A COMPARATIVE APPROACH TO TESTING FACE PERCEPTION: FACE AND OBJECT IDENTIFICATION BY ADULTS IN A SIMULTANEOUS MATCHING TASK

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Experimental studies of face perception tend to use small samples of participants taken from a narrow age range. This often makes it difficult to use the results in clinical studies. Combined with the fact that current face processing tests are of limited use for an in depth analysis of prosopagnosia it is often difficult to assess face recognition problems. Here we present the results from a study of a wide age group (21-50 yrs) tested with a comprehensive face perception battery that was developed to provide a new tool for critically measuring intact face perception. We critically review existing tests and motivate our choice for the present design which is unique in that it uses in the same task setting faces and objects and therefore allows a more specific evaluation of face specific abilities than was hitherto possible.

Face recognition difficulties have been put on the neuropsychological map by the classical studies of prosopagnosia by Bodamer (1947). Prosopagnosia is a relatively rare deficit in the basic ability to recognise a person by the face in the presence of normal recognition of personal identity by voice, gait, clothing and other features. A number of cases of prosopagnosia have been reported and described over the last hundred years and as clearly shown in the overview of the literature provided at the end of the eighties, almost all of them have associated deficits in object recognition (Farah, 1990). Many cases have been reported since but they have not settled the debate about whether prosopagnosia is exclusively a face deficit or whether the face deficit is dominant or even one among many among other object recognition

problem. Lively debate will undoubtedly continue as long as new ways of testing face specificity are being developed that reflect increasingly better understanding of face recognition.

When prosopagnosia occurs in normal adults as a consequence of brain damage, it is most often associated with lesions in the occipito-temporal brain regions (Barton, Press, Keenan, & O'Connor, 2002; Damasio, Damasio, & Van Hoesen, 1982; Landis, Cummings, Christen, Bogen, & Imhof, 1986; Levine & Calvanio, 1989; Meadows, 1974; Sergent & Signoret, 1992). In other cases, there is no evidence of brain damage and the exact etiology of face recognition deficits is unknown (de Haan & Campbell, 1991; McConachie, 1976). The pattern of deficits in acquired and developmental prosopagnosia is similar as far as some basic aspects of face processing are concerned (de Gelder & Rouw, 2000b). But in analogy with developmental dyslexia, the term developmental prosopagnosia is best used for the latter cases because at present it is not known what the congenital basis of face recognition may be nor how a tentative genetic basis interacts with face recognition development known to occur in during infancy and childhood.

From the few cases studied in detail it is clear that a critical problem concerns configural perception, usually defined as the processing routine whereby the whole face is represented at a glance (Young, Hellawell, & Hay, 1987). Its hallmark is the inversion effect (Yin, 1969), a dramatical drop in recognition performance when a face is presented upside-down. The notion is that upside-down presentation blocks encoding of the face as a whole (its configural properties) and makes observers shift to a feature-based perceptual routine instead (Carey & Diamond, 1977, 1994; Yin, 1969). Neuropsychological studies have shown that prosopagnosics do not process the face image as an integrated whole or a configuration, but use a feature-based recognition procedure instead, and seem to attend to facial features in a serial fashion. This is reflected in their laborious processing of normally oriented faces (Barton et al., 2002; Behrmann, Avidan, Marotta, & Kimchi, 2005; de Gelder, Bachoud-Levi, & Degos, 1998; de Gelder & Rouw, 2000a, 2000b; Farah, Wilson, Drain, & Tanaka, 1995; Joubert, Felician, Barbeau, Sontheimer, Barton, Ceccaldi et al., 2003; Levine & Calvanio, 1989; Nunn, Postma, & Pearson, 2001; Sergent & Signoret, 1992). As a consequence, performance on upright faces is often the same, or even worse than performance on inverted faces (de Gelder et al., 1998; de Gelder & Rouw, 2000a, 2000b; Farah et al., 1995), and in some cases this can even lead to a paradoxical inversion effect, as when upside-down faces are easier to match than normally oriented ones (de Gelder et al., 1998; de Gelder & Rouw, 2000b).

The present paper reports the application to a large population of ordinary adults of a simultaneous matching task that has been used for some time in our group's work with brain damaged, mainly prosopagnosic, patients and controls,

but was not used previously on a large sample of the population at large.

The principle of the task is that every trial consists of the simultaneous presentation of three pictures of human faces, one, the target, in frontal view, and two probes, both in ¾ profile. One of the probes (the "positive probe") represents the same person as the target, the other (the "negative probe") a different person of the same sex. The two probes are displayed side by side under the target, and the participant's instructions are to designate the lateral location of the positive one, by pressing one of two keys. On separate trials, the three faces are displayed either in the habitual upright orientation, or upside-down. Intermixed with experimental face trials are control trials on which the pictures represent non-face objects, in the present version of the task, shoes.

The design of the task takes account of key results of recent research, among which three are worth stressing.

First, the task was meant to measure face identification independently of memory. Many well known studies of face processing have used a face recognition task in which participants are first presented with a series of target faces, each of which is in a later test phase presented together with a distracter, and the instructions are to designate the target (Warrington, 1984; Yin, 1969, 1970). Recognition performance measured in that way obviously reflects both identification and memory of the presented faces. The same problem can arise with sequential versions of the matching task, in which probes are compared to an earlier presented target (Bertelson, Vanhaelen, & Morais, 1979; de Gelder & Rouw, 2000b). In the simultaneous matching task, all the information necessary to choose the response is on each trial presented at the same time, so that no form of retention is required. One reason for wanting to achieve the separation of identification from retention is the possibility that the two operations obey different rules. For another phenomenon, the so-called "object superiority effect" (Weisstein, 1974), there is evidence that it might occur only when mnemonic retention of the object is involved, not in the latter's absence (Mermelstein, Banks, & Prinzmetal, 1979).

A second important aspect of the face matching task is that the positive probe, calling for the "same" response, is a photo of the person in the target picture taken from a different angle (¾ profile instead of frontal). In some studies based on face matching, "same" trials involved two identical pictures. The problem with this "physical identity matching" situation is that the decision can be reached on the basis of non-facial features like a difference in lighting or sharpness between the probes, or the presence on one of them of a scratch or a stain. Attention was first drawn on this problem in the late 70s by two independent studies (Bertelson et al., 1979; Moscovitch, Scullion, & Christie, 1976). Both were concerned with the conditions of occurrence of left visual field superiority for face identification, then considered as one of the main specific attributes of face processing. Bertelson et al. (1979) asked

participants to decide if a probe photo presented unpredictably in their left or their right visual field represented the same person as a target presented earlier in central location. Left field superiority was observed in the "facial identity condition", in which targets were frontal views and probes ¾ profiles, but not in the "physical identity condition", in which targets and probes were both ¾ profiles, so that the "same" response was given to probes physically identical to the target. Moscovitch et al. (1976) had participants make same-different judgments to pairs of human faces. They obtained left field superiority when pairs involved a photo and a caricature (of the same or two different persons) but not with two "identikit" pictures, physically identical on "same" trials. These results clearly converged on showing that physical matching could bypass the hypothetical lateralized facial processing system, while facial identity matching imposed resort to that system.

One face recognition test that is still frequently used in both clinical work and research, Warrington's (1984) Recognition Memory Test for Faces (RMF), may fail to impose proper facial processing for two reasons: a) its pictures include usable non-face details like clothing, facial hair or hairline, and b) the positive probes of the final decision tests are physically identical to the originally presented targets. Strong support for that view is the fact that participants tested by Duchaine and Weidenfeld (2003) on a modified version in which the faces were occluded, leaving only the eyebrows and the hairline visible, could nevertheless achieve scores in the normal range.

Finally, faces are presented both in the habitual upright orientation and upside-down, providing a measure of the "inversion inferiority effect", i.e., the fact that faces are less well processed when presented upside-down instead of upright. The contemporary interest in that phenomenon started with a study by Yin (1969). Using the face recognition task with healthy adults, Yin showed that their performance was strongly deteriorated (in both accuracy and RT) by upside-down presentations. With other mono-oriented objects like houses or airplanes, on the other hand, no (or smaller) decrements were observed. Yin proposed that the origin of this pattern laid in the existence of a processing system specifically dedicated to the identification of upright faces. Inverted faces, he reasoned, could only be dealt with by general object identification processes. These notions received important support from the subsequent finding (Yin, 1970) that face inversion inferiority was absent in patients with damage to the posterior right hemisphere, the presumed site of face processing. Later neuropsychological work has now largely established the absence of inversion inferiority as a major symptom of prosopagnosia (de Gelder & Rouw, 2000b; Van den Stock, van de Riet, Righart, & de Gelder, 2008).

An important new step in the exploration of inversion effects has been that some prosopagnosic patients actually present better face identification on inverted faces than on upright ones (de Gelder et al., 1998; Farah et al.,

1995). This "inversion superiority" phenomenon has important implications concerning the distinction between two components of face perception, face detection, i.e., categorisation of the stimulus as a face, and personal identification. As explained by de Gelder and Rouw (2000b), patients in that condition must have some preserved capacity to recognise the general configuration of the human face, which, in spite of its impaired personal identification competence, inhibits the use of general-purpose processes for identifying upright faces. Inverted faces would not trigger such inhibition, and thus benefit from the better competence of the general purpose processes.

The simultaneous matching task has so far been used mainly in studies with prosopagnosic patients and healthy control participants, generally university students. We got the opportunity to administer it to a population of ordinary adults when an airline organisation asked our help in the assessment of the face identification abilities of identity badge controllers. All participants had been recruited as part time employees and had no previous expertise with face recognition. They had not been selected on the basis of any particular skills or previous employment in jobs that required recognising faces. None of them had been in this job for longer than 12 months. So any expertise they may have acquired was of recent date and makes them similar to the population at large.

Method

Participants

75 staff members, 24 women (aged 21-46) and 51 men (aged 21-50) were delegated as participants in the experiment. They were tested individually in a single session taking place in the premises of their employer.

Stimuli

Faces

Eight young women (aged 21 to 35 years) and eight young men (aged 20 to 32 years) were photographed in gray scale in both frontal and right three quarter profile views, displaying a neutral expression. They wore no paraphernalia such as shades, spectacles or earrings, and none of the men had a beard or a moustache. In profile views, the model turned to the left, thus displaying the right side of the face. Whether in frontal or in profile views, the model always looked toward the camera. Depending on the type of trial, the faces were presented either upright or upside-down.

Shoes

Eight shoes were photographed (also in gray scale), from above with the tip pointing downward (front view) and 30 deg to the right (profile view). On different trials the pictures were presented as taken (upright) or rotated 180 deg (inverted).

Procedure

On each trial, three pictures, all three either faces or shoes, in the same orientation (upright or inverted) were presented simultaneously on the screen, a target picture on top, in central position, and two probe pictures side by side underneath. The target picture was always shown in frontal view, and the two probes in ¾ profile. One probe (the "positive" one) represented the same face (or shoe) as the target, and the other ("negative") probe a different item. Representative frames are shown in Fig. 1 for faces, and in Fig. 2 for shoes.
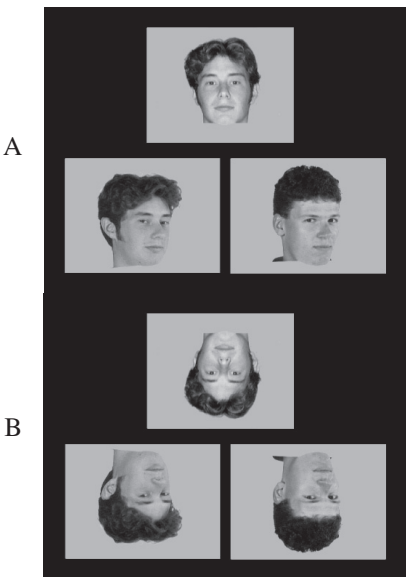

Figure 1
Representative displays with faces.
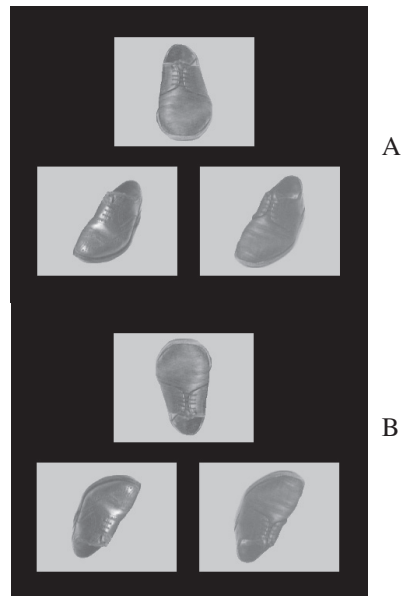Frame A *Upright faces*.
Frame B *inverted faces*

Figure 2
Representative displays with shoes.
Frame A *Upright shoes.*
Frame B *inverted shoes*

The participant's task was to indicate the location (left or right) of the positive probe, by pressing one of two adjacent keys on a keyboard. Pictures remained on the screen until one key press was recorded.

For trials with each material, the frontal views of eight of the available faces or shoes were used throughout as targets. For faces, they comprised four women and four men. The profile views of the remaining eight faces or shoes were used as negative probes, and the same negative probe was always paired with each target. That probe was presented in either left or right position on half of the trials.

The session involved four blocks of 64 trials each, resulting from the combination of 8 target/negative probe pairs, 2 orientations (upright/inverted: U/I), 2 layouts of the probes (positive left, negative right/positive right, negative left) and 2 materials (faces/shoes: F/S).

Results

Overall results per condition appear in Table 1.

Table 1
Overall results per condition

|	Faces		Shoes	
	Upright	Inverted	Upright	Inverted
Mean % correct	98.9	96.6	98.0	98.6
Mean RTs	1633.06	2318.23	1280.84	1398.17
Standard Error	64.87	197.35	44.28	57.66

Accuracy

Mean percentage correct responses is very close to 100 in every condition. More than half the participants (65.3% for FU, 49.3% for FI, 58.7% for SU and 52.0% for SI) made no single error.

Reaction times (RTs)

Most participants had a few unusually long RTs. All those above a cutting point situated 2 Standard Deviations (SDs) from the mean RT of the participant for the condition were eliminated. This procedure affected from 1 to 9 RTs (out of 64) per participant in each condition.

Mean corrected RTs are given in Table 1. Two main results are apparent. First, mean RTs are longer for faces than for shoes. Second, they are for both materials increased by inversion, but that effect is much smaller for shoes

than for faces. These observations were confirmed by a repeated measurement ANOVA with material (faces/shoes) and orientation (upright/inverted) as factors. The main effects of material, $F(1, 74) = 77.0$, $p < .0001$, of orientation, $F(1, 74) = 22.8$, $p < .0001$ and their interaction $F(1, 74 = 15.9$, $p < .0001$), are highly significant. The significance of the interaction indicates that the inversion effect is effectively larger with faces than with shoes. Finally, separate t-tests showed that it was nevertheless significant as well for shoes, $t(74) = 2.27$, $p < .0001$, as for faces, $t(74) = 4.78$, $p < .0001$.
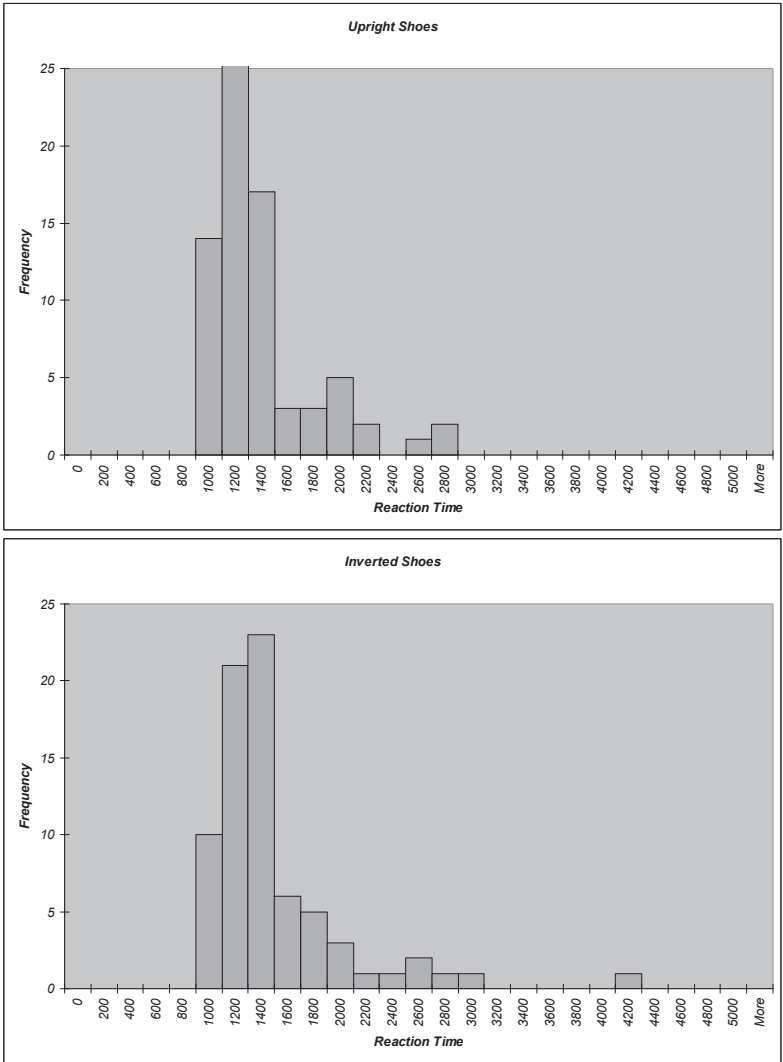

Upright Faces

Inverted Faces
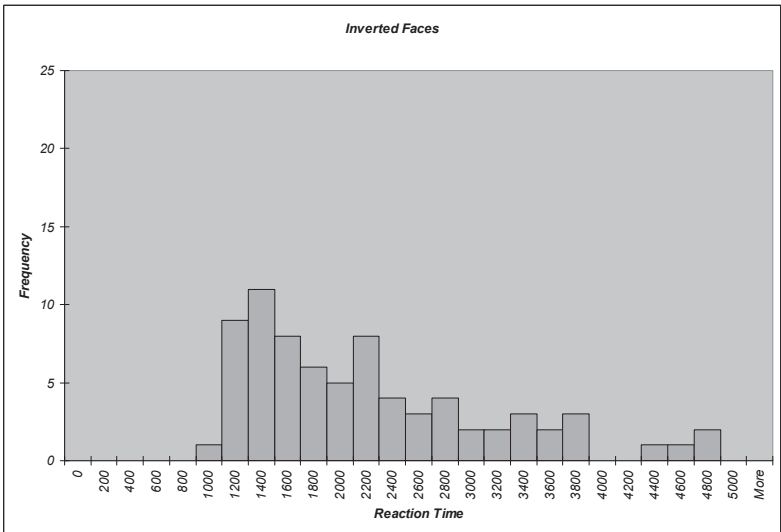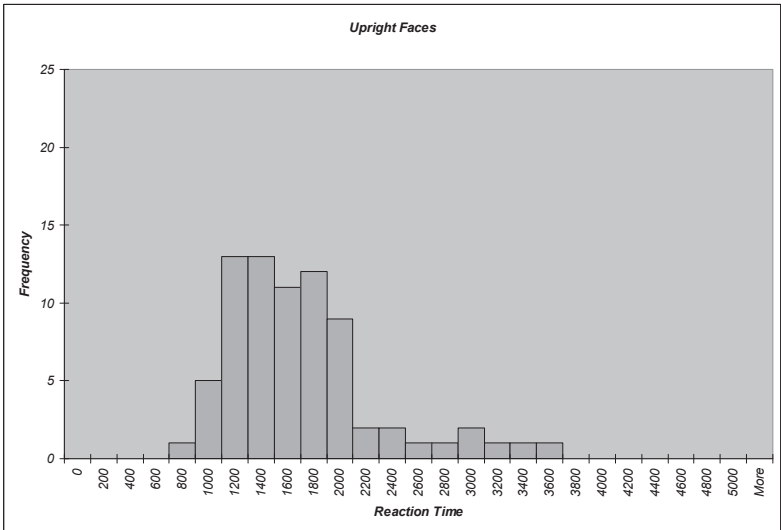
Figure 3
Individual mean RTs per condition (Histograms)

Individual differences in RTs

Distributions of individual RTs are given in histogram form for the four conditions in Figure 3.

For faces, the most striking difference between the distributions for upright and inverted presentations is a much longer tail of large RTs in the inverted case. This is of course the pattern one could expect from the fact that in Table 1 the increased mean RT went together with a huge increase in standard error. For shoes, no comparable change in the shape of the RT distribution accompanied the (much smaller) increase in mean RT.

To further explore the latter differences, individual mean RTs to upright and inverted stimuli are represented in scatter diagram form in Figures 4 and 5.
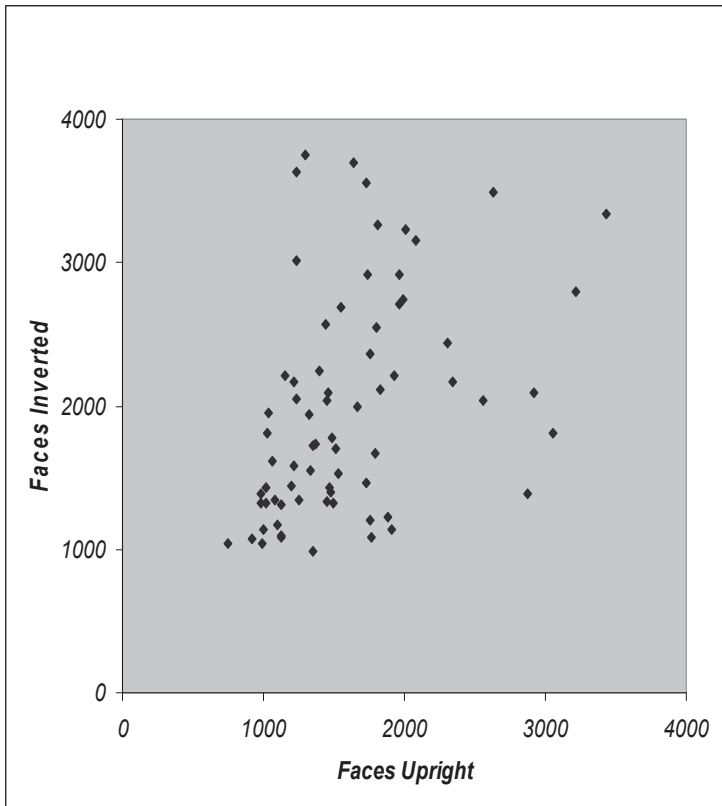

Figure 4
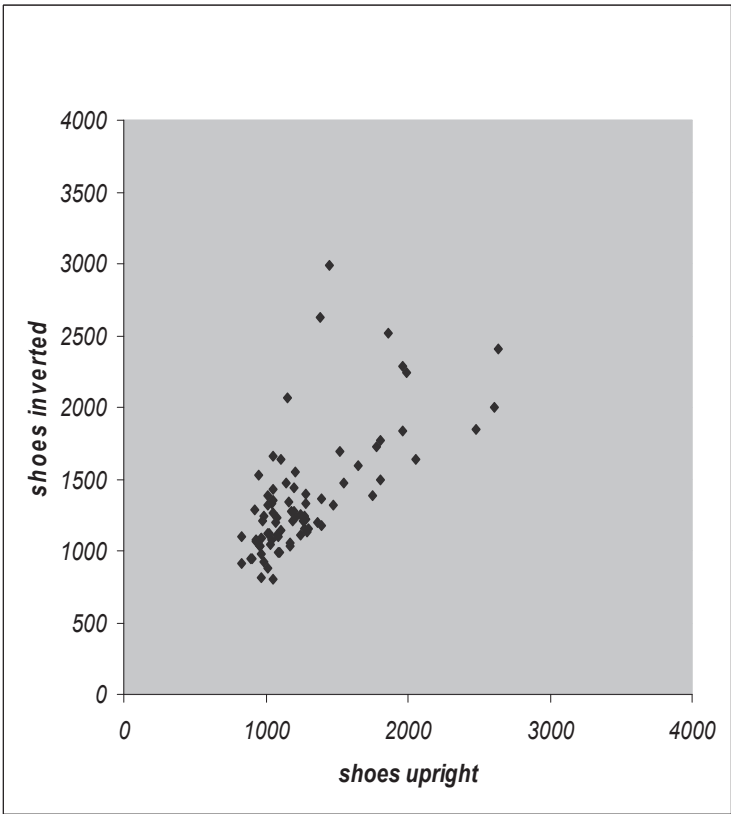*Individual RTs to upright and inverted faces (Scattergram)*

Figure 5
Individual RTs to upright and inverted shoes (Scattergram)

On these figures, individual inversion effects appear as deviations from the diagonal line. The most general observation they allow is that the effects of face inversion differ considerably among participants, and much more than those of shoe inversion. These data lead to the hypothesis that participants vary in the strategies they use to deal specifically with inverted faces. A second potentially important point is that some normal participants display a pattern of inversion superiority, i.e., a paradoxical inversion effect, described so far only for some prosopagnosic patients.

Discussion

The goal of the present study was to improve on currently available tools for measuring normal face processing by comparing performance on face and object recognition in a setup that uses the closest possible match between stimulus and task requirements. Three major theoretical considerations have motivated our approach. The three were the original pillars of our investigations of prosopagnosia. A further goal was to test a representative sample of the population at large. In view of increasing reports of developmental prosopagnosia it is important to have more norm data than the available controls for the prosopagnosic patients we tested so far.

Indeed, the tasks developed for prosopagnosics may be too easy and if so, used on a large normal population they may only show performance at ceiling and not allow any conclusions. In that case one may recommend variations of the tasks also used with prosopagnosics, like delayed matching as done in a few studies. But this introduces a confound with encoding and memory skills. To avoid the latter was the first major motivation of our approach. A second important aspect of the face and object-matching task is to avoid matching based on visual image properties and not tap into the requirements of person recognition that are essential for face recognition. Therefore our task makes sure that the positive probe, calling for the "same" response, is a photo of the person in the target picture taken from a different angle. Finally, we use the inversion effect as a measure of the critical ability faces are presented both in the habitual upright orientation and upside down, providing a measure of the "inversion inferiority effect", i.e., the fact that faces are less well processed when presented upside-down instead of upright.

Many studies on normal and impaired face recognition abilities have now used the inversion effect. But its interpretation remains difficult and the comparison with a control object category is important. But very few have systematically measured the inversion effect also for objects. In our view this is an essential step to avoid confounds generated by the peripheral stimulus differences between object categories which make any direct comparison problematic. And in view of the ongoing debate about face specificity it appears essential to consider performance on object recognition, also if not more so, for developmental prosopagnosia. Indeed, our data clearly illustrate that face recognition skills are not evenly distributed in the population and that it is safe to assume that 10% of the population at large has serious difficulties in rapidly matching faces and to a lesser extend also in matching objects. In support of this we see that there is much more variability in the face than there is in the object matching performance. Furthermore, we observe that around 15% of the normal face recognisers show a paradoxical inversion effect.

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