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Culture Shapes Spatial Frequency Tuning for Face Identification

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Many studies have revealed cultural differences in the way Easterners and Westerners attend to their visual world. It has been proposed that these cultural differences reflect the utilization of different processes, namely holistic processes by Easterners and analytical processes by Westerners. In the face processing literature, eye movement studies have revealed different fixation patterns for Easterners and Westerners that are congruent with a broader spread of attention by Easterners: compared with Westerners, Easterners tend to fixate more toward the center of the face even if they need the information provided by the eyes and mouth. Although this cultural difference could reflect an impact of culture on the visual mechanisms underlying face processing, this interpretation has been questioned by the finding that Easterners and Westerners do not differ on the location of their initial fixations, that is, those that have been shown as being sufficient for face recognition. Because a broader spread of attention is typically linked with the reduced sensitivity to higher spatial frequency, the present study directly compared the spatial frequency tuning of Easterners (Chinese) and Westerners (Canadians) in 2 face recognition tasks (Experiment 1 and 2), along with their general low-level sensitivity to spatial frequencies (Experiment 3). Consistent with our hypothesis, Chinese participants were tuned toward lower spatial frequencies than Canadians participants during the face recognition tasks, despite comparable low-level contrast sensitivity functions. These results strongly support the hypothesis that culture impacts the nature of the visual information extracted during face recognition.

Keywords: culture, face processing, psychophysics, spatial frequency, visual perception

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Several recent articles describe visual perception differences between Western and Eastern cultures (Boduroglu, Shah, & Nisbett, 2009; Masuda et al., 2008; McKone et al., 2010; Nisbett, Peng, Choi, & Norenzayan, 2001). One of the dominant hypothesis in the literature regarding cultural differences in perception proposes that Easterners attend more holistically to their visual world than Westerners, whereas Westerners attend more analytically to their visual world than Easterners (Nisbett & Miyamoto, 2005; Nisbett et al., 2001). Results obtained in many studies using substantially different experimental paradigms and kinds of stimuli (e.g., complex visual scenes, objects, faces) have supported that hypothesis.

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Studies comparing the attentional strategies of Easterners and Westerners during the processing of complex visual scenes have shown that Easterners allocate less attentional resources on focal objects in a scene than Westerners, and instead process the relations between the background/nonfocal objects and the focal objects (Kitayama, Duffy, Kawamura, & Larsen, 2003; Masuda et al., 2008; Masuda & Nisbett, 2001). For instance, a seminal work by Masuda and Nisbett (2001) showed that when asked to recognize whether an object was or was not part of previously viewed visual scenes, Easterners' performance dramatically dropped if the focal objects were presented on a different background than the original one (see, however, Evans, Rotello, Li, & Rayner, 2009). Based on these results, it was suggested that Westerners encode the focal objects independently from the background of a visual scene, whereas for Easterners, the focal objects are bounded with their background in the memory trace. Moreover, the differences observed in the way Easterners and Westerners encode visual scenes in memory were shown to be linked to different eye movement patterns (Chua, Boland, & Nisbett, 2005). In fact, when viewing visual scenes, Westerners fixate more than Easterners on the focal objects, and they start fixating on focal objects earlier than Easterners, whereas Easterners make more saccades to the background of the scene (see, however, Evans et al., 2009; Rayner, Li, Williams, Cave, & Well, 2007).

Further support to the hypothesis that Easterners attend more holistically than Westerners was obtained in studies comparing the performance of both cultural groups at inhibiting some components of a visual object while processing other components of that object. For instance, in a rod-and-frame test (Witkin et al., 1954), in which a line appears in a frame that can rotate independently of the line, Easterners are more influenced than Westerners by the orientation of the frame when they are asked to judge the orientation of the line (Ji, Peng, & Nisbett, 2000), suggesting that they are impaired at processing the line independently of the frame. Similar results were obtained in another study using a task in which participants needed to draw a line within a square, and were asked to adjust the length of the line such that it was identical to another line displayed in a square of different size (i.e., the framed-line test). In that study, Westerners were more accurate than Easterners when they were asked to adjust the length of the line in an absolute manner—without taking into account the size of the square in which the line was displayed (Kitayama et al., 2003).

In addition to the Easterners' bias at processing the relations between objects and their context, some evidence suggest they also have a bias at processing visual information in a more global manner. In fact, McKone et al. (2010) have shown that Easterners are quicker at processing the global than the local information, using Navon letters— hierarchical stimuli representing large letters (global information) composed of smaller letters (local information)—and that this bias is far more pronounced than for Westerners. Moreover, there is some evidence that Easterners allocate their attention more broadly during the processing of a visual stimulus. Using a change detection task with four squares of different colors, it was shown that Easterners are better than Westerners at detecting changes occurring in periphery, but worse at detecting changes occurring in central vision (Boduroglu et al., 2009). This cultural difference was obtained using brief displays (150 ms), so it is unlikely attributable to differences in eye movements; the first saccade typically occurs after 200 ms (Carpenter, 1988). Rather, it more likely reflects an early cultural difference in the attentional breadth.

Studies comparing the visual strategies of Easterners and Westerners during face processing have led to results that are in agreement with the idea that Easterners attend more holistically or globally than Westerners. Indeed, when identifying a face, Easterners fixate less the local features (i.e., eyes, mouth) of a face than Westerners (Blais, Jack, Scheepers, Fiset, & Caldara, 2008), a cultural difference that has been replicated many times (Caldara, Zhou, & Miellet, 2010; Kelly et al., 2011; Miellet, He, Zhou, Lao, & Caldara, 2012; Miellet, Vizioli, He, Zhou, & Caldara, 2013; Rodger, Kelly, Blais, & Caldara, 2010). This pattern is observed despite the fact that the same facial areas—the eyes and mouth—are used by both cultures to perform the task (Caldara et al., 2010). To reach this conclusion, Caldara et al., (2010) asked Easterners and Westerners to recognize faces in a limited perception setting: through a gaze-contingent Gaussian window. When the diameter of the Gaussian window was large (8° of visual angle), Easterners adopted the same strategy as they normally did: they made fewer fixations to the eyes and mouth than Westerners. When the window was smaller (2° and 5°), Easterners were constrained to fixate the eyes and mouth if they needed to gather visual information from these parts of the face in order to recognize the face. In these latter conditions, the fixation pattern of Easterners was the same as Westerners. In other words, Easterners as well as Westerners use information from the eyes and mouth to recognize faces, but when Easterners have visual access through a larger window, they do not need to fixate the eyes and mouth as frequently as Westerners to get information from these areas. These results have generally been interpreted as suggesting that while Easterners fixate the nose, there is a broader allocation of attention, extending to the other facial features, which allows them to visually process these other facial areas while they are located more peripherally in the visual field.

This interpretation was based on eye fixation patterns obtained by averaging the fixations occurring within the first 1.5 s or so (Blais et al., 2008; Caldara et al., 2010; Kelly et al., 2011; Miellet et al., 2012, 2013; Rodger et al., 2010). Recent evidence has revealed that the initial eye fixations of Easterners and Westerners are very similar during a face identification task (Or, Peterson, & Eckstein, 2015; see also Rodger, Blais, & Caldara, 2010). Because two fixations have been shown to suffice for face recognition (Hsiao & Cottrell, 2008), Or et al. (2015) proposed that the differences previously observed in the fixation patterns occurring during the first 1.5 s following stimulus presentation may not reflect cultural differences in the visual mechanisms underlying face recognition per se but, rather, cultural differences in the acceptable duration of eye contact.

However, two groups of observers can gaze on the same area and use different information (Arizpe, Kravitz, Yovel, & Baker, 2012), so similar initial eye fixations could occur while using different kinds of visual information. Moreover, as we have argued above, the cultural differences in the pattern of fixations occurring during the first 1.5 s or so of processing is congruent with the greatest part of the literature on cultural differences in visual attention suggesting a holistic/global bias as well as a broader allocation of attention in Easterners. Many studies have shown that eye movements are in part guided by top-down processes (e.g., Borji & Itti, 2014; DeAngelus & Pelz, 2009; Torralba, Oliva, Castelhano, & Henderson, 2006). In most of these studies, the eye movements were recorded and analyzed over periods much longer than actually required to process the visual information. Thus, even if the initial fixations occurring during face recognition are similar in Easterners and Westerners, the divergence occurring later on between both groups may indicate differences in how they have deployed their attention over the face or how they have encoded the stimuli.

Differences in how broadly the attention is allocated may be linked with culture somehow modulating the granularity of visual information used to resolve the task at hand. In fact, it has been shown that attending to the global structure of an object facilitates the processing of lower spatial frequencies (SF), whereas attending the local structure of an object facilitates the processing of higher SFs (Shulman & Wilson, 1987). Moreover, studies on the impact of attention on spatial resolution have shown that the narrower the attended space, the higher the resolution (Balz & Hock, 1997; Goto, Toriu, & Tanahashi, 2001). Thus, if Easterners allocate their attention over a face more broadly than Westerners, it should lead them to process information coded in lower SFs. Comparing the SFs used by both cultures may therefore offer a new alternative to verify if culture influences the visual strategies underlying face recognition. The direct comparison of SF tunings avoids the shortcomings inherent to the interpretation of eye fixations measurements, namely the imperfect correlation between gaze position and information utilization.

The present study compared the SFs used by Easterners and Westerners to succeed at recognizing faces. To the best of our knowledge, this is the first study to perform such a comparison. We used SF bubbles (Caplette, West, Gomot, Gosselin, & Wicker, 2014; Royer et al., 2016; Tadros, Dupuis-Roy, Fiset, Arguin, & Gosselin, 2013; Thurman & Grossman, 2011; Willenbockel, Bacon, Lepore, & Gosselin, 2013; Willenbockel, Fiset, et al., 2010; Willenbockel, Lepore, Nguyen, Bouthillier, & Gosselin, 2012). The method consists in randomly sampling the SF content of an image—in the present case a face—and measuring the performance of the participants—here, at recognizing faces—with these subsamples of SF. The underlying logic is that when the SFs used by the participant to correctly recognize a face are sampled, the probability of a correct response will increase, whereas when they are not sampled, the probability of a correct response will decrease. The method typically controls the total amount of SF information needed by the participant to maintain their accuracy level at a preselected performance threshold. This grants considerable flexibility and sensitivity in the link one can find between the SFs sampled and the performance. For instance, take the hypothetical case where both cultural groups use SFs between 3 and 30 cycles per face (cpf), but Easterners rely more on lower SF, located between 8 and 15 cpf, and Westerners rely more on medium-high SFs located between 13 and 20 cpf. The fact that the total amount of SF information available in the stimulus is manipulated to maintain performance at threshold will allow to reveal cultural differences in the relative reliance on different SFs: it will allow to reveal an increase of performance for both groups for SFs located between 3 and 30 cpf, but a higher increase for SFs located between 8 and 15 cpf for Easterners, and for SFs located between 13 and 20 cpf for Westerners. In that sense, the method proposed here offers a much precise way to reveal cultural differences than merely comparing the performance with low-pass and high-pass filtered faces. Moreover, because the method consists in randomly and continuously sampling the SF content of an image, it offers the major advantage that no arbitrary a priori decision needs to be taken regarding the cutoffs to be used in the SF filtering. This is particularly important in the context of studying cultural differences. In fact, an arbitrary and incorrect decision on the cutoffs could veil existing cultural differences. For instance, in the hypothetical case presented above, imagine that the performance of Easterners and Westerners is compared with stimuli low-pass filtered at 8 cpf and high-pass filtered at 32 cpf—typical cutoffs in the face recognition literature (used, e.g., by Goffaux & Rossion, 2006). The performance of both subject groups would be very similar with the two classes of stimuli because these cutoffs exclude the SFs they use differently. The SF filtering method employed in the present study overcomes these methodological difficulties, and allows to compare the relative use of SFs of Easterners and Westerners without making any a priori decisions regarding what range of SFs should be sampled. If culture impacts on the visual mechanisms underlying face recognition such that, as proposed based on late eye fixations (Blais et al., 2008), Easterners deploy their attention more broadly than Westerners, Easterners should be tuned toward lower SFs than Westerners. However, if culture does not impact on the visual mechanisms underlying face recognition, no difference in the SF tuning is expected.

Experiment 1

Method

Participants. Twenty-two Caucasian Canadian (8 men; mean age of 24; $SD = 4$) and 22 Asian Chinese (7 men; mean age of 19; $SD = 1$) participants completed the task. Chinese participants were tested in Hangzhou (Zhejiang province), were all born in China, lived in China and had little to no experience with occidental cultures. Participants from Canada were tested in Gatineau and Montreal (Quebec), were born in Canada or France, lived in Canada, and had little to no experience with oriental cultures. All Chinese and most (20 out of 22) Canadian participants were postsecondary students or had postsecondary education. The sample size was decided prior to experiment based on previous studies using the SF bubbles method (Royer et al., 2016; Willenbockel, Fiset, et al., 2010). All participants had normal or corrected-to-normal vision.

Materials and stimuli. All tasks were run on MATLAB with the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997). Caucasian face images were drawn from the Radboud (Langner et al., 2010), KDEF (Lundqvist, Flykt, & Öhman, 1998), and the Psychological Image Collection at Stirling (Hancock, 2008) databases, and Chinese face images were drawn from the CUFS (Wang & Tang, 2009) and from William Hayward's face database. All faces had a neutral facial expression. Accidental local features such as brown spots or rashes were removed using Photoshop. Faces were aligned as well as possible in the least-square sense on the positions of eyes, nose and mouth using translation, rotation, and scaling. They were revealed through a unique mask to hide external facial features such as hair and ears. Following the mask application, luminance and spatial frequency content were homogenized throughout face images using the SHINE toolbox (Willenbockel, Sadr, et al., 2010). Viewing distance was maintained constant using a chin rest. The face width subtended 6° of visual angle.

Stimuli were created with the SF bubbles method by randomly sampling the spatial frequencies of the faces on every trial. The steps involved in the creation of one stimulus are illustrated in Figure 1. First, the image was padded in order to reduce edge artifacts (Figure 1a). Second, a fast Fourier transform was applied to the padded stimulus (Figure 1b). Third, a smooth vector was created by generating a random vector of 10,240 elements consisting of *N* ones (representing the number of bubbles) among zeros (Figure 1c), and then convolving it with a Gaussian kernel that had a standard deviation of 1.5 elements (Figure 1d-1e). Fourth, the vector was log transformed so that the SF sampling

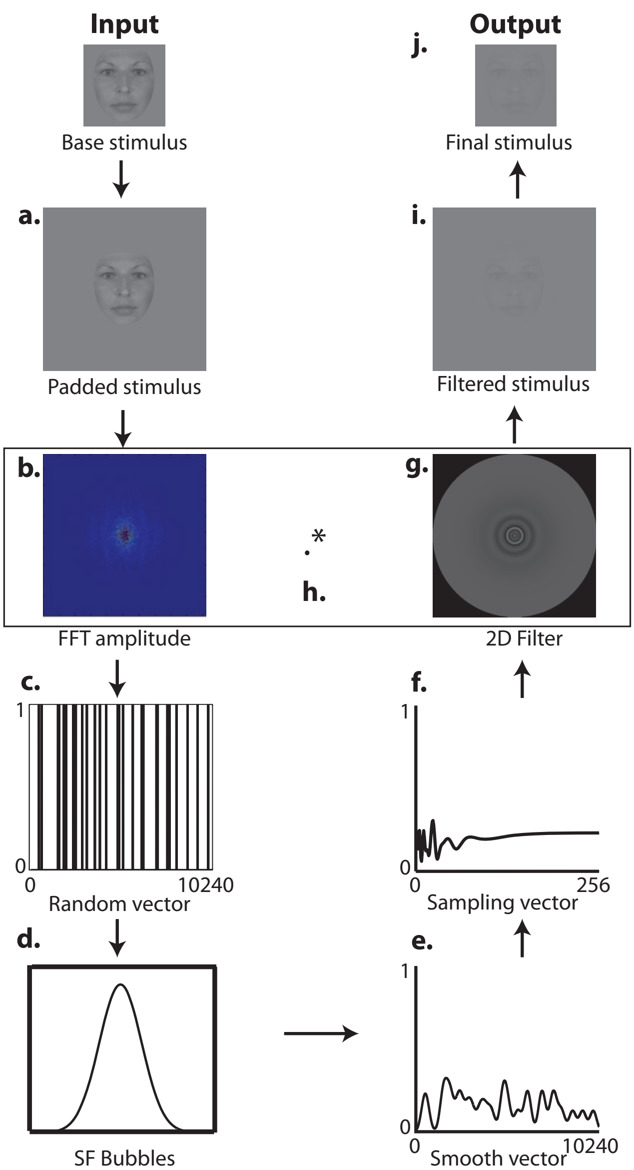

Figure 1. Example of the creation of one stimulus with the spatial frequency (SF) bubbles method. See the Method section for more details. See the online article for the color version of this figure.

approximately fits the SF sensitivity of the human visual system (Figure 1f; see De Valois & De Valois, 1988). The resulting vector, which contained 256 elements, was then rotated about its origin to create a two-dimensional isotropic SF filter (Figure 1g). A pointwise product of the Fourier transformed stimulus and the two-dimensional filter was performed (Figure 1h), and the result was submitted to an inverse fast Fourier transform (Figure 1i). The central part (256 × 256 pixels) of the resulting image consisted in the final stimulus on that trial (Figure 1j). Figure 2 provides more examples of stimuli produced with the SF bubbles method.

Procedure. All participants first learned a series of 16 faces: 8 Asian faces (4 men) and 8 Caucasian faces (4 men; see Figure 3). Each face identity was associated with a letter from the Latin alphabet; participants first learned the face-letter associations and practiced at identifying the faces, presented unaltered on a computer screen, by pressing on the appropriate keyboard keys. Faces were shown until a response was given, and feedback was provided following mistakes. All participants had to achieve at least a 95% accuracy rate in 100 trials for both ethnicities before continuing to the bubbles task.

The bubbles task was identical, except that faces were filtered as explained above, and no feedback was provided. Each participant performed 30 blocks consisting of 100 trials, alternating between blocks of Asian and Caucasian stimuli. For each participant, the same number of bubbles was applied across the two face ethnicities to equalize the amount of spatial frequency information revealed for both stimuli ethnicities. This decision renders possible the direct comparison of the SFs used by a participant with each face ethnicity, and the interpretation of any difference in the SF tuning as coming from differences in the relative reliance on SFs. The number of bubbles was adjusted using QUEST (Watson & Pelli, 1983) to achieve a 51% accuracy rate in the first block, using Asian faces, and thereafter the same number of bubbles was used with both face ethnicities in order to equalize the average energy available in both conditions.

The same block order—starting with Asian faces before alternating between blocks of the two ethnicities—was used for Chinese and Canadian participants in order to minimize methodological differences between the two cultures. Note that all participants had already practiced with faces of the two ethnicities before starting the bubbles task, and reached an accuracy of 95% with both face ethnicities. Thus, they already had equal familiarity with both face ethnicities, and always starting the first block with filtered Asian faces should not interact with the results. As we describe below, as well as in the online supplemental materials, the results suggest that it was indeed the case, as the pattern of cultural differences remains the same for both face ethnicities.

Results and Discussion

First, an independent *t* test was conducted on the number of bubbles necessary for the task for the Canadian participants (18.29 bubbles, $SD = 2.12$, 95% confidence interval [CI] [17.35, 19.23]) and the Chinese participants (18.84 bubbles, $SD = 1.86$, 95% CI [18.02, 19.67]). The number of bubbles reflects the quantity of spatial frequency information (and, as a result, the total amount of energy contained in the stimulus) needed by the participants. No significant difference on the number of bubbles was found, $t(42) = 0.919$; $p > .250$; Cohen's $d = -.276$; 95% CI [−0.66, 1.77].

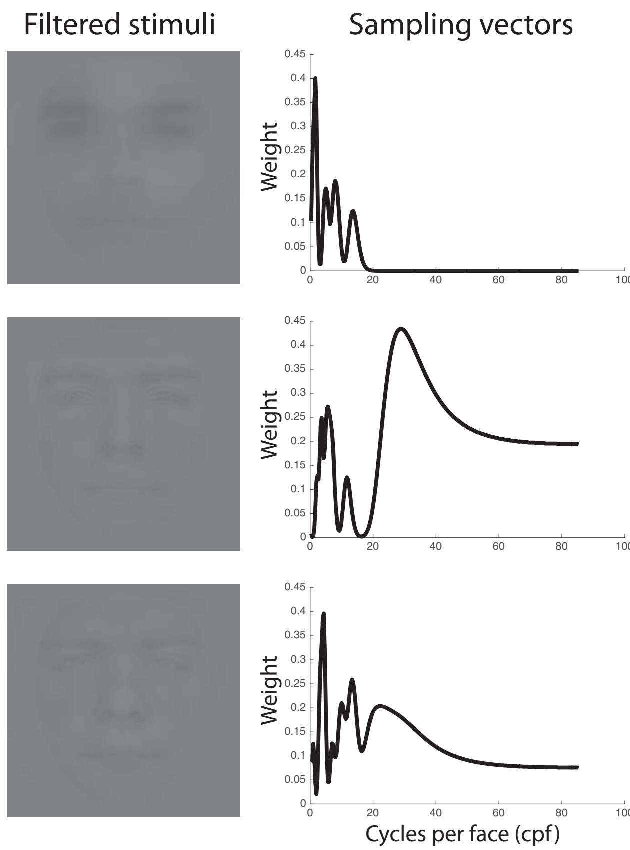

Figure 2. Examples of stimuli produced with the spatial frequency bubbles method. The final stimuli are presented on the first column, and the sampling vectors (i.e., see Figure 1f) that were used to filter the face are presented on the second column.

Across all trials, Chinese participants had an average accuracy rate of 56.2% (SD = 12.8%; 95% CI [50.5, 61.8]) with Asian face stimuli, and of 63.9% with Caucasian face stimuli (SD = 12.8%; 95% CI [58.2, 69.6]). Canadian participants had an average accuracy rate of 72.4% (SD = 11.7%; 95% CI [67.3, 77.6]) with Asian stimuli, and of 88.8% (SD = 7.2%; 95% CI [85.7, 92.0]) with Caucasian stimuli. As it was mentioned, the difficulty of the task was adjusted in the first block by adapting the number of bubbles. Participants' performance thus slightly changed after the first block, and it did so differently for Caucasian and Asian subjects. A 2 × 2 mixed analysis of variance (ANOVA) with the factors of participants' culture and stimulus ethnicity indicates the presence of an interaction effect between both factors on accuracy, $F(1, 42) = 12.95$; $p = .001$. Paired-samples t tests show that both Canadian and Chinese participants performed significantly better with Caucasian than with Asian face stimuli, Canadian participants: $t(21) = -8.59$; $p < .001$; Cohen's $d = -1.16$; 95% CI [−.204, −.124]; Chinese participants: $t(21) = -5.30$; $p < .001$; Cohen's $d = -0.61$; 95% CI [−.108, −.047]. The interaction effect indicates that the difference in accuracy rate across stimulus ethnicities was greater for Canadian participants; an own-race bias was present for these subjects. However, this bias was not observed in Chinese participants, although the difference in performance between the two face ethnicities was smaller than for Canadians.

The absence of own-race bias in our Chinese participants might have resulted from the fact that our Asian faces were more difficult to discriminate than our Caucasian faces. Unfortunately, selecting a small number of identities for each face ethnicity can occasion unexpected differences in the discriminability of the identities between the face sets. With this in mind, we conducted an ideal observer analysis with the aim of determining the difficulty of identification of the faces selected in the present study for both ethnicities. The ideal observer was an image matcher that correlated, on each iteration, the face it was supplied with to the other 7 face images of the same ethnicity. Noise was added to images to maintain the ideal observer's accuracy rate at 75%, using QUEST (Watson & Pelli, 1983) to adjust the signal-to-noise ratio. The ideal observer completed 15,000 trials with each facial ethnicity dataset. The results revealed that the ideal observer needed a higher signal-to-noise ratio when identifying faces from the Asian dataset (average face contrast of 0.27 in the last 5,000 trials) than the Caucasian dataset (average face contrast of 0.21 in the last 5,000 trials). This difference in the amount of signal required to achieve the same accuracy criterion may explain the absence of own-race bias for the Chinese participants. However, as will be explained below, it does not jeopardize the main conclusions of this study.

To evaluate the SF information used for the task, classification vectors were computed using a method that amounts to a multiple linear regression between accuracy and the unsmoothed SF filters on each trial. More specifically, for each participant and for each face ethnicity, the sum of the unsmoothed SF filters (i.e., the random vectors in Figure 1) that led to incorrect responses was subtracted from the sum of the unsmoothed SF filters that led to correct responses. This resulted in classification vectors in which the positive (vs. negative) values indicated the SFs that were associated with an increase (vs. a decrease) in the probability of responding correctly. The classification vectors were smoothed using a Gaussian kernel with a standard deviation of 2.1 elements. The classification vectors were then log transformed. Finally, they were transformed into z scores using a bootstrap procedure. Each individual classification vector represents the participant's SF tuning for Chinese and Caucasian faces.

We first verified if the SF tuning of our Chinese and Canadian participants interacted with the face ethnicity presented. For this, mixed 2 (cultures) × 2 (face ethnicities) ANOVAs were conducted on each point of the classification vectors of each culture and each face ethnicity. This provided us with F scores of the interaction between culture and face ethnicity for each SF point in the vector. The Pixel test from the Stat4CI toolbox (Chauvin, Worsley, Schyns, Arguin, & Gosselin, 2005)—which takes into account the multiple comparisons across the SFs—was then applied. No interaction was significant, all $ps > .250$; $\sigma = 2.1$; $F_{crit}(1, 42) = 15.15$; maximal $F = 4.48$. Group classification vectors were therefore computed for both face ethnicities combined by calculating t scores from the individual smooth classification vectors of all the participants within each cultural group. Applying statistical tests to t scores rather than z scores allows to take into account the variance within each group. They were calculated for each SF point from the z score of each participant for that point, resulting in a t score for each SF point, for each cultural group. Finally, the

Figure 3. Images of the eight learned identities of each ethnicity.

statistical significance of the resulting classification vectors was assessed by applying the Pixel test (Chauvin et al., 2005; $p < .025$; $\sigma = 2.1$; $t_{crit} = 3.89$). Note that classification vectors obtained separately for both face ethnicities are available in the online supplemental materials.

Figure 4 shows the classification vectors for Caucasian and Chinese participants, as well as the difference between the two cultures (i.e., Chinese minus Caucasian classification vectors). The result of the Pixel test shows that Chinese participants made a significantly greater use than Canadian participants of the SFs between 2.3 and 6.3 cpf, and Canadian participants made a greater use than Chinese participants of the SFs above 26.0 cpf.

Next, SF tuning peaks were calculated for each participant's classification vector using the 50% area spatial frequency measure (ASFM; Tadros et al., 2013). The ASFM corresponds to the SF point that splits the area under the curve and above the significance threshold in two equal parts. Note that for some participants (3 Canadian subjects), no SF information was above the significance threshold. In these cases, the raw maximum was used. For the Chinese participants, the ASFM peak of the SF tuning is found at an average of 11.3 ($SD = 1.52$) cpf and 9.1 ($SD = 0.68$) cpf for Chinese and Caucasian faces, respectively. For the Caucasian participants, the ASFM peak of the SF tuning is found at an average of 17.98 ($SD = 10.29$) cpf and 13.74 ($SD = 4.16$) cpf for Chinese and Caucasian faces, respectively. The peaks revealed for both cultures fall within the range of SFs that has previously been reported as critical for face recognition. Indeed, most studies have reported that SFs ranging from 8 to 20 cpf are given a higher weight during face identification (Gaspar, Sekuler, & Bennett, 2008; Näsänen, 1999; Peli, Lee, Trempe, & Buzney, 1994; Willenbockel, Fiset, et al., 2010).

A 2 × 2 mixed ANOVA with the factors of participants' culture and face ethnicity was conducted on the peaks of the individual SF tunings. The interaction between both factors was not significant, $F(1, 42) = 1.002$; $p > .250$; $\eta_p^2 = .023$, replicating the absence of interaction found in the previous analysis on the classification vectors. The main effects of culture was significant, $F(1, 42) = 13.60$; $p = .001$; $\eta_p^2 = .245$, indicating that the peaks of the Chinese participants are located in lower SFs than those of the Canadian participants. The main effect of face ethnicity was also significant, $F(1, 42) = 7.49$; $p = .009$; $\eta_p^2 = .151$, indicating peaks at higher SFs with Asian than with Caucasian faces. The cultural difference observed is unlikely to be due to the Asian faces comprised in our face sets being more difficult to discriminate from one another than the Caucasian faces. In fact, we conducted a separate analysis in which we reproduced the steps explained above, but using only the trials with four Caucasian faces and four Asian faces matched in difficulty across face ethnicity. This analysis showed that (a) there is still no interaction between participants' culture and face ethnicity on SF tuning, and (b) the cultural difference in SF tuning remains, that is, Chinese participants are tuned toward lower SFs than Canadian participants. It is interesting to note that the main effect of face ethnicity does not remain: participants from both cultures are not tuned toward higher SFs for

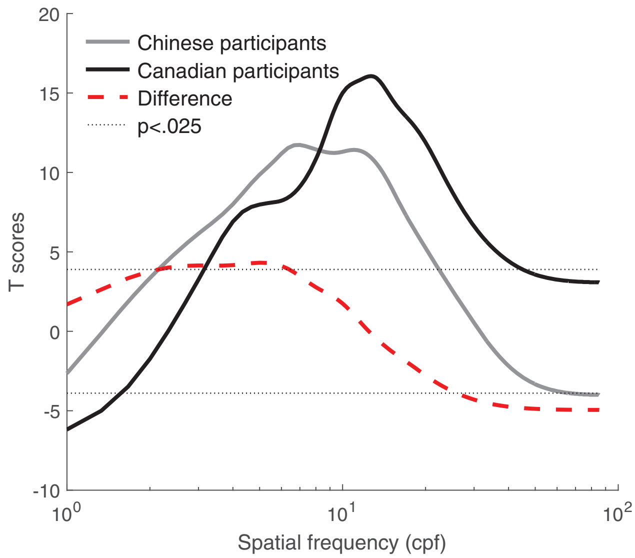

Figure 4. Classification vectors representing the spatial frequencies used by Chinese and Canadian participants, averaged across both face ethnicities. See the online article for the color version of this figure.

Asian faces when face difficulty is matched (see online supplemental material for more detailed explanations).

As mentioned earlier, the overall accuracy of the Chinese and Canadian participants was different (i.e., Chinese participants had a lower accuracy). Further analyses of our data suggest that the cultural differences observed in the SF tuning were not driven by accuracy differences. First, we correlated accuracy with individual classification vector ASFM peaks, separately for each cultural group. If the cultural difference revealed above was indeed due to differences in accuracy, we should observe a positive correlation between accuracies and ASFM peaks, whereby the higher the accuracy, the higher the ASFM peak. No correlation reached significance (Chinese participants: $r = .261$; $p = .241$; Canadian participants: $r = .098$; $p > .250$). Furthermore, we matched subgroups of 10 participants in accuracy rate—10 Chinese participants: $M = 71.3\%$; $SD = 7.1\%$; 10 Canadian participants: $M = 72.4\%$; $SD = 4.6\%$; $t(18) = -.441$; $p = .664$—and, still, in these matched subgroups, the ASFM peaks of the classification vectors were located at higher spatial frequencies for Canadian subjects ($M = 15.70$ cpf; $SD = 4.85$) than for Chinese subjects, $M = 11.20$ cpf; $SD = 4.62$; $t(18) = -2.124$; $p = .048$.

In summary, Experiment 1 shows that Chinese and Canadians participants use a different range of SFs when identifying faces. Canadian participants make a greater use of relatively higher SFs and Chinese participants, of relatively lower SFs. This effect is shown with Asian as well as with Caucasian faces, and it cannot be explained by differences in face set difficulty.

Experiment 2

The results of Experiment 1 suggest that culture alters the nature of visual information used in a face identification task. A task in which a small number of faces are repeatedly presented to the participant, although typical in face processing studies using psychophysical methods such as the one used here, comes with the downfall that participants may develop atypical strategies in which they rely on specific details in order to discriminate faces from one another. Experiment 2 was designed to test if the differences observed in Experiment 1 can be generalized to another face recognition task. More specifically, a familiarity task was used, which is more akin to the day-to-day task of recognizing someone familiar on the street, among unfamiliar individuals.

Method

Participants. Fifteen Caucasian Canadian (6 men; mean age of 22; $SD = 3$) and 15 Asian Chinese (4 men; mean age of 19; $SD = 1$) participants completed Experiment 2. Among these participants, six Canadian and 14 Chinese participants had also taken part in Experiment 1. All Chinese participants and 14 out of 15 Canadian participants were postsecondary students or had postsecondary education. Participants who also participated in Experiment 1 completed Experiment 2 beforehand. As in Experiment 1, Chinese participants were both tested and born in China, and Canadian participants were tested in Canada, but were born either in Canada or France. All participants had normal or corrected-to-normal vision.

Materials and stimuli. The same software as in Experiment 1 was used. Face stimuli were drawn from the same face database, and were prepared following the same procedure as in Experiment 1. Including the set of faces that were used in Experiment 1, the database comprised 130 Caucasian and 130 Asian faces. These faces were randomly filtered according to the requirements of the SF bubbles technique exactly as in Experiment 1. Viewing distance was maintained constant using a chin rest. The face width subtended 6° of visual angle.

Procedure. All participants first learned the 16 identities used in Experiment 1 (see Figure 3). The learning phase was done in the same way as Experiment 1. All participants achieved at least a 95% accuracy rate for both ethnicities before continuing to the SF bubbles task. Participants who also participated in Experiment 1 obtained a 95% accuracy rate before starting Experiment 1 as well as before starting Experiment 2.

In the second phase of the experiment, the faces learned in the learning phase were labeled as "friends," and the participant received the instruction of indicating whether faces presented on the center of the computer screen were part of the "friends" set or not, using two different buttons on the keyboard. "Friends" and "new" faces were each presented on half trials, in a random order. Each participant completed 30 blocks consisting of 100 trials, alternating between blocks of Asian and Caucasian stimuli. All participants began with Asian face stimuli. The number of bubbles was adjusted using QUEST (Watson & Pelli, 1983) to achieve a 65% accuracy rate in the first block only, for the reasons given in the Procedure section of Experiment 1.

Results and Discussion

First, an independent *t* test was conducted on the number of bubbles necessary for the task for the Canadian participants (20.45 bubbles, $SD = 4.52$, 95% CI [17.95, 22.96]) and the Chinese participants (24.07 bubbles, $SD = 3.83$, 95% CI [21.95, 26.19]). Chinese participants needed a larger number of bubbles to complete the task, $t(28) = 2.367$; $p = .025$; Cohen's $d = -.86$; 95% CI [0.49, 6.75].

Accuracy for Chinese participants was of 63.2% (SD = 2.6%) for Asian faces, and of 63.3% (SD = 5.2%) for Caucasian faces. For Canadian participants, it was, respectively for Asian and Caucasian faces, of 66.8% (SD = 4.5%) and 76.5% (SD = 6.7%). A mixed ANOVA revealed an interaction between face ethnicity and participants' culture, $F(1, 28) = 30.91$; $p < .001$; $\eta_p^2 = .53$. Paired-samples t tests between Asian and Caucasian faces revealed an own-race bias for Canadian participants, $t(14) = -6.7$; $p < .001$; Cohen's $d = 1.7$; 95% CI [−.13, −.07], but not for Chinese participants, $t(14) = -0.106$; $p = .917$.

We performed the same analyses as in Experiment 1 to evaluate the SF information used for this task. Only trials containing learned faces were analyzed to reveal the SFs used to recognize a face. Classification vectors were first computed for each cultural group and each face ethnicities. Similarly to Experiment 1, point-wise mixed 2 (cultures) × 2 (face ethnicities) ANOVAs followed by a Pixel test were conducted on the classification vectors in order to verify if there was an interaction between culture and ethnicity on the SF utilization. The interaction between face ethnicity and participants' culture was not significant, $\sigma = 2.1$; $F_{crit}(1, 28) = 16.70$; maximal $F = 11.81$. Group classification vectors were therefore computed for both face ethnicities combined by calculating t scores from the individual smooth classification vectors of all the participants within each cultural group. The SF tunings obtained independently with each face ethnicity are provided in the online supplemental material. Figure 5 shows the classification vectors for Caucasian and Chinese participants, as well as the difference between the two cultures. The statistical significance of the resulting classification vector of difference was assessed by applying the Pixel test (Chauvin et al., 2005; $p < .025$; $\sigma = 2.1$; $t_{crit} = 3.89$). The result of the Pixel test shows that Canadian participants made a significantly larger use than Chinese participants of the SF band ranging from 16.33 to 28.67 cpf. In this task, Chinese participants did not make a significantly higher use of low SFs as was observed in Experiment 1, despite a trend in this direction.

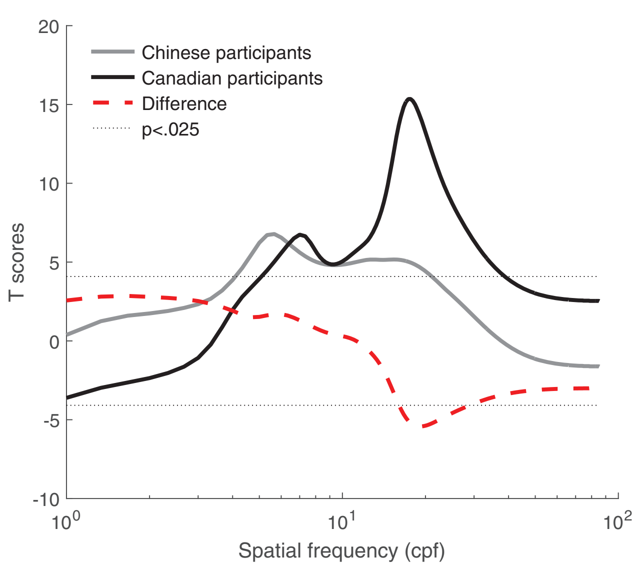

Figure 5. Spatial frequency use by Canadian and Chinese participants for both face ethnicities, in Experiment 2. See the online article for the color version of this figure.

Critically, a mixed 2 (cultures) × 2 (face ethnicities) ANOVA on the ASFM individual classification vector peaks indicates that they are located at lower SFs for Chinese participants, $F(1, 28) = 14.278$; $p = .001$; $\eta_p^2 = .338$. Canadian participants' ASFM peaks were at an average of 20.44 cpf (SD = 7.02) for Asian faces, and 16.84 cpf (SD = 10.82) for Caucasian faces. Chinese participants had ASFM peaks at an average of 9.44 cpf (SD = 5.86) and 9.20 cpf (SD = 3.63) respectively for Asian and Caucasian faces. The main effect of face ethnicity was not significant, $F(1, 28) = 3.55$; $p = .07$, although there was a trend in the same direction as the one observed in Experiment 1 (i.e., an utilization of higher SFs with Asian faces). Face ethnicity did not interact with the participants' culture, $F(1, 28) = 2.71$; $p = .111$.

We conducted the same analysis as in Experiment 1 to ascertain that our results were not driven by the accuracy differences in the two cultural groups. Indeed, none of the correlations between accuracies and ASFMs peaks reached statistical significance (Chinese participants: $r = .252$; Canadian participants: $r = -.102$; both $ps > .250$). Because the number of bubbles differed between the two cultural groups, we also verified that none of the correlations between number of bubbles and ASFM peaks reached statistical significance (Chinese participants: $r = -.002$; Canadian participants: $r = .098$; both $ps > .250$). We also matched subgroups of 9 participants on accuracy rate, 9 Chinese participants: M = 65.5%; SD = 2.6%; 9 Canadian participants: M = 66.3%; SD = 5.9%; $t(16) = -.363$; $p = .724$. Note that the number of participants included in the subgroups was chosen to respect two criteria: (a) include as many participants as possible, and (b) minimize the difference in accuracy rates, thereby the different number of participants included in the subgroups created in Experiments 1 and 2. Once again, the ASFM peaks of individual classification vectors were located at higher spatial frequencies for Canadian subjects (M = 22.04 cpf; SD = 10.65) than for Chinese subjects, M = 11.15 cpf; SD = 4.94; $t(16) = -2.783$; $p = .013$, in these matched subgroups. Note that the cultural difference in number of bubbles was not statistically significant between these subgroups, Chinese: M = 23.6; SD = 4.4; Canadian: M = 20.7; SD = 4.8; $t(16) = -1.348$; $p = .197$. It is therefore unlikely that performance was a factor that influenced the SF usage cultural differences uncovered here.

In summary, Experiment 2 revealed a pattern of results similar to the one observed in Experiment 1. The analysis on the ASFM peaks shows that Canadian participants are tuned toward higher SFs compared with Chinese participants. The analysis on the classification vectors replicates the finding of Experiment 1 showing that Canadian participants make a greater use of midhigh SFs to recognize familiar faces. However, it does not replicate the higher utilization of low SFs by Chinese participants, although there is a trend in this direction. It is probable that this difference between Experiments 1 and 2 stems from the lower number of participants and smaller number of trials (only trials with familiar faces were analyzed), which lead to noisier classification vectors. In fact, the t scores are generally lower in Experiment 2 compared with Experiment 1, but the general pattern of results reveals a higher—although not statistically significant—utilization of low SFs by Chinese than by Canadians.

Another possibility, however, is that the difference comes from the different tasks used. Experiment 1 involved explicitly identifying a face, Experiment 2 a familiarity judgment. It has been proposed that familiarity judgments and face identification may rely on different processes (Hintzman & Curran, 1994; Mandler, 1980; Rugg & Yonelinas, 2003; Smith, Volna, & Eming, 2016). Thus, it may be that familiarity judgments and face identification rely on the processing of slightly different SFs, and that the cultural difference on the SF tuning manifests itself only for higher SFs.

Experiment 3a

A possible explanation for the finding that Asian and Caucasian participants exhibit different SF tuning during face recognition is that they have different low-level contrast sensitivities to sinusoidal gratings of different SFs or, put more succinctly, that they have different contrast sensitivity functions. There is no convincing evidence in the literature of any discrepancies between the contrast sensitivity functions of Caucasian (e.g., Campbell & Robson, 1968) and of Asian observers (e.g., Zhou et al., 2006). However, these studies were carried out with different methodologies. The goal of Experiments 3a and 3b is to compare the contrast sensitivity functions of Asian and Caucasian observers with the same methodologies.

Method

Participants, materials, and stimuli. The same participants that took part in Experiment 1 also completed the contrast sensitivity function task. The stimuli consisted in sinusoidal gratings of six different SFs: 0.5, 1, 2, 4, 8 and 16 cycles per degree (cpd). They were revealed through a Gaussian window with a full width at half maximum equals to 2° of visual angle. Noise-bit dithering was applied to every stimuli (Allard & Faubert, 2008). Viewing distance was maintained constant using a chin rest.

Procedure. The method of limits was used to estimate contrast thresholds. Each of the 6 spatial frequency gratings was presented 10 times, in a random order, in the middle of the screen. On half of the trials with each SF, the contrast adjustment was ascending and on the other half, it was descending. The participants slowly adjusted the contrast using a button on the keyboard and indicated, using another button, when the threshold was reached (i.e., in ascending trials, the point at which they start perceiving the stimulus; in descending trials, the point at which disappearance of the stimulus is perceived). Possible Michelson contrast values varied between 0.1% and 20% in discrete steps of 0.1%.

Results and Discussion

For each remaining participant, a mean of the contrast threshold estimates was calculated for each SF tested, from both ascending and descending trials. A log-parabola was fitted on the sensitivity values (sensitivity = 1/contrast) using the Trust region algorithm implemented in the Curve Fitting Toolbox by MathWorks. The log-parabola is often used to describe the contrast sensitivity function, and is defined by only 3 parameters (e.g., Chung, Legge, & Tjan, 2002):

$$\log(y) = \log(y_{max}) - \frac{4}{\log(2)\beta^2}(\log(x) - \log(f_{max}))^2$$

The first two parameters define the peak of the function: y_{max} is the highest sensitivity, and f_{max}, the SF at which this highest sensitivity is reached. The third parameter, β, represents the full width at half maximum of the function in octaves. It is a good indicator of how narrowly (or widely) tuned the visual system is to the peak SF.

If the results from Experiments 1 and 2 were the consequence of low-level differences in SF sensitivity, we would expect the contrast sensitivity function of Canadian participants to be skewed toward higher SFs compared with that of the Chinese participants. In other words, we would expect f_{max} to be higher for Canadian than for Chinese participants. What to expect for the other two parameters is less straightforward and less important. Indeed, if f_{max} does not differ between the two cultures, neither differences in y_{max}, nor differences in β could explain the results of Experiments 1 and 2. That being said, in Experiment 1 and 2, we noticed that Canadian participants performed better than Chinese participants with the same amount of SFs, which suggests that the former may be associated with greater y_{max}—are more sensitive—than the latter.

We excluded 11/22 Chinese and 7/22 Canadian participants from the analyses because the log-parabola fitted poorly their contrast sensitivities ($r^2 < .55$). (Note that the main results of Experiment 1 remain the same with the participants included in the current analyses: an ANOVA performed on their ASFM peaks in Experiment 1 indicates a significant main effect of culture, $F[1, 24] = 5.333$; $p = .030$; $\eta_p^2 = .182$.) Canadian and Chinese participants did not differ significantly on f_{max}, (Chinese participants: $M = 4.58$, $SD = 1.83$ cpd; Canadian participants: $M = 4.10$, $SD = 2.81$ cpd; $t(24) = 0.494$; $p > .250$). Canadian participants were associated with greater y_{max}, (Chinese: $M = 316.06$, $SD = 151.94$; Canadian: $M = 448.90$, $SD = 112.90$; $t(24) = -2.562$; $p = .017$; Cohen's $d = -.992$), and with greater β, (Chinese: $M = 3.48$, $SD = .60$; Canadian: $M = 4.68$, $SD = 1.80$; $t(17.93) = -2.120$; $p = .027$; Cohen's $d = -.894$), than Chinese participants.

In sum, Experiment 3a suggests that the contrast sensitivity functions of the two cultural groups cannot explain the findings that Canadian participants make a greater use of midhigh SFs to recognize familiar faces and that Chinese participants make a greater use of lower SFs to do the same.

Experiment 3b

A weakness of Experiment 3a is the utilization of a *subjective* psychophysical method to measure the contrast sensitivity function of the two cultural groups. On every trial there was a target present and, therefore, there were no objective correct or incorrect responses. Subjective methods are vulnerable to response biases. An observer could be very conservative and always respond that a grid is invisible unless it's absolutely obvious, whereas another observer could be more liberal and willing to respond that a grid is visible even when the evidence is weak. Response biases are believed to depend on relatively high-level cognitive processing. They could explain, at least partly, why the log-parabola fitted so poorly the sensitivities of so many observers. In Experiment 3b, we evaluated the contrast sensitivity function of Canadian and Chinese participants using an *objective* method.

Method

Participants. Eight Caucasian Canadian and 8 Asian Chinese participants completed the study. All participants were newly recruited and did not take part in any of the previous experiments. Canadian participants were all tested in Montreal, Quebec, and Chinese participants, in Hangzhou, Zhejiang. The two groups were matched in gender (7 women in each group) as well as age, Chinese participants: 18 to 24 ($M = 20.37$; $SD = 2.26$), and Canadian participants: 18 to 23 ($M = 20.37$; $SD = 1.51$).

Participants, materials, and stimuli. The stimuli consisted in sinusoidal gratings of seven SFs: 0.5, 0.99, 1.96, 3.87, 7.66, 15.16, and 30 cycles per degree. As in Experiment 3a, they were revealed through a Gaussian window with a full width at half maximum equal to 2° of visual angle and noise-bit dithering was applied to every stimuli (Allard & Faubert, 2008). Viewing distance was maintained constant using a chin rest.

Procedure. The method of constant stimuli was used to estimate contrast thresholds. Participants were asked to press on different keyboard buttons when the orientation of the grating was horizontal or vertical. Orientation was determined randomly for each trial. This task is objective because on every trial there is a correct response. Contrast was independently adjusted for each SF using QUEST (Watson & Pelli, 1983) to achieve a correct response rate of 82%. The initial contrast threshold estimates were determined using the Gabor data from ModelFest (Carney et al., 1999). Each participant completed 252 trials in blocks of 84 trials. Each SF was therefore repeated 36 times for each subject.

Results and Discussion

For each participant, the final contrast threshold estimates were transformed into contrast sensitivities and fitted with a log-parabola. One Chinese participant was excluded from the remaining analyses because the log-parabola fitted poorly his contrast sensitivity estimates ($r^2 < .55$). We did not find a significant difference on f_{max} between the two cultural groups, Chinese: $M = 3.48$, $SD = .79$; Canadian: $M = 3.23$, $SD = .26$; $t(13) = .863$; $p > .250$; Cohen's $d = .085$. However, y_{max} (Chinese: $M = 127.45$, $SD = 30.00$; Canadian: $M = 292.77$, $SD = 76.00$; $t(9.369) = -5.669$; $p < .001$; Cohen's $d = -2.861$) was greater for Canadian than for Chinese participants, and β (Chinese: $M = 3.66$, $SD = .27$; Canadian: $M = 2.95$, $SD = .27$; $t(13) = 5.041$; $p < .001$; Cohen's $d = 2.630$) was greater for Chinese than for Canadian participants. In sum, results from Experiment 3a and 3b do not support the hypothesis that different sensitivity tunings underlie cultural differences in SF utilization during face processing.

General Discussion

The dominant hypothesis in the field of cultural differences in visual attention proposes that Easterners attend to their visual world more holistically, and allocate their attention more broadly, than Westerners (Nisbett et al., 2001; Nisbett & Miyamoto, 2005). The first series of studies assessing cultural differences in the visual mechanisms underlying face recognition was consistent with that hypothesis (Blais et al., 2008; Caldara, Zhou, & Miellet, 2010; Kelly et al., 2011; Miellet et al., 2012, 2013; Rodger et al., 2010): it revealed a higher density of eye fixations on the eyes and mouth by Westerners than Easterners, suggesting that Easterners allocate their attention more broadly than Westerners during face processing. However, a recent study has shed doubt on that interpretation by showing that Easterners and Westerners do not differ on the location of their first two fixations (Or et al., 2015), which have been shown as being sufficient for face recognition (Hsiao & Cottrell, 2008). Thus, it was proposed that the cultural differences observed in fixations following the two initial ones may not be linked to cultural differences in the visual mechanisms underlying face processing per se but, rather, to socially acceptable duration of eye contact (Or et al., 2015).

However, eye movements are slower than attention (Carpenter, 1988), and can sometimes be dissociated from attention (Arizpe et al., 2012), so cultural differences in the visual information extracted may exist despite similar early fixations. The present study directly compared the visual information used by Chinese and Canadian participants to process faces. In two face perception tasks, the results clearly show an influence of culture on SF tuning: Chinese participants are tuned toward lower SFs than Canadian participants. To the best of our knowledge, it is the first time that cultural differences have been found at such early processes in spatial vision. Furthermore, our measures of the contrast sensitivity function in Experiments 3a and 3b do not support the hypothesis that these results stem from low-level visual differences. As explained in the Introduction, the space over which visual attention is deployed has been shown to modulate SF utilization: sensitivity to high SFs is higher when attention is spread over a narrow than over a broad space (Goto et al., 2001). The present finding of a higher reliance on high SFs by Westerners than Easterners is thus consistent with the hypothesis that Easterners deploy their attention more broadly than Westerners during face processing.

A low SF bias in Easterners is in fact the result that was predicted, based on the fixation bias of Easterners and Westerners during the first 1.5 s or so of processing (Miellet et al., 2013), if one assumes that these fixations reflect the attentional and cognitive processes underlying face recognition even though they are not necessary for recognition. Indeed, during that period of processing time, Easterners spend less time foveating the main facial features than Westerners (Blais et al., 2008), while still needing this information to succeed at identifying faces (Caldara et al., 2010). Moreover, Miellet et al. (2012) have shown that Easterners have a tendency to process facial information extrafoveally. Because high SFs are more difficult to process outside of the fovea (Hilz & Cavonius, 1974; Thibos, Still, & Bradley, 1996), the finding that Easterners rely more on low SFs, and less on high SFs, than Westerners is consistent with the cultural differences previously observed in eye fixation patterns.

Although the main aim of the present study was to assess cultural differences in the visual mechanisms underlying face recognition, the design also allowed to test if the so-called other-race effect is linked to differences in the SF processing of own- and other-race faces. The other-race effect refers to the finding that identification tends to be more accurate for faces of members of subjects' own race than for faces of members of other races (Lindsay, Jack, & Christian, 1991). Different theories have been proposed to explain this effect, that can be put in two main categories: perceptual expertise theories, according to which expert perceptual mechanisms do not develop with other-race faces because of a lack of exposure; and social–cognitive theories, according to which a weaker performance with other-race faces is observed because of a lack of motivation to individuate other-race faces (for a review, see Young & Hugenberg, 2012). Among the perceptual expertise theories, some propose differential perceptual processing for own and other-race, whereby the expert mechanism underlying own-race face recognition (holistic processing) is inefficient with other-race faces, leading them to being mostly processed analytically (Michel, Caldara, & Rossion, 2006; Michel, Rossion, Han, Chung, & Caldara, 2006; Rhodes, Brake, Taylor, & Tan, 1989; Tanaka, Kiefer, & Bukach, 2004). It is interesting to note that the holistic perceptual strategy is believed by some authors to rely on the processing of lower SF information (e.g., Goffaux & Rossion, 2006; see however: Cheung, Richler, Palmeri, & Gauthier, 2008; Gaspar et al., 2008; Royer et al., 2016; Willenbockel, Fiset et al., 2010). Thus, the hypothesis that own-race faces are processed holistically, and that other-race faces are processed analytically, would predict, in our study, an interaction between participants' culture and face ethnicity. More specifically, it would predict a shift toward lower SFs when Canadian process Caucasian faces compared with when they process Asian faces; and a shift toward lower SFs when Chinese process Asian faces compared with when they process Caucasian faces. The results of the Experiments 1 and 2 did not support this hypothesis. Indeed, we found no interaction between participants' culture and face ethnicity, and this was true for both face recognition tasks. However, the absence of an interaction in the SF tuning observed here should be interpreted with caution. An ideal observer analysis revealed that the Asian faces selected in the present study were more similar from one another than the Caucasian faces. This may have hindered a shift toward lower SFs in Chinese participants with Asian faces. How the other-race effect is linked with the SF utilization during face recognition should therefore be the focus of other studies.

One question arising from the present results is whether the impact of culture on SF utilization generalizes to other object recognition tasks. In fact, as stated in the Introduction, most of the literature on cultural differences in visual attention points toward a tendency of Easterners to process their environment in a holistic manner and of Westerners to process it in an analytic manner (Nisbett & Miyamoto, 2005). Moreover, results indicating different breadth of attention in Easterners and Westerners, including the ones in the present study, have been obtained using different experimental paradigms, suggesting that they are generalizable. However, the higher ability of Easterners to use extrafoveal visual information in other tasks than face processing remains a matter of debate. For instance, Miellet et al. (2012) have shown that in a visual search task, Easterners and Westerners present comparable performance when forced to use extrafoveal visual information by masking central vision. Congruently with the results of the current study, it suggests that any differences in SF utilization come from a difference of strategies or representations instead of a difference in abilities to process extrafoveal and/or low SFs per se. Future studies should therefore compare the utilization of SFs by both cultures during the processing of other categories of stimuli than faces, as well as in different kinds of tasks, in order to better understand when and how culture impacts visual processes.

Conclusion

In the last few years, many studies have highlighted the impact of culture on scene and face processing. The present study goes further by showing that culture modulates the nature of the visual information which is processed during face recognition tasks, but that it does not shape processes as basic as the sensitivity to different SFs. Thus, cultural differences begin to affect visual processing somewhere between V1 and the specialized face processing cortical areas. Further studies will allow to specify when, in the visual pathway of information extraction, do cultural differences begin to affect processing.

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