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You may cite this version as: Davidoff, Jules B., Fonteneau, Elisabeth and Fagot, J.. 2008. Local and global processing. Observations from a remote culture. *Cognition*, 108(3), pp. 702-709. ISSN 00100277 [Article] : Goldsmiths Research Online.

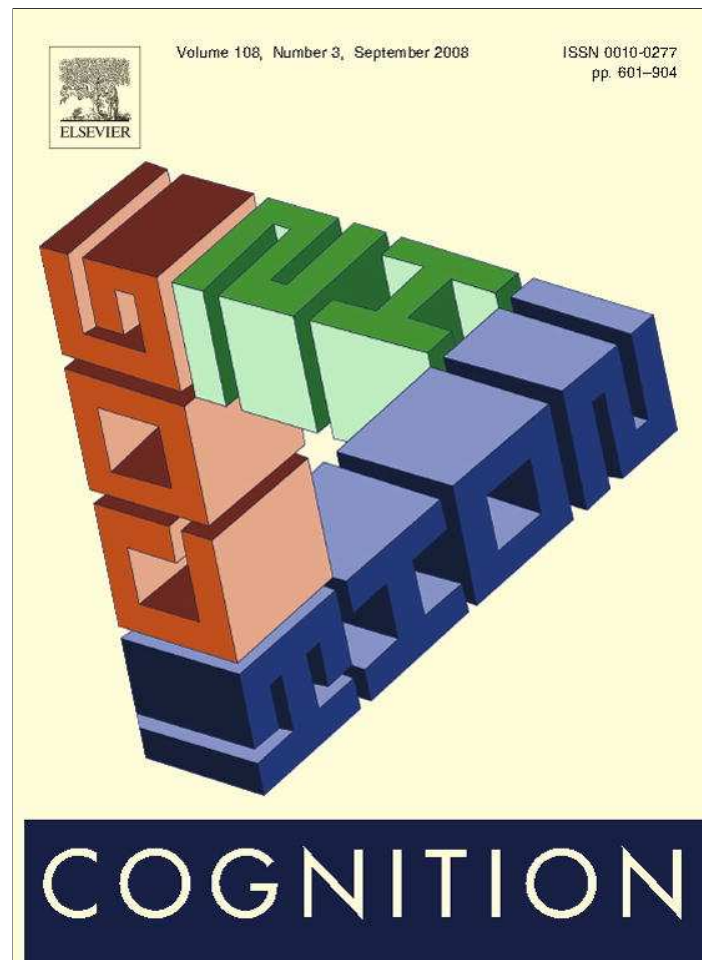
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Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Local and global processing: Observations from a remote culture

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ARTICLE INFO

Article history:

Received 2 July 2007

Revised 9 May 2008

Accepted 7 June 2008

Keywords:

Local/global processing

Faces

Navon

Cross-culture

ABSTRACT

In Experiment 1, a normal adult population drawn from a remote culture (Himba) in northern Namibia made similarity matches to [Navon, D. (1977). Forest before trees: The precedence of global features in visual perception. *Cognitive Psychology*, 9, 353–383] hierarchical figures. The Himba showed a local bias stronger than that has been previously observed in any other non-clinical human population. However, in Experiment 2, their recognition of normal or distorted (“Thatcherized”) faces did not appear to have been affected by their attention to detail as has been suggested for autistic populations. The data are consistent with a cultural/experiential origin for population differences in local processing and suggest that attention to the local and global properties of stimuli may differ for hierarchical figures and faces.

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1. Introduction

Paying attention to either the global or local aspects of visual input has been claimed to have important cognitive consequences (Behrmann, Thomas, & Humphreys, 2006; Frith, 1989; Happé, 1999; Nisbett, Peng, Choi, & Norenzayan, 2001; Rankins, Bradshaw, & Georgiou-Karistianis, 2005). For example, an influential account in the theory of autism proposes that a deficit in the processing of global coherence would produce attention to local details (Frith, 1989) with the potential consequence of limited face recognition abilities and withdrawal from social contact (Happé, 1999). Likewise, a substantial positive correlation between the extent of local processing (as measured in the hierarchical geometric figures introduced by Navon, 1977) and the increased latency for face discrimination has been argued to show a causal connection in the autistic face processing deficit (Behrmann et al., 2007). A similar deficit account proposes that abnormal lateralisation, and

consequent difficulties in processing at the global-stimulus-level are to be found in obsessive-compulsive disorders (Rankins et al., 2005). Such accounts tend to base the normal priority to the global level on the functioning of hardwired mechanisms such as the magno- and parvocellular pathways (Michimata, Okubo, & Mugishima, 1999) or superior temporal sulcus (Dakin & Frith, 2005) or, in the case of schizophrenia, to disturbances in visual areas V3/V3A (Johnson, Lowery, Kohler, & Turetsky, 2005).

From a reverse causal perspective, performance on hierarchical figures is seen as a result of experience in one's culture that could prime, even permanently, people to treat displays globally or locally (Nisbett et al., 2001). Thus, the collectivist culture of East Asians is held to make them more sensitive to the visual background and hence more likely than Westerners with an individualistic culture to consider the global aspects of a display (Nisbett et al., 2001). Manipulation of such styles of thought (Western vs. Eastern) has been shown to alter performance with Navon figures (Förster & Higgins, 2005; Kühnen & Oyserman, 2002) that can even be observed with neuroimaging (Lin, Lin, & Han, 2008). On the view of Nisbett et al. (2001), the use of global or local processing is much more likely to be seen to be variable by task demands and across cultures.

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Even those that hold a deficit account of autism are clear that the connection between local processing biases and face recognition impairments in autism is multi-determined (Behrmann et al., 2006). For a start, not all studies of autistic populations have even found deficits in global processing with hierarchical figures (Mottron, Burack, Iarocci, Belleville, & Enns, 2003) or faces (Rouse, Donnelly, Hadwin, & Brown, 2004). In other disorders, where the connection between impaired local processing and impaired face recognition is clearly established (Behrmann, Avidan, Marotta, & Kimchi, 2005; Christen, Landis, & Regard, 1985), one notes that the dual impairment does not produce the social deficits of autism. Therefore, in the present study, we want to explore another source of evidence in order to distance the bias towards local processing from any simple causal link to deficits in face processing.

Our research was prompted by two recent observations in a remote culture (Himba of northern Namibia: see Roberson, Davidoff, & Shapiro, 2002) and was aimed at providing the first direct test on the prevalence of a local mode of processing in an otherwise normal population. The first observation was that, when asked to sort shapes or colors, the Himba made a large number of groups each containing only a few items with highly similar features or hues (Roberson, Davies, Corbett, & Vandervyver, 2005b; Roberson et al., 2002). The second was that the Himba were extremely accurate in judging relative size in the Ebbinghaus (Titchener) illusion (De Fockert, Davidoff, Fagot, Parron, & Goldstein, 2007). Those data suggested that the Himba have such focal attention that they can process the central target independently of its perceptual context. Lack of susceptibility to the Ebbinghaus illusion has been observed with other populations (autistic children: Happé, 1996; young children: Kaldy & Kovacs, 2003; men: Phillips, Chapman, & Berry, 2004). However, none of these groups showed so little illusion as did the Himba.

In Experiment 1, we assessed the relative contributions of local and global processing for the most commonly used stimuli in related work – the hierarchical geometric figures of Navon (1977). Based on our previous observations, we predict that the Himba should show a pronounced local bias. In Experiment 2, we assessed in the same individuals whether global processing was the default processing style with human faces. From pilot studies, we knew that the Himba had long latencies in standard laboratory tasks; so, we required a face task for which we could assess normal performance by accuracy rather than latencies. We made use of the well-known observation that face inversion makes face recognition difficult by preventing the use of global processing (Yin, 1969). The Himba have no apparent face recognition or social communication deficits, so we had no reason to believe that the Himba would have anything else but normal global processing for faces and hence impaired accuracy for recognition from inverted faces.

2. Experiment 1: Hierarchical stimuli

Experiment 1 asked participants to make a similarity judgement to alternatives that matched the sample at either the local or global level. Two test phases were run

in Experiment 1. These two phases used stimuli of different shapes and densities, and contrasted geometrical shapes with stimuli that might be culturally relevant.

2.1. Method

2.1.1. Participants

The Himba are semi-nomadic and live in an isolated region of Northern Namibia with rigid social roles (Bollig & Schulte, 1999; Crandall, 2000). Those Himba tested in the present study live more than one day's drive from the nearest Western influence.

Their language contains no words for geometric shapes like circles and squares and they have little exposure to images of 2-D stimuli. Himba do not have a written language. All Himba tested were monolinguals with normal vision and had never been involved in experimental research.

For the test phases, the sample consisted of 36 Himba (19 women, 17 men) with mean estimated age: 25 years 6 months, range: 19–35 years. On a separate occasion, a further 16 Himba (eight men) of approximately the same mean age took part in control trials for Experiment 1. Himba were rewarded in kind.

Seventeen undergraduates from Goldsmiths' College (nine women, eight men) who were native English speakers (mean age: 24 years 6 months, range: 18–34 years) also took part and were paid or validated course credits. Testing of English speakers was mostly aimed at replicating the global advantage found in French participants with similar stimuli (Fagot & Deruelle, 1997).

2.1.2. Stimuli and procedure

The stimuli were hierarchical Navon-like global/local figures and the testing proceeded in two consecutive phases. Phase 1 used hierarchical stimuli made equally of three geometrical shapes (circles, squares, and crosses) at both global and local levels (see Fig. 1a). In that phase, the large global shape was composed of either eight (global shape: circles and squares) or nine (global shape: crosses) local elements. At a viewing distance of 60 cm, the global stimuli subtended approximately 2° of visual angle and the local elements 0.5° promoting processing at the global stimulus level (Lamb & Robertson, 1990). To further encourage global processing, phase 2 involved hierarchical figures of higher densities. They were organized to form a larger global shape (6°) but composed of many more (20) local elements (approximately 0.5°). Shapes at the global level were half of geometrical shapes (equal numbers of circles, squares, triangles and crosses, see Fig. 1b) and the other half schematic cow shapes composed of geometric elements (see Fig. 1c).

Testing was conducted on a solar-powered computer screen for Himba participants and a desktop computer for the English participants. In each trial, the target figure was at the top of the display with two comparison figures below and side-by-side. Each comparison figure shared only one level (global or local similarity; see Fig. 1a–c) with the target and were equally presented on the right or left. The task consisted of indicating which of the two comparison figures “looks most like” the target figure. Himba

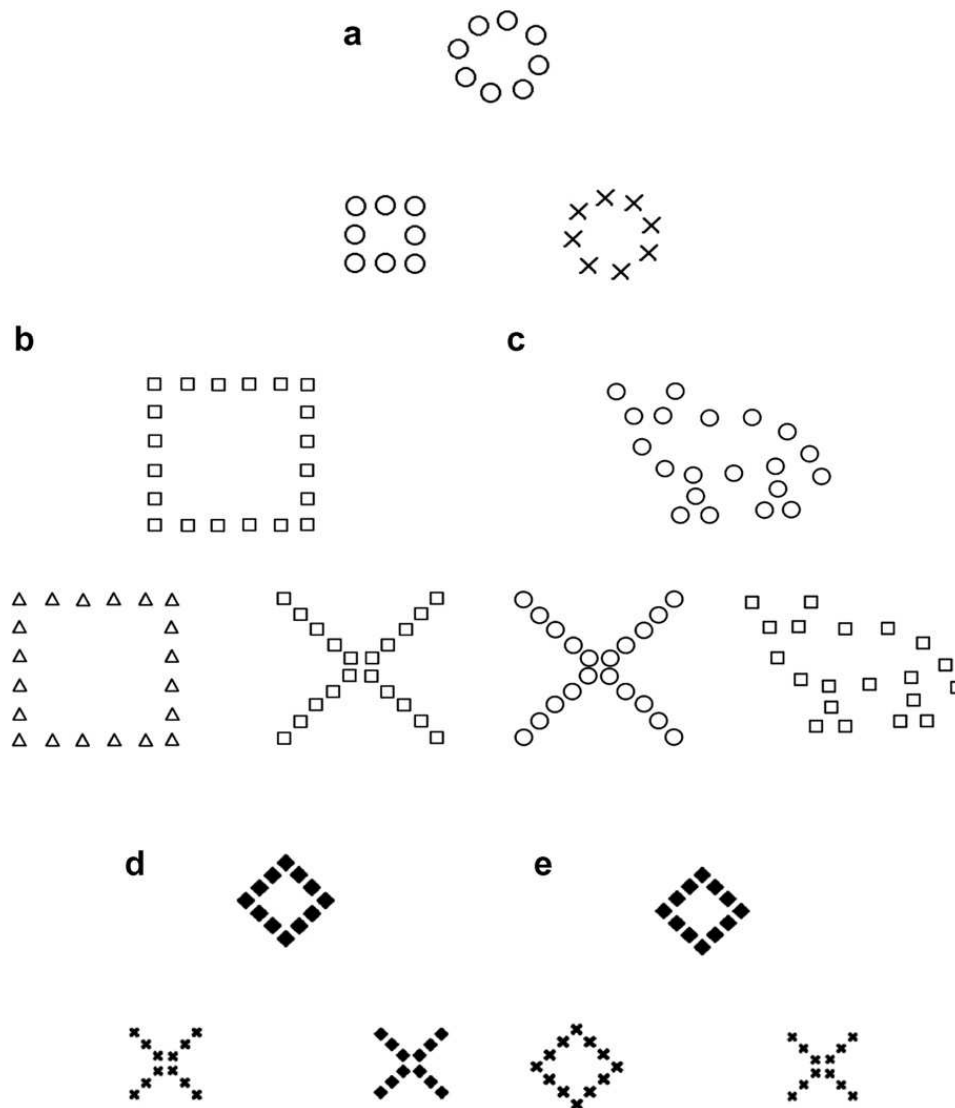


Fig. 1. Examples of the hierarchical stimuli used in Experiment 1. (a) An gives an example of geometrical shapes used in phase 1, (b, c) examples of the geometrical shapes and cows used in phase 2. (d, e) are Examples of stimuli used to show that the Himba could interpret the instructions to match at both the local (d) and global levels (e).

testing was conducted through an interpreter. To ensure that the question, as posed in Himba, was capable of interpretation as similarity at either level, on a previous visit, we carried out a preliminary study where one comparison figure matched at either the global or local level, and the other comparison figure matched at neither level.

A group of 16 Himba adults were each given 32 randomly presented trials in a control condition (see Fig. 1d and e) of eight hierarchical targets each presented four times (two global matches and two local matches). Stimulus sizes were as in phase 1. The Himba preferred the one level match (in 74.2% of the trials on average, $p < .05$) over the neither match showing that they understood the task. In addition, the Himba did not differ between global (71.5% correct) and local one-level matches (76.8%; by participant: two-tailed paired t -test, $t(15) = 1.83$, $p > .05$; by item: $t(7) < 1$) showing that the question as posed was capable of interpretation as matching at either the global or local level.

In test phases 1 and 2, participants had to press the left or right button on a response box according to whether they chose the comparison figure on the left or right. There were a total of 36 trials in phase 1. In phase 2, there were 40 trials presented randomly half with global geometric shapes and half with schematic cow shapes. Both populations performed phase 1 prior to phase 2.

2.2. Results and discussion

To compare the performance of Western and Himba participants, we performed a 2 (Culture: Western vs. Himba) \times 3 (Target: Geometrical shapes – Phase1 vs. Geometrical shapes – Phase2 vs. Cows – Phase2) mixed analysis of variance (ANOVA) using the percentage of global choices (arcsin transformed) as the dependent measure. We also calculated an estimate of effect size (partial η^2) for all significant effects. The Western participants made significantly more global choices ($86.01 \pm SE 7.5\%$) whereas the

Himba population made few global choices ($22.81 \pm SE$ 5.2%), $F(1,51) = 44.77$, $p < .00001$, partial $\eta_2 = .46$. There was a significant effect of Target, $F(2,102) = 4.26$, $p < .03$, partial $\eta_2 = .07$. As predicted, participants made more global choices in phase 2 compared to phase 1. Post-hoc analyses (Tukey Honestly significant tests, $p < .05$) revealed reliably more global choices in geometrical shapes-Phase 2 compared to geometrical shapes-Phase 1 and there were also reliably more global choices for cows-Phase 2 compared to geometrical shapes-Phase 1. There was no difference in global choices between cows and geometrical shapes in phase 2. The interaction between Culture \times Target was not significant, $F(2,102) < 1$, showing that the Himba were also affected in their global choices by the density of the display but nevertheless maintained their remarkable local bias with the more dense stimuli.

The Navon tasks gave rather dramatic confirmation of the Himba inclination to process locally. The local bias was present in both test phases including for cow global shapes, though it may be that the Himba did not interpret the figures as cows. The local bias observed for the Himba is far more pronounced than has been observed in any other normal population. The local bias is, in fact, larger than that observed for autistic children where data are mixed (Plaisted, Dobler, Bell, & Davis, 2006). However, the Himba are capable of a global analysis in Navon figures as shown by their preference for a global match in the control condition. So, it is reasonable to ask whether or not their local processing bias extends to face processing as it does in autistic populations (Behrmann et al., 2007).

3. Experiment 2: Face perception

Western humans show effects of global processing for faces only when faces are shown upright (Hole, 1994; Maurer, LeGrand, & Mondloch, 2002). By contrast, they process inverted faces in a part-based (local) manner leading to deteriorated discrimination performance for inverted compared to upright faces (De Gelder & Rouw, 2000; Leder, Candrian, Huber, & Bruce, 2001; Murray, Yong, & Rhodes, 2000; Thompson, 1980). Indeed, susceptibility to face inversion is regarded as the key function that should be examined in any claim for normal or atypical face processing (Karmiloff-Smith et al., 2004).

Experiment 2 therefore used upright and inverted faces to further investigate the global/local processing modes of the Himba. It comparatively examined the ability of our two populations to discriminate “Thatcherized” faces, derived from Thompson (1980), known to produce large inversion effects (Bartlett & Searcy, 1993; Rhodes, Brake, & Atkinson, 1993). Examples of the Thatcherized faces are shown in Fig. 2. These faces look glaringly wrong only in their upright version because a configural/global mode of processing is applied to upright faces. As a consequence of a local mode of processing, faces look normal or close to normal when shown upside-down, making the Thatcherized face harder to discriminate from its normal version. It was reasoned that if the Himba show superior performance for upright over inverted faces, that would suggest a global mode of processing is applied to upright facial

stimuli by the Himba as it is by Westerners. By contrast, an equally poor discrimination of the Thatcherized normal and inverted faces would suggest that their local processing bias generalizes to both upright and inverted faces.

3.1. Method

3.1.1. Participants and stimuli

The same 36 Himba and 24 further Western participants (12 men, 12 women; mean age: 24 years 4 months, range: 18–38 years) took part in Experiment 2. Color digitized frontal views of Western and Himba faces (three female, one male of both face types), and their Thatcherized versions (see Fig. 2) were shown on a black background and subtended approximately $8^\circ \times 8^\circ$ of visual angle.

3.1.2. Test procedure

One “Thatcherized” and one normal face were presented side-by-side on the computer screen. The task was simply to detect the normal version and to press a two-response box with the left button for the left picture and the right button for the right picture. Accuracy was emphasised rather than speed. Normal faces were allocated equally to left or right responses. The 16 trials were blocked by Face Type (Himba vs. Caucasian faces) with blocks consisting of eight upright and eight inverted trials. The order of trials within a block was randomized. Alternate participants were tested first on the Caucasian or Himba faces. Himba participants were equally divided as to whether they did first Experiment 1 or Experiment 2. The interval between the experiments was around 20 min.

3.2. Results

There was no suggestion to participants that they should make speeded responses. However, there is always the possibility that poor performance with inverted faces is due to making hurried decisions in that condition. So, prior to analysis of the accuracy scores we verified that there was no indication of any speed-accuracy trade-off. As there was none, we compared the performance of Western and Himba participants in a $2 \times 2 \times 2$ mixed ANOVA with factors Culture (Himba vs. Western), Face (Himba vs. Western) and Orientation (Upright vs. Inverted) using correct choices as the dependant measure.

A significant effect of Culture, $F(1,58) = 37.72$, $p < .00001$; $\eta_2 = .39$, indicated that the Himba were less accurate (72%) compared to the Western participants (87.7%). A main effect of Face showed that participants were more accurate with the Western faces (83.1%) compared to the Himba faces (76.6%), $F(1,58) = 8.36$, $p < .005$; $\eta_2 = .12$. A main effect of Orientation showed that participants were more accurate with the upright faces (97.5%) compared to the inverted faces (62.2%), $F(1,58) = 204.87$, $p < .00001$; $\eta_2 = .77$. Orientation interacted significantly with Culture, $F(1,58) = 27.45$, $p < .00001$; $\eta_2 = .32$. Post-hoc (Tukey HSD) analyses indicated that Himba participants (47.9%) were less accurate than Western participants (76.5%) with inverted faces only. No differences were found for upright faces ($p > .86$, see Fig. 3). A significant

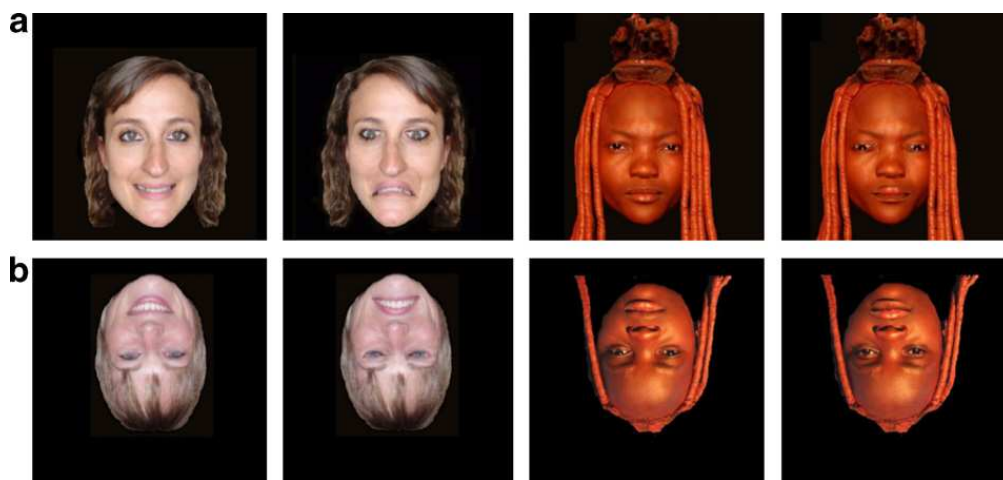


Fig. 2. Illustration of the face stimuli and their “Thatcherized” version used in Experiment 2. All facial stimuli were presented upright (a) and inverted (b).

interaction between Orientation and Face, $F(1,58) = 9.64$, $p < .003$; $\eta_2 = .14$, showed that both groups of participants were less accurate for the Himba Faces (52%) compared to the Western Faces (66%) when presented inverted (Tukey test, $p < .05$). No differences were found for upright presentations (Tukey test, $p > .05$). No other interactions were significant, $F_s < 1$.

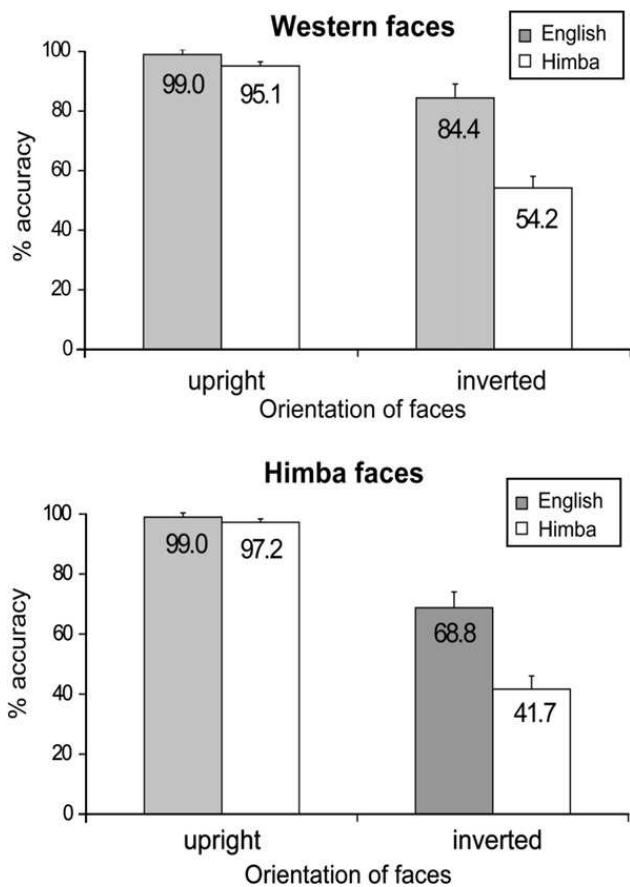


Fig. 3. Percentage accuracy (and standard errors) for Western and Himba participants in judging the correct Western and Himba face (see Fig. 2) when presented upright or inverted.

Drawing attention to the global or local aspects of Navon figures has been claimed to have dramatic short-term effects on face or word recognition tasks (Macrae & Lewis, 2002; Perfect, 2003; but see Large & McMullen, 2006). As half of the Himba carried out the Navon task first (Experiment 1), we were able to investigate effects of task order for the Himba. However, a $2 \times 2 \times 2$ mixed ANOVA Order (Experiment 1 first vs. Experiment 2 first) \times Face (Himba vs. Western) \times Orientation (upright vs. inverted) using correct choices as the dependant measure gave no effect of Order, $F(1,34) = 1.14$, $p > .29$; $\eta_2 = .03$, and no interactions with the other factors, $F_s < 1$. Other effects were as in the previous analysis.

3.3. Discussion

Both Himba and Westerners showed an effect of inversion with no evidence of any speed-accuracy trade-off suggesting that they both process the upright faces globally. Inverted Himba faces were harder to discriminate for both populations and this would be likely due to the Himba faces having a more neutral expression without visible teeth. Lip curvature and visible teeth provide cues for the task that would be available only for the Western faces. The Himba were even more disrupted by inversion than the Western observers and thus showed more evidence that they used global processing in face identification. The superior accuracy with inverted faces by Western observers could be due to several strategies that the Westerners could have employed to raise themselves above chance performance in the inverted condition (Maurer et al., 2002). One of these strategies could be mental rotation of the facial display until upright (e.g., Valentine & Bruce, 1988), but their exact approach to the task is not our present concern. Our conclusion is very clear: the local bias observed in the Himba with hierarchical geometrical stimuli does not generalize to a pervasive attention to details in the processing of upright faces or inverted faces.

4. General discussion

The Himba showed a pronounced local bias with hierarchical stimuli (Experiment 1) that is consonant with their accurate relative size judgements (De Fockert et al., 2007) and grouping by close perceptual similarity (Roberson, Davidoff, Davies, & Shapiro, 2005a; Roberson et al., 2002; Roberson et al., 2005b). In Experiment 2, as our informal observations predicted, attention to local detail was not the Himba default processing procedure for faces. Therefore, the present research adds to the variety of population related factors that affect local and global processing modes. Moreover, it showed that the use of a processing mode in one domain does not predict its use in another rather in line with Peterson and Deary (2006) who found that individual biases in the Navon task did not predict the cognitive style (Wholistic–Analytic) that the same individuals showed in similarity judgements.

Global processing is the norm for both tasks in typical Western adults so one might enquire why that is not the case for the Himba. In fact, for hierarchical (Navon) stimuli, there are variations across test groups with the strength of the global bias varying as a function of age and gender (e.g., Dukette & Stiles, 1996; Kramer, Ellenberg, Leonard, & Share, 1996; but see De Lillo, Spinozzi, Truppa, & Naylor, 2005). However, there is a notable, and unresolved, contradiction between the findings in preschool children and the consistent global precedence asserted in 3- and 4-month-old infants (Columbo, 2001; Freeseaman, Colombo, & Col-dren, 1993; Frick, Colombo, & Ryther Allen, 2000; Ghim & Eimas, 1988). This ontogenetic variation only reinforces what has become clear from the last few decades of research on hierarchical figures that both local and global biases are available to the typical adult but, interestingly, with a different neural location associated with each bias (Fink et al., 1997; Mevorach, Humphreys, & Shalev, 2006; Yamaguchi, Yamagata, & Kobayash, 2000). Local and global biases vary according to task demands (Macrae & Lewis, 2002) and physical state (Van der Linden & Eling, 2006) so it should not surprise that they could also be altered by cultural mediation.

Isolating the alternative cultural variation responsible for the pronounced Himba local bias must at present be a matter of speculation. However, one can rule out the suggestion of Nisbett et al. (2001) that it derives from an individualistic culture as that is not their society's organization (Crandall, 2000). A more likely potential cultural explanation concerns the pronounced ability of the Himba to distinguish between their herd animals (Crandall, 2000). Their skill at animal pattern discrimination has been recently demonstrated in a 2-Alternative Forced-Choice recognition task where they were shown to possess perceptual categories for animal patterns that are opaque to Western observers (Goldstein & Davidoff, 2008). It is possible that these skills have led the Himba to pay attention to detail when dealing with unfamiliar visual displays. Equally likely, is an account that concerns literacy as we compared populations with and without writing and reading skills. It is known that reading skills are related to global, but not local, acoustic pattern perception (Foxton et al.,

2003) and more directly that differences in global and local biases correspond to the acquisition of writing/reading skills (Dukette & Stiles, 2001). Either of these cultural explanations could account for the local bias in our previous observations (De Fockert et al., 2007; Roberson et al., 2005a; Roberson et al., 2005b) and also in the present data.

Whatever interpretation turns out to be correct for the origins of the pronounced Himba local bias, there is still the issue of why the Himba fail to show the same bias with faces. While there is still considerable argument about whether faces are unique in their involvement of any particular type of global processing (Gauthier & Tarr, 2002; Haxby et al., 2001) and to its development throughout childhood (Maurer et al., 2002), there is no doubt that faces are the type of stimulus most likely to require some form of global processing. There are two good reasons why this should also apply to the Himba and thus not be surprising that the two tasks recruit different resources. First, the pictures of faces were characterized by continuous variations of dimensions such as color, texture and brightness unlike the spatially independent elements in the Navon figures. The discontinuity may enhance the relative saliency of the local elements, in particular for the Himba unfamiliar with geometrical shapes. Second, notwithstanding any innate bias for global perception for faces (Haan, Pascalis, & Johnson, 2002; Johnson, Dziurawiec, Ellis, & Morton, 1991) that might be seen in any normal population, the need to distinguish individual faces must be as valuable for the Himba as it is for any society. The inefficiency of local processing, as shown by the performance of those unable to apply a global analysis to faces (Behrmann et al., 2005), would therefore make it likely, in a population where both strategies are available, for them to use global rather than local processing for face perception. Indeed, even nonhuman primates that show a strong local bias for processing hierarchical stimuli (Fagot & Deruelle, 1997) do not necessarily transfer that processing mode to faces (Martin-Malivel & Fagot, 2001).

Appeals to parsimony (reductionist accounts) within psychology are common and seductive (though one notes the warning in Scerif and Karmiloff-Smith (2005) against a simple mapping of genotype to phenotype). With respect to local bias, it has been tempting to relate this to perceptual differences (Bertone, Mottron, Jelenic, & Faubert, 2005) with the aim to link that back to neurophysiology (Dakin & Frith, 2005) and even genetics (Happé, Brinkman, & Frith, 2001). However, the present paper shows that the Himba have a local bias for hierarchical pattern quite as pronounced as it is in autism (Happé, 1999) but there has been no similar developmental trajectory and no similar facial processing. Our data showing local attentional biases in a normal population would therefore offer a caution against any claim for a direct causal relationship between local processing biases and those disorders (autism, schizophrenia) that have been associated with a local bias.

Acknowledgements

The research was funded by EU SEDSU (012-984). J.F. was supported by the European Community OMLL

research program. We thank Saskia Sabelus and Julie Goldstein for data collection.

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