
Eyes wide apart: Overestimating interpupillary distance[†]

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Received 3 December 2001, in revised form 20 February 2002

Abstract. Our ability to perceive many aspects of the human face is so acute that some would propose that we possess specialised face-processing mechanisms. One example of this exquisite performance is our ability to discriminate differences in the lateral separation of the eyes in pairs of otherwise identical faces—see Kemp et al (1990, *Perception* **19** 531–543). However, we have found that our ability to estimate our own interpupillary distance (IPD) shows no such accuracy. Subjects were asked to indicate, without undue rumination, their own IPD and, by way of control, the distance from the bridge to the tip of their own nose. Compared to the true distances, IPD was overestimated by more than 30% while nose length was underestimated by 11%. Although a plausible reason for the nose length underestimation is foreshortening of the image, the reason for the overestimation of eye separation remains obscure.

1 Introduction

According to the textbooks, the interpupillary distance (also called the pupillary distance but here abbreviated to IPD) for the average ‘Caucasian’ (though why the eyes of these mountain people should have attracted such attention is a mystery ...) is 65 mm, with the normal range being around 58 to 72 mm. The average IPD for ‘Caucasian’ females is 61 mm, with the normal range between 57 mm and 65 mm (Reinecke and Herm 1983). These measurements should be amongst the least surprising facts imaginable as we are constantly devoting considerable processing to human faces and, indeed, some of us spend considerable lengths of time looking at our own faces in the mirror. Furthermore, there is good evidence (Kemp et al 1990) that very small alterations to IPD can be detected. Kemp et al found that small changes in IPD can be discriminated more acutely in an ‘upright positive’ face than in either an inverted face or a negative face.⁽¹⁾

Despite our familiarity with eye position in the head, it is clear that most people cannot reproduce the correct positioning when asked to do so. That the eyes are positioned about half way up (or down) the face is commonly known, and many tutorials on drawing the human face will stress this point. However, that the male IPD is only 65 mm (2.6 inches) and the female IPD 61 mm (2.4 inches) seems to be less appreciated, and, anecdotally, generations of students have expressed surprise at this figure, clearly anticipating that IPD should be larger than this.

Having failed completely to discover any existing literature on this subject, I have carried out an empirical study to determine subjects’ estimates of IPD.

[†] This title has been chosen in homage to Michael Morgan who wrote a piece in *The Guardian* newspaper entitled “Eyes wide apart”, in which some aspects of the findings of this study are discussed.

⁽¹⁾ It should be stressed here that the terms ‘positive’ and ‘upright’ refer to contrast polarity and orientation and not to any moral quality. The face used in this experiment was that of Michael Morgan.

2 Methods

2.1 Subjects

Eighty-one undergraduates (eighteen males, sixty-three females) took part in the experiment. All might be described as 'Caucasian' but a more accurate description would be 'white European'. All subjects were naïve to the purpose of the experiment.

2.2 Design

All subjects estimated their own IPD and the length of their own nose. The actual IPD and nose length of each subject was measured by the experimenter.

2.3 Materials and apparatus

Subjects were presented with a response sheet (see figure 1) and received detailed instructions as to their task. First, they were informed that they should estimate their IPD, ie the distance from the centre of the pupil of one eye to the centre of the pupil of the other eye. The position of the centre of one eye was already marked on the upper part of the response sheet with a vertical tick-mark; their task was to draw a second tick-mark that delineated the IPD. Second, they were asked to rotate the response sheet through 90° and mark the distance from the bridge to the tip of their nose on the second (now vertical) line. Instructions were given that the bridge of the nose was defined as the point on the midline of the nose intercepted by a line between the pupillary centres. The definition of the tip of the nose was less rigorous, being simply 'the tip of the nose'. All subjects reported that they understood the instructions unambiguously. One week after these estimates had been made, the real IPD and nose length of each subject was recorded.

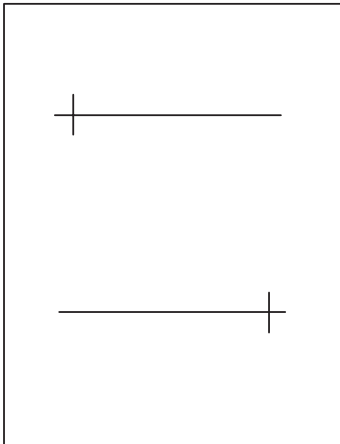


Figure 1. The response sheet. Subjects were asked to mark their IPD on the upper line; for half the subjects the already-marked point was on the left, for the remaining subjects this point was on the right. Having estimated IPD, subjects were invited to rotate the response sheet through 90° and indicate on the lower, now vertical, line their nose length.

Two different IPD measurements are commonly described in the literature: first the 'near IPD' measures the IPD when the subject is fixating a point 14 inches away, while the 'distance IPD' measures the IPD with the subject's visual axes parallel, that is fixating a distant object. The near IPD is generally 2–3 mm less than the distance IPD; it is not obvious whether, asked to estimate their IPD, subjects would choose one of these measures rather than the other but, given that our hypothesis in this paper is that perceived IPD is overestimated, the distance IPD value was measured. The measurement was carried out along the lines of the standard manner recommended in optometry and ophthalmology texts (eg Reinecke and Herm 1983, page 173). The subject, facing the experimenter, was instructed to look at the experimenter's left-eye pupil; the experimenter looked into the subject's right eye with his left, and aligned the zero value of a millimetre rule with the centre of the subject's right pupil. The subject

was then instructed to look at the experimenter's right-eye pupil, and the experimenter looked into the subject's left eye with his right, and read off the IPD on the millimetre scale—see figure 2.

The length-of-nose measurements were also made with a millimetre scale, by measuring a straight line from the bridge of the nose to its tip.

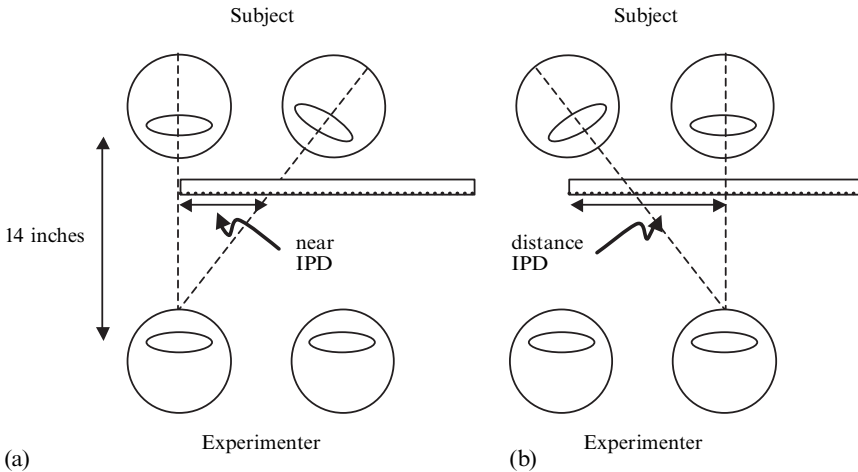


Figure 2. Measuring interpupillary distance. Near IPD can be measured when 14 inches (35 cm) from the subject as shown in (a). Distance IPD—the measure used in this study [see (a) and (b)]—measures the distance between the eyes when the subject is looking at a distant object.

3 Results

Accepted IPD norms for 'Caucasian' subjects are 65 mm for males and 61 mm for females. The mean measured IPD for the eighteen males in the chosen sample was 64.6 mm (SD = 2.45 mm) and that of the sixty-three females was 61.8 mm (SD = 3.4 mm). These measurements are well within the expected range. The estimated IPD for the male subjects produced a mean of 89.1 mm and for the females a mean of 80.3 mm. These means represent overestimates of 38% and 30%, respectively, and are statistically significant (for males: $t_{17, \text{two-tailed}} = 5.122$, $p < 0.001$; for females: $t_{62, \text{two-tailed}} = 6.236$, $p < 0.001$). One male subject estimated his IPD to be 149.5 mm—more than twice the true separation; this clearly identifies this subject as an outlier in the group. Were we to remove this subject, the mean estimated male IPD would fall to 85.5 mm, an overestimate of 32% and more in line with the female figure. Incidentally, this rogue male produced a fairly accurate estimate of his nose length.

We know of no norms for the nose length of 'Caucasian' subjects. Our males had a mean nose length of 51.4 mm (SD = 3.76 mm) while they estimated their nose length to be 44.4 mm (SD = 6.7 mm). A paired t -test showed this underestimate to be highly significant ($t_{17, \text{two-tailed}} = -3.641$, $p < 0.005$). The females also underestimated their nose length: actual length, 47.6 mm (SD = 4.2 mm); estimated length, 42.2 mm (SD = 10.7 mm). Again, this is a highly significant underestimate ($t_{62, \text{two-tailed}} = -3.746$, $p < 0.001$).

An independent-samples t -test determined that there are no sex differences, either in the IPD data ($t_{79, \text{two-tailed}} = 0.966$, $p = 0.337$) or the nose-length data ($t_{79, \text{two-tailed}} = -0.536$, $p = 0.593$). Taking the results together, we see that eye separation is overestimated by 32% while nose length is underestimated by about 12%—see figure 3.

A Pearson correlation of estimated and actual eye separation produced no significant difference ($r = -0.005$ for females; $r = 0.105$ for males)—therefore it is not the case

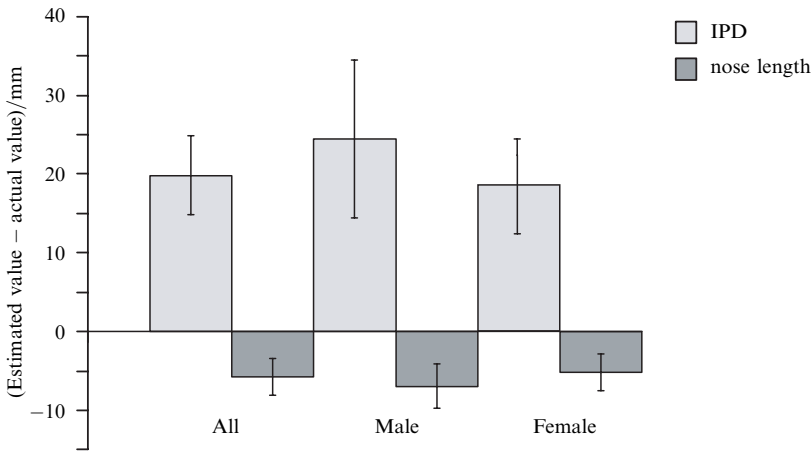


Figure 3. Perceived errors in eye separation (IPD) and nose length, expressed for all eighty-one subjects, just the male subjects, and just the female subjects. The error bars illustrate the 95% confidence limits.

that people's estimates of their IPDs reflect actual IPDs at all. A similar correlation on estimated and actual nose-length measures revealed a similar lack of significance ($r = 0.022$ for females; $r = -0.101$ for males).

4 Discussion

The main experimental result, that subjects overestimate IPD⁽²⁾ was in line with expectations, but the finding that the control measurement of nose length was significantly underestimated was not expected. On reflection, a simple explanation presents itself: noses are subject to a degree of foreshortening. Figure 4 illustrates this point; the actual length of the nose, n , is related to the foreshortened perceived length, p ,

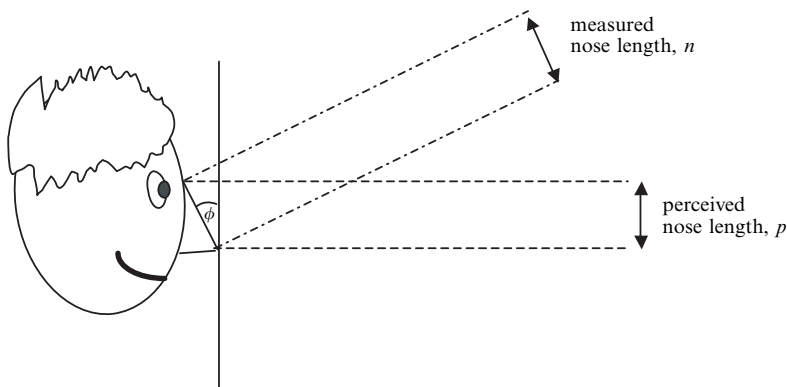


Figure 4. Explanation of the underestimation of nose length. The extent of the foreshortening in the perceived nose length, p , will depend upon the angle of the nose from the vertical, ϕ : $p = n \cos \phi$.

⁽²⁾It should be stressed that the result here is that people overestimate *their own* IPD. Whether they overestimate other people's IPDs is an open (and interesting) question. On the suggestion of Professor Chris McManus we hope to ask subjects to estimate their own IPD and that of their spouse. Perhaps men overestimate their wives' IPDs even more as they imagine them to look more like Michelle Pfeiffer than they really are. Ms Pfeiffer has eyes that are noteworthy widely spaced and has described herself as "looking like a duck".

by the equation:

$$p = n \cos \phi , \tag{1}$$

where ϕ is the angle of the nose from the vertical.

I have investigated the mean angle of the nose by measuring this in thirty-five profile images (eighteen female, seventeen male) from the PICS database (PICS—The Psychological Image Collection, University of Stirling; <http://pics.psych.stir.ac.uk/>). The mean angle of these noses from the vertical was 35° , with no differences between the sexes. Applying this angle to equation (1) we find:

$$\frac{p}{n} = 0.82 .$$

This compares with an actual ratio from our experiment of 0.88, which would have required a nose angle of 28° rather than 35° . We should not make too much of these figures—first, estimating the angle ϕ depends on estimating the vertical position of the head and it is quite likely that subjects in the PICS database held their heads higher than usual while being photographed, and, second, there is no reason to expect any foreshortening effect to be complete. The claim here is simply that foreshortening of the nose is at least a plausible explanation for the underestimates of nose length that were found. However, foreshortening cannot play a role in the misperception of the eye separation, nor can any appeal to the vertical–horizontal illusion be sustained, as the horizontal eye separation was estimated on a horizontal response line.

Since these data were presented at a conference (Thompson 1999), several suggestions have been made in an attempt to explain the effect. First, it has been proposed that we choose to exaggerate eye separation as more widely spaced eyes are perceived as more attractive. Although there is evidence (eg Cunningham 1986) that females with big IPDs are perceived to be more attractive than those with small IPDs, this in itself does not constitute an explanation of the results presented here. Cunningham's belief is that IPD serves as a neonate cue; during fetal development the eyes move towards each other but the newborn infant still has large IPDs in comparison with other dimensions of the infant's body, eg shoulder width. This might suggest that IPDs will be most overestimated in faces where other neonate cues are present, such as large eyes, small nose, smooth skin, and lighter hair.⁽³⁾

A second suggestion is that the effect might be related to another classic example of misperception—the fact that the image of our own head in a mirror is much smaller than one might expect. (Try closing one eye and drawing round the image of your head in a mirror with a piece of soap or lipstick. The image is remarkably small, because the image itself lies twice as far from us as the mirror surface. However, impressive though this demonstration is, it is hard to imagine how this fact helps understand the misperception of IPD.)

Third, I have failed to be persuaded by those claiming the effect is the result of the fact that we see the world through two spatially separated windows and introspectively these windows appear to be further apart than they actually are. Despite attempts by several very articulate people, this argument has never been couched to me in an articulate form.

Therefore it appears that this robust phenomenon has, at present, no coherent explanation. It is clear that further research is necessary; first, we might ask whether the IPD overestimation is just one reflection of a general misperception of head (and other parts of the body?) size. However, generations of anecdotal schoolboys have *underestimated* the size of their heads and found the park railings they put their heads

⁽³⁾I am indebted to Michael Cunningham for sharing these ideas with me.

into are more closely spaced than they expected. It is possible that our self-image is distorted towards a more attractive neonate stereotype and that we misperceive our hair colour, skin texture, and eye size as well as our IPD. We might wonder also whether the overestimated IPD is learned or whether it is present in early childhood. Ongoing investigations with young children should answer this question.

Acknowledgments. I cannot say how grateful I am to Professor Michael Morgan for the interest he has shown in this work. I thank Peter Hancock of University of Stirling for interesting discussions. The referees improved the manuscript considerably; Professor Chris McManus made several valuable points on the wider implications of the data and Dr Steve Hammett ensured that the statistics were not only reported correctly, but fully understood by the author.

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