Change detection vs. change localization for own-race and other-race faces

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Public Significance Statement

We compared change detection and change localization tasks to evaluate the holistic processing of own-race and other-race faces. We also assessed the amount of contact with people of other races over three time periods: elementary school, secondary school, and university. Change detection performance was better than change localization performance for own-race faces, indicating holistic processing; there were no differences in change detection and change localization performance for other-race faces. Importantly, the amount of contact with other race people in elementary school – but not in secondary school or university – was related to change detection performance for other-race faces.

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Abstract

The other-race effect (ORE) is a well-known phenomenon in which people discriminate and recognize faces from their ethnic group more accurately than faces from other ethnic groups. Holistic processing, or the mandatory tendency to process all parts of an object together, has been proposed as an explanation for the ORE. According to the holistic perspective of the ORE, other-race faces might be subject to weaker holistic processing than own-race faces. However, evidence for this hypothesis is inconsistent. Although it is generally assumed that holistic processing helps the individuation of objects, holistic processing may also come at a cost. Specifically, holistic processing may reduce the capacity to localize changes in the constituent parts of an object, but not in detecting changes to an object as a whole. In the present study, we examined change detection and change localization accuracy for Caucasian and African faces, and houses. Performance was better for change detection than change localization for Caucasian faces. While clear costs of holistic processing for Caucasian faces were thus found, the difference between change localization and change detection was not obvious for African faces. However, childhood exposure to other-race people correlated with change detection for African faces, but not with change localization for African faces. Our results thus show that holistic processing of other-race faces may depend on early contact with other-race people.

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Keywords: ORE; faces; holistic processing; change detection; change localization

Introduction

The other-race effect (ORE) is a well-known phenomenon in which people tend to discriminate and recognize faces of their ethnic group more accurately than faces of different ethnic groups (Bothwell, Brigham, & Malpass, 1989; Meissner & Brigham, 2001, for reviews). Even though the ORE has been investigated extensively during the past decades, the processes underlying this phenomenon remain poorly understood.

Holistic processing has been proposed as one important mechanism underlying the ORE (Michel, Rossion, Han, Chung, & Caldara, 2006; Rossion & Michel, 2011). Adults' expert face recognition has holistic processing as its hallmark (Farah, Wilson, Drain, & Tanaka, 1998). Faces are commonly identified at the level of an individual (e.g., “Paulo”), in contrast with other common objects that are typically identified at a category level (e.g., “cat”; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Such individuation requires discrimination between faces that share the same set of features (eyes, nose, and mouth) in a similar general configuration (eyes above nose, nose above mouth) while differing in minute details concerning the shapes of and the spatial relationships between features. Holistic processing, or the mandatory tendency to process all parts of an object together, is believed to facilitate such detailed discrimination (Diamond & Carey, 1986; Gauthier & Tarr, 2002; McKone, Crookes, Jefferey, & Dilks, 2012; Richler & Gauthier, 2014).

According to the holistic perspective of the ORE, people are inefficient at integrating facial components from other-race faces into a full representation (Hayward, Crookes, & Rhodes, 2013; Tanaka, Kiefer, & Bukach, 2004) and therefore other-race faces might be subject to weaker holistic processing than own-race faces. A task commonly used to evaluate holistic processing is the composite task. The composite task requires subjects to ignore one half of the face (e.g., bottom) of two sequentially presented faces, and infer whether the other half of the face (e.g., top) is the same or different. One usually has trouble in limiting attention to one face part which apparently reflects obligatory attention to all parts (see Richler & Gauthier, 2014, for a review; but see Rossion, 2013 for different designs and interpretations). Although own-race faces have been shown to have stronger holistic processing than other-race faces (e.g., Michel, Rossion, Han, Chung, & Caldara, 2006), the findings are inconsistent. Indeed, other studies have shown equivalent levels of holistic processing of own and other-race faces (e.g., Harrison et al., 2014; cf. for a recent example, Wong, Estudillo, Stephen & Keeble, 2021).

The fact that different versions of the composite task were used may help explain the disparity. Harrison et al. (2014) and Wong et al. (2021) used the complete design, while Michel, Caldara, and Rossion (2006) and Michel, Rossion, Han, Chung, and Caldara (2006) used the partial design. The irrelevant half of the face is always different in partial design, while the target half may be the same or different. Holistic processing is operationalized as an alignment effect (e.g., Goffaux & Rossion, 2006; Hole, 1994; Young, Hellawell & Hay, 1987). This alignment effect is however very prone to response bias (Richler & Gauthier, 2014; Cheung, Richler, Palmeri, & Gauthier, 2008; Richler, Mack, Palmeri, & Gauthier, 2011).

The complete design overcomes these constraints by orthogonally manipulating alignment and congruency (Gauthier & Bukach, 2007). Congruent and incongruent trials are included in both same- and different-response trials, and holistic processing is signaled by a significant interaction between alignment and congruency across response-type. This index is much less susceptible to response bias (for a meta-analysis see Richler & Gauthier, 2014).

The distinctions between partial and complete designs of the composite task are not the end of the story. The part-whole task is another well-known measure of holistic processing that does not have the kind of problems found with different versions of the composite task. In the part-whole task, it is easier to identify a feature (e.g., eyes) when it is presented on a whole face than when it is presented separately, indicating facilitation of the whole on part processing (Tanaka and Farah, 1993). Using the part-whole task, some studies found stronger holistic processing for own-race faces compared to other-race faces (e.g., Tanaka, Kiefer, & Bukach, 2004), while other studies found no evidence of stronger holistic processing effect for own- than other-race faces (Wong, Estudillo, Stephen & Keeble, 2021).

There is a widespread assumption in the face perception literature that the part-whole and the composite face tasks measure the same underlying (holistic) mechanism (e.g., Behrmann, Richler, Avidan, & Kimchi, 2015; Piepers & Robbins, 2012). However, a recent study by Rezlescu et al. (2017) examined the relationships between composite, inversion, and part-whole effects. Intriguingly, the three holistic processing measures did not show a high overlap, with a significant and moderate correlation found only between the inversion and part-whole effects (r= .28). Thus, the composite task and the part-whole task are probably measuring different mechanisms of holistic processing (Richler, Palmeri, & Gauthier, 2012). The difficulty in limiting our attention to one object part found in the composite task reflects obligatory attention to all parts of an object. For faces, it has been suggested that such a perceptual strategy may have become automatized with experience and/or due to a history of learned attention to diagnostic parts (cf. Richler & Gauthier, 2014). The common interpretation of the part-whole effect is that object parts are not represented in isolation but instead integrated as a larger chunk or unit possibly covering the whole object. It remains unclear how these various proposed mechanisms and measures are related (cf. Richler et. al., 2012; Rezlescu et al., 2017).

The literature of holistic processing entails a view that holistic processing is always beneficial for object processing, for example in helping individuate objects made with a similarly organized set of features. However, an intriguing possibility is that whether holistic processing is useful or not depends on task demand. In fact, in some situations, holistic processing may come with a cost. For example, Wilford and Wells (2010) hypothesized that holistic processing may allow one to better detect changes occurring to a face yet disrupt the ability to locate where the changes occur. Wilford and Wells (2010) adopted a change-blindness paradigm with faces (involving holistic processing) and houses (involving part-based processing) in which participants were asked whether a change occurred. In the other task, the test object always changed, and participants were asked about what changed. This new condition was critical for testing Wilford and Wells's (2010) proposition that holistic processing facilitates change detection but impedes change localization.

And indeed, they found that participants could detect changes to a face better than changes to a house yet localize where the changes were was better for a house than a face. This difference disappeared when the face and house images were inverted. Mathis & Kahan (2014) found similar results with Kanizsa rectangle patterns that were arranged to either form a Gestalt whole or not. A similar conclusion was reached by Poljac, de-Wit & Wagemans (2012) using a different paradigm with biological motion figures.

These three studies show that holistic, meaningful patterns, are extracted quickly from the visual environment and that the formation of a more abstract (and therefore global and meaningful) representation may lead to a reduction in the conscious accessibility of the information from which that abstraction is formed. This potentially paradoxical picture whereby objects are rapidly extracted, and provide a useful reference frame, but at the same time lead to the reduced accessibility of the parts making up that object can be understood in terms of Hochstein and Ahissar's reversed hierarchy theory (Hochstein & Ahissar, 2002; Hochstein, Pavlovskaya, Bonneh, & Soroker, 2015). According to this model, the information on which conscious perception is based is extracted by default from the most abstract (and thus global and meaningful) stage of visual information processing, and that feedback mechanism is required to go back and extract the details from which this abstraction is made.

Our first goal in the present study was to evaluate the holistic processing of own-race and other-race faces. We adopted the change blindness paradigm of Wilford and Wells (2010) and compared change detection and localization performance for own-race and other-race faces and houses to evaluate whether the cost of holistic processing would generalize to other-race faces. This would help understand whether the effect found by Wilford and Wells was specific to the geometry of an upright face or is instead more a result of experience/contact. The amount of social contact one has with certain groups is said to be a key factor influencing one's performance with faces of different ethnicities. According to the contact hypothesis, the more contact an individual has with the faces of a specific ethnicity, the better she/he is at recognizing members of that group (Goldstein & Chance, 1985). In general, studies on the role of contact (both geographical and self-report) in face recognition have shown that the magnitude of the ORE decreases as contact increases. (for a recent example: Mousavi & Oruc, 2020). One tentative explanation for studies that did not find evidence of social contact impacting the ORE may be that the range of scores in the measures of social contact is not substantial, with contact scores being relatively low (Childs et al., 2021).

If the cost of holistic processing observed by Wilford and Wels (2010) hinges on the geometry of an upright face, then there should be an advantage of change detection over change localization for own-race and other-race faces (upright presentation), but not for houses. If the cost of holistic processing depends mainly on recognition experience, then the advantage of change detection should occur for own-race faces, with which one has extensive experience, and less so for other-race faces for which we have less experience/contact, and the least for houses.

Recently, McKone et al. (2019) measured the age at which interracial social contact has an impact on the other-race effect. McKone et al. measured the ORE in adult participants using own- and other-group variants of the Cambridge Face Memory Test. McKone et al. then examined the correlation of people’s adult ORE with the amount of natural social contact with own-race people, and the target group of other-race people, people report having previously experienced at different ages. Childhood contact eliminated poor other-race recognition. Critically, however, the developmental window for easy acquisition of other-race faces closed by approximately 12 years of age, and social contact as an adult - even over several years and involving many other-race friends - produced no improvement.

Our second main goal in the present study was to evaluate the role of amount of contact with other races, the quality of contact, and the time window of that contact. We adopted McKone et al. (2019) questionnaire of social contact to evaluate whether the time at which social contact occurs might predict holistic processing for other-race faces: specifically, we predict higher holistic processing for people with a higher amount of natural social contact during basic school with the target group of other-race people. Contact during high-school years or at the University should not moderate holistic processing of the target group of other-race people.

Humphreys, Hodsol, and Campbell (2005) had already used a change blindness task with own- and other-race faces. However, there are crucial differences in the paradigm adopted by Humphreys et al. and the paradigm we adopted. In Humphreys et al. participants were Caucasian and Asian Indian students. The photographs used always included two female Caucasian and two female Asian Indian actors took within the campus of the University of Birmingham. All actors wore jeans and coats. In Humphreys et al. change could be located in the face (i.e., replacement), body, or environment, while Wilford and Wells (2010) explored within-face changes. Also, Humphreys et al. had only a change detection task, but it is crucial to compare change detection to change localization tasks to clearly understand the holistic processing of different ethnic categories. Also, comparison of upright and inverted presentations is important to evaluate holistic processing, but there is no inverted condition in Humphreys et al. Finally, the two photographs in a trial of Humphreys et al. were presented for 200 ms each. In Wilford and Wells's (2010) paradigm, each image in a trial was presented for 1,5 s which would allow ample time for scanning the images for features. That is a crucial aspect of the paradigm: even with ample scanning time, participants are better at face change detection than face change localization.

As for the results, Humphreys et al. found that changes to whole faces were detected more easily than changes to body parts. Humphreys et al. also found an ORE in change detection. When there were changes to the whole faces of White actors, White participants responded fastest; when there were changes to the whole faces of Indian Asian actors, Indian Asian participants responded fastest. Thus, change detection seems to be easier for own- compared to other-race faces, but the comparison with change localization tasks in upright and inverted presentations would be crucial to understand the holistic processing of these categories.

Pilot Study

The tasks we used in the main study were identical to those used by Wilford and Wells (2010). Ninety images were created for this study. These included six original Caucasian faces, six original African faces, and six original houses. Five variations of each of the six original Caucasian faces, six original African faces and of each of the six original houses were created by changing one feature at a time - for both types of faces: hair, nose, eyes, mouth, or chin; for houses: roof, chimney, window, door, or porch. The faces were created and manipulated utilizing FacesTM software (IQ Biometrix, Inc., http://www.iqbiometrix.com/products_faces_40.html) which is the same software used by Wilford and Wells (2010). Houses were manipulated with Adobe Photoshop. Confer Figure 1 for examples of materials.

Thus, our faces are not photographs of real people. FacesTM software does not categorize features by “Caucasian” and “African”, but it includes hundreds of examples of hair, nose, and mouth features that can be used to create different race faces. Also, all faces were created with the help of an experienced forensic artist. Nevertheless, it might be the case that participants do not categorize these faces as Caucasian or African. In this pilot study, we evaluated how participants categorized each face on a five-point scale of perceived ethnicity. We included the 12 base faces and the faces that were created by changing each feature.

Method

Participants

Fifteen participants took part in the Experiment. Participants were all graduate or post-graduate students in Faculdade de Psicologia of Universidade de Lisboa and who have collaborated in several studies with the first author of this paper. Participants were blind to the goals of the study.

Material

Sixty Caucasian or African images were created for the main study. These included six original Caucasian faces and six original African faces. Five variations of each of the two types of faces were created by changing one feature at a time - for both types of faces: hair, nose, eyes, mouth, or chin (Figure 1). Changes were made by replacing a feature with a close feature of the same type in the FacesTM software. For example, a sharp nose was replaced by another nose in the library of sharp noses in FacesTM (IQ Biometrix, Inc.). The distance between the two features in the respective library of FacesTM (IQ Biometrix, Inc.) was always smaller than or equal to three-feature step changes.

Procedure

The task was run online using EPrime Go. Participants had to evaluate the ethnicity of each face on a five-point scale: 1- a White face definitely; 2- seems more like a White face; 3- I am not sure about ethnicity; 4- seems more like a Black face; and 5- a Black face. Participants used the keyboard to provide their judgment.

Results

African faces were evaluated as Black faces (4,55), while Caucasian faces were evaluated as White faces (1,37), $t(14)= 24.21$, $p < .0001$. Thus, faces created in FacesTM software were indeed categorized as either Black or White.

Experimental study: detection change vs. localization change for Caucasian faces, Afro faces, and Houses

Method

Participants

Eighty-two participants took part in the Experiment. There were four materials: Caucasian faces, African faces, words, and houses, but we report here only the results for three materials: Caucasian faces, African faces, and houses Due to computer problems, only 78 participants had data for the three materials. According to More Power (Version 6.0.4; Campbell & Thompson, 2012), a sample size of 60 would be required to detect a medium-sized effect (with $\eta p2=.10$) at $\alpha=0.05$ with a power of 0.9 for a repeated-measures ANOVA with a 3x2x2 within-subject factor: 3 (image type: Caucasian faces vs. African faces vs. houses) x 2 (task: change detection vs. change localization) × 2 (image orientation: upright vs. inverted). We included all participants enrolled in an introductory psychology course forecasting some sample attrition.

This study's protocol adhered to guidelines of the Declaration of Helsinki, the Portuguese deontological regulation for Psychology, and was approved by the Deontological Committee of Faculdade de Psicologia of Universidade de Lisboa. All participants provided written informed consent. Participants received course credit.

Material

The task was identical to that in Wilford and Wells (2010). Ninety images were created for this study. These included the Caucasian faces, and African faces, used in the pilot study and six original houses each with five variations created by changing one feature at a time - roof, chimney, window, door, or porch. The faces were created and manipulated utilizing FacesTM software (IQ Biometrix, Inc.), while houses were manipulated with Adobe Photoshop. Confer Figure 1 for examples of materials.

Design

Participants were tested in groups of two. The two participants did either all localization tasks first or all detection tasks first. The order of the materials within the task was randomly chosen before each of the sessions and was equal for the two participants in a session. We used a 3 (image type: Caucasian faces vs. African faces vs. houses) x 2 (task: change detection vs. change localization) × 2 (image orientation: upright vs. inverted) design. Task, image type, and orientation were all manipulated within subjects. Task and material were blocked while orientation was intermixed.

Procedure

In the *change-localization condition*, participants completed 60 trials for each type of material; each of six original Caucasian faces, six original African faces, and six original houses were tested with each of five possible feature variations, once in an upright orientation and once inverted. Both images in each trial were displayed in the same orientation. Each material was preceded by training with 20 trials. In all trials, there was a change from the original image. Each image was shown an equal number of times upright and inverted, and the inverted and upright images were randomly intermixed.

In the *change detection* condition, participants completed 120 trials for each type of material. In half of the trials there was a change from the original image, while in the other half of the trials, there was no change. Both images in each trial were displayed in the same orientation. Each image was shown an equal number of times upright and inverted, and the inverted and upright images were randomly intermixed.

Each trial presented an original image (1.5 s), a blank mask (0.3 s), and then a test image (1.5 s), followed by an instruction screen. In the *change-localization condition*, the instruction screen read, “Please identify what change you believe could have occurred.” The five possibilities were listed, and participants used the keyboard (1 to 5 keys) to signal the chosen feature. In the change detection condition, the screen read, “Did a change occur in the face [house] you were originally presented?” Participants used the “yes” or “no” labeled keyboards to signal their options. Stimuli were presented on a 17” CRT monitor, and E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2012a, b) was used to control stimulus presentation and response recording.

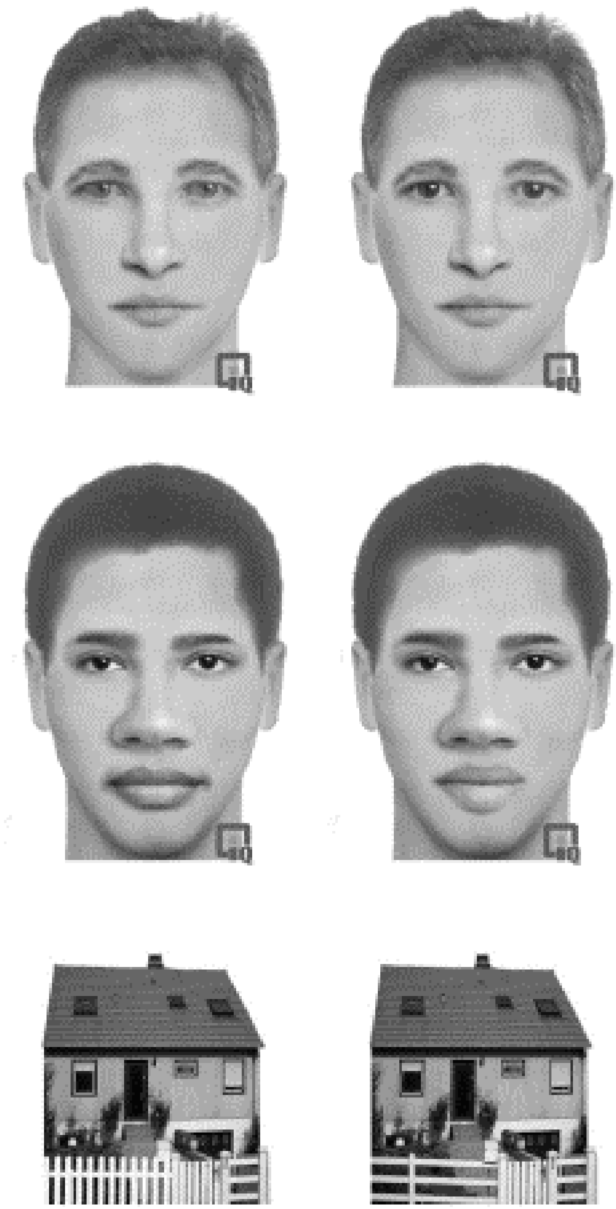

Figure 1. Examples of the Caucasian faces, African faces, and houses used in the experiment. For each category, the left and right images are the original and the altered versions respectively. In these examples, the eyes of the Caucasian face, the lips of the African face, and the fence of the house were changed. The symbol appearing on the bottom of each face picture is a trademark of the FacesTM software (IQ Biometrix, Inc., http://www.iqbiometrix.com/products_faces_40.html) and appeared on all the face images in the experiment (like what can be seen in Wilford & Wells, 2010).

Results

As the chance performance was different for the two tasks (50% for detection but 20% for localization), each participant's accuracy was corrected for chance using the formula (%correct - %chance) / (100% - %chance) following Wilford and Wells (2010). Figure 2 shows the accuracy of detection and localization tasks for different object categories in their upright and inverted versions. Accuracy was higher for change detection than localization for Caucasian faces but higher for change localization than detection for houses. For African faces, there was not much difference between the two tasks. Although inversion impaired the general performance in both tasks, it did not affect much the accuracy difference between tasks across different categories.

An analysis of variance (ANOVA) was conducted with category, task, and orientation as factors. The most important analyses concern the interaction between task and category, and the three-way interaction. The category x task interaction was significant, $F(2, 154) = 47.2$, $p < .0001$, partial η^2 =.38. Accuracy was higher for detection than localization only for Caucasian faces, $t(77)$= 6.33, $p < .0001$ (Figure 2). In contrast accuracy was higher in localization than detection for houses, $t(77)$= 7.3, $p < .0001$. For African faces the two tasks did not differ in accuracy, $t(77)$= 1.62, p = .11. The three-way interaction between category, task, and orientation was not significant, $F < 1$. Other significant effects include the main effect of category, $F(2, 154) = 123.74$, $p < .0001$, partial η^2 =.62, the main effect of orientation, $F(1, 77) = 127.19$, $p < .0001$, partial η^2 =.63, the interaction between category and orientation, $F(2, 154) = 47.21$, $p < .0001$, partial η^2 =.38, and the interaction between task and orientation, $F(1, 77) = 6.7$, $p = .01$, partial η^2 =.08.

The amount of natural social contact with own-race people, the target group of other-race people (African) and other races were evaluated at different ages (cf. McKone et al., 2019): we divided contact measures into three age ranges chosen to refer to life stages that our young adult participants ought to be able to clearly distinguish in memory, specifically: contact obtained between 6 and 12 years of age (basic school), between 12–18 years (secondary school), and recently as adults (University). We measured: contact with friends (high-quality contact requiring individuation and including positive social interactions); contact with classmates (requiring individuation but not necessarily positive social interactions); and exposure within the general neighborhood (assessing incidental exposure). Participants were asked to estimate the percentage of friends, classmates, and neighbors (excluding oneself) who were Caucasian, African, and Other races. Two important results were found by McKone et al. (2019): first, the contact must be early. Other-race face recognition is not sensitive to contact after 12 years old (even with up to 5 years exposure in a country where the other-race forms most people). Second, McKone et al. (2019) did not find evidence for the idea that "high-quality" contact might be more effective in reducing the ORE than mere exposure.

Considering the social contact questionnaire, we computed the correlations between aggregated contact (friends, classmates, neighbors) at basic school, secondary school, University and the performance for African faces in change detection and change localization. We found a positive correlation between change detection performance for African faces and contact at basic school period ($r = .26$, $p = .025$) but not between change localization performance for African faces and contact at basic school period ($r = .06$, $p = .59$). We performed a test of the equality of two correlation coefficients obtained from the same sample, with the two correlations sharing one variable in common (Lee and Preacher, 2013), and found evidence for a difference between the two correlation coefficients, $z = 1.73$, $p = .04$.

The other correlations for change detection had *ps* > .10 and the other correlations for localization detection had *ps* > .86.

To evaluate the hypothetical role of quality of contact in childhood, we compared the correlation coefficients (Lee and Preacher, 2013) between change detection for African faces and high-quality contact with Black people (friends) in childhood ($r = .16$, $p = .17$) and between change detection for African faces and mere exposure contact (neighborhood) in childhood ($r = .26$, *p*

= .02) and found no difference between the two correlation coefficients, $z = .74$, $p > .46$. Thus, quality of contact had no effect in modulating change detection performance for African faces.

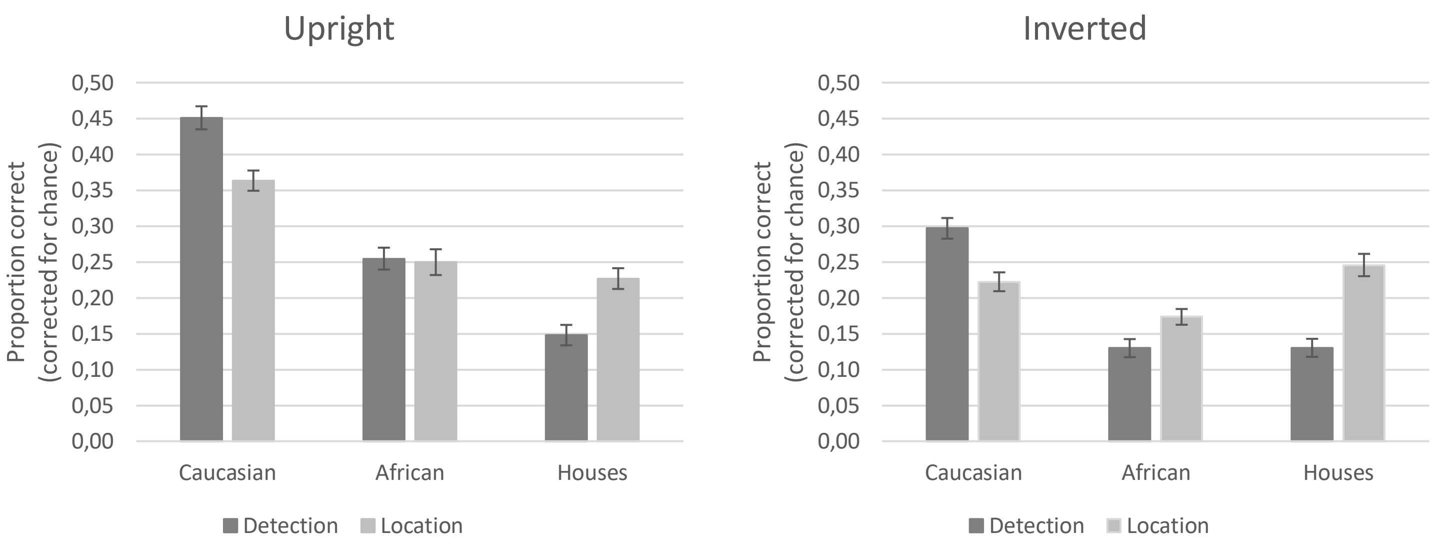

Figure 2. Accuracy in detection and localization tasks for different stimulus categories in their upright and inverted versions.

Follow-up study - Scrambled faces

The Caucasian face and house stimuli in the current study were similar to those in Wilford and Wells (2010). Intriguingly, different patterns of results were obtained between the two studies. In Wilford and Wells (2010), inversion changed the task performance difference across faces and houses. Specifically, better performance was found in detection for upright faces and in localization for inverted faces, while performance was always better in localization for houses. In the current study, the same pattern was found for houses, yet detection was always better for Caucasian faces presented either upright or inverted.

The results for faces could be interpreted considering the engagement of holistic processing for inverted faces (Richler et al., 2011; Sekuler et al., 2004; cf. for recent evidence, Murphy, Gray

& Cook, 2020), but there are also several studies showing that inversion disproportionately impairs holistic processing (e.g., Rossion & Boremanse, 2008 and Van Belle et al., 2008).

To provide direct evidence that the results we obtained in the upright presentation truly reflect holistic processing, in the next follow-up study we examine change detection and change localization for Caucasian faces and African faces made with scrambled face parts. Thus, the features used are the same but not in the configuration we are used to and these faces should not be processed holistically. If the pattern of results we obtained for faces in the main study truly reflect holistic processing, then we should obtain a flipped pattern with localization better than detection for faces presented either upright or inverted.

Method

Participants

Thirty-nine participants took part in the Experiment. This study's protocol adhered to guidelines of the Declaration of Helsinki, the Portuguese deontological regulation for Psychology, and was approved by the Deontological Committee of Faculdade de Psicologia of Universidade de Lisboa. All participants provided written informed consent. Participants received course credit.

Material

We included the six original Caucasian faces and six original African faces used in the pilot study and the main study. Also included were the five variations of each of the two types of faces. To build the scrambled faces, we followed this procedure: mouth in the forehead, nose in the middle-left side of the face, one eye in the middle-right side of the face, and the other eye at the level of the mouth. This transformation was applied to all the faces (cf. Figure 3).

Design and Procedure

The design was the same as in the main study with the exception that we only used two image types: a 2 (image type: scrambled Caucasian faces vs. scrambled African faces) x 2 (task: change detection vs. change localization) × 2 (image orientation: upright vs. inverted) design.

The procedure was the same as in the main study. The task was run online using EPrime Go.

Figure 3. Examples of the scrambled Caucasian faces, and scrambled African faces used in the experiment. For each category, the left and right images are the original and the altered versions respectively. In these examples, the eyes of the Caucasian face, and the lips of the African face were changed. The symbol appearing on the bottom of each face picture is a trademark of the FacesTM software (IQ Biometrix, Inc., http://www.iqbiometrix.com/products_faces_40.html) and appeared on all the face images in the experiment (like what can be seen in Wilford & Wells, 2010).

Results

Figure 4 shows the accuracy of detection and localization tasks for scrambled Caucasian faces and scrambled African faces in their upright and inverted versions. Accuracy was higher for localization detection than change detection for scrambled Caucasian faces and scrambled African faces.

An analysis of variance (ANOVA) was conducted with category, task, and orientation as factors. Accuracy was higher for localization detection than change detection $F(1, 38) = 25.8$, $p < .0001$, partial $\eta^2 = .41$. The category x task interaction was not significant, $F(1, 38) = 2.19$, $p = .15$, partial $\eta^2 = .05$. The category x task x orientation interaction was not significant $F < 1$.

Other significant effects include the main effect of category, $F(1, 38) = 26.05$, $p < .0001$, partial $\eta^2 = .41$, and the main effect of orientation, $F(1, 38) = 5.81$, $p = .02$, partial $\eta^2 = .13$.

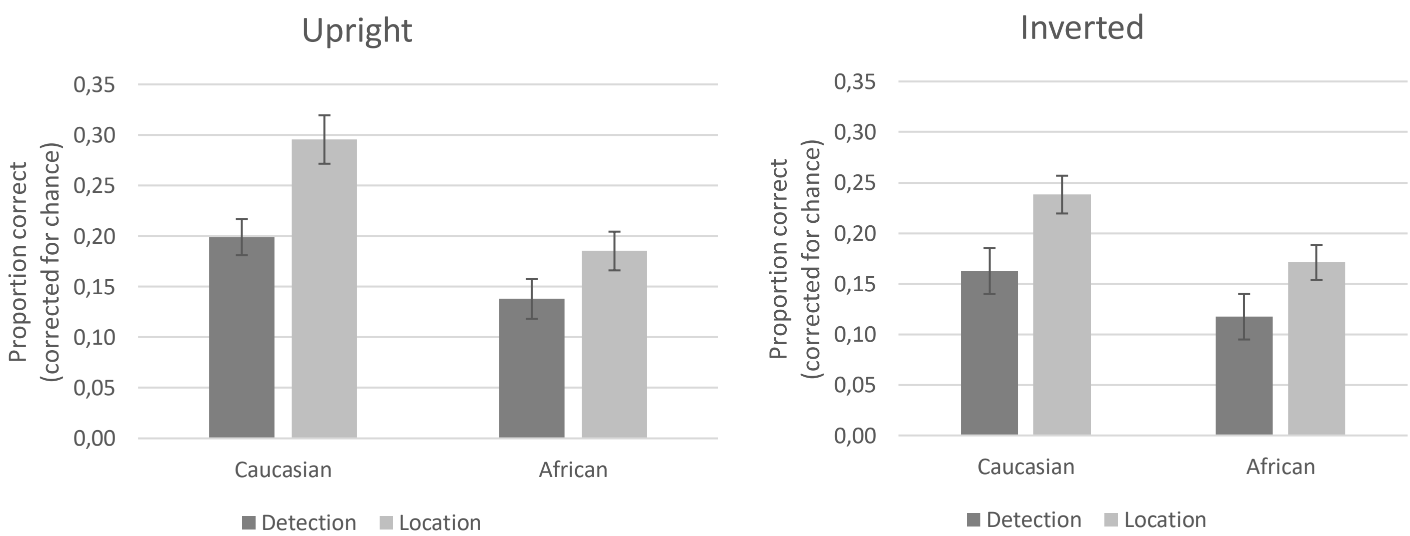

Figure 4. Accuracy in detection and localization tasks for different scrambled stimulus categories in their upright and inverted versions.

General Discussion

Holistic processing has been proposed as one important mechanism underlying the ORE (Michel et al., 2006; Rossion & Michel, 2011). According to the holistic perspective of the ORE, people are inefficient at integrating facial components from other-race faces into a full representation (Hayward, Crookes, & Rhodes, 2013; Tanaka, Kiefer, & Bukach, 2004) and therefore other-race faces might be subject to weaker holistic processing than own-race faces. However, and as reviewed in the Introduction, evidence obtained with the two most common tasks used to evaluate holistic processing (composite task, part-whole task) is contradictory. Also, a recent study showed that these two tasks do not seem to share the same holistic mechanisms (Rezlescu et al., 2017) and it remains unclear how different proposed holistic mechanisms for the composite task and the part-whole task are related (cf. Richler et. al., 2012; Rezlescu et al., 2017).

According to the holistic processing literature, holistic processing is always beneficial for object processing, such as assisting in the individuation of objects made with a similarly organized set of features. However, in some cases, holistic processing may come with a cost. Indeed, Wilford and Wells (2010) hypothesized that holistic processing may improve the ability to detect changes to a face while impairing the ability to locate where the changes occur. The benefit of holistic processing is that it is sensitive to changes that may occur at any of an object's many possible feature locations. This type of processing, however, comes at a cost: a relatively poor ability to localize which specific feature of the overall image changed. Thus, holistic processing can be inferred from a comparison of categories (faces, houses), tasks (detection, localization), and stimuli orientation (upright, inverted).

Our first goal in the present study was to evaluate the holistic processing of own-race and other-race faces. We adopted a design similar to the one used by Wilford and Wells (2010), comparing three categories (Caucasian faces, African faces, and houses) presented either upright or inverted and using two tasks: change detection vs. change localization. Our findings showed that the relative ability to detect a change vs. localize the change depends on object category. Detection was easier than localization for Caucasian faces and localization was easier than detection for houses. For African faces, there was no clear advantage of change detection vs. localization. While own-race faces are regarded as mainly holistically processed and houses are regarded as being processed in a part-based manner, this result might suggest that other-race faces are somewhere in between own-race faces (holistic-based) and houses (part-based).

However, and very importantly, we showed that early contact (before 12-years old) with a target other-race group moderates holistic processing of the target other-race faces. We used the social contact questionnaire of McKone et al. (2019) and found a positive correlation between change detection performance for African faces and contact at basic school but not between change localization performance for African faces and contact at basic school. McKone et al. (2019) found no evidence that "high-quality" contact may be more effective than mere exposure in reducing ORE. Congruently, we found no role of the quality of contact in moderating the relationship between the degree of contact in childhood and change detection performance for other-race faces.

In their seminal study, McKone et al. (2019) measured the age at which interracial social contact has an impact in the other-race effect measured, in adult participants, using own-and other-group variants of the Cambridge Face Memory Test and found that contact in childhood is crucial to improve recognition of other-race faces. Our study has an important contribution showing the effect of this early childhood contact in promoting holistic processing of other-race faces. Contact after this early time window does not seem to impact the holistic processing of other-race faces.

A recent study by Hwang et al. (2020) suggests that even preverbal exposure to racial diversity may help direct attention to racial outgroup members. Indeed, preverbal exposure to racial diversity may change two neuro-cognitive responses - the modulation of top-down attention and the propensity to activate one's motor system when viewing others’ actions to racial outgroup members. White infants from more racially diverse neighborhoods exhibited greater frontal theta oscillation (an index of top-down attention) and more mu rhythm desynchronization (an index of motor system activation and potentially neural mirroring) to racial outgroup individuals than White infants from less racially diverse neighborhoods.

We found an advantage of face detection in the main experiment for both upright and inverted faces. This pattern of results seems to reflect the possibility of holistic processing even for inverted faces. (Richler et al., 2011; Sekuler et al., 2004; cf. for recent evidence, Murphy, Gray & Cook, 2020), although there are also several studies showing that inversion impairs holistic processing (e.g., Rossion & Boremanse, 2008 and Van Belle et al., 2008). Maybe the task used did not disproportionately impair holistic processing.

To provide direct evidence that the results we obtained in the main study truly reflect holistic processing, we examined change detection and change localization for Caucasian faces and African faces made with jumbled face parts. Thus, the features used are the same but not in the structure we are used to. We found an advantage for change localization both for Caucasian faces and African faces. Thus, these faces with jumbled parts are not seen as faces and are treated as an object, with a similar pattern as for houses. Thus, we can be confident that faces in the main study were indeed processed holistically.

In conclusion, we found evidence that early exposure to other-race people during the first twelve years is crucial in promoting the holistic processing of other-race faces. Importantly, it is the quantity, not the quality of contact, that matters.

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Consent for publication: not applicable

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