriented figures, such as inverted faces, may be similar to that studied by Shepard and Metzler (1971) in a task where subjects had to rotate pictures of three-dimensional objects mentally in order to match them. If this is true, subjects who are good at Shepard and Metzler's task should also be good at recognising inverted stimuli, and this hypothesis is tested in the present investigation.

Yin (1969) observed that those subjects who were poor at recognising upright faces tended to be relatively good on inverted faces, and vice versa. But this negative correlation was not found for other types of stimuli where the relationship was positive. Yin (1970) found a somewhat similar result in a study of brain-damaged patients. He compared patients with right-posterior lesions with other unilateral-lesion cases and normal controls. In accordance with previous findings (e.g. Hecaen and Angelergues 1962; De Renzi and Spinnler 1966; Warrington and James 1967), the right-posterior group was significantly worse than the others on a recognition test for upright faces. But with inverted faces, the right-posterior group had higher scores than the normals or the other unilateral patients, although only the latter difference was statistically significant. When the tests were repeated with pictures of houses, this interaction was not found.

This surprising result led Yin to propose that the brain may possess a specific mechanism for processing normally oriented faces, which does not handle other visual stimuli, including inverted faces. It is not clear from this interpretation why the right-posterior patients should actually do better than other groups on inverted faces —one might expect them to have about the same score. Nor is it clear why, in the earlier paper, Yin (1969) found a negative rather than a zero correlation. One possibility has been tested by Ellis and Shepherd (1975), who suggested that inverted faces may be processed in the left cerebral hemisphere. This could have caused Yin's control-group patients, who had mostly left lesions, to perform poorly on the test of inverted faces. But, using normal subjects, Ellis and Shepherd showed that a same/different judgment was significantly faster when presented to the left visual field for both normal and inverted faces. This suggests that faces in any orientation are processed better by the right hemisphere.

It is difficult to distinguish experimentally between a specific mechanism for faces, as proposed by Yin, and a more general one which is overtaxed by the complexity of faces, as suggested for example by Rock.

Possibly a more useful question and certainly a more tangible one, is to ask: which stage in the process of learning and recognising a face is especially disrupted by inversion? Rock suggests that the difficulty is largely the perceptual problem of correcting an inverted stimulus. Others, for example Hochberg (1968), have argued that inverted faces are difficult to store.

When faces are learned upside down, a perceptual explanation would require subjects to try to rotate the face and store it the right way up, but subjects rarely report doing this. On the other hand, an explanation purely in terms of memory is not plausible when subjects first see, and presumably store, upright faces, and then have to recognise them turned upside down. Yin's (1969) data show this is as hard as the other inversion conditions.

Two independent factors may be operating. This is tested by attempting to replicate Yin's (1969) finding that performance on upright-face recognition correlates negatively with performance on inverted faces, both for the case where faces are learned from an upside-down presentation, and also where faces are learned normally and subsequently tested upside down. If there is a single factor working, we might expect both conditions to show a negative correlation.

2 Method

2.1 *Subjects*

Ninety-five volunteers from candidates for admission into the Psychology Department at University College London, divided into several small groups, participated on the same day that they were interviewed and given selection tests. There were thirty men and sixty-five women aged between seventeen and thirty-eight years (median eighteen years). All subjects had been living in the United Kingdom for at least nine out of the last ten years.

2.2 *Shepard and Metzler test*

The tasks are described in the order they were given, which was the same for all subjects.

As a measure of subjects' ability to rotate objects mentally, they were given a test booklet containing twenty pairs of stimuli similar to those used by Shepard and Metzler (1971). For each pair, subjects ticked 'same' or 'different', depending on whether or not it was possible to rotate one of the pair so that it was identical with the other. The time limit was 2 min and the score was the number of correct responses minus the number incorrect. Copies of this test together with its norms are available from the authors.

2.3 *Television viewing*

Subjects were asked to rate their frequency of watching television on a four-point scale. It was explained that this was to assess their exposure to the mass media, and it was emphasised that the answers would be treated as confidential information.

2.4 *Memory tests*

A slide projector controlled by an electronic timer was used to present the material, which was all monochrome. Subjects were asked to read a slide showing a page of printed text and anyone who had difficulty doing this was seated closer to the screen.

In tests of face recognition, all the pictures were full-face, and were of white men without glasses, beards, or other obtrusive features. All pictures had a similar plain background and, as far as possible, the pictures were cropped to eliminate clothing.

In the first test, subjects were asked to remember twenty faces of male university students projected for 1·5 s each with 1·5 s between slides. Yin (1969) also used a 3 s rate. After about 30 s, subjects saw a further twenty faces consisting of ten old and ten new items. They were asked to write 'old' or 'new' for each picture, guessing when uncertain. The test slides were projected for 4·5 s with 1·5 s between slides. The score was d'.

About 5 min later subjects began the recognition test for inverted faces. The procedure was identical, except that different faces were shown, and these were both presented and tested upside down. Subjects were instructed to keep their heads upright. After the test they answered a short questionnaire about their strategies.

Next, subjects saw pictures of twelve well-known male faces which they were asked to name, or otherwise identify. Slides were projected for 2 s each with 6 s between slides. An answer was scored as right if the correct surname was given, or any other information which uniquely identified the person. Replies such as 'film star' or 'footballer' were counted as wrong. The twelve faces were Harold Wilson, Elvis Presley, Richard Nixon, Bruce Forsyth, Charlie Drake, Kenneth More, Humphrey Bogart, Michael Parkinson, Rod Stewart, Alfred Hitchcock, Tony Jacklin, and Aristotle Onassis.

The test was then repeated with another twelve well-known faces projected upside down. These were Winston Churchill, Jimmy Saville, Edward Heath, Les Dawson, Quintin Hogg, Hughie Green, Jimmy Young, David Essex, Patrick Campbell, Jack Warner, Jack Hawkins, and Michael Caine. A pilot study had established that the two sets of twelve faces were of roughly equal difficulty in the upright orientation.

In order to compare faces with other visual stimuli, two further recognition tests used photographs of woodcuts by Thomas Bewick (1818). These were taken from his illustrations for the *Fables of Aesop* and each picture included one or more animals, but no human figures. As the same type of animal often appeared in several pictures, someone who learned only the animal names would have scored poorly. Woodcuts were chosen as complex stimuli of about the same difficulty as faces on an upright recognition test. There were two tests of woodcut recognition using upright and inverted presentation, following a procedure identical to that used in the face recognition tests.

3 Results

The means and standard deviations for the memory tests are shown in table 1. Pearson product-moment correlations were calculated between each pair of scores and these are shown in table 2.

Table 1. Means for the memory tests, with standard deviations in parentheses. Because the order of the tests was constant, comparisons between these means may not be reliable.

	Well-known faces (out of twelve)	Face recognition (d')	Woodcut recognition (d')
Normal	8·12 (2·62)	2·16 (0·64)	2·34 (0·64)
Inverted	3·39 (1·85)	0·91 (0·60)	1·61 (0·87)

Table 2. In this correlation matrix, U is upright presentation, I is inverted presentation, WK is well-known faces, FR is face recognition, WR is woodcut recognition, S & M is test based on Shepard and Metzler (1971), TV is frequency of watching television. A positive correlation with sex indicates a superior performance by men.

	UWK	IWK	UFR	IFR	UWR	IWR	S&M	TV	SEX	AGE
UWK	-	0·50***	0·26*	0·03	0·04	0·07	0·00	0·15	0·08	0·16
IWK	0·50***	-	0·32**	−0·01	0·02	−0·02	−0·03	0·16	−0·14	−0·07
UFR	0·26*	0·32**	-	0·04	0·13	0·07	0·05	−0·08	−0·14	0·12
IFR	0·03	−0·01	0·04	-	0·10	0·26*	0·14	−0·09	0·06	−0·01
UWR	0·04	0·02	0·13	0·10	-	0·41***	0·30**	−0·01	0·05	−0·01
IWR	0·07	−0·02	0·07	0·26*	0·41***	-	0·25*	0·00	0·09	−0·03
S&M	0·00	−0·03	0·05	0·14	0·30**	0·25*	-	0·16	0·42***	−0·06
TV	0·15	0·16	−0·08	−0·09	−0·01	0·00	0·16	-	0·17	−0·19
SEX	0·08	−0·14	−0·14	0·06	0·05	0·09	0·42***	0·17	-	−0·02
AGE	0·16	−0·07	0·12	−0·01	−0·01	−0·03	−0·06	−0·19	−0·02	-

*** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$, two tails.

4 Discussion

Using a sample of twenty-six subjects, Yin (1969) found a negative correlation between recognition performance on upright and inverted faces, but a positive correlation for other types of stimuli. In this study, the recognition tests for upright and inverted woodcuts showed a significantly positive correlation ($r = 0{\cdot}41$; $p < 0{\cdot}001$, two tails) which is in agreement with Yin. However, on the face recognition test the correlation coefficient was close to zero ($r = 0{\cdot}04$) and on the test of well-known faces it was significantly positive ($r = 0{\cdot}50$; $p < 0{\cdot}001$, two tails). Not only do these results conflict with Yin's negative finding, but they also differ from each other. It seems unlikely that the positive correlation is due to differences in exposure to well-known faces. The subjects formed a fairly homogeneous group (similar age, education, all United Kingdom residents) and when the frequency of television viewing is partialled out, the correlation is hardly changed ($r = 0{\cdot}49$). The positive correlation ($r = 0{\cdot}32$) between inverted well-known faces and the upright-face recognition test also goes against an exposure explanation.

The face recognition test and the well-known faces test are similar in that both show a substantial decrement in performance going from upright to inverted presentation (see table 1). But when upright performance and inverted performance are correlated, the two types of test show very different results: the face recognition test has a zero correlation while the well-known faces test shows a clear positive correlation. This suggests that two different factors are operating.

Yin found his negative correlation when faces were first presented upside down and then tested upside down, and this was also the procedure for the face recognition test used here. Yin's negative correlation can be attributed to the small sample he used (he was not in the business of studying correlations and this was only a minor part of his paper). When subjects are asked to remember an inverted face, it is possible that they may either store it as an inverted face, or correct it and store it as an upright face. But introspective reports suggest that, in fact, neither of these strategies is followed. According to Yin (1969), subjects who learned upright faces attempted "to get a general impression of the whole picture" but in learning inverted faces they sought "some distinguishing feature". In the present study, subjects answered four questions on how they had learnt upside-down faces. The first two questions asked whether they had been able to rotate the picture mentally, either in whole or in part. The third question asked if they remembered the facial expression, and the fourth asked if they tried to remember isolated details of the face (see table 3). When the answers were correlated with performance on the inverted-face recognition test, only the last question showed a significant correlation ($r = 0{\cdot}21$;

Table 3. Subjects' reported strategies for remembering inverted faces, and their correlation with the inverted-face recognition test.

Strategy	Frequency of use			Correlation with IFR
	never	occasionally	frequently	
Rotate whole[a]	83	9	3	0·04
Rotate parts[b]	84	11	0	0·01
Expression[c]	22	43	30	0·07
Isolated details[d]	3	15	77	0·21

[a] I mentally rotated the *whole* face so that it was the right way up.
[b] I mentally rotated parts of the face (e.g. just the eyes) so that they were the right way up.
[c] I tried to remember the expression on the upside-down face.
[d] I tried to remember isolated details of the face (e.g. just the hair, just the mouth).

$p < 0 \cdot 05$, two tails). It is apparent that the best strategy in learning upside-down faces is to concentrate on isolated features and, in effect, forget they are faces altogether.

When subjects attempt to recognise inverted pictures of well-known faces, it is likely that they attempt to correct the stimulus so that it can be matched to their upright memory trace. But Rock suggests that the complexity of a face overtaxes this corrective mechanism. Although this correction is difficult to do, subjects are still treating the stimuli as faces. Unlike the face recognition test, there is no possibility of treating them as sets of isolated features, because they have already been encoded as faces.

Rock's explanation works equally well for both types of test. In one case, the difficulty in correcting inverted faces leads subjects to encode them as isolated features, and in the other, subjects have no choice but to try to correct the inverted face.

The different correlation coefficients are easy to explain. In the face recognition test, the upright condition tests people's ability to remember faces, but the inverted condition tests memory for isolated features, and so it is not surprising that the correlation is close to zero. In the well-known faces test, both conditions test memory for faces and therefore the correlation is positive.

Rock (1973) has suggested that the mechanism for correcting disoriented stimuli may be similar to the mental rotation task studied by Shepard and Metzler (1971). But the test based on Shepard and Metzler's task does not show a significant correlation with either of the tests using inverted faces ($r = -0 \cdot 03$, $0 \cdot 14$), and so this prediction is not supported. There is a significant correlation with the test of inverted woodcuts ($r = 0 \cdot 25$), but as there is a larger correlation with upright woodcuts this cannot be due to mental rotation ability. Shepard and Metzler's task may be rather special in that subjects report the conscious experience of rotating the objects, while correcting disoriented objects in order to recognise them does not seem to be accompanied by this experience.

It is of interest to try to apply Rock's explanation to Yin's (1970) data from brain-damaged patients. Lesions in the right hemisphere are frequently associated with poor face recognition, and it is probable that these patients seek strategies to overcome their difficulty. In order to simplify the stimulus, they may try to code faces as isolated features. Although this is usually an inefficient way of remembering upright faces, it seems to be the best way of learning inverted faces, and so one might expect them to have an advantage on a recognition test for inverted faces.

Although Rock's explanation for our difficulty with inverted faces is in good agreement with the data, Yin's proposal of a specific mechanism could account for it equally well. But whereas Rock's explanation rests on a simple perceptual phenomenon, Yin's necessitates the existence of a brain mechanism with the sole function of processing faces. Therefore, at least on the grounds of parsimony, the pattern of correlations reported here can be taken to support Rock.

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