Culture Shapes Face Processing

Caroline Blais and Roberto Caldara

Oxford Handbook of Cultural Neuroscience and Global Mental Health
Edited by Joan Y. Chiao, Shu-Chen Li, Robert Turner, Su Yeon Lee-Tauler, and Beverly A. Pringle

Print Publication Date: Dec 2021 Subject: Psychology, Clinical Psychology
Online Publication Date: Mar 2022 DOI: 10.1093/oxfordhb/9780190057695.013.16

Abstract and Keywords

Cross-cultural studies have revealed striking differences in visual perception. Recent research has shown that even processes that have long been assumed to be universal, such as face processing, are in part shaped by the cultural environment in which one has grown up. This chapter gives an overview of the main findings with regard to the impact of culture on the visual processes involved in face identification and facial expression recognition. The chapter also discusses neurological conditions affecting face perception and how culture may interact with these conditions to modulate visual perception.

Keywords: culture, face recognition, facial expressions, visual perception, eye movements, psychophysics

Introduction

As with globalization multiculturalism increases in our contemporary societies, we are confronted with the ethical responsibility of developing a health system that should ideally take into account all sorts of variations across human beings. Some of these individual differences are obvious. For instance, it is well established that gender influences the response to some medications (e.g., Bergiannaki & Kostaras, 2016; Ohlsen & Pilowsky, 2007). Culture and ethnicity also play a critical role in modulating health issues (e.g., Yuan et al., 2005). However, what is much less obvious is the impact of culture on how individuals perceive their world, and how this may affect not only their approach to health (e.g., Gupta, 2010), pain (e.g., Edwards et al., 2001; Hsieh et al., 2010) and the health system in general (e.g., Pavlish et al., 2010; Sheikh & Furnham, 2000), but also the effectiveness and appropriateness of the treatments they receive (Fiscella et al., 2000).

Research in psychology has revealed that one's perception of the world is deeply influenced by cultural learning. Evidence of cultural influences span from complex, high-level psychological processes, such as how one interprets someone else's behavior (Choi et al., 1999; Morris & Peng, 1994) or makes important life decisions (Levine et al., 1995), to basic perceptual processes, such as the visual information on which one relies to process faces (Blais et al., 2008; Caldara et al., 2010; Tardif et al., 2017; for a review see Caldara,

(p. 310) 2017), objects (Gutchess et al., 2006; Kelly et al., 2010; Paige et al., 2017), or simple visual arrays (Ueda et al., 2018).

With regard to face perception, research has so far focused on characterizing the cultural differences in the behavior and brain processes of normal individuals. However, deficits of face perception are observed in many neurological conditions, and how culture interacts with these conditions to modulate visual perception remains unknown. The present chapter will first provide an overview of the research on cultural differences in visual perception in general, and face perception in particular, as well as the potential sources for these differences. Then we will review some neurological conditions affecting face processing for which knowledge gathered so far suggests that treatments may benefit from being tailored to the individual's culture.

Cultural Differences in Visual Perception

The last few decades of research have led to evidence supporting the idea that the same visual stimulation is not perceived in the same way by all observers; in particular, culture has been shown to deeply affect visual processes (Caldara, 2017; Chen & Jack, 2017; Nisbett et al., 2001). A large part of the studies assessing the impact of culture on visual perception has compared individuals from East Asia (mainly from China, South Korea and Japan) with Westerners. This may be explained by a methodological issue: to assess the universality of a process, it is necessary to compare very different populations with regard to culture while controlling for the level of education, because the latter may affect the interpretation of instructions (Heine, 2015). Easterners and Westerners adhere to very different systems of values (Hofstede, 1991; Nisbett et al., 2001) but have similar systems of education. Thus, the present chapter will mostly focus on face processing studies comparing Easterners and Westerners, research in other populations is still cruelly lacking.

The cultural differences highlighted so far in visual perception may be grouped around three main categories of findings: (a) when processing a visual scene, Easterners attend to the context/background more than Westerners, and Westerners attend more to the focal objects of the scene than Easterners (Chua et al., 2005; Masuda et al., 2008; Masuda & Nisbett, 2001; but see Miellet et al., 2010); (b) Easterners process visual stimulations in a more global manner than Westerners (McKone et al., 2010; Nisbett & Miyamoto, 2005); and (c) Easterners deploy their visual attention over a larger area of their visual field than Westerners (Boduroglu et al., 2009; Boduroglu & Shah, 2017; Miellet et al., 2013; Tardif et al., 2017).

Attention to Context Versus Focal Objects

A seminal study by Masuda and Nisbett (2001) has revealed that when asked to describe a visual scene, Easterners describe more of the background than Westerners. Most interestingly, when presented with focal objects of the previously viewed scenes, the ability of Easterners to remember these objects depended on the background on which (p. 311) they were presented. More specifically, their performance dropped when the objects were presented over a new background. Crucially, this drop in performance was not observed for Westerner observers. The authors of that study concluded that Easterners encode focal objects in memory by binding them to the context in which they were perceived, whereas Westerners encode objects in memory separately from their context.

This conclusion was later extended by showing that not only memory-encoding processes are affected by culture, but also the final percept per se (Masuda et al., 2008). In fact, when Easterners have to judge the facial expression of a focal individual surrounded by other expressive individuals, their affective evaluation is more affected by the expression of the surrounding individuals than the Westerners. Interestingly, only ocular fixations occurring later than 1 second after stimulus onset differed in both cultural groups, which led the authors to conclude that the differences observed reflected late decisional processes rather than early perceptual processes. However, the ocular fixation pattern was averaged over 1-second periods, which decreased the temporal resolution of the results. In contrast, a study assessing the ocular fixations of Easterners and Westerners while they viewed natural visual scenes revealed cultural differences as early as 420 ms (Chua et al., 2005). Moreover, as will be discussed in more detail in the section "Cultural Differences in Face Identification", eye movements alone do not provide a complete picture of visual information processing. In fact, differences in late ocular fixation patterns may reflect earlier differences in covert attention (Estéphan et al., 2018; Tardif et al., 2017). Thus, the processing stage at which the background affects the foreground perception in Easterners is worth further investigation.

A higher tendency for Easterners than for Westerners to bind the background with focal objects was also observed with simpler visual stimulation. For instance, in the Rod and Frame test (Witkin et al., 1954), in which one has to judge the orientation of a "rod" (depicted as a line) independently of the frame (depicted as a square) in which it appears, Easterners are more affected than Westerners by the frame's orientation (Ji et al., 2000). In a similar vein, Easterners show more difficulty at inhibiting the context in the absolute version of the Frame-Line test (Kitayama et al., 2003; but see Zhou et al., 2008). The absolute version of that test consists in adjusting the length of a line inside a square such that it is of equal length with a previously viewed line appearing inside a square of different size. To perform accurately in such a task, one needs to process the line independently from the square in which it appears. Thus, evidence so far suggests that Easterners and Westerners differ in the degree to which they attend to the context of a visual scene and integrate this context with the objects it contains. Further evidence for such cultural perceptual bias has been recently found for a famous visual search problem parametrically varying in difficulty: *Where's Waldo* (Lüthold et al., 2018). East Asian observers were significantly much more impaired than Western Caucasian observers for finding Waldo, despite all observers having a comparable level of familiarity with the vignettes. Interestingly, Easterners showed a peculiar and systematic eye movement (p. 312) strategy consisting in returning more often to previously visited locations compared to Westerners. This suboptimal eye movement strategy in the Easterners might arise from their perceptual bias in using more extra-foveal information, which impaired the visual search for Waldo. Overall, this subtle perceptual difference shows that the processing of active visual search in scenes is modulated by the culture of the observer.

Global Versus Local Processing of Information

In addition to the differences observed in the processing of relations between objects and the context in which they appear, some have proposed that Easterners and Westerners differ in the degree to which they rely on global versus local processes. Using hierarchical letters (i.e., large letters composed of smaller ones, for instance, large H composed of small Es), it was shown that Easterners show a larger global advantage than Westerners (McKone et al., 2010). With hierarchical letters, a global advantage consists in being better at detecting a target letter when it is displayed as the large (global) letter than when it is displayed as the small (local) letters composing it. Using electrophysiology, Lao et al. (2013) showed that the higher tuning toward global than local information occurred in earlier processing stages for Easterners than for Westerners. Adding further support to the idea that Easterners process information in a more global manner than Westerners, it was also shown that they have a stronger tendency than Westerners at perceiving a face in Arcimboldo paintings (paintings depicting faces composed of objects such as fruits or vegetables; Rozin et al., 2016).

Nevertheless, not all studies assessing cultural differences on global versus local perceptual bias have found a larger global bias for Easterners than Westerners. In the aforementioned study by Lao and colleagues, although they found cultural differences in brain activity, they did not replicate the finding of a larger global advantage for Easterners than Westerners at the behavioral level. Another study using similar stimuli (hierarchical geometrical shapes) but a different task (visual similarity judgments instead of a target detection) obtained a larger global bias for British than for Japanese individuals (Oishi et al., 2014). Thus, although many studies point toward cultural differences in the global or local perceptual bias, findings are not systematic across studies. Note, however, that a study has shown that hierarchical letters and hierarchical shapes tap into different aspects of global/local processes (Dale & Arnell, 2013), which may explain the discrepancies observed across the studies described previously.

Breadth of Attentional Deployment

The third category of findings suggests that Easterners deploy their visual attention over a broader area of their visual field than Westerners. For instance, in a change detection task, Easterners have been shown to perform better than Westerners when the changes occur in more peripheral locations, whereas Westerners perform best when the changes occur in more central locations (Boduroglu et al., 2009). Moreover, it was recently shown (p. 313) that the spatial resolution with which Easterners process a simple visual scene is lower than that of Westerners (Boduroglu & Shah, 2017), a finding that would be expected following a broader allocation of attention (Balz & Hock, 1997; Goto et al., 2001). In fact, the findings of a global perceptual bias and of a broader deployment of attention by Easterners and Westerners may represent the same perceptual mechanism: it was shown that attending to the global versus local structure of an object affects the resolution with which it is processed (Shulman & Wilson, 1987). More specifically, attending to the global structure, which usually spans a larger area of the visual field, facilitates the processing of lower spatial frequencies, which code for coarser visual information. In contrast, attending to the local structure, which usually spans a smaller area of the visual field, facilitates the processing of higher spatial frequencies, which code for finer visual information. Cultural differences in the visual processing of objects have recently been supported by brain-level analyses: simple objects involve distinct multivoxel representations in the visual cortex of Easterners and Westerners (Ksander et al., 2018). Most interestingly, the authors of that study reported supplemental analysis suggesting that these distinct representations may be associated with the processing of distinct spatial frequencies (i.e., lower spatial frequencies for Easterners than Westerners). This finding coincides very well with the finding of cultural differences in the spatial frequencies used during face processing (Estéphan et al., 2018; Tardif et al., 2017), which will be described in more detail in the section “Cultural Differences in Face Identification”.

Attentional Processes and System of Values

The findings of a different use of the relation between objects and their context, of different perceptual biases, and of different attentional breadth have for the most part been related to a dominant theory in the field proposing that exposition to an individualistic versus collectivistic system of values led to the development of different perceptual strategies (Nisbett et al., 2001). More specifically, according to this theory, exposition to collectivistic values prioritizing the group over the individual would shape cognitive and perceptual processes such that one tends to attend more to the relation between events and objects and deploy their attention across a broader area of the visual field. In contrast, exposition to individualistic values, prioritizing the individual over the group, would shape cognitive and perceptual processes such that one tends to attend more to focal objects located in a specific/local area of their visual field.

Another account that has recently gained support by studies measuring the global versus local perceptual bias in a remote African population, the Himba (Caparos et al., 2012; Linnell et al., 2013), proposes that many of the findings described earlier are attributable to the kind of physical environment to which one is exposed (Masuda & Nisbett, 2006). More specifically, exposition to a dense visual environment would lead to perceptual strategies favoring the processing of the background and the deployment of attention over broader areas, thus facilitating a global perceptual bias. The fact that Easterners show a (p. 314) larger global perceptual bias than Westerners, who themselves show a larger global perceptual bias than traditional Himba people, is congruent with the visual density to which each of these populations is exposed (Caparos et al., 2012).

Although more work is necessary to understand the source of cultural differences highlighted previously, evidence so far reveals a relatively systematic pattern of findings whereby culture modulates the way in which attention is deployed over the visual field.

As will be described in the next section, this pattern of findings has also been observed in face perception studies.

Cultural Differences in Face Identification

In 2008, we published the first study revealing cultural differences in the visual strategies underlying face processing (Blais et al., 2008). We revealed that when encoding or recognizing the identity of a face and when categorizing the ethnicity of a face, Easterners and Westerners displayed different eye fixation patterns. Easterners fixated more the central area of a face than Westerners, whereas Westerners fixated more the eye and mouth areas than Easterners. Interestingly, these different eye fixation patterns were deployed despite the fact that the same facial areas, namely the eyes and the mouth, were used by both groups. In fact, the latter conclusion was reached in a following study where Caldara et al. (2010) used a gaze-contingent paradigm in which the size of the window through which the stimulus was visible was manipulated. When the size of the window was reduced, Easterners adopted a fixation pattern similar to that of Westerners, whereby they directly fixated the eye and mouth areas. Thus, this suggested that Easterners, just like Westerners, rely on the eye and mouth areas to recognize faces. However, Westerners spend more time than Easterners foveating these areas during visual information extraction. In contrast, Easterners spend more time than Westerners processing these areas in more peripheral locations of their retina. Interestingly, when using an inverse parametric gaze-contingent technique consisting in dynamically masking central vision – the *Blindspot* – Westerners progressively shifted the eye movements towards the typical Eastern central fixation pattern (Miellet, et al, 2012). This later observation confirmed the robustness of a fixation bias in a *focal* (i.e., Western) versus *peripheral* (i.e., Eastern) visual information sampling across cultures.

The different patterns of eye fixations during face processing corroborate well the findings described previously, consisting in a more global/larger attentional breadth in Easterners than Westerners. In fact, to process the features of a face while fixating on a more central location, one has to deploy their attention more broadly. Accordingly, Miellet et al. (2013) developed a computational model to estimate the breadth of attention in Easterners and Westerners during face processing and to estimate the resolution, in terms of spatial frequencies, with which they process visual information. Based on their model, they proposed that Easterners' attentional breadth is larger than Westerners', and that the former rely less than the latter on higher spatial frequencies. Also consistent with (p. 315) the reliance on a more global perceptual strategy, at least two studies have found a higher reliance on holistic/configural processing during face processing (Miyamoto et al., 2011; Rozin et al., 2016).

Nevertheless, the conclusion of different visual strategies and of a reliance on different granularities of visual information in Easterners and Westerners was challenged in a study by Or et al. (2015). These authors did not find cultural differences in early ocular fixations during face processing. Yet, early fixations have been shown to be sufficient for face recognition (Hsiao & Cottrell, 2008), thereby leading to questioning of whether the cultural differences observed in later ocular fixations are truly associated with face processing per se. In fact, Or and colleagues proposed that they most likely reflected norm-based cultural differences in the appropriateness of fixating someone else in the eyes, instead of differences in the perceptual strategies per se. However, this view has been challenged by the eye movement strategy deployed during the recognition of the facial expressions of emotion. East Asian observers deploy more fixations toward the eye region than toward the mouth region to decode facial expressions; this contrasts with the Western Caucasians' strategy whereby the fixations are evenly distributed on the eyes and mouth area (Geangu et al., 2016; Jack et al., 2009; see section "Cultural Differences in Facial Expression Processing"). Therefore, East Asian observers directly gaze at the eyes when this is task relevant. Social gaze avoidance as a potential explanation for the cultural contrast in face recognition also is not supported by the persistent central fixations directed toward nonface objects (i.e., Greebles) and nonhuman faces (i.e., sheep faces) by Easterners during recognition (Kelly et al., 2010). Or et al. (2015) study involved a face-matching task, while all our previous study used an old/new face recognition task. In addition, the methodological peculiarities adopted in the eye movement experiment conducted by Or et al. (2015) elicited the use of only a few fixations and did not prevent for anticipatory strategies. As such, those factors and differences across studies seem to be at the root of the absence of cultural differences observed in their study.

Further supporting the idea that culture impacts early processes in face identification, two recent studies have shown cultural differences in low-level visual information extraction occurring at early processing stages (Estéphan et al., 2018; Tardif et al., 2017). More specifically, using spatial frequency Bubbles (Willenbockel et al., 2010), a psychophysical classification image method, Tardif et al. (2017) showed that during two different face-processing tasks (face identification and face familiarity), Easterners use more of the lower spatial frequencies than Westerners, and Westerners used more of the higher spatial frequencies than Easterners. This pattern of results was replicated by Estéphan and colleagues, who further showed that the reliance on different spatial frequencies by both cultural groups started as early as 35 ms after stimulus onset. This makes very unlikely the conclusion that Easterners and Westerners differ only in late perceptual stages reflecting cultural norms in the appropriateness of looking someone else in the eye. Moreover, the pattern of spatial frequency utilization closely reflects what was expected based on the (p. 316) eye fixation pattern (i.e., when not considering the temporal dimension). Thus, this may indicate that even later ocular fixations reflect cultural differences in early covert attention.

So far, the source of these cultural differences in face processing remains unknown. The pattern, since it suggests a larger attentional breadth in Easterners than in Westerners, is consistent with both of the accounts mentioned in the section "Attentional Processes and System of Values". In fact, the theory proposing that exposure to different systems of values may shape perceptual processes predicts a larger attentional breadth in Easterners, who are exposed to more collectivistic values, than in Westerners, who are exposed to more individualistic values. A study by Kelly et al. (2011) has attempted to verify if the eye movement pattern of British-born Chinese was correlated with the degree to which they adhere to collectivistic values and failed to reveal a significant relation. The sample size was, however, relatively small, so the relation between visual strategies and adherence to collectivistic or individualistic values remains worth investigating.

Similarly, the theory proposing that exposure to dense visual environments leads to the adoption of a larger attentional breadth and a global perceptual bias is also consistent with the pattern of findings obtained in face processing. Testing a rural African population would help disambiguate between the two potential explanations. In fact, as explained earlier, traditional Himba people have been shown to be more local than British and Japanese individuals in two visual processing tasks that did not involve face stimuli (Caparos et al., 2012). In contrast, the system-of-values theory would have predicted a larger global bias for Himba than for British people, as the former adhere to more collectivistic values than the latter. Thus, although the system-of-values theory would predict a pattern of ocular fixations and a spatial frequency tuning closer to the one observed with Easterners in rural African populations, the visual environment hypothesis would predict rather a higher reliance on high spatial frequency and denser ocular fixations on the main facial features in rural Africans than in Westerners.

Another possibility is that the pattern of findings observed with faces reflects a different mechanism than the one underlying the findings in visual tasks involving nonsocial stimuli. In fact, Han and Ma (2014) have shown that different neural networks are associated with cultural differences during the processing of social and nonsocial visual stimuli. Perhaps one potential explanation lies in the frequency of exposure to face stimuli during early infancy and the preferred distance at which infants view faces across cultures. It was recently shown that Western infants younger than 3 months have front-view faces in their visual field almost three times more often than toddlers of 18 months (Jayaraman et al., 2017). Moreover, this high exposure to faces during young infancy is crucial for the development of face-processing mechanisms. In fact, young infants deprived of such exposure because of congenital cataracts show deficits in configural face processing even after having the cataracts removed and having been exposed to faces for many years (Le Grand et al., 2001). Nevertheless, although cultural differences in the frequency of face-to-face interactions have been observed (Keller, 2007), cultural differences in the developmental (p. 317) trajectory of this phenomenon have not been investigated so far. Most importantly, the distance at which infants from different cultures view faces most frequently may affect the degree to which they learn to rely on lower versus higher spatial frequencies. In fact, as the distance increases between someone’s eyes and the face to be processed, the availability of higher spatial frequencies decreases (F. W. Smith & Schyns, 2009). Interestingly, a study comparing infant–mother interactions in Japan and the United States has shown that during face-to-face interactions, American mothers stand closer to their child (Fogel et al., 1988). This finding may be consistent with the Westerners tuning toward higher spatial frequencies. In any case, a systematic investigation of the frequency and distance at which infants of different cultures are exposed to faces may represent an interesting avenue for understanding the findings described in the present chapter with faces.

Cultural Differences in Facial Expression Processing

The field of emotion studies has witnessed a long-standing debate regarding the universality or cultural specificity of facial expressions of emotion and their recognition. The seminal work of Ekman and colleagues (Ekman et al., 1969; Ekman & Friesen, 1971) has argued in favor of the universality of a subset of emotions, called basic emotions (i.e., anger, disgust, fear, happiness, sadness, and surprise). A large part of the argument was first based on the discovery that a remote, isolated culture in New Guinea had the capacity to recognize, with a performance higher than chance, the emotions expressed by North Americans (Ekman & Friesen, 1971). The reverse was also true—that is, North Americans displayed a performance higher than chance at recognizing facial expressions displayed by Papua individuals. Thus, the authors suggested that enough signal was shared among the North Americans' and Papuasians' expressions to conclude that they were biologically determined and universal.

However, despite being able to recognize the expressions emitted by the other culture, both groups were impaired in comparison with their performance at recognizing their own-group expressions. In fact, a meta-analysis revealed a systematic impairment, across studies, at recognizing facial expressions of basic emotions when they are emitted by another cultural group than the observer (Elfenbein & Ambady, 2002). Interestingly, such an impairment can even be observed when observers come from a different region, but from the same country, than the emitter (Elfenbein & Ambady, 2002). Although an impairment at recognizing other-group expressions does not preclude the possibility that these expressions are universal, it suggests that culture at least nuances their appearance.

Revealing those nuances, however, is not trivial. For instance, one method consists in capturing spontaneous expressions in emotion-inducing situations. Using such a method, it is difficult to make sure that the situation used to induce emotions is interpreted in the same way across cultures and effectively induces the same emotion across cultures. An alternative to this method has been proposed in a series of studies using reverse correlation (Jack, Caldara, & Schyns, 2012; Jack, Garrod, et al., 2012; Jack et al., 2016). The (p. 318) traditional version of the reverse correlation method (Ahumada & Lovell, 1971; Eckstein & Ahumada, 2002; Mangini & Biederman, 2004) consists in embedding a stimulus in visual noise, such that the noise alters the stimulus appearance. On each trial, the noise is different, therefore changing the stimulus's appearance, and the participants are asked to make a decision about the stimulus presented. For instance, the noise properties, when added over a neutral face, may create stimuli that appear closer to someone's representation of anger, sadness, disgust, etc. After many such trials, it is possible to infer which noise properties led the participant to perceive each of these expressions; the method thus allows accessing the participant's mental representation of each expression.

Using that method, Jack, Caldara, and Schyns (2012) showed that Easterners and Westerners build different representations of facial expressions of basic emotions. In fact, whereas expressions of Westerners include facial features located around the mouth, eye, and eyebrow areas, expressions of Easterners are mostly represented by changes in the eye area.

Building on this work, Jack and colleagues (2016) used a method developed by Yu et al. (2012) that combines dynamic structural face computer graphics with reverse correlation to extract the facial movements (i.e., more specifically, the Facial Action Units, based on Ekman and colleagues' work; Ekman & Friesen, 1978) representative of each facial expression of emotion in Chinese and British participants. In a very elegant study, they modeled over 60 culturally valid expressions of emotions in these two cultures and showed that they share four different patterns of facial movements. Based on these results, they suggested the existence of four, rather than six, emotions shared across cultures. Moreover, they showed that these basic patterns are nuanced by what they called "accents" and that those accents differed across cultures (for a similar proposition, see also Elfenbein, 2013). The observation, on the one hand, of cultural commonalities, and, on the other hand, of cultural accents to facial expressions was further supported by a recent study using a completely different method (Cordaro et al., 2018).

Slight differences in the appearance of facial expressions, like the ones observed across cultures, are likely to be associated with the development of different visual strategies during decoding. However, although many studies have investigated the visual strategies used by Westerners to recognize facial expressions of emotions (e.g., Adolphs et al., 2005; Blais et al., 2012, 2017; Calvo et al., 2014; Eisenbarth & Alpers, 2011; M. L. Smith et al., 2005), only a few have investigated if and how these strategies are modulated by culture (Jack et al., 2009; Mai et al., 2011). Jack and colleagues (2009) have shown that when categorizing the six basic facial expressions of emotions, Westerners' ocular fixations are mostly directed on the mouth and eye areas, whereas Easterners fixate mostly the eye area. This finding was congruent with those described earlier, showing that Easterners mostly represent the six basic facial expressions using variations in the eye area, whereas Westerners represent the basic expressions using featural variations in the eye, eyebrow, and mouth areas (Jack, Caldara, & Schyns, 2012). Consistently with these results, a study showed that the Chinese participants who perform better in a fake smile detection task are (p. 319) the ones who rely the most on the eye area (Mai et al., 2011). Although these studies are informative with regard to the areas typically fixated by Easterners and Westerners, more research is needed to compare different cultures on their utilization of low-level visual information, for instance, spatial frequencies, during facial expression recognition. More recently, Geangu et al. (2016) reported that such cultural differences are already present in 7-month-old infants. Altogether, these findings demonstrate that from an early stage in life, culture shapes the visual sampling strategies used to decode facial expressions of emotion.

Future Directions

As pointed out in the introduction, deficits at processing faces are observed in many neurological conditions or mental health disorders. For instance, impairments in recognizing facial expressions are observed in autism (Baron-Cohen et al., 2001; Humphreys et al., 2007; Wallace et al., 2008), schizophrenia (Kohler et al., 2009; Mandal et al., 1998), and social anxiety (Montagne et al., 2006). Moreover, profound impairments in processing the identity of a face are found in congenital (Behrmann & Avidan, 2005; Duchaine, 2000) and acquired (Rossion, 2014) prosopagnosia, conditions that are actually defined by that deficit. Several studies have looked into the visual strategies that may be associated with these perceptual deficits. However, whether culture interacts with these conditions in determining the type of visual strategies used during face perception remains unknown.

Interestingly, research has shown that certain genes interact with culture such that reverse behaviors may be observed in individuals with a similar genetic predisposition but different cultures (Kim & Sasaki, 2014). For instance, Kim et al. (2009) investigated the link between a serotonin receptor gene and the locus of attention, namely whether individuals reported paying more attention to focal objects or to the background of a scene. They found that the same genotype (homozygous on the G allele of the 5-HTR1A gene) was associated with inverse strategies as a function of culture: while Westerners with this genotype reported paying more attention to focal objects than to the background, Easterners with the same genotype instead reported paying more attention to the background than to focal objects. This finding is fascinating, as it suggests that individuals with similar biological constitutions may develop different perceptual strategies because of the way they might react and adapt to cultural forces. It also raises the question of whether similar neurological conditions may be associated with different perceptual deficits. In fact, on the one hand, cultural forces may interact with similar neurological alterations to create different behavioral manifestations. On the other hand, the studies presented in this chapter highlight striking differences in the visual perception of normal individuals of different cultures. Thus, it is highly plausible that an acquired neurological condition, such as prosopagnosia following a cerebral lesion, as well as developmental conditions, such as congenital prosopagnosia or autism, will be associated with different visual strategies in different cultures.

(p. 320) Take, for instance, the case of prosopagnosia. This condition has been associated, in Westerner populations, with an alteration at fixating (de Xivry et al., 2008) and processing (Bukach et al., 2008; Caldara et al., 2005) the eye area during the recognition of face identities. Moreover, it has been suggested that this condition is associated with a smaller perceptual window (Van Belle et al., 2015). No study has so far verified the visual strategies used by non-Western populations suffering from this condition. As explained in the section “Cultural Differences in Face Identification”, during face recognition, Easterners fixate less the eye area, deploy their attention more broadly, and are tuned toward lower spatial frequencies than Westerners. What would be the functional consequence of a lesion leading to prosopagnosia in Easterners? Since they already make few fixations to the eye area because of their larger attentional breadth, would prosopagnosia lead to changes in fixations to the eye area? Would it be associated with a change in the spatial frequency tuning? Similarly, prosopagnosia is associated, in Westerners, with a deficit in recognizing facial expressions of emotion (Bowers et al., 1985; De Gelder et al., 2000) and with a decrease in the ocular fixations directed to the eye area, as well as a decreased processing of the visual information conveyed by that area (Fiset et al., 2017). As explained in the section “Cultural Differences in Facial Expressions Processing”, Easterners rely mostly on the eye area during emotion categorization, making few fixations to the mouth area, compared with Westerners. Thus, would Easterner prosopagnosics be even more impaired than Westerner prosopagnosics at recognizing emotions? Would they show the same impairment in processing the eye area? Similar questions may be raised with regard to autism. In fact, Western individuals with autism have been shown to fixate (Spezio et al., 2007a) and process (Spezio et al., 2007b) less information conveyed by the eye area during the processing of faces (both identity and expressions). Since Easterners use this information less during the processing of identity but rely mostly on that information during the processing of emotion, would the same differences in perceptual strategies between neurotypical and autistic individuals be observed in East Asia?

Conclusion

In recent years, an important trend in research on face processing has been to characterize as precisely as possible the visual strategies underlying this biological skill, as well as the ones underlying deficits in this ability, to gather the necessary information to develop interventions that may help improve face-processing abilities (Caldara et al., 2005; Fiset et al., 2017; Nusseck et al., 2008; Peterson & Eckstein, 2012; Richoz et al., 2015; Royer et al., 2018; M. L. Smith et al., 2005; Tardif et al., 2019; Yovel & Duchaine, 2006). Cross-cultural studies have revealed striking differences in the visual strategies underlying the processing of faces, but the evolutionary, social, and biological forces rooting such effects are not well understood. In addition, as pointed out by Kitayama and Salvador (2017), we acknowledge that the field needs to expand the span of populations compared and whenever possible study other cultures. The question of whether the cultural differences (p. 321) reported here are genuinely related to culture or related to other environmental or biological forces remains to be validated, as these factors have been confounded in the large majority of cross-cultural studies.

Finally, whether and how these strategies are altered in different neurological and mental health conditions in non-Western populations remains unknown. Such knowledge, coupled with functional neuroimaging studies in the healthy population, will be very important to gather in the next years to develop interventions that are adapted to the culture, and thus to the nature of the visual deficit, of the patients.

References

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature*, *433*(7021), 68.

Ahumada Jr., A., & Lovell, J. (1971). Stimulus features in signal detection. *Journal of the Acoustical Society of America*, *49*(6B), 1751–1756.

Balz, G. W., & Hock, H. S. (1997). The effect of attentional spread on spatial resolution. *Vision Research*, *37*(11), 1499–1510.

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, *42*(2), 241–251.

Behrmann, M., & Avidan, G. (2005). Congenital prosopagnosia: Face-blind from birth. *Trends in Cognitive Sciences*, *9*(4), 180–187.

Bergiannaki, J. D., & Kostaras, P. (2016). Pharmacokinetic and pharmacodynamic effects of psychotropic medications: Differences between sexes. *Psychiatriki*, *27*(2), 118–126.

Blais, C., Fiset, D., Roy, C., Saumure Régimbald, C., & Gosselin, F. (2017). Eye fixation patterns for categorizing static and dynamic facial expressions. *Emotion*, *17*(7), 1107.

Blais, C., Jack, R. E., Scheepers, C., Fiset, D., & Caldara, R. (2008). Culture shapes how we look at faces. *PloS One, 3*(8), e3022.

Blais, C., Roy, C., Fiset, D., Arguin, M., & Gosselin, F. (2012). The eyes are not the window to basic emotions. *Neuropsychologia*, *50*(12), 2830–2838.

Boduroglu, A., & Shah, P. (2017). Cultural differences in attentional breadth and resolution. *Culture and Brain, 5*(2), 169–181.

Boduroglu, A., Shah, P., & Nisbett, R. E. (2009). Cultural differences in allocation of attention in visual information processing. *Journal of Cross-Cultural Psychology*, *40*(3), 349–360.

Bowers, D., Bauer, R. M., Coslett, H. B., & Heilman, K. M. (1985). Processing of faces by patients with unilateral hemisphere lesions: I. Dissociation between judgments of facial affect and facial identity. *Brain and Cognition*, *4*(3), 258–272.

Bukach, C. M., Le Grand, R., Kaiser, M. D., Bub, D. N., & Tanaka, J. W. (2008). Preservation of mouth region processing in two cases of prosopagnosia. *Journal of Neuropsychology*, *2*(1), 227–244.

Caldara, R. (2017). Culture reveals a flexible system for face processing. *Current Directions in Psychological Science*, *26*(3), 249–255.

Caldara, R., Schyns, P., Mayer, E., Smith, M. L., Gosselin, F., & Rossion, B. (2005). Does prosopagnosia take the eyes out of face representations? Evidence for a defect in representing diagnostic facial information following brain damage. *Journal of Cognitive Neuroscience, 17*(10), 1652–1666.

Caldara, R., Zhou, X., & Miellet, S. (2010). Putting culture under the ‘spotlight’ reveals universal information use for face recognition. *PLoS One, 5*(3), e9708.

Calvo, M. G., Fernández-Martín, A., & Nummenmaa, L. (2014). Facial expression recognition in peripheral versus central vision: Role of the eyes and the mouth. *Psychological Research*, *78*(2), 180–195.

Caparos, S., Ahmed, L., Bremner, A. J., de Fockert, J. W., Linnell, K. J., & Davidoff, J. (2012). Exposure to an urban environment alters the local bias of a remote culture. *Cognition, 122*(1), 80–85.

Chen, C., & Jack, R. E. (2017). Discovering cultural differences (and similarities) in facial expressions of emotion. *Current Opinion in Psychology*, *17*, 61–66.

(p. 322) Choi, I., Nisbett, R. E., & Norenzayan, A. (1999). Causal attribution across cultures: Variation and universality. *Psychological Bulletin*, *125*(1), 47.

Chua, H. F., Boland, J. E., & Nisbett, R. E. (2005). Cultural variation in eye movements during scene perception. *Proceedings of the National Academy of Sciences, 102*(35), 12629–12633.

Cordaro, D. T., Sun, R., Keltner, D., Kamble, S., Huddar, N., & McNeil, G. (2018). Universals and cultural variations in 22 emotional expressions across five cultures. *Emotion, 18*(1), 75–93.

Dale, G., & Arnell, K. M. (2013). Investigating the stability of and relationships among global/local processing measures. *Attention, Perception, & Psychophysics, 75*(3), 394–406.

De Gelder, B., Pourtois, G., Vroomen, J., & Bachoud-Lévi, A. C. (2000). Covert processing of faces in prosopagnosia is restricted to facial expressions: Evidence from cross-modal bias. *Brain and Cognition*, *44*(3), 425–444.

de Xivry, J. J. O., Ramon, M., Lefèvre, P., & Rossion, B. (2008). Reduced fixation on the upper area of personally familiar faces following acquired prosopagnosia. *Journal of Neuropsychology, 2*(1), 245–268.

Duchaine, B. C. (2000). Developmental prosopagnosia with normal configural processing. *Neuroreport*, *11*(1), 79–83.

Eckstein, M. P., & Ahumada, A. J. (2002). Classification images: A tool to analyze visual strategies. Journal of Vision, 2(1), doi: **https://doi.org/10.1167/2.1.i**.

Edwards, C. L., Fillingim, R. B., & Keefe, F. (2001). Race, ethnicity and pain. *Pain*, *94*(2), 133–137.

Eisenbarth, H., & Alpers, G. W. (2011). Happy mouth and sad eyes: Scanning emotional facial expressions. *Emotion*, *11*(4), 860.

Ekman, P., Sorenson, E. R., & Friesen, W. V. (1969). Pan-cultural elements in facial displays of emotion. Science, 164(3875), 86–88.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology*, *17*(2), 124.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: Investigator's guide*. Consulting Psychologists Press.

Elfenbein, H. A. (2013). Nonverbal dialects and accents in facial expressions of emotion. *Emotion Review, 5*(1), 90–96.

Elfenbein, H. A., & Ambady, N. (2002). On the universality and cultural specificity of emotion recognition: A meta-analysis. *Psychological Bulletin, 128*(2), 203.

Estéphan, A., Fiset, D., Saumure, C., Plouffe-Demers, M. P., Zhang, Y., Sun, D., & Blais, C. (2018). Time course of cultural differences in spatial frequency use for face identification. *Scientific Reports*, *8*(1), 1816.

Fiscella, K., Franks, P., Gold, M. R., & Clancy, C. M. (2000). Inequality in quality: Addressing socioeconomic, racial, and ethnic disparities in health care. *Jama, 283*(19), 2579–2584.

Fiset, D., Blais, C., Royer, J., Richoz, A. R., Dugas, G., & Caldara, R. (2017). Mapping the impairment in decoding static facial expressions of emotion in prosopagnosia. *Social Cognitive and Affective Neuroscience, 12*(8), 1334–1341.

Fogel, A., Toda, S., & Kawai, M. (1988). Mother-infant face-to-face interaction in Japan and the United States: A laboratory comparison using 3-month-old infants. *Developmental Psychology, 24*(3), 398.

Geangu, E., Ichikawa, H., Lao, J., Kanazawa, S., Yamaguchi, M. K., Caldara, R., & Turati, C. (2016). Culture shapes 7-month-olds' perceptual strategies in discriminating facial expressions of emotion. *Current Biology*, *26*(14), R663–R664.

Goto, M., Toriu, T., & Tanahashi, J. I. (2001). Effect of size of attended area on contrast sensitivity function. *Vision Research*, *41*(12), 1483–1487.

Gupta, V. B. (2010). Impact of culture on healthcare seeking behavior of Asian Indians. *Journal of Cultural Diversity*, *17*(1), 13–19.

Gutchess, A. H., Welsh, R. C., Boduroĝlu, A., & Park, D. C. (2006). Cultural differences in neural function associated with object processing. *Cognitive, Affective, & Behavioral Neuroscience*, *6*(2), 102–109.

Han, S., & Ma, Y. (2014). Cultural differences in human brain activity: A quantitative meta-analysis. *NeuroImage*, *99*, 293–300.

Heine, S. J. (2015). *Cultural psychology* (3rd International Student ed.). WW Norton & Company.

Hofstede, G. (1991). *Cultures and organizations: Intercultural cooperation and its importance for survival: Software of the mind*. McGraw-Hill.

Hsiao, J. H. W., & Cottrell, G. (2008). Two fixations suffice in face recognition. *Psychological Science*, *19*(10), 998–1006.

(p. 323) Hsieh, A. Y., Tripp, D. A., Ji, L. J., & Sullivan, M. J. (2010). Comparisons of catastrophizing, pain attitudes, and cold-pressor pain experience between Chinese and European Canadian young adults. *Journal of Pain*, *11*(11), 1187–1194.

Humphreys, K., Minshew, N., Leonard, G. L., & Behrmann, M. (2007). A fine-grained analysis of facial expression processing in high-functioning adults with autism. *Neuropsychologia*, *45*(4), 685–695.

Jack, R. E., Blais, C., Scheepers, C., Schyns, P. G., & Caldara, R. (2009). Cultural confusions show that facial expressions are not universal. *Current Biology*, *19*(18), 1543–1548.

Jack, R. E., Caldara, R., & Schyns, P. G. (2012). Internal representations reveal cultural diversity in expectations of facial expressions of emotion. *Journal of Experimental Psychology: General*, *141*(1), 19.

Jack, R. E., Garrod, O. G., Yu, H., Caldara, R., & Schyns, P. G. (2012). Facial expressions of emotion are not culturally universal. *Proceedings of the National Academy of Sciences*, *109*(19), 7241–7244.

Jack, R. E., Sun, W., Delis, I., Garrod, O. G., & Schyns, P. G. (2016). Four not six: Revealing culturally common facial expressions of emotion. *Journal of Experimental Psychology: General, 145*(6), 708.

Jayaraman, S., Fausey, C. M., & Smith, L. B. (2017). Why are faces denser in the visual experiences of younger than older infants?. *Developmental Psychology, 53*(1), 38.

Ji, L. J., Peng, K., & Nisbett, R. E. (2000). Culture, control, and perception of relationships in the environment. *Journal of Personality and Social Psychology*, *78*(5), 943.

Keller, H. (2007). *Cultures of infancy*. Erlbaum.

Kelly, D. J., Jack, R. E., Miellet, S., De Luca, E., Foreman, K., & Caldara, R. (2011). Social experience does not abolish cultural diversity in eye movements. *Frontiers in Psychology, 2*, 95.

Kelly, D. J., Miellet, S., & Caldara, R. (2010). Culture shapes eye movements for visually homogeneous objects. *Frontiers in Psychology*, *1*, 6.

Kim, H. S., & Sasaki, J. Y. (2014). Cultural neuroscience: Biology of the mind in cultural contexts. *Annual Review of Psychology*, *65*, 487–514.

Kim, H. S., Sherman, D. K., Taylor, S. E., Sasaki, J. Y., Chu, T. Q., Ryu, C., Suh, E. M., & Xu, J. (2009). Culture, serotonin receptor polymorphism and locus of attention. *Social Cognitive and Affective Neuroscience, 5*(2–3), 212–218.

Kitayama, S., Duffy, S., Kawamura, T., & Larsen, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at new look. *Psychological Science*, *14*(3), 201–206.

Kitayama, S., & Salvador, C. E. (2017). Culture embrained: Going beyond the nature-nurture dichotomy. *Perspectives on Psychological Science, 12*(5), 841–854.

Kohler, C. G., Walker, J. B., Martin, E. A., Healey, K. M., & Moberg, P. J. (2009). Facial emotion perception in schizophrenia: A meta-analytic review. *Schizophrenia Bulletin*, *36*(5), 1009–1019.

Ksander, J. C., Paige, L. E., Johndro, H. A., & Gutchess, A. H. (2018). Cultural specialization of visual cortex. *Social Cognitive and Affective Neuroscience, 13*(7), 709–718.

Lao, J., Vizioli, L., & Caldara, R. (2013). Culture modulates the temporal dynamics of global/local processing. *Culture and Brain*, *1*(2–4), 158–174.

Le Grand, R., Mondloch, C. J., Maurer, D., & Brent, H. P. (2001). Neuroperception: Early visual experience and face processing. *Nature, 410*(6831), 890.

Levine, R., Sato, S., Hashimoto, T., & Verma, J. (1995). Love and marriage in eleven cultures. *Journal of Cross Cultural Psychology*, *26*, 554–571.

Linnell, K. J., Caparos, S., de Fockert, J. W., & Davidoff, J. (2013). Urbanization decreases attentional engagement. *Journal of Experimental Psychology: Human Perception and Performance*, *39*(5), 1232.

Lüthold, P., Lao, J., He, L., Zhou, X., & Caldara, R. (2018). Waldo reveals cultural differences in return fixations. Visual Cognition, 26(10), 817–830.

Mai, X., Ge, Y., Tao, L., Tang, H., Liu, C., & Luo, Y. J. (2011). Eyes are windows to the Chinese soul: Evidence from the detection of real and fake smiles. *PloS One, 6*(5), e19903.

Mandal, M. K., Pandey, R., & Prasad, A. B. (1998). Facial expressions of emotions and schizophrenia: A review. *Schizophrenia Bulletin*, *24*(3), 399–412.

Mangini, M. C., & Biederman, I. (2004). Making the ineffable explicit: Estimating the information employed for face classifications. *Cognitive Science*, 28(2), 209–226.

Masuda, T., Ellsworth, P. C., Mesquita, B., Leu, J., Tanida, S., & Van de Veerdonk, E. (2008). Placing the face in context: Cultural differences in the perception of facial emotion. *Journal of Personality and Social Psychology*, *94*(3), 365.

(p. 324) Masuda, T., & Nisbett, R. E. (2001). Attending holistically versus analytically: Comparing the context sensitivity of Japanese and Americans. *Journal of Personality and Social Psychology*, *81*(5), 922.

Masuda, T., & Nisbett, R. E. (2006). Culture and change blindness. *Cognitive Science, 30*(2), 381–399.

McKone, E., Davies, A. A., Fernando, D., Aalders, R., Leung, H., Wickramariyaratne, T., & Platow, M. J. (2010). Asia has the global advantage: Race and visual attention. *Vision Research, 50*(16), 1540–1549.

Miellet, S., Zhou, X., He, L., Rodger, H., & Caldara, R. (2010). Investigating cultural diversity for extrafoveal information use in visual scenes. *Journal of Vision*. *10*(6), 1–18.

Miellet, S., He, L., Zhou, X., Lao, J. & Caldara, R. (2012). When East meets West: gaze-contingent Blindspots abolish cultural diversity in eye movements for faces. *Journal of Eye Movement Research*, *5*(2), 1–12.

Miellet, S., Vizioli, L., He, L., Zhou, X., & Caldara, R. (2013). Mapping face recognition information use across cultures. *Frontiers in Psychology, 4*, 34.

Miyamoto, Y., Yoshikawa, S., & Kitayama, S. (2011). Feature and configuration in face processing: Japanese are more configural than Americans. *Cognitive Science*, *35*(3), 563–574.

Montagne, B., Schutters, S., Westenberg, H. G., van Honk, J., Kessels, R. P., & de Haan, E. H. (2006). Reduced sensitivity in the recognition of anger and disgust in social anxiety disorder. *Cognitive Neuropsychiatry*, *11*(4), 389–401.

Morris, M. W., & Peng, K. (1994). Culture and cause: American and Chinese attributions for social and physical events. *Journal of Personality and Social Psychology*, *67*(6), 949.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review, 108*(2), 291.

Nisbett, R. E., & Miyamoto, Y. (2005). The influence of culture: Holistic versus analytic perception. *Trends in Cognitive Sciences*, *9*(10), 467–473.

Nusseck, M., Cunningham, D. W., Wallraven, C., & Bülthoff, H. H. (2008). The contribution of different facial regions to the recognition of conversational expressions. Journal of Vision, 8(8), doi: **https://doi.org/10.1167/8.8.1**

Ohlsen, R. I., & Pilowsky, L. S. (2007). Gender and psychopharmacology. In M. Nasser, K. Baistow, & J. Treasure (Eds.), *The female body in mind: The interface between the female body and mental health* (pp. 238–252). Routledge/Taylor & Francis Group.

Oishi, S., Jaswal, V. K., Lillard, A. S., Mizokawa, A., Hitokoto, H., & Tsutsui, Y. (2014). Cultural variations in global versus local processing: A developmental perspective. *Developmental Psychology*, *50*(12), 2654.

Or, C. C. F., Peterson, M. F., & Eckstein, M. P. (2015). Initial eye movements during face identification are optimal and similar across cultures. Journal of Vision, 15(13). doi: **https://doi.org/10.1167/15.13.12**

Paige, L. E., Ksander, J. C., Johndro, H. A., & Gutchess, A. H. (2017). Cross-cultural differences in the neural correlates of specific and general recognition. *Cortex*, *91*, 250–261.

Pavlish, C. L., Noor, S., & Brandt, J. (2010). Somali immigrant women and the American health care system: Discordant beliefs, divergent expectations, and silent worries. *Social Science & Medicine*, *71*(2), 353–361.

Peterson, M. F., & Eckstein, M. P. (2012). Looking just below the eyes is optimal across face recognition tasks. *Proceedings of the National Academy of Sciences, 109*(48), E3314–E3323.

Richoz, A. R., Jack, R. E., Garrod, O. G., Schyns, P. G., & Caldara, R. (2015). Reconstructing dynamic mental models of facial expressions in prosopagnosia reveals distinct representations for identity and expression. *Cortex, 65*, 50–64.

Rossion, B. (2014). Understanding face perception by means of prosopagnosia and neuroimaging. *Frontiers in Bioscience (Elite Edition), 6*, 308–317.

Royer, J., Blais, C., Charbonneau, I., Déry, K., Tardif, J., Duchaine, B., Gosselin, F., & Fiset, D. (2018). Greater reliance on the eye region predicts better face recognition ability. *Cognition*, *181*, 12–20.

Rozin, P., Moscovitch, M., & Imada, S. (2016). Right: Left: East: West. Evidence that individuals from East Asian and South Asian cultures emphasize right hemisphere functions in comparison to Euro-American cultures. *Neuropsychologia, 90*, 3–11.

Sheikh, S., & Furnham, A. (2000). A cross-cultural study of mental health beliefs and attitudes towards seeking professional help. *Social Psychiatry and Psychiatric Epidemiology, 35*(7), 326–334.

Shulman, G. L., & Wilson, J. (1987). Spatial frequency and selective attention to local and global information. *Perception*, *16*(1), 89–101.

Smith, F. W., & Schyns, P. G. (2009). Smile through your fear and sadness: Transmitting and identifying facial expression signals over a range of viewing distances. *Psychological Science*, *20*(10), 1202–1208.

(p. 325) Smith, M. L., Cottrell, G. W., Gosselin, F., & Schyns, P. G. (2005). Transmitting and decoding facial expressions. *Psychological Science*, *16*(3), 184–189.

Spezio, M. L., Adolphs, R., Hurley, R. S., & Piven, J. (2007a). Analysis of face gaze in autism using “Bubbles.” *Neuropsychologia*, *45*(1), 144–151.

Spezio, M. L., Adolphs, R., Hurley, R. S., & Piven, J. (2007b). Abnormal use of facial information in high-functioning autism. *Journal of Autism and Developmental Disorders*, *37*(5), 929–939.

Tardif, J., Fiset, D., Zhang, Y., Estéphan, A., Cai, Q., Luo, C., Sun, D., Gosselin, F., & Blais, C. (2017). Culture shapes spatial frequency tuning for face identification. *Journal of Experimental Psychology: Human Perception and Performance*, *43*(2), 294.

Tardif, J., Morin-Duchesne, X., Cohan, S., Royer, J., Blais, C., Fiset, D., Duchaine, B., & Gosselin, F. (2019). Use of face information varies systematically from developmental prosopagnosics to super-recognizers. *Psychological Science, 30*(2), 300–308.

Ueda, Y., Chen, L., Kopecky, J., Cramer, E. S., Rensink, R. A., Meyer, D. E., Kitayama, S., & Saiki, J. (2018). Cultural differences in visual search for geometric figures. *Cognitive Science, 42*(1), 286–310.

Van Belle, G., Lefèvre, P., & Rossion, B. (2015). Face inversion and acquired prosopagnosia reduce the size of the perceptual field of view. *Cognition, 136*, 403–408.

Wallace, S., Coleman, M., & Bailey, A. (2008). An investigation of basic facial expression recognition in autism spectrum disorders. *Cognition and Emotion*, *22*(7), 1353–1380.

Willenbockel, V., Fiset, D., Chauvin, A., Blais, C., Arguin, M., Tanaka, J. W., Bub, D. N., & Gosselin, F. (2010). Does face inversion change spatial frequency tuning? *Journal of Experimental Psychology: Human Perception and Performance*, *36*(1), 122.

Witkin, H. A., Lewis, H. B., Hertzman, M., Machover, K., Meissner, P. B., & Wapner, S. (1954). *Personality through perception: An experimental and clinical study*. Harper.

Yovel, G., & Duchaine, B. (2006). Specialized face perception mechanisms extract both part and spacing information: Evidence from developmental prosopagnosia. *Journal of Cognitive Neuroscience, 18*(4), 580–593.

Yu, H., Garrod, O. G., & Schyns, P. G. (2012). Perception-driven facial expression synthesis. *Computers & Graphics*, *36*(3), 152–162.

Yuan, H. Y., Chen, J. J., Lee, M. M., Wung, J. C., Chen, Y. F., Charng, M. J., Lu, M. J., Hung, C. R., Wei, C. Y., Chen, C. H., Wu, J. Y., & Chen, Y. T. (2005). A novel functional VKORC1 promoter polymorphism is associated with inter-individual and inter-ethnic differences in warfarin sensitivity. *Human Molecular Genetics, 14*(13), 1745–1751.

Zhou, J., Gotch, C., Zhou, Y., & Liu, Z. (2008). Perceiving an object in its context—Is the context cultural or perceptual? Journal of Vision, 8(12), **doi:https://doi.org/10.1167/8.12.2**.

Caroline Blais

Caroline Blais, Department of Psychology, University of Quebec in Outaouais, Quebec, Canada, Canada

Roberto Caldara

Roberto Caldara, Department of Psychology, University of Fribourg, Fribourg, Switzerland, Switzerland