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Vztah mezi percepční a strukturální variabilitou obličeje: mezikulturní srovnání

Disertační práce

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Relationship between perceptual and structural variation of human faces: cross-cultural comparison

Dissertation thesis

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Prohlášení

Prohlašuji, že jsem předkládanou práci *Vztah mezi percepční a strukturální komponentou variability lidského obličeje: Mezikulturní srovnání* vypracoval samostatně a za použití jen uvedených pramenů a literatury. Dále prohlašuji, že tato práce ani její podstatná část práce nebyla využita k získání jiného nebo stejného titulu na této ani jiné univerzitě.

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Declaration

I hereby declare that I worked on this thesis *Relationship between perceptual and structural variation of human faces: cross-cultural comparison* on my own using only sources mentioned in the Bibliography section. Moreover, no degree, diploma, or distinction has been conferred on to me before, either at this or in any other university, for the present thesis or its substantial part.

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Abstrakt

Vnímání rysů obličeje je základním aspektem lidské kultury, který ovlivňuje každodenní interakce a vztahy. Tato práce zkoumá mezikulturní dynamiku vnímání obličeje. Teoretický úvod nejprve stanoví ústřední význam vnímání obličeje napříč kulturami. Empirické studie zahrnuté v této práci objasňují konvergenci a divergenci standardů atraktivity mezi kulturami. Tato práce dále zkoumá i vzájemné působení dimorfismu tvaru obličeje, barevného dimorfismu a typičnosti napříč různými populacemi.

Kontext vietnamských přistěhovalců v České republice nabízí jedinečný pohled pro studium vlivu sociokulturního prostředí na vnímání a preference obličeje. Studie zahrnuté v této práci analyzují hodnocení atraktivity českých a vietnamských tváří, poskytnuté Čechy, českými Vietnamci a asijskými Vietnamci. Studie zahrnuté v této práci dále objasňují konvergenci a divergenci standardů atraktivity napříč těmito skupinami. Výsledky těchto studií podtrhují roli průměrnosti obličeje jako univerzálně významného rysu při posuzování atraktivity.

Studie přidané do příloh, jsou zaměřené na vztahy mezi vnímáním sebe sama a vnímáním druhými, a také popisují roli hlasových a pohybových signálů v hodnocení obličeje. Ač nejsou primárně multikulturního zaměření, poukazují na mnohoúrovňovou povahu zkoumání vnímání vzhledu obličeje, která může stát za vznikem smíšených signálů v kontextu mezilidské komunikace.

Tato práce přispívá k našemu pochopení univerzálnosti a kulturní specifičnosti vnímání obličeje a překlenují propast mezi biologií, kulturou a individuálními zkušenostmi při utváření lidských interakcí a vztahů.

Klíčová slova

Percepce tváře; obličej; atraktivita; morfologie; mezikulturní; Vietnamci; Češi;

Abstract

The perception of facial features is a fundamental aspect of human culture, influencing daily interactions and relationships. This thesis explores the cross-cultural dynamics of facial perception. First, the theoretical introduction establishes the centrality of facial perception across cultures. Empirical studies included in this thesis elucidate the convergence and divergence of attractiveness standards among cultures. Additionally, this thesis explores the interplay between facial shape dimorphism, color dimorphism, and typicality across a wide variety of populations.

The context of Vietnamese immigrants in the Czech Republic offers a unique lens to study the impact of the sociocultural environment on facial perception and preferences. By analyzing attractiveness assessments provided by Czech Europeans, Czech Vietnamese, and Asian Vietnamese raters for Czech and Vietnamese faces, the studies included in this thesis further elucidate the convergence and divergence of attractiveness standards across these groups. The results of these studies underscore the role of facial averageness as a universally significant trait in attractiveness judgments.

Studies added to the appendix explore relationships between self-perception and external perception, as well as investigate the role of vocal and movement cues in conjunction with facial appearance. Albeit not cross-cultural, these studies highlight the multifaceted nature of facial appearance and its contribution to mixed signals in interpersonal communication.

The findings contribute to our understanding of the universality and cultural specificity of facial perception, bridging the gap between biology, culture, and individual experiences in shaping human interactions and relationships.

Keywords

Facial perception; face; attractiveness; morphology; cross-cultural; Vietnamese; Czech

Contents

Part 1

1 Introduction

Face is one of the most crucial parts of human culture. Its perception influences our everyday lives, interactions and relationships. We use it as a major identification cue to individual's identity and emotional state, as it conveys plenty of information about the individual to perceivers, sometimes so clearly that it is "written all over his/her face". Indeed, the importance of perceiving faces is also metaphorically expressed in many languages. Examples from English include idioms like "wearing long-face", "being two-faced", "showing his true face" or "dealing with someone face to face". In Asian cultures, the greatest shame is expressed as "losing face", meaning losing the respect of others.

Our perception of faces and the subsequent formation of judgements about them are subjected to various biases, many of which depend on our self-identification and personal attributes, such as age, gender, race, social status, group identity and number of others. However, the faces of people we like and love, daily interact with or those we barely notice while passing them on the street, calibrate our internal templates of average faces. These templates in turn influence our preferences and judgements regarding attractiveness, masculinity and other face-related traits.

The context of Vietnamese immigrant population in Czech Republic and their descendants presents a unique research opportunity. This group exhibits both strong family and community ties, along with relatively high level of enculturation and integration into major society. Their phenotypical distinctiveness often serves as a practical example of the other race effect among Czech majority, who frequently struggle with recognizing and remembering Vietnamese individuals (often while saying "They look all the same to me!"). Simultaneously, the Vietnamese immigrant population experiences similar challenges, i.e. Westerners look all the same to them, since the other-race effect, which causes similar deficits in face memory and recognition, manifests in both directions. It is not uncommon for individuals to perceive faces from visually distinct ethnicities or races as more similar compared to faces of their own race (Johnson & Fredrickson, 2005).

What are the differences in facial preferences between Vietnamese in Czech Republic, who have regular interactions with Caucasians and sometimes may even choosing them as partners, and Vietnamese in Vietnam, who are primarily surrounded by other Vietnamese faces and thus lack a comparable amount of experience with Caucasian faces? Do Czech Vietnamese judge facial attractiveness in the similar manner as Czech Caucasians, or their Asian Vietnamese counterparts? And do they perceive Asian and Czech faces differently?

And what about the difference between how we see ourselves compared to the way others see us? Often there is clearly a considerable disparity between these two assessments, which not only affects facial preferences but also influences relationships to a certain extent. Additionally, to what extent is facial appearance associated with vocal or movement cues? Does it convey a coherent message about the individual, or, conversely, do the perception of multiple modalities contribute to mixed and ambiguous signals?

2 Theoretical background of face processing mechanisms

2.1 Face perception

Face perception constitutes a substantial part of our everyday interactions with others. Whether we're meeting a friend, ordering a coffee, bumping into a stranger on a street or watching the news, we pay considerable attention to faces and their characteristics, features, expressions and emotions. While we also notice other aspects and modalities like body proportions, clothing, voices, smells, gestures, body posture, movement and behavior, faces are typically the first visual contact we have available and arguably the most crucial social stimuli (Little et al., 2011a). Faces automatically attract attention (Langton et al., 2008) and provide an abundance of instantaneously accessible information about sex and age, but also health, strength, ethnicity, social status, emotional state, fighting performance and various personality traits (Carré et al., 2009; Kleisner et al., 2014; Linke et al., 2016; Tan et al., 2018; Todorov et al., 2015; Třebický et al., 2013). In a fraction of a second, humans are able of forming opinion-shaping judgements about numerous personality attributes, appearance and preferences of complete strangers based solely on facial clues, and these judgements tend to remain relatively stable even with longer exposure to that face. (Albert et al., 2021; Todorov et al., 2009; Willis & Todorov, 2006).

As a consequence, we rely heavily on faces in recognition and identification of specific individuals. Intuitively, this also implies that distorting facial features or concealing part of the face, such as wearing sunglasses or a surgical mask, has a large detrimental effect on face recognition in both adults and children (Carragher & Hancock, 2020; Noyes et al., 2021; Stajduhar et al., 2022)

2.1.1 Development of facial processing

2.2

From the first moments of life, newborns prefer face-like stimuli over other categories (Mondloch et al., 1999). They also show preference for attractive faces over unattractive faces (Slater et al., 2000), for faces of gender of their primary caregiver (Quinn et al., 2002) and display recognition and preference for their mother's face over stranger's face within few hours after birth (Bushnell, 2001; Sai, 2005). These findings suggest a special, pre-wired innate domain biased toward faces, which becomes more functionally specialized with visual experience (Di Giorgio et al., 2013). The effectiveness of mechanisms for facial detection and facial recognition increases with age, and around the age of 10, children begin to process faces more holistically (Joseph et al., 2015; Pascalis et al., 2011). Face-to-face contact plays important role in development of children's social relationships, particularly with family and kin, providing opportunities for interaction and strengthening bonds (Davies, 2012).

During puberty, perception systems undergo recalibration from „caregiver-bias“ to „peer-bias“, meaning that adolescents become better in recognizing faces with a pubertal status similar to their own (Picci & Scherf, 2016). During the later stages of puberty, alongside sexual maturation, adolescents begin to develop the capacity to differentiate more intricate facial expressions, including those associated with sexual interest, shame, and contempt. These expressions become increasingly relevant as the interest in romantic and sexual relationship emerges, in contrast to basic facial expressions like happiness and anger, that are important even for younger pre-pubescent children aged 6-8 (Garcia & Scherf, 2015; Motta-Mena & Scherf, 2017).

The identification of specific brain regions, networks and pathways responsible for face processing still remains an area of active research interests, particularly in the fields of neurology and neuropsychology. Certain cortical regions, such as fusiform face area gyrus, the lateral occipital face region, superior temporal sulcus and the occipital face area in occipito-temporal cortex, exhibit selective response to faces compared to other stimuli, even when presented in various formats and angles. These areas are primarily involved in encoding faces, enabling us to recognize faces even when they are blurred, rotated or flipped upside-down, presented as images, drawings or silhouettes and with various emotions and expressions. (Anzellotti & Caramazza, 2014; Behrmann et al., 2016; Grill-Spector et al., 2018; Tsao &

Livingstone, 2008). However, there are other regions and networks, such as anterior temporal lobe and amygdala, as well as the third visual pathway, that function as a „extended“ face processing systems and play critical role in computing semantic information, emotional context and the identity of faces (Freiwald, 2020; Liu et al., 2021; Pitcher & Ungerleider, 2021). Understanding the underlying neural mechanisms allows us to gain insights into the development of facial perception and explore possible improvements. For example, stronger activation of gyrus fusiformis in older children (12-14) compared to younger children (8-10) suggests a certain age-related qualitative difference in the processing of faces (Aylward et al., 2005).

The focus on recognizing faces is anchored so deep in us, that we sometimes perceive facial-like patterns even in inanimate objects. This phenomenon, known as face pareidolia, has also been observed in other primates and monkeys as well, suggesting the existence of a broadly tuned face detection system shared across species rather than being uniquely human trait (Alais et al., 2021; Taubert et al., 2017). When presented with inanimate objects that have facial-like features, there is significant inter-rater agreement on expression and gaze direction of illusory face (Palmer & Clifford, 2020). Seeing faces where they shouldn’t be could also evoke variety of emotions and changes in direction of attention, depending on perceiver’s sex or emotional state. It may even provide an explanation for some religious and miraculous revelations, such as seeing Mother Theresa on a cinnamon bun or Virgin Mary on a piece of burned toast (L. F. Zhou & Meng, 2020)

In contrast, the inability to recognize, or rather identify faces creates a profound social handicap. This cognitive disorder, known as prosopagnosia or face blindness, can either manifest as a developmental deficit without apparent structural lesions, or be acquired as a consequence of brain damage. The former is more common, with prevalence up to 2,5% in the population, but is less well understood (Kennerknecht et al., 2008). Although individuals with prosopagnosia typically do not suffer from any associated particular visual impairment and are aware that face is a face and not a car or a tree, they are unable to match a face to a specific person or even remember having seen that face before. As a result, they have to rely on other identity cues, such as gait, voice, hairstyle or clothing (Corrow et al., 2016; C. Smith & Susilo, 2021). The failure to recognize closest friends, family members or work colleagues can cause severe difficulties in social interaction, leading to feelings of embarrassment, guilt and anxiety and eventually results in limiting social behavior, dependence on others, and a loss of self-confidence (Yardley et al., 2008).

2.2.1 Configural, holistic and feature-based face perception

Although there is not a definitive consensus on the terminology, it is widely agreed that there are a few major cognitive strategies involved in face processing. Configural face processing primarily relies on the individual face parts and their spatial configuration for recognition and identification, sometimes referred to as first-order and second-order relations (Gold et al., 2012; Maurer et al., 2002). Conversely, holistic approach emphasizes processing the face as a whole unit, or „gestalt", rather than focusing solely on its specific components (Farah et al., 1998; Richler et al., 2012) and it is believed to underlie expertise in human face recognition (Konar et al., 2013; Meinhardt-Injac et al., 2017; Richler & Gauthier, 2014; Stajduhar et al., 2022). Additionally, analytical or featural processing refers to perceiving, analyzing and utilizing individual face features (Joseph et al., 2015).

However, there are various methodological approaches in studying holistic face processing and the exact definition of holistic representation and how different paradigms relate to each other are still subjects of debate(for review see Piepers & Robbins, 2012).

2.2.2 Other-race effect and other biases

Despite human's ability to recognize thousands of faces and to make judgements based on various facial attributes, they do not process every face in the same way or to the same effect. Extensive body of literature describes various biases that affect performance in facial processing in favor of own group faces, notably better recognition and memory for members of the same race, called *own-race bias* or *other-race effect*, sometimes also *cross-race effect* or *own-race bias*. Other largely studied biases are own-gender bias (Herlitz & Lovén, 2014; Hills et al., 2018) and own age bias (Rhodes & Anastasi, 2012), however they will not be discussed further, as they are beyond the scope of this thesis.

Numerous published studies indicate that individuals often perform better at processing faces of their own race compared to faces of another race (Hayward et al., 2013; Meissner & Brigham, 2001). In other words, the ability to recognize faces of other visually distinct race is generally poorer compared to faces of one's own race. This ubiquitous phenomenon affects various aspects of facial processing, including facial memory (Meissner et al., 2005), encoding (Walker & Tanaka, 2003), learning (Hayward et al., 2017; Tullis et al., 2014), perception of gaze (Collova et al., 2017), judgments of faces (G. Rhodes, Lee, et al., 2005; G. Rhodes et al., 2009), and even extends to face recognition software (Cavazos et al., 2021).

2.2.3 Possible mechanisms and explanations of Other–race effect

One of the prominent explanations for the mechanisms underlying the other-race effect suggests a lack of perceptual expertise. Not enough experience in communication with people from different ethnicities, and therefore with processing faces of other races (Bukach et al., 2012; McKone et al., 2019; Tanaka et al., 2013), possibly accentuated by level of education or social distance (Kovalenko & Surudzhii, 2014) results in lowered ability to process other-race faces.

However, it is believed that sufficient perceptual expertise could reduce or even reverse the other-race effect (Lebrecht et al., 2009; Thorup et al., 2018; X. Zhou et al., 2019). Such expertise could be achieved through various means, including living in multi-cultural areas and cities (X. Zhou et al., 2022), speaking foreign languages (Burns et al., 2019), perceptual training (Lebrecht et al., 2009; Qian et al., 2017), or simply being exposed to faces of other races (Marsh, 2021; Zebrowitz et al., 2008). For more information on the Mere Exposure Effect, , see (Montoya et al., 2017).

Although even newborns and infants shows preferences for faces of their own race, enough visual experience and perceptual learning can mitigate the impact of this infantile perceptual narrowing (Anzures et al., 2012; Ellis et al., 2017; Sangrigoli et al., 2005; Sangrigoli & de Schonen, 2004). However, merely exposing infants and children to other-race faces without at least some attention and training does not provide sufficient stimulus to reduce their own-race preference (Markant & Scott, 2018; Qian et al., 2017; L. S. Scott & Monesson, 2009). Considering that majority of infant‘s visual experience with own-race faces is developed through interactions with their primary caregivers, their own-race preferences are attributed to home exposure (Rennels & Davis, 2008; Sugden et al., 2014).

Another line of thought attributes the other race effect to the holistic and configurational processing paradigm, proposing that there are reduced holistic processing abilities in other-race faces (Michel et al., 2006; Mondloch et al., 2010; Tanaka et al., 2004; Zhao et al., 2014). However, others did not find sufficient evidence for differences in holistic processing (Wong et al., 2021; Yan et al., 2016).

This is essential for understanding another related bias in face perception and processing, which is based on in-group/out-group categorization (Sporer, 2001). Faces categorized as in-group members are better recognized (Hehman et al., 2010), remembered (Krumhuber & Manstead, 2011; Wolff et al., 2014), and are processed more holistically than outgroup members in same-race scenarios (Bernstein et al., 2007; Hugenberg & Corneille, 2009). However, in other-race scenario, racial dimension takes precedence over other ingroup/outgroup contextualizations (e.g. university affiliation), leading to all faces of the same-race being perceived and processed as in-group members (Cassidy et al., 2011; Shriver et al., 2008).

The categorization-individuation model of the other race effect is based on the utilization of two qualitatively different pathways of facial procession during face encoding. In particular, individuation is the act of discriminating among exemplars of a category, such as identifying individuals within a racial group, whereas categorization involves classifying exemplars into categories based on shared dimensions, like attending to facial characteristics that imply belonging to a racial group. The Categorization-Individuation model of other-race effect then proposes tendency to selectively focus on identity-diagnostic features in own-race, in-group faces, while attending to category-diagnostic characteristic in other-race, out-group faces (Hugenberg et al., 2007, 2010)

Categorization occurs rapidly and spontaneously upon encountering a face, distinguishing among potentially relevant social categories, (such as race, gender, age cohort etc.) and activating category prototypes (Hugenberg et al., 2010). Despite its cognitive efficiency, categorization may potentially become limited or overloaded when confronted with multiple competing categories simultaneously. To deal with this complexity of social categories, perceivers often select one, or maybe just a few of the most relevant categories among the many available, inhibiting the others (Hugenberg & Sacco, 2008). In contrast, individuation involves processing and focusing on features and traits unique for the individual, enabling the perceiver to move beyond the pre-existing categories and stereotypes. However, this process of extracting individual identity can be potentially impaired under suboptimal viewing conditions or due to a lack of cognitive capacity, experience, time, attention and/or motivation (Young et al., 2012).

Needless to say, categorical thinking about out-group members is not inevitable. As a matter of fact, increasing motivation, potentially through instructions, social hierarchy or simple awareness of perceptual racial biases, serves as a sufficient stimulus to reduce the other-race effect, possibly through shift to more individuated styles of processing (G. Rhodes et al., 2009; Shriver & Hugenberg, 2010; Susa et al., 2019; Young & Hugenberg, 2012).

Positive emotions may also have potential benefits in attenuating the other-race effect. According to Frederickson's *Broaden Hypothesis* (Fredrickson & Branigan, 2005), positive emotions, even induced by external stimuli as done in their study, could widen the scope of one's attention, potentially reducing the other-race effect by facilitating holistic perception and promoting more socially inclusive categorizations (Johnson & Fredrickson, 2005). Additionally, attitudes and prejudices towards members of another race have minimal to no effect on the magnitude of own-race bias (Ferguson et al., 2001; Slone et al., 2000).

In addition to the own-race bias, there is evidence for other perceptual biases favoring one's own-group – own-gender bias (Herlitz & Lovén, 2013) or own-age bias (M. G. Rhodes & Anastasi, 2012).

2.2.4 Eye tracking evidence

Eye tracking studies report different eye movements and patterns of eye fixation used when processing own-race faces compared to other-race faces, observed both in adults (Hirose & Hancock, 2007; Wu et al., 2012) and children (Wheeler et al., 2011). Nevertheless, the results are inconsistent and sometimes even slightly contradictory.

In an interesting series of studies conducted with Chinese adults and children viewing Chinese (own-race) and Caucasian (other-race) faces, significant differences in gaze direction and fixation patterns were observed between scanning own-race and other-race faces. When viewing Chinese faces, both adults and children spent more fixation time on the nose and mouth areas of the face. Conversely, they spend more time fixating on the eye area when viewing Caucasian (other-race) faces. (Fu et al., 2012; Hu et al., 2014). Goldinger et al. (2009) reported similar patterns for Caucasians participants, with more fixation on the eye area when viewing Caucasian faces and more fixation on the nose area when viewing Asian faces, potentially emphasizing the effect of face race.

In Asian participants, however, the pattern is reversed - they fixated more on the eye area when looking at Asian faces (own-race) while giving more attention to nose and mouth area in Caucasian (other-race) faces (Goldinger et al., 2009). Interestingly, in a study concluded by Brielmann et al. (2014), Caucasians fixated more on the eye area when viewing Caucasian faces and more on the nose area when viewing Asian faces, suggesting different eye fixation patterns when viewing own-race compared to other-race faces. And yet, in cross-cultural comparisons, Caucasians tend to fixate more on the eye region, while Asians have more fixation in the nose region, regardless of the race of the presented face (Blais et al., 2008; Caldara et al., 2010).

Nevertheless, evidence from measuring lower pupil dilation (Goldinger et al., 2009) and lower saccade amplitude on own-race faces, even more so in adults than children (Hu et al., 2014), indicates a more fine-tuned perceptual processing when viewing own-race faces, compared to a greater effort when encoding other-race faces.

Moreover, age group comparisons revealed that Chinese children spent more time fixating on the eyes as compared to adults, regardless of target face. This could be related to cultural norms in Chinese society, where direct eye contact is avoided out of respect for others and due to social experience, this habit is more established in adults. Children, less experienced in cultural norms and habits, therefore processed faces without gaze restriction, learned by enculturation (Hu et al., 2014).

These findings align with cultural differences in recognizing various facial expressions. Study by Koda and Rutkay (2017) suggests that when recognizing facial expression, Asians (Japanese) pay more attention to facial cues in the eye region than Europeans (Hungarians), who in contrast attend to cues in the mouth region more than the Asians (Koda & Ruttkay, 2017). Taken together, this implies the presence of underlying, culture-specific mechanisms in gaze directing, which may influence facial processing.

2.3 Perceived facial attractiveness

Why is it important?

Physical attractiveness judgements are influenced by information from diverse senses, including. appearance, voice, scent, movement, or behavior (Little, Connely, et al., 2011; Little, Jones, et al., 2011b). Given the significance of faces in everyday lives, as described in text above, extensive research has focused on facial attractiveness, its associated traits, potential explanations and its numerous impacts on day-to-day interactions (Cheng et al., 2022; Pandey & Zayas, 2021; Todorov et al., 2015).

Attractive people are often attributed more positive traits (Lan et al., 2022; Little, Jones, et al., 2011a; Lorenzo et al., 2010) being seen as more intelligent (Moore et al., 2011), competent (Verhulst et al., 2010) or healthier (G. Rhodes, 2006). Consequently, being regarded as attractive can lead to potential advantages in various social and occupational environments and scenarios (Baert & Decuypere, 2014; Desrumaux et al., 2009; Markowitz-Elfassi et al., 2019; Pansu & Dubois, 2002). Attractive people also tend to have more dates, engage in first sexual experiences at younger age, and their dating partners report being more satisfied (Lee et al., 2008; G. Rhodes, Simmons, et al., 2005). The "What is beautiful is good" stereotype, or the reversed „Ugly is bad" perspective (Griffin & Langlois, 2006) holds true even in online environment, benefitting attractiveness in dating or marketing contexts (Brand et al., 2012; Jaeger et al., 2019). All that is even more significant insofar as assessing attractiveness is automatic, inevitable and mandatory process – meaning there is no escape from the judgement of others (Ritchie et al., 2017).

An important point to consider is that self-perceived attractiveness is not always correlate with judgements made by others, and both being differently related to objective measures (Brewer et al., 2007; Muñoz-Reyes et al., 2015; Pereira, Silva, et al., 2019). First of all, the representation of one's facial features may not even match the real image. People tend to underestimate the size of their eyes and mouths but overestimate the size of their noses (Felisberti & Musholt, 2014). Moreover, exposure to highly attractive same-sex images can lead to lowered self-reported attractiveness (Little & Mannion, 2006). Additionally, self-perceived attractiveness predicts self-esteem, in women strongly than in men (Bale & Archer, 2013).

Furthermore, attractiveness as a whole is not a constant and unchangeable state. In all corners of the world people adopt various beauty-enhancing strategies, ranging from mild and fairly conservative to radical and extreme (Bradshaw et al., 2019; Madan et al., 2018). On average, women are more dissatisfied with their appearance (Davis & Arnocky, 2022), but, contrary to popular belief, men and women in western cultures spend roughly the same amount of time on activities enhancing their attractiveness - women spend more on make-up and cosmetics usage, while men spend more on exercising and bodybuilding (Kowal & Sorokowski, 2022).

Indeed, being attractive seems like a boon, but what exactly defines attractive face? Are there any specific traits, colors or morphological properties that constitute universal beauty criteria? The well-known and widely used phrase "beauty is in the eye of beholder" broadly implies that there is no gold standard for facial beauty. Instead, many factors may play the role, regarding both the perceiver and the face perceived.

Although the influence of individual preferences and inter-individual differences cannot be ignored (Hönekopp, 2006; Little et al., 2002), people from different cultures generally agree on what is and what is not attractive, with shared preferences for certain traits indicating a biological basis for attractiveness (Coetzee et al., 2014; Cunningham et al., 1995; Langlois et al., 2000; Little, 2014; G. Rhodes, Yoshikawa, et al., 2001; Sorokowski et al., 2013). This was also the case with our two cross-cultural studies on Czechs and Vietnamese ((Pavlovič et al., 2021, 2023).

Evolutionary psychology links attractiveness and associated traits to various markers of biological quality and adaptiveness (Little, Jones, et al., 2011a; Morrison et al., 2013; G. Rhodes, 2006). According to the available literature, some of the most prominent markers are sexual dimorphism (masculinity/femininity), averageness, symmetry, color, health, age, and adiposity/relative body weight. These specific markers of biological quality will be further discussed in the following chapters.

2.4 Morphological facial traits

2.4.1 Sexual dimorphism – Femininity / Masculinity

Sexual dimorphism in humans affects various domains. Masculinity and femininity manifest in morphological dimorphism of the face and body, colors and textures of skin and hair, physical prowess and strength, voices and speech, scents and pheromones, but is also reflected in movement, such as dance or gait (Fink et al., 2015; Groyecka et al., 2017; Kleisner et al., 2021; Röder et al., 2013). Despite multimodal nature of sexual dimorphism, the majority of the study designs are focused on isolated cues, primarily faces or voices (Wells 2009).

Needless to say, there is whole domain of culturally mediated and determined traits and behaviors that are regarded primarily as masculine or feminine, with a lot of grey areas in between. These culture-specific behavioral patterns can also significantly influence attractiveness judgement and mate preferences (Locke et al., 2020; Madureira, 2018; Rochelle, 2019; P. H. Smith & Bamberger, 2021). However, the topic of gender identity and conformity is a general and broad problem that goes far beyond the scope of this thesis and is mentioned here only for the sake of completeness.

It is, therefore, important to distinguish between two possible conceptualizations of terms masculinity or/and femininity. In a strictly morphological sense, masculinity/femininity is a individual variation of features that, on average, differ between sexes. On the other hand, perceived masculinity/femininity is a mental construct, a psychological concept, that is usually assessed by other individuals (Mitteroecker et al., 2015).

In human faces, sexual dimorphism becomes most apparent around puberty due to maturation of secondary sexual characteristics. These differences are the result of rising level of sex hormones, including estrogens, androgens and progestogens, commonly listed only as estrogens and testosterone. The average male face differs from the average female face in the size and shape of particular features, such as jaws, lips, eyes, nose, brows or cheekbones and in distance between them. Needless to say, there is also considerable intrasexual variability (Marečková et al., 2011; Whitehouse et al., 2015).

Another key point is that the magnitude and direction of sexual dimorphism vary across populations. In a recent study, Kleisner et al. (2021) illustrated differences in the levels of morphological dimorphism in eight populations across the world. Their analysis of morphometrical data revealed that European and South American populations displayed higher level of shape dimorphism than populations from Africa. Correspondingly, we report that Czechs exhibit higher levels of shape dimorphism than Vietnamese (Pavlovič et al., 2021, 2023). However, considering the multimodal nature of dimorphism mentioned earlier, it is in fact possible that populations with lower levels of shape dimorphism could compensate in different domains, such as exhibiting more color-related cues and preferences (Pokorný et al., *submitted for publication*).

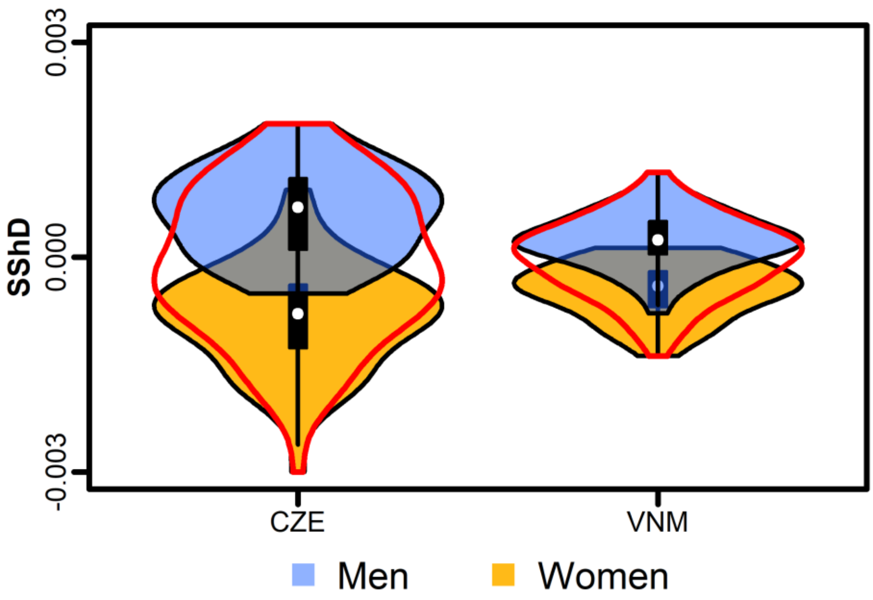

Fig.1. Czech exhibit higher levels of shape dimorphism than Vietnamese.

Preference for sexual dimorphic traits depends on other contexts. Cross-cultural evidence suggests that preferences for sexually dimorphic traits weaken with increasing environmental harshness. In other words, under favorable economic and ecological conditions, with fewer potential health hazards, preferences for sexually dimorphic traits become stronger (Little et al., 2007; Marcinkowska, Rantala, et al., 2019; I. Scott et al., 2008).

Femininity

More feminine faces are, on average, narrower with relatively larger eyes and smaller brow ridges, smaller and less prominent jaws, and fuller lips. These feminine features are associated with higher perceived attractiveness of women's faces both intraculturally and across cultures, as evidenced by studies of various designs and using manipulated, non-manipulated, or composite stimuli (Fiala et al., 2021; Foo, Simmons, et al., 2017; Mogilski & Welling, 2017; Muñoz-Reyes et al., 2015; G. Rhodes et al., 2000; F. G. Smith et al., 2009).

From an evolutionary perspective, femininity is usually interpreted as a signal of health, fertility, and potential maternity investment (Law Smith et al., 2005; Puts et al., 2012; G. Rhodes, Zebrowitz, et al., 2001; Wheatley et al., 2014).

Masculinity

The development of masculine traits, such as wider faces, more defined jawbones with larger chin projection, prominent cheekbones and eyebrow ridges, a more pronounced nose, flatter lips and thinner cheeks, is mainly testosterone-dependent (Kanavakis et al., 2021; Penton-Voak et al., 2004; Whitehouse et al., 2015). As testosterone is thought to have an immunosuppressive effect (although both positive and negative effects on immune functions have been reported; for meta-analysis see Foo, Nakagawa et al., (2017)), a high level of testosterone-driven cues is interpreted as a signal to immunocompetence, because only high-quality individuals are able to develop such costly traits (Rantala et al., 2012; G. Rhodes, 2006). However, evidence linking testosterone or masculinity and disease resistance is scarce, inconsistent, and mostly negative (Booth et al., 1999; Granger et al., 2000; M. L. Roberts et al., 2004; I. M. L. Scott et al., 2013; Thornhill & Gangestad, 2006). Masculine traits are associated with higher perceived dominance (Albert et al., 2021; Sherlock et al., 2017), higher social status (Lukaszewski et al., 2016) and good fighting ability (Třebický et al., 2019), but also with low partner fidelity (Polo et al., 2019) and aggressiveness (Björkqvist, 2018).

In a similar manner, preferences for masculinity are ambiguous and much less straightforward compared to femininity. Some studies found a preference for more masculine faces (Fink et al., 2007; Foo, Simmons, et al., 2017; Johnston et al., 2001), while others report a preference for less masculine, more feminine faces (Alharbi et al., 2020; Little & Hancock, 2002; G. Rhodes et al., 2000). A number of other studies found no preferences for either feminine nor masculine facial traits (Mogilski & Welling, 2017; I. M. L. Scott et al., 2010; Stephen et al., 2012) or found such preferences only in some cultures but not others (Fiala et al., 2021).

Moreover, relationship status and potential relationship duration influence women's preferences for facial masculinity. Women tend to prefer more masculine faces in short-term rather than long-term contexts or when considering extra-relationship connections. (Marcinkowska, Rantala, et al., 2019). Higher self-reported attractiveness also correlates with preferences for facial and vocal masculinity, but did not when attractiveness was rated by a third party (Docherty et al., 2020; Feinberg et al., 2012), implying that womens‘ beliefs about their own attractiveness, rather than objective attractiveness per se, may constitute basis for their masculinity preferences and should not be overlooked.

The role of menstrual cycle

The role of sex hormones in facial preferences has been extensively discussed in literature. The influence of women's menstrual cycle on preferences for masculinity in male faces has led to conflicting findings. Women prefer more masculine faces in their follicular phase of the cycle, when their fertility is at the highest point (Ditzen et al., 2017; Little et al., 2008), and vice versa, at lowest fertility phase women prefer more feminine faces (both in men and women) and report stronger commitment to their romantic relationship (B. C. Jones et al., 2005). This pattern has been referred to as dual-mating strategy, where women may opt for more masculine males in short-term relationship to potentially secure „high-quality genetic material" for their offspring, while preferring more feminine, nurturing, investing and pro-social males during infertile phases, seeking cooperation and security in parental care (Little et al., 2002). It is essentially a strategy of maximizing genetic quality and parental investment.

The dual-mating strategy has faced challenges in recent research, and an alternative proposition suggests that increased sexual motivation during the fertile phase may have evolved prior to pair-bonding and might not necessary be linked to reproduction-related benefits, or influence the type of men women are attracted to (B. C. Jones et al., 2019). Others argue that the average level of ovarian hormone levels throughout the cycle might be a better predictor for masculinity preferences rather than the daily fluctuations (Marcinkowska et al., 2018).

Also, women's facial attractiveness and perceived health increases during the fertile phase of menstrual cycle, possibly by changes in skin tone and texture, and by reduced facial asymmetry, as compared to luteal phase (Bobst & Lobmaier, 2012; Oberzaucher et al., 2012; Pflüger et al., 2012). However, other studies failed to replicate these effects (Catena et al., 2019; A. L. Jones & Jaeger, 2019) and the mixed results more likely reflect different methodical approaches in measuring fertility and attractiveness (Marcinkowska et al., 2021). The use of hormonal contraceptives significantly minimizes these effects (Pflüger et al., 2012) and vastly reduces peaks in masculinity preferences (Ekrami et al., 2021; Vukovic et al., 2008). However, recent literature is increasingly skeptical towards the influence of oral contraceptives, as some studies report no evidence that hormonal status affects female facial preferences (B. C. Jones et al., 2018; Marcinkowska, Hahn, et al., 2019; Stern et al., 2021).

In conclusion, women potentially engage in a trade-off between desirable and undesirable characteristics of masculine males, leading to discrepancies in research findings on this subject (B. C. Jones et al., 2019). The optimal balance of masculinity preferences appears to be influenced by environmental conditions as well as individual characteristics, such as relationship context, self-rated attractiveness, and possibly the physiological and hormonal states.

2.4.2 Averageness

Averageness of the face refers to how closely the facial features resemble the average facial configuration within the population. Average faces are generally perceived as attractive and healthy (Baudouin & Tiberghien, 2004; Langlois et al., 1994; Pavlovič et al., 2021, 2023; G. Rhodes, 2006; G. Rhodes, Yoshikawa, et al., 2001; G. Rhodes & Tremewan, 1996). Having average traits could reflect higher biological quality, such as heterozygosity, developmental stability and immunocompetence (Little, Jones, et al., 2011a; G. Rhodes, 2006). However compelling this theory may seem, actual empirical evidence of preferences for faces of individuals with greater MHC heterozygosity is not entirely conclusive. Some studies have shown a connection between female preferences for heterozygous men (S. C. Roberts et al., 2005; Winternitz et al., 2017), while others have found no supportive evidence for this relationship (Coetzee et al., 2007; Thornhill et al., 2003). It is worth noting that preferences for average traits need not to be explained strictly through biological signaling and adaptive contexts, because it is observed even in non-face stimuli and inanimate objects (Damon et al., 2017; Halberstadt & Rhodes, 2000, 2003). Averageness, or typicality, is also processed more fluently and quickly by the brain, potentially serving as a prototype for comparisons and acting as a baseline for attractiveness judgments (Trujillo et al., 2014).

The „average is attractive" hypothesis, as re-introduced by Langlois & Roggman (1990), can be originally traced back to Galton (1878). He created composite faces by projection several component faces on a single photographic plate, and found that composite faces are more attractive than component faces, from which they were created. This finding has been replicated and confirmed in modern studies that use digital technology for blending photographs, even with modern methods, composite faces are consistently reported to be more attractive (Halberstadt & Rhodes, 2003; Perrett et al., 1994; Rhee & Lee, 2010).

While facial averageness is highly positively correlated with attractiveness, it's worth noting that the most attractive faces of both sexes are not necessarily the most average ones (Baudouin & Tiberghien, 2004; DeBruine et al., 2007; Langlois et al., 1994; Perrett et al., 1994).The key point to understand is that averageness contributes to attractiveness of the face only when it is average to the specific group to which the face belongs (Potter & Corneille, 2008).

This relationship can also be interpreted in reverse: - faces with high deviations from the average are often rated far less attractive. Some argue that more likely *distinctiveness is unattractive*, rather than averageness itself being attractive. However, distinctiveness is not always contrasting with averageness and the definition of facial distinctiveness and typicality is somewhat more complex and need not to be as closely tied to population average (Kleisner et al., 2019; Wickham et al., 2000).

The representation of the average face is not fixed, but is based on our experience and constantly updated in what is known as "face space" (Valentine et al., 2015). As evidenced in a number of studies, familiarity and recent experience with certain stimuli positively influence the perception of its attractiveness (Batres et al., 2017; Cooper & Maurer, 2008; Halberstadt & Rhodes, 2000; Peskin & Newell, 2004). This is consistent with cross- cultural studies, emphasizing the importance of visual experience with the populations being rated (Apicella et al., 2007; Kočnar et al., 2019; Tovée et al., 2006), a point that may be particularly relevant to immigrants residing in a foreign land (Pavlovič et al., 2021). In essence, the experience and perceptual adaptation can recalibrate the internal representation of what is considered average

(Principe & Langlois, 2012; G. Rhodes et al., 2003). Exposure to faces from a specific population can lead to a reshaping of our internal prototype for attractiveness. As a result, our perception of what is attractive is influenced by our visual experiences and can vary based on the populations we are exposed to over time.

2.4.3 Facial symmetry

The role of symmetry in facial perception has been widely discussed in the literature. Lower asymmetry in facial features is associated with higher perceived health (G. Rhodes, Zebrowitz, et al., 2001), intelligence (Banks et al., 2010), and greater facial masculinity in men (Gangestad & Thornhill, 2003). Furthermore, it is related both to self-perceived and male-rated attractiveness in women (Muñoz-Reyes et al., 2015). More symmetrical faces are also attributed more positive personal attributes, even when attractiveness is controlled for (Fink et al., 2006; Noor & Evans, 2003).

Fluctuating asymmetry, which refers to random deviations from bilateral symmetry, is considered an estimate of organism's relative developmental instability. It is influenced by environmental and genetic stress, as well as random spontaneous developmental processes (Graham & Özener, 2016; Özener & Fink, 2010). As a result, it is widely conceived indicator of biological quality (Graham et al., 2010; B. C. Jones et al., 2001; G. Rhodes et al., 1998; Scheib Joanna E. et al., 1999).

Previous research on the impact of facial symmetry on facial attractiveness has yielded equivocal results. Some studies report a positive effect of lower facial asymmetry on facial attractiveness (B. C. Jones et al., 2007; Komori et al., 2009; Perrett et al., 1999), while others found no significant relation (Farrera et al., 2015; Kočnar et al., 2019; Van Dongen, 2014). The inconsistency of reported results may be a consequence of diverse methodologies used in these studies. Many studies on symmetry utilize dissimilar and thus hardly comparable stimuli – some work with unmanipulated photographs, while others use artificially manipulated images, diverging even further in terms of the manipulation techniques employed (Graham & Özener, 2016; Little, Jones, et al., 2011a).

2.4.4 Age

Signs of youth are generally seen as desirable traits, especially in women, where older age is associated in decline in perceived attractiveness (Furnham et al., 2004). This age-related decline of attractiveness appears to be stable and consistent across cultures (Ebner et al., 2018; Maestripieri et al., 2014). Although men also experience a decrease in attractiveness with increasing age, this decline is not as steep and may be compensated by a simultaneous increase in perceived power and dominance(Maestripieri et al., 2014; Neave & Shields, 2008).

Increasing infertility with age reduces the potential to conceive and produce healthy offspring, particularly in women (Dunson et al., 2004). From evolutionary perspective, youthfulness is seen as a signal to fecundity and potential parenthood (Muñoz-Reyes et al., 2015). The use of hormonal contraceptives largely minimizes this effect (Pflüger et al., 2012) and nullifies peaks in masculinity preferences (Vukovic et al., 2008).

The age of the perceiver also matters, particularly for women. Women tend to perceive themselves as more attractive with age, reporting higher self-rated attractiveness on average compared to younger women (Muñoz-Reyes et al., 2015). Additionally, consistent with own-age bias, older participants tend to rate older faces less negatively compared to younger participants (Ebner & Ebner, 2008; Foos & Clark, 2011; Zebrowitz & Franklin, 2014).

2.4.5 BMI and facial adiposity

Body mass index (BMI) has a significant impact on perceived attractiveness and social judgments. Both heavier individuals (relative to their height) and extremely underweight individuals are often perceived as less attractive(Brierley et al., 2016; Kościński, 2013a). The relative body weight of individuals affects facial features to such extent that people can estimate BMI from facial cues alone (Re & Rule, 2016; Żelaźniewicz et al., 2020). In this context, perceived weight in the face, mainly noticeable as facial adiposity, is linked to perceived health, attractiveness, or other personal attributes, such as leadership abilities (de Jager et al., 2018; Foo, Simmons, et al., 2017; Re & Perrett, 2014). However, the most attractive level of facial adiposity is not fixed and varies slightly between populations (Coetzee et al., 2011; Re et al., 2011; Stephen & Perera, 2014). This suggests that attractiveness judgments related to facial adiposity may be influenced by cultural or regional factors.

2.4.6 Color-related cues

Apart from shape-related traits, skin color and color distribution also play a significant role in perceived attractiveness and health (Stephen et al., 2012; Tan et al., 2018), with cultural differences in preferences and the utilization of color-related cues (Lu et al., 2021). Human skin color is influenced by both external and internal aspects, and its variation correlates with latitude and other environmental factors, as well as health and genetics (Deng & Xu, 2017; Rocha, 2020). Skin coloration also appears to be sexually dimorphic (Carrito et al., 2016; Carrito & Semin, 2019; Little, Jones, et al., 2011b) and can serve as a cue in gender recognition (Dupuis-Roy et al., 2009; Russell, 2009). Sexual dimorphism in terms of type and degree can differ significantly among human populations. When there is limited dimorphism related to shape, it is plausible that such populations might rely more on cues related to color as a compensatory mechanism. (Pokorný, *Submitted to press*).

Despite considerable variations between human populations, men have overall more darker and redder skin, while women are generally lighter (Jablonski & Chaplin, 2000; Pokorný & Kleisner, 2021; Tarr et al., 2001). In female faces, lightness and high contrast are associated with attractiveness (Coetzee et al., 2012; Russell, 2003) and may be interpreted as signs of fecundity (Aoki, 2002), youth and health (Russell et al., 2016). Intersexual differences are also found in color contrast between skin and various facial features. Women, with overall lighter skin, tend to have higher contrast between the luminance of their eyes and lips and the surrounding skin (Russell, 2003, 2009; Stephen & McKeegan, 2010). On the other hand, men exhibit higher contrast between their eyebrows and surrounding skin, possibly due to higher density of eyebrows or darker facial hair (Frost & Frost, 2014; A. L. Jones et al., 2015).

2.4.7 Voice, movement, and other cues to biological quality

The attractiveness, femininity, and masculinity of both the face and voice are positively correlated in both women and men (Pereira, Varella, et al., 2019; Saxton et al., 2006; Wheatley et al., 2014). While studies of women‘s preferences for facial masculinity have yielded mixed results, as discussed in previous chapters, preferences for vocal masculinity appear to be fairly consistent (Besser et al., 2022; Collins, 2000; Feinberg et al., 2006; Saxton et al., 2006). On the other hand, men generally prefer higher-pitched, more feminine voices (Feinberg et al., 2008; Puts et al., 2011).

Similarly, body movement, particularly gait and dance, provides information about an individual's health and strength (Fink et al., 2015, 2021; Hugill et al., 2010) and is also utilized in assessment of attractiveness, both by males and females (Fink et al., 2016; Morrison et al., 2018). Moving faces on video clips, as compared to static photos, are easier to recognize and are perceived as more attractive and healthy (Lander & Chuang, 2005; Post et al., 2012). However, other studies report similar results for dynamic and static stimuli, with a high correlation in judgements of attractiveness, sexual dimorphism and other traits (Kościński, 2013b; Rhodes et al., 2011).

2.5 Methodological pitfalls

2.5.1 Viewing context

Context plays a crucial role when looking at faces, and it is essential to be mindful of its impact, particularly in face perception research. Temporal (previously seen) and spatial (seeing one among many) context can significantly influence the judgement of viewed faces, potentially skewing experimental data and research results.

Visual perception can be influenced by what was recently seen, leading to *sequential bias* or *serial dependence bias*. In the context of face perception, judgments of faces can be affected by previously viewed faces. However, the direction of this judgment shift is a subject of ongoing debate in recent literature. Some studies suggest an inclination towards the previous judgement, indicating a positive effect or association (Kok et al., 2017; Kondo et al., 2012; Kramer et al., 2013), while others propose a judgement shift away from the previous one, indicating a negative effect or contrast (Cogan et al., 2013; Wedell et al., 1987). Moreover, faces are generally perceived as more attractive when seen in a group compared to when seen alone, which is referred to as *cheerleader effect* (Carragher et al., 2021). This awareness of contextual influences is essential to ensure the validity and reliability of face perception research.

East Asians exhibit a higher susceptibility to the influence of previous context compared to Westerners (North Americans and Western Europeans), as reported by Fang et al. in a study on emotional perception (Fang et al., 2021) as well as in non-facial contexts (Masuda et al., 2008; Masuda & Nisbett, 2006)

Fig.2. Difference between stimuli photograph (left) and naturally occuring face expression (right) of the same person.

Undoubtedly, facial expression provides much more context about the person than just the neutral face. Be that as it may, one of the most ubiquitous expressions – *smile* – can be manifested in many ways by variety of facial configurations, each bearing multiple meanings and functions with interpretations largely dependent on interpersonal and cultural context (Ekman, 1992; Frank & Ekman, 1993; Rychlowska et al., 2017). While smiles are generally considered universally recognizable, subtle nuances can lead to misunderstandings. In Eastern cultures, smiles may be used as a mask to conceal negative emotions, such as shame, or distress, often with relation to managing social hierarchies, whereas in Western cultures, smiles are associated with bonding and positive feelings (Fang et al., 2021; Martin et al., 2017; Rychlowska et al., 2015). Failing to understand the appropriate context in communication involving members of another culture could lead to awkward and uncomfortable social situations. Just imagine nervous young Western man on a first meeting with his Asian girlfriend's extended family circle.

2.5.2 Online data collection

In recent years, there has been a notable increase in online experiments and data collection through various crowd-sourcing or data-collection web apps. Some fields even talk about *exodus to cyberspace*, witnessing massive expansion to online space. However this shift to online data collection comes with both advantages and drawbacks (Tourangeau et al., 2018; H. Zhou & Fishbach, 2016)

One potential pitfall in online data collection is variability in screen size among respondents‘ devices, which can influence how faces are judged. According to study done by Söderlund et al. (Söderlund et al., 2019) on online data collection, faces viewed on larger screens are often perceived more positively and as more attractive. Additionally, participants using computes also tend to provide longer answers in open questions compared to smartphone users. Another challenge of collecting research data online is high attrition, meaning a high rate of dropouts, which require much larger number of participants and careful approach in study designs to ensure validity of experiments (H. Zhou & Fishbach, 2016).

These factors mentioned above also have implication for everyday use of online services, social media, and dating apps (Pino, 2022; Taubert et al., 2016). Our judgments of others can be influenced by the type of device we use, the faces we have seen previously or those in the close proximity, lightning conditions (Fotios et al., 2015), the orientation of the face, i.e. whether we look at the face straight from the front or in an angle (Brielmann et al., 2014; Park et al., 2021; Tovée & Cornelissen, 2001), the direction of its gaze (Ho et al., 2018) and whether the face is moving or smiling (Kim et al., 2018; Penton-Voak & Chang, 2008). Understanding these potential pitfalls is crucial to ensure the reliability and validity of online experiments and to interpret results accurately in the context of online interactions and social platforms.

3 Vietnamese in Czechia

Vietnamese people form the largest non-European immigration group in Europe and within Czech Republic, their diaspora is the third largest Vietnamese community on the continent. In the Czech Republic, they represent the third largest minority population (following Slovaks and Ukrainians, with over 63 000 registered Vietnamese citizens as by 2021. When considering Vietnamese residents who have already acquired Czech citizenship, they emerge as the most prominent visually distinct group in Czech society.

3.1 History of immigration

The history of Vietnamese immigration to Czech countries can be divided into two distinct phases, with a major turning point being the Velvet Revolution in November 1989, which marked the fall of communist regime in Czechoslovakia. Subsequently, minor differences in immigration patterns can also be observed after the year 2000.

3.1.1 Migration during Socialist era (pre-1989)

The former Czechoslovakia established official diplomatical relations with the Vietnamese Democratic Republic on 2nd of February 1950, setting foundation to almost four decades-long relationship primarily focused on industrial aid and cultural cooperation between the two socialist countries.

During the first initial phase, the main recurrent narrative was providing the aid to Vietnamese people affected by war, granting them access to education, training and work opportunities.

Even as early as in 1956, around 100 children from families affected by "the French war" (also known as the "first Indochinese war", 1946-1954) came to Czechoslovakia. They were placed in Chrastava and provided with three Vietnamese teachers, so that they could keep up with their education. Fifteen of them completed high school, some even obtained university degrees. While most of them returned to Vietnam after few years and achieved prominent positions such as university professors, army officers, journalists, and officials, some chose Czechoslovakia as their new home and started families.

During the "second Indochinese war" (1964 – 1973), between Vietnam and United States, a majority of immigrants to Czechoslovakia were war refugees from socialist North Vietnam. The reunification of South and North part of Vietnam to form the Socialistic Republic of Vietnam only became possible after the fall of Saigon regime in 1976. Three decades of armed conflicts, along with challenges of uniting pro-communist North and pro-democratic South, both of which stood on rather dissimilar ideological, political and economical principles, had devastating and impoverishing effects on Vietnamese territories and their inhabitants (Brouček, 2005; Kušniráková, 2012).

During the 1970s and early 1980s, several contracts were signed between Czechoslovak and newly united Vietnamese government leading to the organized influx of thousands Vietnamese students and trainees in heavy industry, machinery and other state-preferred fields. The peak of Vietnamese immigration occurred between 1980 and 1983 when an estimated 35,000 people, mostly male manual workers, came to Czechoslovakia. The numbers of Vietnamese workers started to decline after 1985, reaching around 17,000 by the time the bilateral government contract was terminated in early 1990 (Müllerová, 1998).

The primary motive for large number of immigrants during 70's and early 80's was desire for security, stability, and peace. This was in stark contrast to the decades of internal and external armed conflicts in Vietnam, which left many with little certainty of a safe and peaceful life. Although the migration was controlled exclusively by state, there were always some possibilities for those willing to pay bribes or those unwilling to serve and die in the military service (during second Indochina war and occupation of Cambodia, the conscription age was as low as 15) (Kušniráková, 2012).

Life in Czechoslovakia during this period was however not that easy, as both governments closely monitored everyday activities and employed intense and almost omnipresent surveillance. Students were under constant pressure to excel academically, as the threat of immediate deportation to Vietnam loomed if they did not perform well. Contacts between men and women were restricted and relationships between two Vietnamese were prohibited under the same threat – deportation. Language preparation for their stay in Czechoslovakia began even before their departure from Vietnam, and their stay was limited to either 4- or 7- year period, after which they were sent back to Vietnam, often within just a few weeks (Alamgir, 2017; Brouček, 2005).

3.1.2 90's migration trends

The post-1990 migration of Vietnamese to Czechia took on an standard economical character. Majority migrants in that time came from northern Vietnam, motivated by the desire to earn money to support their families back home. Some came alone, while others brought their family members with them. Most of these 90's migrants started with selling cheap clothes at marketplace stalls, usually at only a few designated places in particular urban areas. They worked hard and sent remittances back to Vietnam, often enduring difficult living conditions and major discomfort in order to provide for their relatives. Most of those traders, shopkeepers or entrepreneurs thought about returning to Vietnam someday, living in state of semi-permanence or temporality, with a huge workload and very little time for their children. This semi-permanence made them less motivated to deeply integrate into Czech society, learn the language and build stronger social connections. Instead, many of them formed local communities, where they could maintain their own cultural and social practices. (Brouček, 2005).

Without any organizational and language support from Vietnamese government, more and more people resorted to paying steep prices, usually several thousand dollars (!) to unofficial intermediaries to arrange residence permits, work visas, and other necessary contracts, documents and licenses. Sometimes it was necessary to sell a house or a piece of land and falling into a debt. Organizations of these intermediaries, often pre-1989 immigrants or their associates with knowledge of Czech language and legal system, frequently engaged in illegal activities and mob practices, including usury, fictional debts, fraud, but sometimes even human trafficking, drug smuggling, and forced prostitution (Nožina, 2010; Nožina & Kraus, 2020; Pechová, 2007).

3.1.3 Recent & contemporary migration

After the year 2000, many Vietnamese traders in Czechia slowly expanded their business activities from selling cheap clothes at marketplace stalls to wide variety of domains with trade and retail remaining as the most profitable. They opened regular shops offering wide variety of goods, including Asian restaurants, sports goods, electronics, groceries, nail studios and dry-cleaners. In some small villages Vietnamese traders also took on the responsibility of running the only grocery stores available, becoming important members of the local communities. New migrants without family ties also often started as factory workers.

The motives for migration shifted from purely economic reasons to ones influenced by family ties and social networks. Many Vietnamese migrants sought to provide high-quality education for their children or reunite with relatives already living in Czechia. (Svobodová, 2017). A lot of Vietnamese immigrants also changed their plans and reconsidered permanent return to Vietnam. After spending many years in Czechia, they realized that readapting to life in Vietnam would be challenging, especially for their children, who have become more attached to Czech (European) culture.

The Vietnamese community in contemporary Czechia is richly stratified in terms of education, age, socioeconomical and marital status. There are also differences in terms of conservativism and traditionalism and strategies of migration and enculturation, with majority of these differences being between generations (Bernard & Mikešová, 2014; Brouček, 2016) . Family bonds and relations are a crucial aspect of community cohesion among Vietnamese immigrants, but different attitudes towards integration can sometimes lead to conflicts between different generations within the community (Martínková, 2008).

3.2 Young generation and generational conflicts

The younger generations of Vietnamese, known as the “one and halfth” and “second” have assimilated very well into Czech society. The “one and halfth” generation refers to those who were born in Vietnam but raised in Czechia since early childhood, while the "second" generation includes those who were born in Czechia. These young Vietnamese individuals are highly integrated into Czech society. They have grown up surrounded by Czech culture and customs, attending Czech schools, are fluent in Czech language, and have generally a lot of contact with their Czech peers. As a result, they often identify themselves as Czechs and have a strong inclination towards Czech (European) culture. This trend has raised concerns among some members of the Vietnamese community who fear the potential erosion of traditional Vietnamese culture and values. As a response, some Vietnamese organizations and private individuals have started organizing Vietnamese language courses to help preserve their language and culture among the younger generations (Martínková 2008). Needless to say, many of young generation regain interest in Vietnamese culture during early adulthood, possibly in connection with rediscovering their identities

This integration has led to the term “Banana kids” or “Banana generation”, which refers to their hybrid nature of their identities - being “yellow on the outside” and “white on the inside”. This commonly used autoidentical term has been popularized from within the community and emphasizes the contrast between the orientation towards Czech culture as a result of their upbringing and the color of their skin, which serves as an involuntary marker tying them to Vietnamese identity (Homoláč & Sherman, 2020; Jirásková, 2017; Svobodová & Janská, 2016). This term reflects their unique position as individuals with both Vietnamese heritage and a strong connection to Czech culture and is a kind of a testament to the complexity of identity formation and integration among immigrant communities in Czechia.

In contrast to their parents' lack of motivation to learn Czech properly, the young Vietnamese generation often use the Czech language fluently. As a matter of fact, these young Vietnamese often speak Czech among themselves to prevent their parents from understanding, despite their great resentment (Bednárová, 2020; Hřebíčková, 2020).

The involvement of Czech women, often pensioners or dependent on social welfare, in assisting Vietnamese families with childcare is an interesting aspect of the Vietnamese community's integration into Czech society. Vietnamese families sometimes seek out and hire Czech women, who effectively step into the role of surrogate grandmothers, providing care and support to young Vietnamese children while their parents are occupied with work. In doing so, they play a significant role in familiarizing the children with Czech norms and culture, contributing to their integration into the wider Czech community. (Souralová, 2015).

In their interactions with Czechs, young Vietnamese sometimes use nicknames that are chosen during their early childhood by the Czech nannies or nursery teachers who care for them. These nicknames are often based on similarities with Czech names, allowing the children to integrate better into their Czech peer groups and avoiding potential pronunciation difficulties with their given Vietnamese names (Linh – Linda, Te Ding – Tedy). This practice helps the young immigrants feel more comfortable and accepted within their social circles during their formative years. As the young Vietnamese enter adolescence and begin exploring and forming their identities, some might choose to switch back to using solely their Vietnamese names or adopt different names altogether. (Phuoc – Lucky) (Bednárová, 2016).

Regarding family and kinship strategies, Vietnamese follow patriarchal and patrilocal system, where the authority in the household is exercised by a man, typically the eldest and the eldest son usually stays with his parents in the house, Additionally, after marriage his bride will also move in with (Nhung 2019). Although Vietnamese society, in general, leans toward collectivism, the young generation, as a consequence of their upbringing in Czech, tend to be more individualistic. Some even exhibit partial tendencies to further re-emigrate to Western European and other developed countries to pursue their own personal development. However, in reality, family ties, social position, gender, and personal context still have a major influence over migration strategies and decision-making; e.g. where, with whom, for how long, or if ever will one travel (Freidingerová, 2014; Nhung, 2019).

3.2.1 Partner preferences

Despite their deep enculturation and integration, respect for family and traditional upbringing often comes first. When it comes to long-term relationship, most young Vietnamese express a preference of the same ethnicity rather than Czech or other European partners. They often fear that language and cultural barriers between their Czech partner and their Vietnamese family may lead to a lot of misunderstanding, embarrassment, and social faux-pas during large family gatherings. Respecting their parents' wishes for a same-ethnicity partner for their children have a huge impact, even though these preferences may sometimes be based merely on negative stereotypes about Czechs. The relatively high divorce rates among Czechs, often interpreted as indicators of inherent infidelity and relationship instability, are especially concerning for Vietnamese parents, as divorce is considered an enormous shame on the whole family, prompting them to try to avoid it (Svobodová, 2017). Additionally, socioeconomic status, material stability and cultural compatibility also heavily influence long-term partner preferences, particularly in women (Bednárová, 2020).

Mixed relationships are generally disapproved of by Vietnamese parents, leading young Vietnamese to keep their relationships secret at least from their parents, for several months or even years. This is especially true for girls, as they are subject to stricter parental control and over-protection compared to boys (Bednárová, 2020). The choice of a long-term partner is therefore not only seen as strictly personal decision, but also in a broad sense as a matter that concerns the whole family. Partner ethnicity can play a decisive role in defining and establishing one's own identity (Svobodová, 2017). This is particularly tough subject for children of transnational migrants. Almost every young Vietnamese encounters racism in various forms, including discrimination, verbal abuse, and sometimes even physical assaults (Bednárová, 2020; Nguyen, 2019; Sýkora et al., 2016).

3.2.2 Identity

Conceptualizing identities of children of Vietnamese migrants through categories like race, nation, or ethnicity could be somewhat problematic. Some argue that their identities are constructed through both symbolic and material exchange spanning across two (or several) countries, making them transnational in nature (Espritu 2003, Hüwelmeier 2017). These young Vietnamese individuals experience transnational ties, as their parents still maintain transnational ties with their relatives in Vietnam through visits, phone calls and financial support. They also hold onto memories, shared images and nostalgia, making them present „here as well as there“ (Evergeti-Ryan 2011).

As a result, many young Vietnamese find themselves existing between two identities, embracing both simultaneously, and switching between them or combining them in different contexts without losing their authenticity. However, this may also lead to an internal conflicts, with some individuals rejecting one or even both of these identities (Svobodová 2017). Some strive to construct a fluid, cosmopolitan or global identity, that transcends nationalistic categories (Hüwelmeier, 2017; Nguyen, 2019).

Despite being born in Czechia, holding Czech citizenship and speaking and behaving as a Czechs, descendants of Vietnamese migrants are often seen by the majority population primarily as Vietnamese nonetheless, simply due to their look. The visual appearance of ethnicity is not optional part of individuality, revealing that racial categorization and visual distinctiveness is used as a primary attribute in defining their identity, at least in the eyes of others. After all, for visually distinct minorities, ethnicity is imperative (Kibria 2002, Eriksen 2007).

4 Conclusions

The human fascination with faces transcends cultures and serves as a central element in our social interactions. However, the prism of racial categorization is still inherently dominant in our categorization and perception of others and it requires additional effort and awareness of the various perceptual biases to minimize its influence on our judgments. Even though the tendencies to make decisions based on visual prototypicality sometimes have their uses and in ancient times of our ancestors were oftentimes life-saving, in day-to-day interactions in modern world could impede effective communication, create unnecessary social tension, and generally be more of a burden than an advantage.

Even when our mate choice is on the line, our innate „race glasses“ are hard to take off. They influence our judgements on what is and what is not attractive from the moments of first impression and thus have the power to distort possible interpersonal connection. However, the average facial prototype in our inner face-space is constantly updated and recalibrated, based on the surrounding faces of people we daily encounter and interact with.

Can any of these biases be affected by one‘s environment, local culture and its population? Or, if different, by one’s own culture? What plays more important role on forming facial preferences – the faces of caregivers and the close family members during infancy and upbringing, or the multitude of faces of the most prevalent population in one’s surroundings?

The main aim of this thesis was to explore how perception and preferences of faces and their features differs across cultures and how sociocultural environments affect this perception. Through a series of studies, including attractiveness ratings and geometric morphometrics analysis, we examine the impact of factors such as sexual dimorphism, facial averageness, and distinctiveness on facial perception.

In study 1 (Pavlovič et al., 2021), we showed that Czech Vietnamese and Czechs converge in perceptions of facial attractiveness, but do not always utilize the same traits. Czech Vietnamese, as compared to Asian Vietnamese, were better at predicting attractiveness of Czech faces. Attractiveness ratings correlated with facial averageness of female faces in all three rater groups, but in all groups of Vietnamese raters sexual shape dimorphism did not correlated with attractiveness.

Study 2 (Pavlovič et al., 2023) with Asian Vietnamese faces as stimuli showed no significant effect of population on facial characteristics attribution. Rater groups of the same origin as in study 1 (although not the identical individuals) judged the attractiveness of Asian Vietnamese facial stimuli more or less in the similar way, with no significant intergroup differences. Moreover, no significant differences were observed also in utilizing shape-related traits, suggesting agreement of all three groups of raters.

These two studies suggest that both environmental factors, such as visual diet and experience, and primary caregivers/parents influence our facial preferences and perception. As seen from path analyses, facial averageness had the most influence on attractiveness ratings in both Czech and Asian Vietnamese facial stimuli, as rated by all three groups of raters of both sexes. This is consistent with the "average is attractive" hypothesis described in the text above.

On the other hand, it is somewhat surprising that sexual shape dimorphism played no significant role in almost any of the rater groups. However, given the overall lower shape dimorphism of Vietnamese faces, other cues may play more significant role, such as color-related traits or abovementioned typicality.

Consistent with the two studies on Czech Vietnamese populations, Study 3 (Kleisner et al, *Submitted to Evolutoin and Human Behavior*), on 10 populations across the world reported that distinctiveness negatively affects facial attractiveness in both sexes, suggesting averageness (prototypicality, population-specific distance from mean) is universally preferred.

Women were rated as more attractive than men in most samples and females with higher femininity were rated as more attractive. Facial femininity therefore had positive effect on female attractiveness, whereas effects of facial masculinity on male attractiveness were only weak or null.

Study 4 (Pokorný et al, *submitted to Archives of Sexual Behavior*) examined the interrelationship between attractiveness, sexual color dimorphism (SCoD) and sexual shape dimorphism (SShD). Three studied populations differed significantly between levels of SCoD and SShD: high SShD and low SCoD in case of Czech dataset, and low SShD and high SCoD in Vietnamese and Cameroonian datasets. While certain level of sexual dimorphism in human faces is always present, the level of its manifestation in various features (e.g., color and shape) differ across populations. Even though there was not a consistent relation between shape and color sex-typicality and attractiveness, our data add to growing evidence of complexity and multidimensionality of human sexual dimorphism in cross cultural contexts.

Facial perception is a complex task, governed by interplay of many variables and influences, both internal and external, with its study bridging the realms of culture, psychology, and human behavior. Identification of those factors and understanding their mechanisms holds the potential to not only mitigate many intercultural misunderstandings, but also unravel the interconnection between human perception and our ever-changing environment. The answer to these questions must encompass large cross-cultural studies exploring various modalities and factors.

This investigation contributes to the understanding of cross-cultural facial perception, shedding light on the interplay between cultural influences, personal experiences, and biological cues in shaping our perceptions of facial attractiveness and traits. The findings provide insights into the complex dynamics of facial perception and have implications for understanding cultural diversity and interpersonal interactions.

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Part 2

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He developed the study concept, contributed to study design, performed the data collection, reviewed the literature, contributed to data analysis, wrote the initial draft of the manuscript, and worked on the manuscript revisions.

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Environmental convergence in facial preferences: a cross-group comparison of Asian Vietnamese, Czech Vietnamese, and Czechs

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It has been demonstrated that sociocultural environment has a significant impact on human behavior. This contribution focuses on differences in the perception of attractiveness of European (Czech) faces as rated by Czechs of European origin, Vietnamese persons living in the Czech Republic and Vietnamese who permanently reside in Vietnam. We investigated whether attractiveness judgments and preferences for facial sex-typicality and averageness in Vietnamese who grew up and live in the Czech Republic are closer to the judgements and preferences of Czech Europeans or to those of Vietnamese born and residing in Vietnam. We examined the relative contribution of sexual shape dimorphism and averageness to the perception of facial attractiveness across all three groups of raters. Czech Europeans, Czech Vietnamese, and Asian Vietnamese raters of both sexes rated facial portraits of 100 Czech European participants (50 women and 50 men, standardized, non-manipulated) for attractiveness. Taking Czech European ratings as a standard for Czech facial attractiveness, we showed that Czech Vietnamese assessments of attractiveness were closer to this standard than assessments by the Asian Vietnamese. Among all groups of raters, facial averageness positively correlated with perceived attractiveness, which is consistent with the "average is attractive" hypothesis. A marginal impact of sexual shape dimorphism on attractiveness rating was found only in Czech European male raters: neither Czech Vietnamese nor Asian Vietnamese raters of either sex utilized traits associated with sexual shape dimorphism as a cue of attractiveness. We thus conclude that Vietnamese people permanently living in the Czech Republic converge with Czechs of Czech origin in perceptions of facial attractiveness and that this population adopted some but not all Czech standards of beauty.

Throughout the history of humankind, various peoples migrated to parts of the world where they were visually distinct from the standards of facial appearance of local majority population. This was also the case of Vietnamese citizens who were coming to Czechoslovakia since 1956 to be trained in mechanical engineering, light industries, or to study at Czechoslovak universities[1]. The arrival of Vietnamese students, trainees, and guest workers was based on friendly diplomatic and economic contacts between the Czechoslovak Socialist Republic and the Democratic Republic of Vietnam. Many of these immigrants did not learn the Czech language, which somewhat isolates this older wave of immigrants who arrived during the era of state socialism from the majority Czech population. After the fall of the Communistic regime in Czechoslovakia in 1989, many more Vietnamese came from Vietnam and from other European countries. After the Velvet Revolution, persons of Vietnamese origin found their niche within the Czech society as small traders in street markets or operators of small grocery shops. The young generation, that is, usually the offspring of the Vietnamese immigrants, is better integrated into Czech society and Czech educational system and many are promising students who successfully aspire to professional careers. They call themselves "the Banana generation"—meaning yellow outside, white inside—because unlike their parents and despite their Asian appearance, they speak fluent Czech. They sometimes feel more Czech than Vietnamese: they were born in the Czech Republic or lived there for most of their life, and they often have an ambivalent relationship to the country their parents came from. It is estimated that the Vietnamese minority in the Czech Republic currently numbers around 60,000. In this study, we recruited members of this younger generation of the Vietnamese minority as "Czech Vietnamese" raters.

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One can learn a lot just by looking at another person's face. Apart from the most obvious information, such as sex and age, faces also provide information about strength, health, health risks, fighting performance, social status, emotional states, and various personality traits[2–7]. Facial perception is thus one of the most important aspects of human social interactions, especially due to its decisive role in forming first impressions[8–10].

It is well documented that people are better at recognizing and remembering faces and reading emotional expressions in faces of own race than in faces belonging to other races[11–16]. This phenomenon is known as the *other-race effect*. It implies that the perception of various attributes of faces belonging to other-race faces is usually less effective than the recognition of attributes of own-race faces. In short, it is more difficult to distinguish and decode particular facial features and their meaning in faces of other ethnicities. These facial perception biases evolve in very early childhood[17–19]. It has been shown that own-race faces are perceived in a more holistic manner that other-race faces[20]. Face perception strongly depends on the viewing context and previous exposure[21]. Greater amount of individuating experiences with other-race faces tend to reduce the other-race effect in holistic processing[22]. On the other hand, recent research had shown that some social traits may be better assessed for outgroup faces[23]. It has been demonstrated that racially typical individuals are more vulnerable to various forms of social discrimination and stigmatization, especially by outgroup members[24]. Other-race (versus own-race) perception may be mediated by nonracial categorization. The people classified as in-group (versus out-group) are perceived in a more positive manner[25]. Own-race bias can be minimized or eliminated by positive emotions, which help promote a broader social identity prior to interpersonal interaction[26]. It has been demonstrated that social categorization on its own can elicit biases in facial recognition and perception and might be thus partially responsible for the other-race effect[27]. It seems that both sufficient perceptual experience with other-race faces and motivation to individuate out-group faces successfully reduces the other-race effect in perception[28].

Attractiveness is among the most frequently studied attributes of face perception, because it plays a key role in both mate choice and social perceptions. Positive personality traits are cross-culturally listed among the most significant factors in mate choice by both sexes and attractive people tend to be attributed more positive qualities by others[29]. For example, attractive individuals are treated more positively than less attractive persons and are perceived as more healthy, intelligent, competent, and more experienced in dating (for a meta-analytic review of stereotypes associated with beauty, see[30]. There is a cross-cultural consensus on attractiveness standards of human faces[31,32] although in various cultures, there may be a different degree of emphasis on various attractiveness features such variation in skin texture, skin color, eye and hair color, facial masculinity, or facial shape[33–40]. Among the traits which contribute to the resulting facial attractiveness the most are averageness (proximity to a population norm), facial symmetry, and sexual dimorphism (the degree of development of sexually dimorphic features).

More average (that is, less distinct) faces are perceived as more attractive due to stabilizing selection[41,42]. Facial averageness reflects higher genetic diversity, greater heterozygosity, and therefore also higher biological quality[29,43,44]. Male and female faces manipulated to greater averageness are regarded as healthier-looking[45]. Faces perceived as the most attractive seem to be those which are close to the average but not the most average ones[42,46–48].

An alternative explanation of preference for typical faces might be that faces were regarded as attractive not in virtue of their proximity to the population norm but rather due to a symmetry resulting from computational averaging that takes place during the production of facial composites[49,50]. That explanation, however, fails to account for the association between attractiveness and averageness calculated as the distance of natural faces from their population mean, which is a method used in this study. When averageness was computed as a Procrustes distance from the average face, higher averageness was positively linked with attractiveness[51]. Moreover, in studies which used composites, averageness accounted for a significant part of attractiveness even after exclusion of the effect of symmetry[52].

In human faces, sexual dimorphism develops around puberty. This process is driven by increasing influence of sex steroids (such as estrogens, androgens, and progestogens, usually listed only as testosterone and estrogens). It has been reported that feminine facial shapes in females are perceived as more attractive both between and within cultures[36,43,53–55]. In virtue of its association with high estrogen levels, facial femininity in women may indicate sexual maturity and high reproductive capacity[43,56] or, due to its association with youthfulness, it may serve as a cue to residual reproductive capacity[57]. With respect to links between attractiveness and individual expression of sexual dimorphism in male faces, on the other hand, reported results are inconsistent. Some studies reported women's preference for more masculine faces[58,59] while other studies found evidence of preference for more feminine male faces[60–62]. It seems that both masculine and feminine male faces might be preferred, whereby the actual preference depends on an interaction between perceived hormone markers and the hormonal state of the female perceiver[63,64]. Moreover, it has been shown that preference for sexually dimorphic traits varies among human cultures and its association with attractiveness may have emerged relatively recently in human evolution, in particular with the appearance of urban Western societies[65]. Alternatively, the variation over preference for sexual dimorphism among different populations can also be explained by other factors such as differences in national health, income inequality, and homicide rate[66,67].

Age serves as a cue to actual and residual fertility in women[68] and, to a lesser extent, also in men[69]. In women, the decline of attractiveness with age is steeper and seems stable across cultures[70–72]. Even in young women, the current attractiveness is negatively associated with their estimated age at menopause (based on woman's mother menopause age)[73]. In men, the attractiveness declines with age more slowly. Middle-aged men may be attractive, as they possess higher status and more resources while keeping a sufficient level of fertility[71].

The actual relative weight (body mass index) predicted a person's perceived adiposity and perceived weight[74,75], though the viewing angle may bias the perception of weight from the face[76]. Both high and low perceived facial adiposity (underweight and overweight) lowers perceived healthiness. High perceived facial adiposity is also associated with worse actual health[74]. Higher BMI is negatively associated with perceived female bodily[77] and facial attractiveness[78]. Nonetheless, there are cross-cultural differences in the most preferred relative weight[79]. In this study, we investigate differences in perceived attractiveness of European faces of Czech origin between Vietnamese persons living in the Czech Republic (henceforth Czech Vietnamese) and Vietnamese permanently residing in Vietnam (henceforth Asian Vietnamese). We expect that attractiveness judgments of Czech Vietnamese raters should be closer to attractiveness judgments of Czech European raters than to assessments by Asian Vietnamese raters. In other words, we hypothesize that the correlation in attractiveness judgments between Czech European and Czech Vietnamese raters is stronger than the correlation between Czech European and Asian Vietnamese raters. Moreover, we expect that this difference should be statistically significant. We also expect that Czech Vietnamese raters should be better adapted to the perception of sexually dimorphic traits of Czech faces and to local morphological typicality in general than Asian Vietnamese raters. In other words, we expect that the Czech Vietnamese raters have a better representation of both Czech facial population mean and the degree of facial masculinization/feminization and that the correlation between attractiveness and degree of shape sexual dimorphism (SShD) measured from faces will be greater between Czech and Czech Vietnamese than between Czech and Asian Vietnamese raters. Finally, we investigate the pattern of relative contribution of objectively measured level of sexual dimorphism and averageness to the perception of facial attractiveness in all three groups of raters (Czech Europeans, Czech Vietnamese, and Asian Vietnamese).

Materials and methods

Ethical statement. All the experiment protocol for involving humans was in accordance to guidelines of national/international/institutional or Declaration of Helsinki. All procedures mentioned and followed were approved by the Institutional Review Board of the Faculty of Science of the Charles University (protocol ref. number 06/2017).

Data acquisition. We took facial portraits of 100 Czech participants (50 women: mean age = 23.64; SD = 4.29; range = 19–36; 50 men: mean age = 24.04; SD = 3.88; range = 19–34). Portraits were collected in Prague, Czech Republic, during several sessions but always in the same room under the same conditions.

Facial portraits were acquired using a standardized procedure[80]. Participants were photographed in front of a white background with a full-frame color camera Canon 6D using a studio flash. We used an EX SIGMA 1.4f 85 mm lens and set the focus point to the left eye. Shutter speed was set to 1/100 s, exposure to ISO 100, aperture F8, and 2/3 of strobe power. Photographs were taken from a tripod adjusted to each participant's height so that the target's face was in the middle of the image. Distance between lens and target's tip of the nose was set to 1.25 m to preserve natural variability in face size in each image and to obtain the sharpest result possible with the lens used. Participants were instructed to adopt a neutral, non-smiling facial expression and refrain from any mimic muscle activity. Participants were asked not to wear any makeup, glasses, jewelry, or other decorations and they all wore a black T-shirt.

Rating of facial images. Facial portraits were assessed for attractiveness by Czech European raters, members of the Vietnamese minority living in the Czech Republic and Vietnamese persons living in Vietnam. In Vietnam, raters were students of the University of Science and Technology of Hanoi. In Czech Republic, raters were Czech university students of European origin. The Czech Vietnamese raters were attendees of the special meeting called "Banana Fest" a multi-genre festival introducing the culture of so-called "banana children", which is a colloquial name for the second generation of Vietnamese migrants living in the Czech Republic. The inclusion criteria for Czech Vietnamese were the participant's ability to fluently speak Czech and the information that they attended Czech education system. The participants from all three rater-groups were asked to report their sexual orientation (heterosexual, homosexual, other). We used only data from individuals that identify themselves as heterosexuals.

Photographs of Czech European women were rated by Czech European men ($N = 34$, mean age = 28.18, $SD = 4.210$), Czech Vietnamese men ($N = 28$, mean age = 23.04, $SD = 6.19$) and Asian Vietnamese men ($N = 53$, mean age = 21.18, $SD = 2.01$). Photographs of Czech men were rated by Czech European women ($N = 89$, mean age = 27.56, $SD = 4.23$), Czech Vietnamese women ($N = 29$, mean age = 24.17, $SD = 7.44$) and Asian Vietnamese women ($N = 32$, mean age = 21.9, $SD = 4.33$). In other words, raters of each sex rated a set of 50 facial portraits of the other sex for attractiveness: men rated photographs of women and vice versa. Raters viewed each portrait on an IPS computer screen with resolution 1980 × 1080 pixels, using a fullscreen setup of survey session, seeing only one photograph at the time, and assessed attractiveness on a 7-point scale (ranging from 1—very unattractive to 7—very attractive). There was no time limit for exposure to each portrait. In each rating session, the order of photographs was randomized.

Cronbach's alpha showed high interrater agreement for attractiveness judgments of Czech female photographs by male Czech European raters ($N = 33$, $\alpha = 0.961$), male Czech Vietnamese raters ($N = 27$, $\alpha = 0.982$), and male Asian Vietnamese raters ($N = 57$, $\alpha = 0.984$). Female raters also showed high interrater agreement when judging the attractiveness of Czech male photographs (female Czech European raters: $N = 89$, $\alpha = 0.971$; female Czech Vietnamese raters: $N = 16$, $\alpha = 0.972$; female Asian Vietnamese raters: $N = 32$, $\alpha = 0.962$).

All participants provided their informed consent by clicking on the 'I agree' button to consent with their participation in the study.

Statistical analyses. Relationships between variables were preliminarily explored using Pearson's zero-order correlation coefficient. Average ratings within each rater group (Czech European, Czech Vietnamese, and Asian Vietnamese) were first calculated for individual facial images.

To analyze the data on the level of individual ratings, we built a mixed effect model using the *lmer* function within the *lmerTest* R package[81], with completely specified varying intercepts and slopes among rater groups and random intercepts of raters within rater groups and random intercepts of rated targets (faces). Attractiveness ratings were set as a response variable and age, BMI, averageness, and sexual shape dimorphism as predictors. Varying intercepts and slopes were included as interaction terms between predictors and rater groups. We evaluated contrasts between pairs of rater-groups using *glht* function from *multcomp* R package[82]. Two separate models were built, one for men and one for women.

In addition to mixed effect models, we used path analysis to investigate directed dependencies between perceived attractiveness, sexual shape dimorphism (SShD), averageness, individual's age, and body mass index (BMI). Path analyses were conducted using the *sem* function within the *lavaan* package available in R software for statistical computing[83]. First, we predicted directed dependencies among the variables (no correlational associations were investigated). Dependencies were directed according to logical constraints, so that for instance age could either positively or negatively affect the BMI but BMI could not affect a person's chronological age. No latent variables were included in the model syntax.

The main dependent variable was attractiveness. SShD, BMI, and averageness were set as mediators between age and attractiveness. Averageness and sexual dimorphism were also viewed as mediators in the association between BMI and attractiveness. A direct association between age and attractiveness was also included in the model. The number of observations was relatively low, which is why we calculated a "robust" p-value using the Monte Carlo permutation procedure. We estimated a full model fit on randomized datasets based on 10,000 simulation runs, on which we derived the distribution of expected regression coefficients.

Geometric morphometrics and anthropometric measurements. A total of 72 landmarks were digitized on the faces of 50 men and 50 women. Not all aspects of facial morphology can be described by discrete homologous points that can be unambiguously identified in every face in the sample. For this reason, 36 landmarks were identified a posteriori as semilandmarks that denote curves and outlines. Facial configurations were aligned by generalized Procrustes analysis using the *gpagen* function in R geomorph package[84]. Procrustes-aligned specimens were projected onto tangent space prior to further computations. An algorithm which reduces the bending energy between each facial configuration and Procrustes mean was used to optimize the semilandmarks positions.

To measure the level of individual expression of SShD, we applied the Procrustes fit (a generalized Procrustes analysis) to all 100 faces (both men and women). Subsequently, we determined the position of each individual facial shape along the axis connecting male and female facial averages[85,86]. By projecting each individual face onto a vector linking the average female and male face, we obtained SShD scores which were used in subsequent analyses.

To calculate facial averageness, we performed a Procrustes fit separately for male and female faces. Average landmark configuration (consensus) was then calculated separately for male and female faces. Procrustes distances between the consensus and each facial configuration in the set were computed and used as a measure of individual averageness. Lower facial averageness scores thus indicate particular configuration's proximity to the mean shape, while higher averageness scores indicate more distinct faces.

The weight of the photographed person was taken by scales, and the height measured by tape measure fixed on the wall. We calculated the body mass index (BMI) of a given person as weight [kg] divided by squared height [m]. The age of the person was self-reported.

Results

Pearson's correlations between attractiveness ratings and anthropometric traits are summarized in Supplementary Tables S1 and S2 for photos of men and women, respectively. The results were adjusted for multiple tests.

The results of mixed effects models are summarized in Tables 1 and 2. The attractiveness ratings of Czech Europeans were used as a standard measure of Czech facial attractiveness. Attractiveness ratings of Czech European and Czech Vietnamese raters were associated more strongly that the ratings of Czech Vietnamese and Asian Vietnamese raters.

Post hoc comparisons of selected pairs of rater-groups (using the Tukey HSD test) indicated that the attractiveness assessment of Asian Vietnamese women was significantly different from Czech Europeans ($\delta_{CZ-AVN} = -0.406$, SE = 0.151, $p = 0.02$) as well as from Czech Vietnamese female raters ($\delta_{CZVN-AVN} = -0.6641$, SE = 0.188, $p = 0.001$). Czech European and Czech Vietnamese female raters did not significantly differ in their attractiveness judgment of Czech European male faces ($\delta_{CZ-CZVN} = -0.258$, SE = 0.157, $p = 0.224$).

In similar vein, the attractiveness assessment of Asian Vietnamese was significantly different from Czech Europeans ($\delta_{CZ-AVN} = -0.487$, SE = 0.1624, $p = 0.008$) as well as from Czech Vietnamese male raters ($\delta_{CZVN-AVN} = -0.602$, SE = 0.171, $p = 0.001$). Czech European and Czech Vietnamese male raters did not significantly differ in their attractiveness perception of Czech European female faces ($\delta_{CZ-CZVN} = -0.115$, SE = 0.188, $p = 0.814$).

The preference for average male faces was statistically different neither between Czech European and Czech Vietnamese ($\delta_{CZ-CZVN} = 0.002$, SE = 0.028, $p = 0.995$) nor between Czech European and Asian Vietnamese ($\delta_{CZ-AVN} = 0.056$, SE = 0.027, $p = 0.096$,) as well as between Czech Vietnamese and Asian Vietnamese ($\delta_{CZVN-AVN} = 0.054$, SE = 0.034, $p = 0.248$) female raters. In case of female faces, the preference for faces with higher averageness was significantly different between Czech European and Czech Vietnamese ($\delta_{CZ-CZVN} = -0.13$, SE = 0.043, $p = 0.008$) and between Czech European and Asian Vietnamese ($\delta_{CZ-AVN} = -0.174$, SE = 0.037, $p < 0.001$) male raters. Averageness preference did not differ significantly between Czech Vietnamese and Asian Vietnamese ($\delta_{CZVN-AVN} = -0.05$, SE = 0.039, $p = 0.475$) male raters.

Random effects							
Groups	**Name**	**Variance**	**SD**	**Corr**			
Ratergroup:rater	(Intercept)	0.523	0.723				
	age	0.002	0.045	− 0.67			
	bmi	0.001	0.028	− 0.35	0.93		
	avrg	0.001	0.029	− 1.00	0.66	0.34	
	sshd	0.001	0.034	− 0.61	− 0.18	− 0.53	0.62
Face	(Intercept)	0.558	0.747				
Residual		0.798	0.893				
Fixed effects	**Estimate**	**SE**	**df**	**t-value**	**p-value**		
(Intercept)	2.779	0.131	96.553	21.186	<0.001***		
age	− 0.029	0.114	45.752	− 0.253	0.802		
bmi	− 0.058	0.114	45.659	− 0.506	0.615		
avrg	− 0.222	0.109	45.668	− 2.033	0.048*		
sshd	− 0.081	0.109	45.697	− 0.745	0.460		
ratergroupCZVN	− 0.258	0.157	147.004	− 1.644	0.102		
ratergroupAVN	0.406	0.151	147.012	2.685	0.008**		
age:ratergroupCZVN	− 0.070	0.031	345.605	− 2.296	0.022*		
age:ratergroupAVN	− 0.036	0.029	345.846	− 1.205	0.229		
bmi:ratergroupCZVN	− 0.014	0.029	802.030	− 0.462	0.644		
bmi:ratergroupAVN	− 0.063	0.028	802.854	− 2.212	0.027*		
avrg:ratergroupCZVN	0.002	0.028	1275.341	0.086	0.932		
avrg:ratergroupAVN	0.056	0.027	1278.423	2.064	0.039*		
sshd:ratergroupCZVN	− 0.027	0.028	392.408	− 0.943	0.346		
sshd:ratergroupAVN	− 0.049	0.027	392.979	− 1.790	0.074		

Table 1. Summary of the results of mixed effects modelling for faces of men (female raters). Significance levels: *$p < 0.05$ **$p < 0.01$ ***$p < 0.001$. *CZVN* Czech Vietnamese, *AVN* Asian Vietnamese, *sshd* sexual shape dimorphism, *avrg* distance from the average, *bmi* body mass index.

The preference for facial dimorphism did significantly differ between in neither of compared rater groups for both male ($\delta_{CZ\text{-}CZVN} = 0.027$, SE = 0.028, p = 0.61; $\delta_{CZ\text{-}AVN} = -0.049$, SE = 0.027, p = 0.17; $\delta_{CZVN\text{-}AVN} = -0.022$, SE = 0.034, p = 0.788) and female photos ($\delta_{CZ\text{-}CZVN} = 0.009$, SE = 0.033, p = 0.959; $\delta_{CZ\text{-}AVN} = 0.028$, SE = 0.028, p = 0.581; $\delta_{CZVN\text{-}AVN} = 0.019$, SE = 0.03, p = 0.797).

We used the path analysis to trace interrelations between attractiveness, age, BMI, SShD, and averageness. In total, we performed six analyses. We separately analyzed the perception of male and female Czech faces by three groups of raters, namely Czech Europeans, the Czech Vietnamese, and the Asian Vietnamese. The results are summarized in Fig. 1.

Path analyses yielded a constant cross-group structure of a causal pattern of interdependencies for both male and female Czech faces. Attractive female faces were closer to the population average. BMI and age had a negative effect on perceived facial attractiveness. In general, the effect of sex-typicality (here represented by SShD) on attractiveness was not statistically significant. Only Czech European male raters tended to be sensitive to female SShD: they associated attractiveness with more feminine-shaped faces. In the case of male faces, averageness influenced the perception of attractiveness but for Czech and Asian Vietnamese female raters, this association was not statistically significant. Otherwise, we found no other differences between Czech European, Czech Vietnamese, and Asian Vietnamese rater groups.

Discussion

As expected, Czech Vietnamese raters were more accurate than Asian Vietnamese raters at predicting the attractiveness of Czech faces (whereby attractiveness of Czech faces as assessed by Czech European raters was considered a standard). In general, however, the results regarding preferences for averageness and sex-typicality did not correspond to the initial theoretical expectations.

The reason why Czech Vietnamese raters were capable of estimating facial attractiveness of Czech faces more accurately (again, with the Czech European judgments taken as a standard) than Asian Vietnamese raters may be in part due to differences in the perceptual narrowing in early childhood. Infants discriminate between faces of their own and other populations equally well until the age of six months. Then this capacity decreases and by the ninth month of life, young children are losing this ability. In later life, people thus discriminate among faces belonging to other populations less well than among faces belonging to their own population[87–90]. All Czech Vietnamese raters in our sample were born in the Czech Republic or moved to the Czech Republic at a very young age. Most of them should thus have some very early experience with European faces, for instance, during visits to a Czech doctor, while the Vietnamese residing in Vietnam would not be likely to have such early experiences of European faces. The better accuracy in the assessment of attractiveness might be thus due to differences in

Random effects							
Groups	**Name**	**Variance**	**SD**	**Corr**			
Ratergroup:rater	(Intercept)	0.520	0.721				
	age	0.005	0.073	− 0.23			
	bmi	0.001	0.038	− 0.20	1.00		
	avrg	0.012	0.109	0.07	0.96	0.96	
	sshd	0.000	0.020	0.04	0.96	0.97	1.00
Face	(Intercept)	0.258	0.508				
Residual		0.791	0.889				
Fixed effects	**Estimate**	**SE**	**df**	**t-value**	**p-value**		
(Intercept)	2.681	0.146	152.60	18.323	< 0.001***		
age	− 0.201	0.077	53.65	− 2.626	0.011*		
bmi	− 0.210	0.076	51.71	− 2.751	0.008**		
avrg	− 0.436	0.078	57.12	-5.584	0.000***		
sshd	− 0.092	0.076	51.19	− 1.206	0.233		
ratergroupCZVN	− 0.115	0.188	111.00	− 0.610	0.543		
ratergroupAVN	0.487	0.162	111.00	2.997	0.003**		
age:ratergroupCZVN	− 0.012	0.038	158.30	− 0.326	0.745		
age:ratergroupAVN	0.032	0.032	158.40	1.002	0.318		
bmi:ratergroupCZVN	0.042	0.034	399.90	1.224	0.222		
bmi:ratergroupAVN	0.103	0.030	400.20	3.479	0.001***		
avrg:ratergroupCZVN	0.129	0.043	124.20	2.996	0.003**		
avrg:ratergroupAVN	0.174	0.037	124.30	4.695	<0.001***		
sshd:ratergroupCZVN	26.810	0.015	1526.00	0.274	0.784		
sshd:ratergroupAVN	− 0.020	0.008	536.50	0.991	0.322		

Table 2. Summary of the results of mixed effects modelling for faces of women (male raters). Significance levels: $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. *CZVN* Czech Vietnamese, *AVN* Asian Vietnamese, *sshd* sexual shape dimorphism, *avrg* distance from the average, *bmi* body mass index.

the perceptual narrowing between the Vietnamese born in the Czech Republic and those who were born and grew up in Vietnam.

Path analysis did not reveal any substantial differences between the three compared rater groups of either sex. Czech men tend to prefer more sex-typical women (r = 0.27). Still, the association was not statistically significant (at alpha = 0.05), and the mixed effects model also did not reveal any nonrandom association between SShD and attractiveness. Female facial attractiveness was negatively associated with age. Age did not significantly affect perceived attractiveness of Czech male faces when rated by women from all three rater-groups. These results support previous findings[69,72]. BMI and attractiveness were mediated by facial sex-typicality in female faces. Higher BMI negatively affected the morphological femininity of Czech female faces.

The degree of sexual dimorphism varies across different human populations[91]. In this context, it may be relevant to note that European faces express a greater level of sexual dimorphism than faces of Asian origin[92]. The lower degree of sexual dimorphism in Vietnamese persons in comparison to more dimorphic Czech Europeans could be the reason why for the Asian Vietnamese sexual dimorphism (facial masculinity/femininity) may be a less efficient cue for assessing overall facial attractiveness. An additional reason why Vietnamese raters of Asian origin did not tend to utilize traits associated with sexual shape dimorphism as a cue of attractiveness may be that Asian people tend to attribute relatively greater significance to facial skin color and texture than Europeans do[93]. Czech Vietnamese raters followed the same pattern as their Asian peers, which seems to contradict the above-mentioned assumption of importance of environmental influence. One may speculate that genetic and/or parental imprinting-like effects might play a greater role in setting the preferences for sexually dimorphic facial traits.

A possible weakness of this study may be the relatively small sample size of female raters belonging to the Vietnamese minority in the Czech Republic. The Czech Vietnamese community is not very open to outsiders and especially female members of this community willing to participate in this research were hard to find. In future research, this limitation could be reduced, for instance, by monetary reward for participation to attract more Czech Vietnamese raters, although a promise of reward may be a selection criterion that could bias the understanding of attractiveness perception among this community. Ideally, future research should be undertaken by a Czech Vietnamese researcher who might be able to secure a higher level of cooperation of the Vietnamese diaspora living in the Czech Republic.

On the whole, we found that facial averageness of female European faces (in contrast to only weak or none effect in males) plays a significant role in attractiveness assessment in all three rater groups that differ in their racial background, country of residence, or both. This is partly consistent with the "average is attractive" hypothesis[41,43]. In both sexes, the place of long-term residence and/or upbringing was a significant factor in their

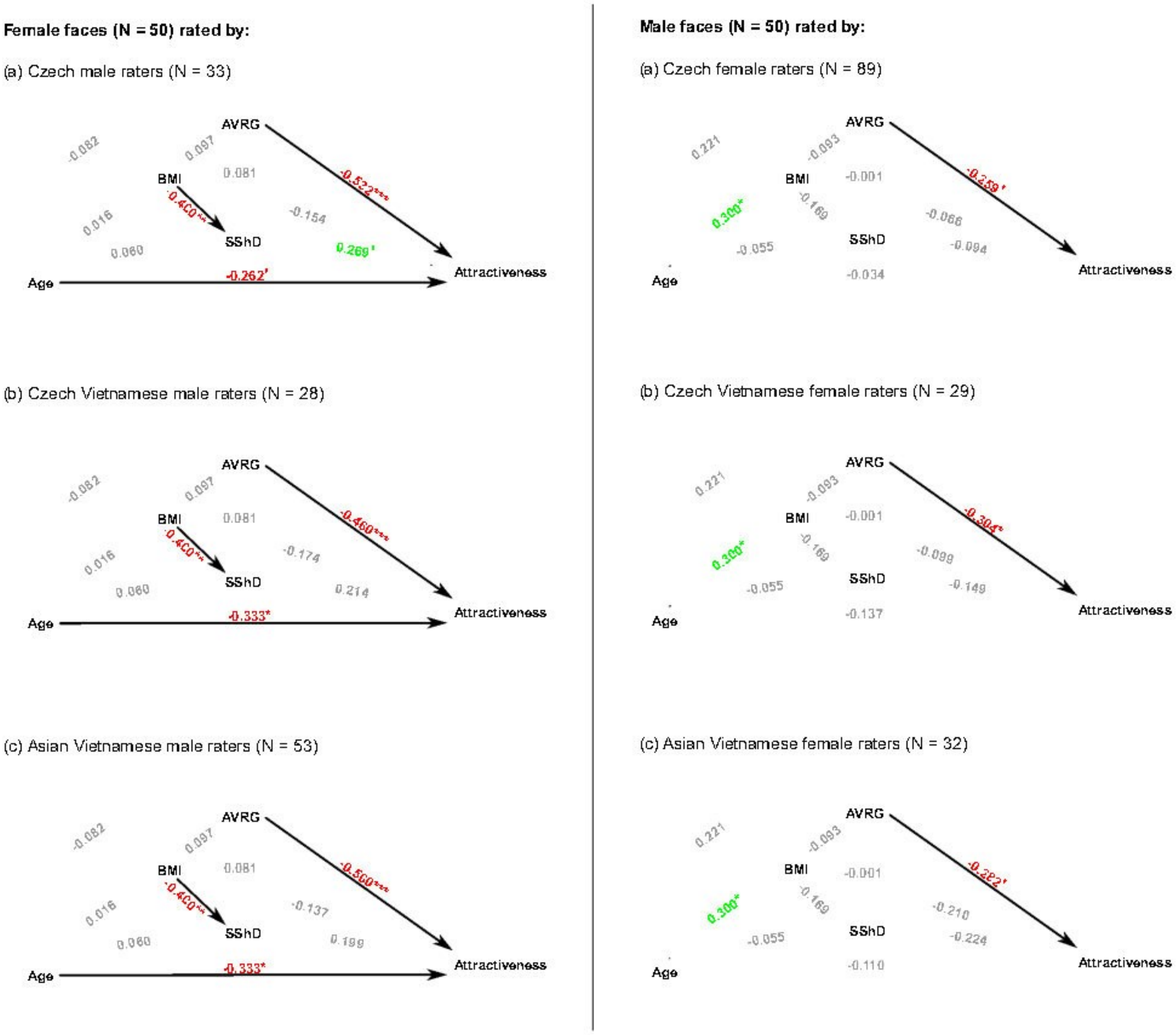

Figure 1. Visualization of path analyses of correlations between reported age, body mass index (BMI), sexual shape dimorphism (SShD), measured averageness (AVRG), and attractiveness. Arrows denote causal directions. The number next to a significant path describes the estimate of regression coefficient of the model with standardized variables. Green color of an arrow denotes a positive coefficient, red color a negative one. Asterisks represent the level of significance ($p < 0.05$*, $p < 0.01$**, $p < 0.001$***) of partial regression coefficient being non-zero. Gray arrows denote absence of a significant relationship. Apostrophe (') denotes a nonsignificant trend ($p < 0.1$, $p > 0.05$). The higher the SShD value, the more female sex-typical is the facial shape. Lower (negative) values correspond to more masculine facial configurations. A positive association between perceived facial attractiveness and SShD in male faces therefore means that less sex-typical male faces are perceived as more attractive. In female faces, a positive association between SShD and perceived attractiveness indicates that women with more sex-typical (feminine) faces are perceived as more attractive. In both sexes, the negative association between averageness and attractiveness means that more average faces were perceived as more attractive.

perception of facial attractiveness. Vietnamese respondents living in Czech Republic were significantly better at predicting attractiveness of Czech faces than Vietnamese living in Vietnam were.

Data availability

The dataset and R code is available at https://osf.io/9a5mt/.

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Author contributions
K.K. developed the study concept and wrote the initial draft of the manuscript, O.P. collected data in the studied populations, V.F. and K.K. provided data analyses, and V.F. designed the figures. All authors discussed the results and contributed to the final manuscript.

Competing interests
The authors declare no competing interests.

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He developed the study concept, contributed to study design, performed the data collection, reviewed the literature, contributed to data analysis, wrote the initial draft of the manuscript, and worked on the manuscript revisions.

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Congruence in European and Asian perception of Vietnamese facial attractiveness, averageness, symmetry and sexual dimorphism

Ondřej Pavlovič✉, Vojtěch Fiala & Karel Kleisner

Attractiveness is a proposed universal cue to overall biological quality. Nonetheless, local raters and raters of the same ethnicity may be more accurate in assessing the cues for attractiveness than distant and unfamiliar raters. Shared ethnicity and shared environment may both affect rating accuracy: our aim was to compare their relative influence. Therefore, we photographed young Vietnamese participants (N = 93, 33 women) from Hanoi, Vietnam. The photographs were rated by Czechs, Asian Vietnamese, and Czech Vietnamese (raters of Vietnamese origin who lived in Czechia for all or most of their life). Using geometric morphometrics, we measured facial shape cues to biological quality: averageness, asymmetry, and sexual dimorphism. We expected that Vietnamese raters residing in Czechia and Vietnam would agree on perceived attractiveness and use shape-related facial cues to biological quality better than Czech European raters, who are less familiar with East Asians. Surprisingly, mixed-effect models and post hoc comparisons identified no major cross-group differences in attributed attractiveness and path analyses revealed that the three groups based their rating on shape-related characteristics in a similar way. However, despite the considerable cross-cultural agreement regarding perceived attractiveness, Czech European raters associated attractiveness with facial shape averageness significantly more than Vietnamese raters.

During the Communist era, people from various socialist countries moved to the Central European socialist states as a result of state-regulated migration. For example, thousands of Vietnamese citizens took part in a state-funded labor training and exchange program in Central Europe[1]. After the collapse of the Communist regimes in the early 1990's, some Vietnamese immigrants returned to Vietnam, while many others remained in Central European countries and established themselves as small traders[2,3]. In subsequent years, more Vietnamese individuals came to the Czech Republic seeking better economic prospects, and their children, who grew up in the Czech society, often have an ambivalent connection to their Vietnamese roots and culture. They grew up among Czech children, often had Czech caregivers[4], their Czech is usually at a native speaker level, they study at Czech universities and are surrounded by Czech friends and sometimes Czech partners[5]. They identify themselves as the "banana generation" (as they themselves say: "yellow on the outside, white on the inside"), feeling more Czech than Vietnamese. In that respect, they often radically differ from their parents' generation[6,7].

Nowadays, there are over 63,000 registered Vietnamese citizens who live in Czechia. They form the third largest minority after Slovaks and Ukrainians[8]. Together with the Vietnamese who have a Czech citizenship, they are by far the most common visually distinct (i.e., non-European looking) group in the otherwise relatively ethnically homogenous Czech society. As such, they may present an ethnic group that is despite the visually distinct appearance quite familiar to Czechs of European origin. It is thus possible that Czechs of European origin are, in terms of social perception, capable of processing Vietnamese faces almost as well as (European) Czech faces. On the other hand, while the Czech majority is aware of people of Vietnamese origin living among them, they still constitute a relatively small fraction of the Czech society. European Czechs may only know a few persons of Vietnamese origin, which could reduce their ability to process Vietnamese faces.

Facial perception. The human face contains a lot of information regarding basic personal characteristics, such as gender, age, and ethnic background. It also provides cues to the mood, attention, health, social status, and various personality traits of the bearer[9–14]. After seeing a face for even a fraction of a second, a perceiver can

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assess traits such as attractiveness[15], trustworthiness[16], or aggressiveness[17]. Moreover, these assessments do not substantively change with a longer exposure to that face[15]. There is thus convincing evidence that the human face plays a pivotal role in social interactions and in the formation of first impressions.

Although humans can recognise thousands of individual faces and assess their attributes, there is good evidence to the effect that people are better at processing faces of their own race than the faces of other, visually distinctive, races[18–20]. Raters thus have a higher processing ability in their own population; we refer to this ability using the term 'perceptual expertise' and shall therefore speak about a 'perceptual expertise hypothesis.' If it is correct, reported cross-cultural disagreement on various perceived facial characteristics, such as attractiveness or trustworthiness[21–23], is the result of a relatively lower perceptual expertise, primarily due to lack of exposure to and experience with processing of faces of other ethnicities[24]. Basic facial encoding schemes develop during the first years of life—mostly through exposure and visual experience[25–28]. Frequent early exposure to faces of visually distinctive populations can allow children to acquire a similar level of perceptual expertise regarding faces from all these distinctive populations[29–31]. Evidence suggests that learning and visual experience can have this effect also in adults[24]. Of equal importance is the fact that differentiation among individual faces[32,33], trait attribution[34], and behaviour towards group members[35] are strongly influenced by individual motivation[36] as well as ingroup/outgroup classification, possibly based on phenotypical differences and ethnicity[37]. As a result, raters from the majority population lacking such motivation may perceive ethnic minorities in a stereotypical way and feel that 'they all look alike'[38].

What remains unclear is the relative contribution of various factors and processes, such as one's own environmental influence or previous exposure and experience, to the formation of judgements and preferences based on facial perception.

Attractiveness. One of the perceived facial characteristics affected by perceptual expertise is attractiveness. Evidence suggests that members of groups that are isolated from each other do not agree on facial attractiveness ratings[21,22,39]. This is significant because attractiveness plays an essential role in mate choice and other social interactions: attractive people tend to be attributed more positive personality traits[40–42], they are seen as healthier[43], more intelligent[44], and they are more likely to be hired for a job[45]. In the context of mate choice, attractive people have more dates, are seen as more competent in dating, and their dating partners report higher satisfaction with their dates[46–48]. While this might be due to the attractiveness halo effect[49] and lack any other function, it may also stem from attractiveness perception being an adaptation. Evolutionary psychology proposes that attractive traits function as cues to various aspects of underlying biological quality[43], and that is why they are preferred.

In the East Asia, ideal woman is youthful, cute and innocent. The most prominent features associated with beauty are the size of an individual's eyes and pale white skin without irregularities or visible defects; preferences for less prominent chin and cheekbones are also reported[11,50–52]. Large and pale eyes are believed to resemble features of all baby mammals. Such configuration, also known as baby schema, is generally perceived as cute[53–55], and makes an individual look younger. This may explain why one of the most common aesthetic procedures in Asia is blepharoplasty, correcting eyelid defects[56].

In most human populations across the globe, including Asian societies, pale white skin is historically associated with high social status, as lower class often had tanner skin from working in the fields[57]. Due to their desire for spotless, clean, fair, white skin, Asian women often tend to limit exposure to sunlight by using long sleeves, protective sunscreen, and by staying in the shade. However, this leads to higher incidence of Vitamin D deficiency in East Asian women[58].

Although these beauty ideals are likely deeply rooted in Asian history and culture, the Eurocentric influence is also a crucial factor[52]. Both in Western and Asian media, a lot of attention is given to people of mixed origins who exhibit European features with Asian appearance, also known as "pan-Asians" due to cosmopolitanism and homogenization of various Asian ethnicities[59]. Moreover, Asian women are more likely to endorse mainstream beauty standards similar to white women, leading to higher rate of body dissatisfaction among East Asian women[60,61]. This tendency for self-comparison to the Western standarts speaks in favor to the idea that East Asians are generally more susceptible to universal sociocultural norms, independent of kinship[62] Averageness (proximity to the population norm), facial symmetry, sexual dimorphism, age, and cues to body mass were described as the most important shape-derived traits that affect facial attractiveness[46]. In the following, we review their contribution to overall attractiveness and their proposed evolutionary significance.

Averageness of face shape (in the sense of low deviation from the population mean) is perceived as attractive and healthy-looking[63–66]. Some studies suggests that averageness of the face shape indicates higher heterozygosity, genetic diversity and immunocompetence, and therefore also a higher biological quality[43,64,67,68]. Nonetheless, it is crucial to refrain from assuming direct and oversimplified linear relationships between genetic diversity and the benefits of genetic heterozygosity, as well as between averageness of face shape, heterozygosity, or facial attractiveness. For instance, research based on populations in Iceland and Denmark reveals an n-shaped curve in the bivariate association between fertility and the degree of kinship within couples, suggesting that genetic diversity is beneficial only to a certain degree. This implies that at least in some populations the reproductive success and fertility rates may rise as the level of kinship increases, with a steep decline among couples who are second cousins or have even closer kinship[69,70]. The association between higher face shape averageness and attractiveness is also not linear: Evidence indicates that while averageness is attractive, the most attractive faces are not the most average ones[63,65,71], which points to the multifaceted nature of human facial attractiveness. Altogether, while face shape averageness exhibits a certain degree of preference across various human populations, some uncertainty still surrounds this phenomenon. Studies based on cross-cultural ratings of mutually isolated groups point to the importance of visual experience with and/or spatial proximity between individuals of the rating and rated population[72,73]. Other studies stress the importance of familiarity with the given stimuli[74,75], providing an explanation that is relatively independent of facial cues regarding biological quality.

It has been suggested that facial symmetry is an indicator of biological quality[76–78]. Fluctuating asymmetry (random deviation from bilateral symmetry) is considered to be a measure of an organism's relative developmental instability and is known to increase under environmental and genetic stress[77,79–81]. Moreover, lower fluctuating asymmetry is linked with higher intelligence[82], higher assessment of perceived health[83], and higher facial masculinity in men[84]. More symmetrical faces are also attributed more positive personality attributes[85,86]. It has been shown that in men, but not in women, facial symmetry is weakly but credibly associated with facial attractiveness[66]. All in all, reports on the relationship between facial symmetry and attractiveness are rather mixed: according to some studies, lower fluctuating asymmetry is linked with higher attractiveness[66,87,88], while other studies found no such effect[72,89,90]. This inconsistency of findings could be due to differences in methodology or perhaps overestimation of effect sizes due to publication bias[91]. Some studies worked with unmanipulated facial photographs, while other studies used images that were artificially manipulated using various manipulation techniques[41].

Sexual dimorphism in human faces emerges around puberty and is the consequence of the increasing effect of sex steroids[92,93]. In the faces of women, feminine facial traits are associated with higher perceived attractiveness within and across human populations[43,94] and often interpreted as reliable cues to fertility and reproductive capacity[95–97].

In the case of male faces, the situation is less clear. Some studies report a preference for more masculine facial configurations[98–100], others found preference for less masculine, i.e., more feminine faces[101–103], and yet other researchers found no preference for either masculine or feminine facial traits[104,105]. Such highly mixed results could be partly due to methodological differences in stimuli preparation[43], but different environmental and socioeconomic conditions[106,107] might also drive some systematic shifts in preferences for facial masculinity across populations[72,108,109]. Moreover, interpersonal differences between female raters related to hormone levels, phase of the menstrual cycle, and relationship status might also affect their masculinity preferences[110,111].

Masculine traits are interpreted as a signal of good health[67]. They are associated with higher perceived dominance[112], higher social status[113], and good fighting ability[114]. While these characteristics are preferable, masculinity is also a cue to aggressiveness[114,115] and low partner fidelity[116], that is, characteristics potentially detrimental to the success of a partnership. Women thus potentially make a trade-off between desirable and detrimental characteristics of masculine males[117], which is why the results of studies on this subject differ: the optimal balance varies depending on both environmental conditions and women's individual characteristics.

Age negatively affects perceived attractiveness, especially in women. Age-related attractiveness decline seems stable across various human populations[118,119]. Although age serves as a potential cue to residual fertility in women[120], the use of hormonal contraception largely nullifies this effect[97]. In men, the age-related decline of attractiveness is much slower and can be partly compensated by simultaneous raise in perceived power and dominance[118,121]. Despite the age-related attractiveness decline, older individuals, in particular women, report on average higher self-perceived attractiveness[122] and individuals of both sexes rate faces of all ages in more balanced manner that younger participants, who tend to rate younger faces as more attractive than old faces[123].

Relative body weight also affects facial features and, in turn, the ascribed characteristics. It has been shown that people can estimate BMI from facial cues alone[124]. Facial cues to relative body mass, mainly facial adiposity, influence perceived attractiveness and health, although the level of facial adiposity that is considered most attractive and most healthy can slightly vary between populations[125–127].

In our previous study on 'Central European facial attractiveness', we made a noteworthy discovery indicating that a shared environment can generate a consensus on perceived facial characteristics, thereby diminishing the influence of one's ethnicity[128].

The current study. Our present study aims to further examine the role of shared environment and ethnical background on the same populations, namely Czechs, Czech Vietnamese (members of the Czech population of Vietnamese origin) and Asian Vietnamese, with Vietnamese faces as stimuli. This dual perspective approach may offer new insights into facial perception among immigrants or other bicultural individuals.

We collected photographic facial stimuli of ethnically Vietnamese persons and had them rated by Asian Vietnamese (AVN), Czech Vietnamese (CZVN), and Czech European raters (CZE). Our aim was to see whether the ratings of these three groups converge. The Czech Vietnamese represent a minority that is both encultured into and phenotypically distinct from the local population of European origin. This makes the Czech Vietnamese a suitable group for investigating the influence of varying level of inaccuracy in facial attractiveness attribution, which may be due to different levels of familiarity with given facial stimuli.

We suggest that Czech raters of European origin are the least familiar with Vietnamese faces, Asian Vietnamese are most familiar with them, while Czech Vietnamese are potentially somewhere in-between the two groups. Based on this, we propose the following hypotheses:

In assessing Vietnamese faces, Vietnamese raters might acknowledge the characteristics which do serve as cues to biological quality but are not noticed by ethnically European perceivers. On the other hand, people of Vietnamese origin who grew up in Czechia surrounded by few Asian and many European faces may judge the target faces in a way that is more similar to the Czech European than the Asian Vietnamese perspective. That would imply that perceptual schemes are based on prevailing visual diet even when the perceived faces are phenotypically different[29] and may be locally adaptive. Under this assumption, raters residing in Europe (Czech Republic) should, regardless of their ethnic origin, assess the attractiveness of Vietnamese faces by 'European optics', which differs from 'East Asian optics' and reflects the demands of local social and environmental factors (hence a hypothesis regarding 'socio-environmental factors').

Alternatively, it is possible that the Czech Vietnamese maintain largely the same preferences as Asian Vietnamese raters, following patterns and adaptations established in East Asian Vietnamese population. These preferences, typical for Asian (Vietnamese) raters, are thus not affected by European socio-environmental conditions. In that case, Czech European raters might judge attractiveness differently. Insufficient exposure to Vietnamese faces may lead Czech European raters to application of the same perceptual schemes as they use for European faces, which could result in overlooking adaptive cues to biological attractivity. If the above is the case, ratings of all Vietnamese raters (from both the Czech Vietnamese and Asian Vietnamese sample) should converge and both should differ from the ratings made by European Czechs. This would amount to support of the hypothesis of 'parental impact effect' in favour of own population.

The Asian Vietnamese are not affected by Czech culture and environment, nor are their preferences for Vietnamese faces shaped by it. On the other hand, it is possible that Czech European raters may trace attractiveness cues equally well as the two Vietnamese groups. In this case, a comparison of ratings by the three groups would reveal no effect of rater population on the attribution of a facial characteristic (thus supporting the hypothesis of a 'cross-population agreement').

Finally, it is possible that differences in the visual diet and other socioenvironmental factors between the three studied populations could be of such magnitude that their preferences could completely diverge, resulting in disagreement in their ratings ('disagreement hypothesis').

Furthermore, we investigated the relative contribution of three objectively measured facial traits—face shape averageness, facial asymmetry, and sexual dimorphism of facial shape—to perceived facial attractiveness across the three groups. While more symmetrical, more average, and more sex-typical configurations (male-like in men, female-like in women) should be generally preferred (see above), the three rating groups may differ in their cue utilisation. There are substantial differences in the magnitude of face shape sexual dimorphism across various populations[129]. In particular, Asian faces are characterised by a lower level of face shape sexual dimorphism than European faces[130] (see also Fig. 2). Perceivers of Vietnamese origin may thus rely more on other shape-related facial cues, for example facial averageness and symmetry. This may render, at least for the Asian and Czech Vietnamese groups, face shape sexual dimorphism effectively irrelevant with respect to perceived attractiveness.

Materials and methods

Data acquisition.

We took facial portraits of 93 Vietnamese participants (60 men, average age 21.1 years; SD = 1.85, range 18–33 years; and 33 women, average age 21.8 years, SD = 4.21, range 18–40 years). The data were collected in Hanoi, Vietnam, during several sessions between 25 January 2018 and 7 February 2018, always in the same room and under the same standardised conditions. Informed consent was obtained from all participants via computer screen prior to participation in the data collection.

Facial portraits were taken using a standardised procedure[131] used in a previous study[128]. Participants were instructed to avoid any facial makeup or jewellery and were given a black t-shirt to exclude any influence of their clothing. They were seated on a chair without a back rest, in front of a white background, and were instructed to sit straight, look directly at the camera, and adopt a neutral facial expression. Photographs were taken from a tripod set to match the sitting height so as to keep the target's face in the middle of the frame. To preserve natural variability in facial size, the distance between the lens and the tip of target's nose was always set to 125cm. This distance allowed us to obtain the sharpest possible picture with the 50mm lens used.

We used a colour camera Canon 60D connected to a studio flash and equipped with a Canon RF 50mm STM lens. The focus point was set to the left eye. Exposure was set to ISO 100, shutter speed 1/100, aperture f/8, and 2/3 of strobe power. Portraits were shot into uncompressed raw files (*.CR2 format) and later processed to JPEG files in sRGB colour space. White balance was corrected and colour correction patch (X-Rite Color Checker) was photographed at the beginning of each session to enable subsequent correction and processing of photographs.

All sampling and experimental procedures conformed to current institutional, national, and international guidelines as well as the Helsinki Declaration. This study does not include information that could lead to the identification of any particular participant. All procedures were approved by the Institutional Review Board of the Faculty of Science of the Charles University (protocol ref. number 04/2020).

Rating of facial images.

The stimuli were assessed for attractiveness by an unrelated sample of Asian Vietnamese, Czech Vietnamese, and Czech Europeans. Raters of each sex rated only portraits of the opposite sex. Some raters did not finish the whole rating session—thus the range in the number of raters. Facial photographs of Asian Vietnamese women were rated by 81–86 Asian Vietnamese men (mean age = 22.2; SD = 3.76; range = 18–47), 46–47 Czech Vietnamese men (mean age 24.2; SD = 2.98; range = 18–33), and 64 Czech European men (mean age = 24.0, SD = 5.13, range =19–43). Facial photographs of Asian Vietnamese men were rated by 116–124 Asian Vietnamese women (mean age = 22.96; SD = 4.26; range = 18–48), 63–67 Czech Vietnamese women (mean age = 23.75; SD = 5.25; range = 18–55) and 97–104 Czech European women (mean age = 25.22; SD = 5.31; range = 18–47).

Raters viewed each portrait on a computer screen in a browser with survey session set to full screen by default. It displayed one portrait at a time, centred to the middle of the screen, in a randomised order for each session, and no time limit for the exposure of each image. Raters assessed facial attractiveness on a 7-point Likert scale (1 being 'very unattractive' and 7 'very attractive'). If raters recognised the stimulus person, they were also instructed to click on 'I know this person' button to skip rating the current image.

Raters were recruited via internet (social media platforms) or asked personally and redirected to an online survey platform (Qualtrics.com). Participants younger than 18 and older than 50, those of non-target ethnicities (other than AVN/CZVN/CZE) and non-heterosexuals (self-reported) were excluded from the analysis. All participants provided informed consent by clicking on the 'I agree' button.

We assessed interrater agreement using intraclass correlation (ICC, 3k; see[132]). Interrater agreement was generally high (ICC for all rater datasets > 0.95; see supplementary Table S1).

Geometric morphometrics and anthropometric measurements. We analysed facial shape variance using geometric morphometrics. In TpsDig2 software[133], we manually landmarked each facial image following a predefined[129] layout of 72 landmarks. Of these, 36 points, true landmarks, denote anatomically and geometrically identical points across faces. Another 36 points, semilandmarks, denote curves between the true landmarks. The semilandmarks are allowed to slide along the denoted curves during shape analysis to minimise the bending energy between corresponding points across faces in a set.

Shape analysis proper was conducted using the Procrustes fit (a generalised Procrustes analysis). The generalised Procrustes analysis was executed using the *gpagen* function of the *geomorph* package[134]. Three variables were computed based on Procrustes residuals: face shape averageness, sexual dimorphism (SShD), and asymmetry. Averageness was computed as the Procrustes distance between the consensus facial configuration and an individual face. It was done separately for male (N = 60) and female (N = 33) facial photographs. To acquire the SShD, we applied the Procrustes fit to pooled male and female shape data (N = 93). Then we projected all faces on an axis connecting male and female averages[108,129,135]. For each face, we extracted a unique score denoting that face's position along a vector intersecting sex-typical averages. Finally, scores of facial asymmetry were calculated as the sum of squared difference between the original and mirrored (horizontally inverted) version of the same facial configuration[136].

Higher values of distinctiveness (lower averageness) indicate a greater distance between an individual and the average face. Higher values of asymmetry imply a less symmetrical facial configuration. Higher positive scores of SShD denote more male-like facial shape, while higher negative scores indicate more female-like facial shape.

We also took the body height and weight measurement of each photographed person using calibrated tools. Subsequently, we calculated the body mass index (BMI) as weight (in kilograms) divided by the square of a person's height (in meters). We recorded the self-reported age of each person.

Statistical analyses. We employed path analyses to trace directed bivariate relationships between attractiveness, measured facial shape (asymmetry, averageness, and SShD), age, and BMI of the photographed stimuli. They were fitted separately for each combination of rater's origin (European Czech, Czech Vietnamese, Asian Vietnamese) and the sex of the stimulus (see Fig. 1) using the *sem* function from the *lavaan* package for R software[137].

Following analyses of Pavlovič et al.[128], we used in our path analyses only directed bivariate associations. Accordingly, attractiveness entered the model as a response variable. It was directly (without mediation by other variables) predicted by age, BMI, averageness, asymmetry, and SShD. Moreover, BMI, facial asymmetry, SShD, and averageness were set as potential mediators of the association between age and attractiveness, because with ageing, the sex-typicality of facial shape might change and facial features could become relatively heavier, less symmetrical, and more distinctive. We also considered the BMI, itself fitted as age-dependent, as a predictor of all other variables. Asymmetry predicted averageness, SShD, and attractiveness. It is likely that faces with more asymmetric configurations would also be less average. Although the effect of asymmetry would probably be mediated by averageness, we also considered a direct path from asymmetry towards perceived attractiveness (see diagram in Fig. 1).

In our previous study[128], raters from the same three samples (i.e., Asian Vietnamese, Czech Vietnamese, Czech European) rated Czech faces of European origin. In that study, the layout of path analyses was the same as here except that now we added facial asymmetry. Readers may thus be advised to directly compare the results of the two studies to acquire a fuller perspective on Czech–Vietnamese perception of facial attractiveness.

Prior to analyses, all variables were standardised (scaled to zero mean and variance unity). Due to the relatively low number of raters (47–131) and in order to follow the setup of analysis from Pavlovič et al.[128], we assessed the significance of effects on the standard 5% alpha level based on 'robust' *p*-values, meaning *p*-values obtained using the Monte Carlo permutation procedure. We ran the model 10,000-times on randomised data. Then we calculated the distribution of expected regression coefficients for each bivariate association and compared them with coefficients based on the original data. A 'robust' *p*-value indicates which portion of distribution density of a given bivariate coefficient is more eccentric than the bivariate coefficient observed in the actual data.

Mixed-effect models were fitted using the lmerTest package for R[138]. We completely specified the varying intercepts and slopes among rater groups, random intercepts for each rater, and random intercepts for each stimulus face. We set the attractiveness ratings as the sole response variable. Age, BMI, averageness, and SShD served as predictors. We included interactions terms between the predictors and rater groups. To do so, we set the varying intercepts and slopes for each of the 'linear predictor:rater group' interactions. To compare ratings across the three groups, we used a post hoc test (Tukey HSD). To evaluate contrasts between the groups of raters, we used the *glht* function of the multcomp package for R[139]. We built separate models for male and female stimuli and standardised the predictors prior to analysis. Electronic supplementary material, including code and data, are available online[140].

Ethics approval. All sampling and experimental procedures conformed to current institutional, national, and international guidelines as well as the Helsinki Declaration. This study does not include information that could lead to the identification of any particular participant. All procedures were approved by the Institutional Review Board of the Faculty of Science of the Charles University (Protocol Ref. Number 04/2020).

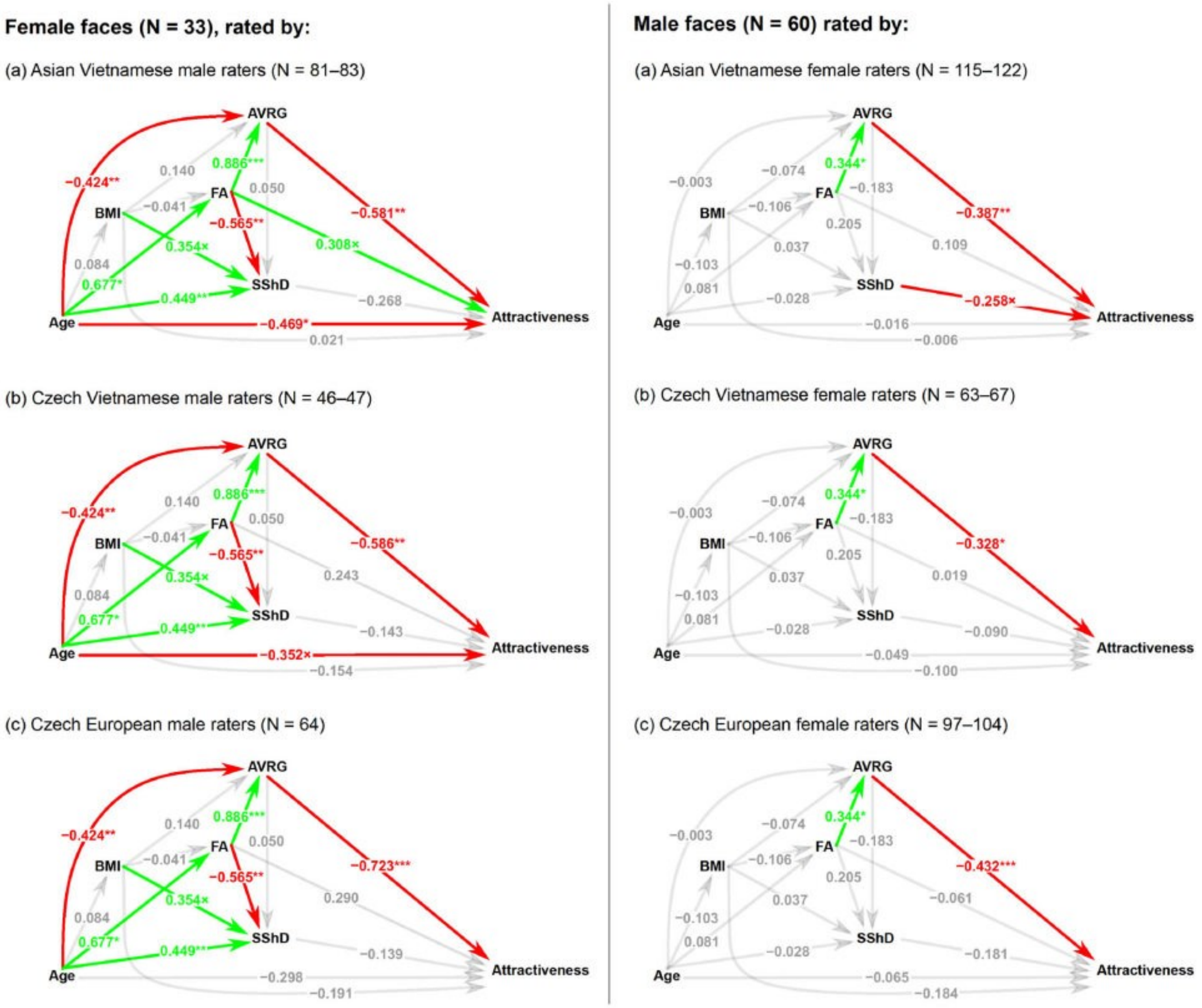

Figure 1. Visualisation of path analyses of correlations between reported age, body mass index (BMI), facial asymmetry (FA), measured averageness (AVRG), sexual shape dimorphism (SShD), and attractiveness. Arrows denote causal directions. Numbers next to paths describe the estimate of regression coefficient of the model with standardised variables. Green arrows denote a positive coefficient, red arrows a negative one. Asterisks represent the level of significance ($p<0.05$*, $p<0.01$**, $p<0.001$***) of partial regression coefficient being non-zero. Gray arrows denote the absence of a significant relationship. Multiplication sign (×) denotes a nonsignificant trend ($p<0.1$, $p>0.05$). The higher the SShD value, the more female sex-typical is the facial shape, while lower (negative) values correspond to more masculine facial configurations. The higher the AVRG value, the more distant is the face from the population average (i.e., less average). The higher the FA score, the less symmetrical is the face.

Results

The results of mixed-effect models are summarised in Tables 1 and 2. Attractiveness ratings of the Asian Vietnamese raters were used as the standard measure of attractiveness for the Vietnamese faces. In the mixed effect models, the predictors of the perceived attractiveness that turned out to be statistically significant followed the statistically significant directed bivariate paths in the path analysis (see the section below). The sole exception was a significant effect of SShD on perceived male attractiveness ($\beta=-0.111$, SE = 0.054, $p=0.041$). There was also a significant interaction term between the male part of SShD and a group of raters in the mixed effects model: the effect of SShD was significantly weaker for the Czech Vietnamese ($\beta=0.072$, SE = 0.017, $p<0.001$) but not for the Czech European female raters ($\beta=0.018$, SE = 0.015, $p=0.227$; both compared to the Asian Vietnamese as the standard measure). Using post-hoc comparison, we found no similar significant interactions between a rater group and SShD for the female stimuli.

In both male ($\beta=-0.164$, SE = 0.058, $p=0.004$) and female faces ($\beta=-0.272$, SE = 0.097, $p=0.004$), averageness was a significant predictor of perceived attractiveness. The models also revealed a significant interaction between averageness and groups of raters. In particular, in comparison with Asian Vietnamese standard, the association between averageness and male attractiveness was significantly stronger for Czech European female

Random effects								
Groups	**Name**	**Variance**	**SD**	**Corr**				
ratergroup:rater	(Intercept)	0. 723	0.850					
	Age	0.001	0.026	− 1.00				
	BMI	0.001	0.038	− 0.52	0.52			
	AVRG	0.003	0.053	− 0.66	0.66	0.99		
	SShD	0.001	0.027	− 0.41	− 0.18	− 0.53	0.62	
	FA	0.001	0.015	1.00	− 1.00	− 0.60	− 0.72	− 0.49
Face	(Intercept)	0. 162	0.403					
Residual		0. 684	0.827					
Fixed effects								
	Estimate	**SE**	**t-value**	**df**	***p*-value**			
(Intercept)	2.449	0.091	26.924	283.987	0.000	***		
Age	− 0.008	0.053	− 0.132	56.384	0.883			
BMI	− 0.002	0.054	− 0.034	56.646	0.965			
AVRG	− 0.164	0.058	− 2.818	56.944	0.004	**		
SShD	− 0.111	0.054	− 2.034	56.421	0.041	*		
FA	0.042	0.058	0.711	56.254	0.471			
ratergroupCZVN	0.081	0.128	0.633	302.824	0.525			
ratergroupCZE	− 0.106	0.111	− 0.961	306.394	0.340			
age:ratergroupCZVN	− 0.015	0.017	− 0.925	2533.303	0.374			
age:ratergroupCZE	− 0.024	0.015	− 1.690	2677.158	0.102			
bmi:ratergroupCZVN	− 0.043	0.017	− 2.500	546.523	0.010	**		
bmi:ratergroupCZE	− 0.094	0.015	− 6.131	551.490	0.000	***		
avrg:ratergroupCZVN	0.020	0.018	0.923	489.288	0.276			
avrg:ratergroupCZE	− 0.059	0.016	− 3.532	495.932	0.000	***		
sshd:ratergroupCZVN	0.072	0.017	4.127	814.154	0.000	***		
sshd:ratergroupCZE	0.018	0.015	1.150	822.379	0.227			
fa:ratergroupCZVN	− 0.036	0.018	− 1.936	5861.841	0.047	*		
fa:ratergroupCZE	− 0.010	0.016	− 0.547	5940.853	0.546			

Table 1. A summary of results of mixed-effects modelling for men's faces (female raters). Significance levels: ˣ $p<.1$ *$p<.05$ **$p<.01$ ***$p<.001$. *CZVN* Czech Vietnamese; *CZ* Czech Europeans; *SShD* face shape sexual dimorphism; *AVRG* distance from the average; *BMI* body mass index; *FA* facial asymmetry.

raters ($\beta = -0.059$, SE = 0.016, $p<0.001$). No such difference was seen for Czech Vietnamese female raters (again in comparison to the Asian Vietnamese ratings as the standard measure; $\beta = 0.020$, SE = 0.018, $p = 0.276$). For female stimuli, we found a significant interaction between a rater group (Czech Europeans) and averageness ($\beta = -0.163$, SE = 0.041, $p<0.001$), suggesting that the attractiveness–averageness association is significantly stronger for Czech European male raters than for the Asian Vietnamese male raters (which formed the standard measure). Once again, this interaction was not significant for Czech Vietnamese male raters.

Post hoc comparisons of selected pairs of rater groups (using the Tukey HSD test) indicated no significant difference between the Asian Vietnamese (AVN), Czech Vietnamese (CZVN), and Czech European (CZE) female raters in their attractiveness assessment of male Asian Vietnamese faces (δ CZVN–AVN = 0.081, SE = 0.128, $p = 0.800$; δ CZE–AVN = − 0.106, SE = 0.111, $p = 0.604$; δ CZE–CZVN = − 0.187, SE = 0.132, $p = 0.333$). Similarly, attractiveness ratings of female faces by Asian Vietnamese, Czech Vietnamese, and Czech European male raters did not significantly differ (δ CZVN–AVN = − 0.305, SE = 0.161, $p = 0.139$; δ CZ–AVN = − 0.073, SE = 0.147, $p = 0.873$; δ CZ-CZVN = 0.232, SE = 0.169, $p = 0.354$).

The preference for average male faces was significantly different between Czech European and Asian Vietnamese female raters (δ CZVN–AVN = − 0.059, SE = 0.016, $p<0.001$) and between Czech European and Czech Vietnamese female raters (δ CZ–CZVN = − 0.079, SE = 0.019, $p<0.001$). Czech Vietnamese and Asian Vietnamese preferences for average male faces did not significantly differ (δ CZVN–AVN = 0.020, SE = 0.018, $p = 0.519$). Similar to the case of female faces, preference for faces with a higher averageness was significantly different between Czech European and Asian Vietnamese male raters (δ CZ–AVN = − 0.163, SE = 0.033, $p<0.001$) as well as between Czech European and Czech Vietnamese male raters (δ CZ–CZVN = −0.131, SE = 0.038, $p = 0.002$). Czech Vietnamese and Asian Vietnamese preferences for average male faces did not significantly differ (δ CZVN–AVN = − 0.032, SE = 0.036, $p = 0.644$).

Preferences for facial dimorphism in male portraits was statistically different between Czech Vietnamese and Asian Vietnamese female raters (δ CZVN–AVN = 0.072, SE = 0.017, $p<0.001$) and between Czech European and Czech Vietnamese female raters (δ CZE–CZVN = − 0.054, SE = 0.018, $p = 0.005$). The difference in preferences for facial dimorphism between Czech European and Asian Vietnamese female raters was not significant (δ

Random effects								
Groups	**Name**	**Variance**	**SD**	**Corr**				
ratergroup:rater	(Intercept)	0. 756	0.869					
	Age	0.012	0.108	0.13				
	BMI	0.022	0.030	− 0.02	0.99			
	AVRG	0.001	0.148	− 0.11	0.97	1.00		
	SShD	0.001	0.037	− 0.85	0.41	0.54	0.61	
	FA	0.012	0.111	− 0.28	− 0.95	− 0.60	− 0.92	− 0.26
Face	(Intercept)	0. 150	0.387					
Residual		0. 667	0.817					
Fixed effects								
	Estimate	**SE**	**t-value**	**df**	***p*-value**			
(Intercept)	2.823	0.118	23.948	153.444	0.000	***		
Age	− 0.221	0.110	− 2.014	29.310	0.043	*		
BMI	0.011	0.077	0.143	28.744	0.885			
AVRG	− 0.272	0.097	− 2.815	30.308	0.004	**		
SShD	− 0.128	0.083	− 1.545	28.782	0.123			
FA	0.145	0.135	1.073	29.110	0.282			
ratergroupCZVN	− 0.305	0.161	− 1.898	191.043	0.058	x		
ratergroupCZE	− 0.073	0.147	− 0.496	191.042	0.619			
age:ratergroupCZVN	0.039	0.045	0.853	356.860	0.347			
age:ratergroupCZE	0.041	0.041	0.997	356.755	0.275			
bmi:ratergroupCZVN	− 0.091	0.029	− 3.099	1348.108	0.002	**		
bmi:ratergroupCZE	− 0.126	0.027	− 4.717	1348.398	0.000	***		
avrg:ratergroupCZVN	− 0.032	0.045	− 0.711	213.597	0.372			
avrg:ratergroupCZE	− 0.163	0.041	− 3.984	213.573	0.000	***		
sshd:ratergroupCZVN	0.055	0.032	1.719	1466.622	0.084	x		
sshd:ratergroupCZE	0.044	0.029	1.534	1466.884	0.125			
fa:ratergroupCZVN	− 0.017	0.054	− 0.337	437.522	0.737			
fa:ratergroupCZE	0.030	0.050	0.592	435.484	0.528			

Table 2. A summary of results of mixed-effects modelling for women's faces (male raters). Significance levels: ^{x} $p<.1$ $^{*}p<.05$ $^{**}p<.01$ $^{***}p<.001$. *CZVN* Czech Vietnamese; *CZE* Czech Europeans; *SShD* face shape sexual dimorphism; *AVRG* distance from the average; *BMI* body mass index; *FA* facial asymmetry.

CZE–AVN = 0.018, SE = 0.015, p = 0.448). Preferences of male raters for facial dimorphism in female faces showed no significant difference between the groups (δ CZVN–AVN = 0.055, SE = 0.032, p = 0.194; δ CZE–AVN = 0.044, SE = 0.029, p = 0.275; δ CZE-CZVN = − 0.010, SE = 0.033, p = 0.947).

Preferences for facial symmetry did not significantly differ between the compared rater groups neither for male faces (δ CZVN–AVN = − 0.036, SE = 0.018, p = 0.114; δ CZE–AVN = − 0.010, SE = 0.016, p = 0.817; δ CZE-CZVN = 0.026, SE = 0.019, p = 0.332) nor for female faces (δ CZVN–AVN = − 0.017, SE = 0.051, p = 0.940; δ CZE–AVN = − 0.030, SE = 0.047, p = 0.802; δ CZE-CZVN = 0.047, SE = 0.054, p = 0.661).

Path analyses. We fitted six path analyses (separately by the sex of the stimuli and the three groups of raters: Asian Vietnamese raters, Czech Vietnamese, and Czech European). The results are summarised in Fig. 1.

In all rater groups, male raters perceived less average female faces as less attractive (β = − 0.581, p = 0.002 for AVN; β = − 0.586, p = 0.001 for CZVN; β = − 0.723, p = < 0.001 for CZE raters). For Asian Vietnamese male raters and female targets, age was negatively associated with perceived attractiveness (β = − 0.469, p = 0.010). Czech Vietnamese raters tended to perceive younger women as more attractive, too (β = − 0.352, p = 0.062). Asian Vietnamese males tended to perceive higher facial asymmetry as more attractive (β = 0.308, p = 0.099). These two moderately strong associations were, however, not significant to the standard significance level (p = 0.05). In other words, males from all three ethnical groups preferred more average female faces. Asian and Czech Vietnamese probably used younger age as a cue to attractiveness. Interestingly, Asian Vietnamese raters tended to use facial asymmetry as an attractiveness cue, but in a reverse direction than predicted.

Moreover, in female faces, facial asymmetry was positively associated with the averageness score (β = 0.886, p < 0.001) and negatively with the SShD score (β = − 0.565, p = 0.003). Age was positively associated with the SShD score (β = 0.449, p = 0.007) and facial asymmetry score (β = 0.677, p = 0.018) and negatively associated with the averageness score (β = − 0.424, p = 0.004). It means that younger female faces were more feminine in shape, more symmetrical, and more average. BMI was marginally positively associated with SShD (β = 0.354, p = 0.051), meaning that heavier Vietnamese female faces tended to be less feminine in their shape.

Path analyses of male stimuli showed that female raters from all three ethnical groups perceived more average male faces as more attractive (β = −0.387, $p = 0.003$ for AVN; β = −0.328, $p = 0.013$ for CZVN; β = −0.432, $p < 0.001$ for CZE raters). There was a nonsignificant correlation trend between SShD and attractiveness as rated by Asian Vietnamese raters (β = −0.258, $p = 0.050$), who perceived more male-like facial shape as slightly less attractive in Vietnamese male facial stimuli. Also in male Vietnamese stimuli, we found a positive association between facial asymmetry and AVRG (β = 0.344, $p = 0.016$).

Discussion

In our previous study[128], we showed that Czech raters of both European (CZE) and Vietnamese (CZVN) origin converge on their rating of Czech European faces, while a post hoc comparison (Tukey HSD) showed that Asian Vietnamese raters (AVN) disagree with both the Czech Vietnamese and Czech Europeans. This previous study thus showed that Asian Vietnamese, probably due to the lack of experience with Czech European faces tend to process their facial attractiveness differently. The Czech Vietnamese, on the other hand, converged in their attractiveness assessment with Czech Europeans, which can be interpreted as evidence in favour of the socio-environmental factors hypothesis.

In contrast, the current study, which investigated the perception of Asian Vietnamese faces and used the same three groups of raters (CZE, CZVN, AVN) and the same procedure (Tukey HSD), revealed no significant differences between the rater groups regarding the attractiveness, ascribed to the faces across the three rating groups. While this might be due to insufficient statistical power, the stimuli counts in the two studies were comparable. Moreover, none of the insignificant effects within this study were of a similar size to significant effects in the previous study. We therefore speculate that rather than being the consequence of insufficient statistical power, our results are due to an actual consensus on attractiveness judgements across the three populations. In other words, our findings support the 'cross-population agreement' hypothesis and indicate that in the current setup, the environment and ethnicity do not influence facial characteristic attribution across these three unique samples. This is in concordance with findings from other studies, suggesting that various human populations concur on their attractiveness ratings[40,50,140] Nevertheless, it would also be problematic to generalise and claim that facial attractiveness preferences are universally shared, because several other reports did show disagreement across populations[21,22,39].

As shown in the previous study[128], Asian Vietnamese raters showed differences in their attractiveness judgments of Czech European faces, whereas no significant differences in attractiveness judgments among the rater groups were found in the present study. This discrepancy could be attributed to the limited exposure and familiarity of AVN raters with Czech European faces, leading to distinct processing of facial attractiveness compared to Czech Vietnamese and Czech European raters. In the current study with the focus on Asian Vietnamese faces, the familiarity level might have been more balanced across the raters, leading to more consistent results.

All groups of raters based their ratings on similar underlying cues to biological quality. Accurate assessment of these cues requires sufficient experience with Vietnamese faces. While the exposure to members of their families and communities may be enough for Vietnamese raters in both countries, this does not apply for Czech raters of European origin. Their experience must stem from a different source. A credible, albeit speculative, explanation of European Czech's perceptual expertise regarding Vietnamese faces is that long-term experience with faces of individuals belonging to the Vietnamese minority may have provided them with sufficient knowledge to compensate for the fact that faces of persons of Vietnamese origin are a relatively small part of their 'visual diet.' Moreover, the coexistence of Czech Europeans and Czech Vietnamese probably led to a substantive weakening of potential causes of cross-populational disagreement on attractiveness rating, which may be due to, e.g., geographic and cultural isolation in conjunction with environmental and socio-economic differences.

It is also conceivable that while the three groups give similar ratings, they base their assessments on slightly different cues[140]. Different characteristics (averageness, sexual dimorphism, youthful appearance) might hypothetically serve as cues to different aspects of biological quality[9,67,83,120]. Still, a person's overall attractiveness is determined by a wide array of clues[141]. The 'backup signal' hypothesis even states that various traits serve as redundant signals to biological quality[142]. To determine whether raters from different groups base their ratings on different facial characteristics which add to the overall attractiveness, we used path analyses, which allowed us to explore potential cross-group differences in a descriptive way, adding up to the results of post-hoc comparison. Moreover, we have also used mixed-effect models with interaction terms between predictor variables and rater groups (entered as fixed effects) to test for possible differences between Asian Vietnamese raters (standard measure) and the other two rater groups.

Across the rater groups, path analyses showed a relatively consistent layout. In general, male raters tended to perceive younger and more average female faces as more attractive. Female raters likewise perceived more average male face as more attractive but did not tend to use age as a cue to male attractiveness.

Shape averageness was thus perceived as an attractive facial characteristic by all three groups of raters with respect to both male and female faces, which is consistent with our previous findings. According to the mixed-effect models, facial averageness was relatively more important for Czech European raters than for Asian Vietnamese raters with respect to both male and female stimuli. No such significant interaction was seen for Czech Vietnamese raters, who preferred facial averageness to a same degree as Asian Vietnamese raters did.

Compared to the two groups of raters of Vietnamese origin, Czech European raters depend more on averageness possibly due to their inability to assess other cues. Facial averageness is a relatively time-stable cue to long-term healthiness[83], while current health[143], ageing[144], and potentially also current fertility[145] are indicated by different facial traits, which may, however, be hard to assess in unfamiliar faces[140]. A higher level of attention to facial averageness (as a cue to long-term biological quality) in faces belonging to a less familiar ethnicity may thus be a way of partly compensating for limited ability to access other, more current and changeable cues to

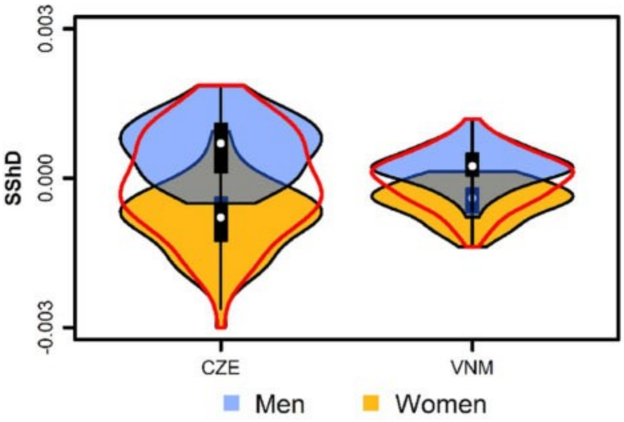

Figure 2. Violin plots comparing the range and variation in sexual shape dimorphism (SShD) between Czech European (CZE) and Asian Vietnamese (VNM) faces. White points indicate medians, black rectangles represent interquartile ranges. The Czech European faces are the same as used in our previous study Pavlovič et al. (2021), Asian Vietnamese faces are identical with those used in the current study.

biological quality. Isolation between groups may even affect the recognition of and preference for average facial traits[73], but while the Czech and the Vietnamese are culturally distant and visually distinct, they are not mutually isolated (see the Introduction). Alternatively, the preference for facial averageness need not have any adaptive functional explanation and might be just an effect of a link between attraction and statistical typicality[146].

According to the mixed-effect model, more male-like facial shape (SShD) predicted lower perceived attractiveness of male faces. There was also a significant interaction between the rater's ethnical group and the effect of SShD on perceived attractiveness, suggesting that the overall negative association between more male-like facial shape and perceived attractiveness is weaker in the Czech Vietnamese than in Czech European or Asian Vietnamese raters. In the path analysis, however, SShD played no significant role in predicting perceived attractiveness for any group of raters except for a marginally significant path for Asian Vietnamese female raters and their assessment of male stimuli. Facial symmetry also played only a limited role: More symmetric female faces tended to be judged by Asian Vietnamese male raters as less attractive, but this effect was not statistically significant in the mixed-effect model and appeared only in the path analysis where various mediation paths were considered. This may potentially point to a limited relevance of measured facial asymmetry as an attractive facial characteristic. While some studies point to the relative importance of facial asymmetry as an attractive trait[87,88] and a measure of biological quality[77], other studies reported no association between measured asymmetry and attractiveness or perceived health[89,90].

Concerning the small effect of the sexually dimorphic facial shape (expressed by SShD) on perceived attractiveness, we can speculate that other sexually dimorphic cues—such as skin coloration or colour contrasts between different facial parts[147]—may play a more important role in attractiveness ratings. In this study, however, they were not considered and no skin colour measurements were taken during the photo sessions.

The magnitude of facial sexual dimorphism varies substantially across populations[129]. Compared to European faces, Asian faces have a lower overall sexual dimorphism[130] and are generally perceived as more feminine[148]. Cross-group differences in the variance of sexually dimorphic facial shape are shown in Fig. 2, which compares the range and variation of SShD across Vietnamese (current study) and Czech European faces (taken from Pavlovič et al[128]). Sex-typical cues other than SShD might affect the ratings of attractiveness. Moreover, perceivers might use different cues, such as facial averageness, to assess the attractiveness of Vietnamese faces. In fact, unlike the SShD, facial averageness was an important predictor of perceived attractiveness for all groups of raters, which is fairly consistent with the 'average is attractive' hypothesis[43,149] and with our previous study[128]. Some studies state that environmental conditions, such as urbanisation[150], or society-level measures of economic development and public health[109,151] also lead to cross-population differences in preferences for sex-typicality. Our data, however, suggest no systematic differences in sex-typicality preference between different groups.

According to the path analyses, age seems to affect the perception of female attractiveness only for Asian Vietnamese and Czech Vietnamese male raters. In similar vein, facial asymmetry and SShD tended to affect the rating only for Asian Vietnamese raters. These trends could imply that age, shape sexual dimorphism, and/or symmetry may be rather ineffective cues to attractiveness rating, especially when it comes to rating the faces of persons from different population. Their effects may raise with increasing experience or long-term exposure to certain distinctive group of faces. Otherwise, perceiver will tend to rely on 'general' cues to attractiveness, such as averageness (as discussed in more detail above).

Limitations. In this study, we used facial photographs, online rating, and frequentist exploratory approach to statistical analysis. While these methods were the most suitable given the ongoing Covid pandemic and relative paucity of prior studies on this or similar subjects (such as preferences regarding own-race faces in a diaspora), it also limits the interpretability of the results. Still, a different approach to such an understudied problem, for instance one based on facial manipulation, could be potentially misleading because any methodological artifacts could easily go unnoticed. Moreover, the methods of geometric morphometrics, which we used to describe facial shape, in conjunction with exploratory multivariate analysis allow for identification of credible associations between facial features and perceived characteristics in highly ecologically valid settings.

The relatively low number of female facial photographs (33 women) lowered the statistical power. On the other hand, the number of observations was sufficient for the use of methods based on linear models (as suggested by[152]) and both the path analyses and mixed-effect models yielded fairly similar results.

The settings of acquisition of facial photographs may also affect study results[131]. We took this into consideration and made sure that all photographs were taken and processed by the same person, with the same camera setting and during a short period of time. Any systematic variation stemming from stimuli collection is thus unlikely to affect the results.

The relatively limited age range of the stimuli group (18–40 years) might reduce the effect of age on the perceived characteristics as compared to general population. But because this age range overlaps with the life stage of choosing a mate and starting a family, it is during this period that attractiveness, a cue to biological quality of a mate, should matter the most.

Conclusions

The aim of the present study was to investigate several factors known to influence judgements of facial appearance among three groups of raters. All three groups rated the attractiveness ratings of Vietnamese faces similarly, that is, in the current setup the rater's population and ethnical origin had no major effect on the perceived attractiveness in terms of face shape averageness, asymmetry and sexual dimorphism. We also found that all three groups perceived an Asian Vietnamese face as being significantly more attractive if it had a more average shape. This was as true for men rating female faces as it was for women rating male faces. As a component of facial attractiveness, an average face shape was significantly more important to Czech Europeans than to either group of Vietnamese origin. This highlights the role of averageness as a universally used trait in face perception. Finally, despite some intrapopulational trends in the impact of SShD, facial asymmetry, and age on attractiveness ratings, the three groups did not differ significantly in their overall ratings of facial attractiveness.

These findings suggests that judgements and preferences regarding facial traits are not significantly affected by sociocultural background and geographical context. In other words, our results suggest a universal agreement in ratings across different ethnical groups. However, further work is needed in order to fully explain the influence of environment, visual diet, individual experience, as well as social context on face perception processes, trait attribution, and formation of judgements.

Data availability

The dataset and R code is available at https://osf.io/jnpxh/?view_only=821a6a876dbc41ccb4649dad1c0d8e85.

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Author contributions

O.P collected data in the studied populations, O.P and V.F wrote the initial draft of the manuscript, K.K developed the study concept, V.F and K.K provided data analyses, and K.K and V.F designed the figures. All authors discussed the results and contributed to the final manuscript.

Competing interests

The authors declare no competing interests.

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Distinctiveness and femininity, rather than symmetry and masculinity, affect facial attractiveness across the world

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ABSTRACT

Studies investigating facial attractiveness in humans have frequently been limited to studying the effect of individual morphological factors in isolation from other facial shape components in the same population. In this study, we go beyond this approach by focusing on multiple components and populations while combining geometric morphometrics of 72 standardized frontal facial landmarks and a Bayesian statistical framework. We investigate preferences in both sexes for three structural components of other sex facial beauty that are traditionally considered indicators of biological quality: symmetry, sexual dimorphism, and distinctiveness (i.e., the opposite of averageness). Based on a large sample of faces (n = 1550) from 10 populations across the world (Brazil, Cameroon, Czechia, Colombia, India, Namibia, Romania, Turkey, UK, and Vietnam), we found that distinctiveness negatively affects the perception of attractiveness in both sexes and that this association is stable across all studied populations. We corroborated some previous results indicating both a positive effect of femininity on male assessment of female facial beauty and a null or weak effect of masculinity on female evaluation of male facial attractiveness. Facial symmetry had no effect on facial attractiveness. In concert with other recent studies, our results support the importance of facial prototypicality but cast doubt on the role of symmetry as one of the key constituents of attractiveness in the human face.

1. Introduction

Facial appearance affects mate evaluation and selection (Little, 2021; Roth, Samara, & Kret, 2021; Toma & Hancock, 2010). Evolutionary studies investigated morphological characteristics that, across cultures, contribute to physical attractiveness. Based on this, the perceptual evaluation of facial attractiveness is thought to utilize major morphological parameters that are potential indicators of underlying individual quality, namely bilateral symmetry, sexual dimorphism, and averageness (Fink & Penton-Voak, 2002; Grammer et al., 2003; Little, 2021; Rhodes, 2006).

Bodily symmetry is considered a marker of developmental instability in humans (Thornhill & Gangestad, 1994; Van Dongen & Gangestad, 2011) and other species (Møller & Pomiankowski, 1993). However, the effects of sexual selection on symmetry may vary in different species with different ecological niches and mating systems (Kruuk, Slate, Pemberton, & Clutton-Brock, 2003). Despite being a subject of a long and ongoing debate (e.g., Weeden & Sabini, 2005; Grammer, Fink, Møller, & Thornhill, 2003), evidence suggests that facial symmetry increases facial attractiveness. Individuals with more bilaterally

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symmetrical faces are perceived as healthier and more attractive (e.g., Little, Apicella, & Marlowe, 2007; Perrett et al., 1999; Rhodes et al., 2001; Zaidel, Aarde, & Baig, 2005) and report fewer health problems (Thornhill & Gangestad, 2006).

Sexual dimorphism is another ancient property of metazoans (Kopp, 2012); it appeared no later than gonochorism (Sasson & Ryan, 2017) and is influenced by sexual selection across animal species (Janicke & Fromonteil, 2021). In humans, the femininity of women's faces is considered attractive to men, but preferences for masculinity in men's faces vary across studies (e.g., Stephen, Salter, Tan, Tan, & Stevenson, 2018). Some evidence indicates that sexual dimorphism is related to general health, fecundity, and pathogen resistance (Law Smith et al., 2005; Rhodes, 2006; Rhodes, Chan, Zebrowitz, & Simmons, 2003; Thornhill & Gangestad, 2006), but other studies find no consistent association between sexual dimorphism and health/fecundity (Boothroyd et al., 2017; Boothroyd, Scott, Gray, Coombes, & Pound, 2013; Lidborg, Cross, & Boothroyd, 2022; Rantala et al., 2013; Zaidi et al., 2019).

Averageness (i.e., prototypicality, or its logical opposite, distinctiveness) is another relevant facial feature for attractiveness research. It measures how close an individual's facial proportions are to (or how far they are from) the average proportion in a given population. As soon as recognition of individuality evolved (Leopold & Rhodes, 2010), the degree of distinctiveness would be available for assessment in social and mating contexts. Arguably, it could indicate the level of inbreeding and/or the extent of kin network present in a population. In humans, the positive impact of averageness can be demonstrated by facial morphing, where the more different faces of the same sex contribute to an averaged composite, the more attractive it is considered (Little, 2021; Rhodes, 2006); this effect likely derives at least partly by correcting individual imperfections, up to roughly 30 faces (Langlois & Roggman, 1990). Averageness is rapidly processed by the brain (Trujillo, Jankowitsch, & Langlois, 2014) and could also tap into a preference for familiarity (Bohrn, Altmann, Lubrich, Menninghaus, & Jacobs, 2013). Moreover, facial averageness is cross-culturally preferred—not only across various European populations but also in the Hadza of Northern Tanzania (Apicella, Little, & Marlowe, 2007)—which suggests universality.

Previous studies have analyzed effects of these facial components independently (for a review see, Rhodes, 2006; Little, 2021). However, everyday facial judgments likely consider them all simultaneously. Grammer et al. (2001) showed that attractiveness assessment integrates facial and bodily traits in a "fast and frugal" way according to a heuristic that has been described as "avoid the worst" – meaning that unattractive features are used for attractiveness decisions rather than highly attractive features. Hence, in order to increase ecological validity, different basic parameters of the face – such as skin texture and color, facial shape, eye and hair color, facial symmetry, and degree of sex-typicality – should be simultaneously investigated in the same study (Apicella et al., 2007; Little et al., 2007). Very few studies have proceeded with this extension of scope to examine relative contributions to facial attractiveness of certain features over others. For instance, Mogilski and Welling (2017) found that individuals prioritize cues to sexual dimorphism over symmetry and healthy coloration, particularly for male faces. In contrast, facial symmetry and healthy coloration were more important in preferences for female faces. Foo, Simmons, & Rhodes, 2017 evidenced the importance of sexual dimorphism, averageness, and symmetry in perception of attractiveness but reported only a weak association between health and facial cues to attractiveness. Jones and Jaeger (2019) found that averageness has a larger effect than symmetry when using manipulations or naturalistic paradigms, but when using machine learning algorithms attractiveness is predicted by shape averageness, dimorphism, and skin texture, but not shape symmetry.

Not so many studies have addressed preferences beyond a single or limited number of North American or Western European populations. Jones and Hill (1993) demonstrated in five populations that age-related traits and averageness (in both sexes) and neotenous and feminine features (in females) influence facial attractiveness. Using European faces, Kočnar, Saribay, and Kleisner (2019) found that sex-typical and average facial traits were positively associated with attractiveness by raters across 10 cultures, while fluctuating asymmetry had no effect. The evidence based on Namibian and Cameroonian faces showed a similar pattern of null preference for fluctuating asymmetry and moderate preference for facial averageness (Kleisner et al., 2017). Using samples from five distant populations, Fiala et al. (2021) examined possible moderating effects of averageness, age, body mass, and facial width on human attractiveness. While women's perceived femininity was positively related to perceived attractiveness, shape sexual dimorphism and averageness were not associated with either perceived facial sexual dimorphism or attractiveness (Fiala et al., 2021). While certain studies evidenced the universality of attractiveness perception (Coetzee, Greeff, Stephen, & Perrett, 2014; Cunningham, Roberts, Barbee, & Druen, 1995; Fink & Neave, 2005; Jones, 1995; Langlois et al., 2000; Rhodes et al., 2001), others acknowledged local variation influenced by sociocultural factors (Jackson, 1992; Kara & Özgür, 2023; Little, Jones, Debruine, & Caldwell, 2011; Voegeli et al., 2021)

We extend these approaches here, but our study is unique for three main reasons. First, many previous studies of the preferences of facial symmetry and typicality used facial stimuli from one or a small number of mostly WEIRD (i.e., Western, Educated, Industrialized, Rich, and Democratic) populations (Apicella & Barrett, 2016; Henrich, Heine, & Norenzayan, 2010). Second, very few of these studies compared large numbers of standardized natural facial portraits from various populations worldwide (e.g., Kleisner et al., 2021; Voegeli et al., 2021). Third, we investigated facial perception based on non-manipulated faces collected from members of the same local population. This is a critical point because the perception of faces in a specific population is neither evolutionarily nor socially independent from the variation of facial morphologies present in that population. Using local and non-manipulated faces, therefore, represents the most ecologically valid setting, sensitive to both morphological and perceptual components of facial variation. Thus, in summary, we aimed to investigate in both sexes the relative importance of facial distinctiveness, sex typicality, and symmetry in terms of their effects on human facial mate preferences from populations across the world.

2. Methods

2.1. Data sampling

The total sample consisted of 1550 faces from 10 different countries. The database of shape coordinates and mean attractiveness ratings from the pre-pandemic (COVID-19) period consisting of Brazilian, British, Cameroonian, Czech, Colombian, Namibian, Romanian, and Turkish faces was published in a previous study (Kleisner et al., 2021). To increase the representativeness of the global population of facial morphologies, this dataset was additionally enriched with a sample of 136 Vietnamese facial configurations (from Pavlovič, Fiala, & Kleisner, 2023) and a sample of 142 Indian faces from the CFD-INDIA database (Lakshmi, Wittenbrink, Correll, & Ma, 2021). Facial attractiveness was operationalized as the mean rating of opposite-sex raters from the faces' own culture. Sample sizes of all facial photograph subsets are accessible in the Supplementary materials (Table S1). The sample used to fit the extended model with body height and BMI contained 1106 faces from 8 countries (see Supplementary materials S1 for sample size decomposition and descriptive statistics). All procedures used in the study were approved by the Institutional Review Board of the Faculty of Science at Charles University (protocol ref. no. 04/2020).

Facial images were taken according to a standardized protocol within each population, using digital cameras, external light sources, and homogeneous white or grey backgrounds. Lighting conditions were not standardized across the samples but were uniform within each sample (population). All participants were instructed to adopt a neutral, non-smiling expression and to remove facial cosmetics, jewelry, or other adornments where possible. Participants were seated at a fixed distance from a digital camera and asked to look directly into it and avoid vertical and horizontal head tilting. The photographs were then edited to set the eyes horizontally at the same height and to leave a standard length of the visible neck.

2.2. Geometric morphometrics

For geometric morphometrics, we manually applied 72 landmarks on each of the faces. The definition of landmarks and semi-landmarks is available in our previous studies (Kleisner, 2021; Kleisner et al., 2021). Landmarks are corresponding locations that can be anatomically or geometrically defined on all objects in the sample. While landmarks reflect homologous structures and locations on the faces of different individuals, semi-landmarks denote curves and outlines. Shape coordinates were superimposed by a Generalized Procrustes analysis (GPA) using the "gpagen" function implemented in the geomorph package in R (Adams & Otárola-Castillo, 2013). GPA standardized the size of the objects and removed rotational and translational effects while minimizing distances between homologous landmarks. The "gpagen" function was also used to align sliding semi-landmarks using the minimum bending energy criterion.

To assess facial averageness (or its logical opposite, distinctiveness), the Procrustes distances between the mean shape and individual facial configurations were computed separately for each population. A lower facial averageness score, therefore, indicates a configuration's closer proximity to the mean shape.

In order to assess asymmetry, the aligned coordinates obtained through Procrustes fitting were initially mirrored along the midline axis. This involved relabeling the paired landmarks on the left and right sides of the faces, swapping the numeric labels of landmarks on the left side with those from the right side, and vice versa (Mardia, Bookstein, & Moreton, 2005). Procrustes distances were then computed between the original configuration and the mirrored (reflected and relabeled) configuration. Larger values of these distances indicate a higher degree of facial asymmetry.

The degree of individual expression of facial traits contributing to sexual shape dimorphism (SShD) was assessed using Procrustes residuals obtained from a Procrustes fit of the combined symmetrized facial configurations of men and women. To examine the morphological differences between men and women, the face of each individual was projected onto the vector between male and female means. The position of each projected face on the sex-specific vector can be numerically expressed as a score that determines the individual's degree of sexually dimorphic traits. This was done separately for each population. To ensure that higher scores represented greater sex typicality, with men exhibiting a more masculine shape and women displaying a more feminine shape, the scores for women were multiplied by −1 to invert them.

2.3. Statistical analysis

We conducted a multilevel linear regression with facial attractiveness as the outcome and sex-typicality (measured as a perpendicular projection of facial shape on a vector connecting male and female mean shape, multiplied by −1 in females to convert geometric maleness/femaleness of facial shape into facial sex-typicality), asymmetry (Euclidean distance between original and mirrored landmark configuration), and distinctiveness (measured as a distance between facial shape and mean shape per sex per nation) as predictors. For the subsample of data where information on body height and BMI (body weight/squared body height) was available, the original model was compared with an extended model that contained these physical variables using WAIC (Widely Applicable Information Criterion) to assess the potential importance of these two additional variables.

We employed Bayesian inference to evaluate the joint posterior distribution of nested varying effects using rethinking R package (McElreath, 2020) with Stan's (Stan Development Team, 2018) MCMC (Markov Chain Monte Carlo) infrastructure. The model included potentially correlated varying intercepts and slopes at the national level, which allowed us to estimate both overall (labeled "hyperparameters" following the naming convention outlined in Statistical Rethinking) and population-level parameters. All intercept and slope hyperparameters were characterized by permissive unbiased priors.

The sex of the target entered the analysis as an index variable, in essence a "switch" (of value = 1 if the target is female and 2 if the target is male) that determined which of the two intercepts and which three (or five in the extended model) slopes were used to predict the average rating of a given target. Distributions of differences between sexes were calculated from these samples.

To illustrate models' predictions, counterfactual plots were obtained by linking simulated data with the sampled posterior distributions. See Supplementary materials S2 for details on statistical analysis.

To demonstrate the robustness of our findings, we also evaluated two more models: (i) a further extension of the model with BMI and Height that included a direct effect of target age, and (ii) a model that treated individual attractiveness rating between one and seven as the unit of analysis (see Supplementary materials S9 for details). The analysis was conducted using R version 4.0.1. The code and data can be found at https://github.com/costlysignalling/Distinctiveness.

3. Results

3.1. Distinctiveness rather than asymmetry

The estimated posterior probability of regression parameters is displayed in Fig. 1. The numerical summarization of the joint posterior distribution can be found in Supplementary materials S4.

Distributions of distinctiveness slope estimates do not overlap zero, while the distributions of likely asymmetry slope values are centered near zero for men and at low positive numbers for women. This pattern suggests that distinctiveness—rather than asymmetry—drives the perceived attractiveness of the human face in both sexes. These two predictors are frequently correlated (in our sample, the correlation between asymmetry and distinctiveness was 0.29 in women and 0.27 in men, see correlograms in Fig. 2); thus, if the multiple regression is not conducted properly, researchers might conclude that there is a negative causal relationship between asymmetry and attractiveness. Of course, asymmetry increases distinctiveness, but the direct causality from predictors to attractiveness is monopolized by distinctiveness (see counterfactual predictions in Fig. 3). The raw correlation between attractiveness and asymmetry in our sample was near zero (Fig. 2). For this reason, when both predictors enter the model, the relationship between asymmetry and attractiveness may appear weakly positive (as in women in our sample; but note that the effect is more likely to be relatively weak, see Table S5). This estimate refers to the effect of asymmetry when distinctiveness is held constant, similarly to how the distinctiveness slope reports the effect of distinctiveness when asymmetry is held constant. As we show in the Supplementary materials S10, it is almost impossible to create an asymmetric face without making it distinctive, while the opposite is quite easy. Any adaptation of preferences that guards against mating with distinctive partners, also automatically guards against mating with asymmetric partners. Asymmetric faces may be rated as less attractive, not because of their asymmetry (Fig. S11), but because they are more distinct (Fig. 3).

3.2. Sex-typicality is desirable only in female faces

Female faces with higher sex-typicality (femininity) were universally rated as more attractive ($bST_F = 0.24$ [89%CI : 0.16, 0.32]). However, attractiveness does not change with increasing masculinity in the faces of men ($bST_M = -0.03$ [89%CI : −0.10, 0.05]).), which is consistent

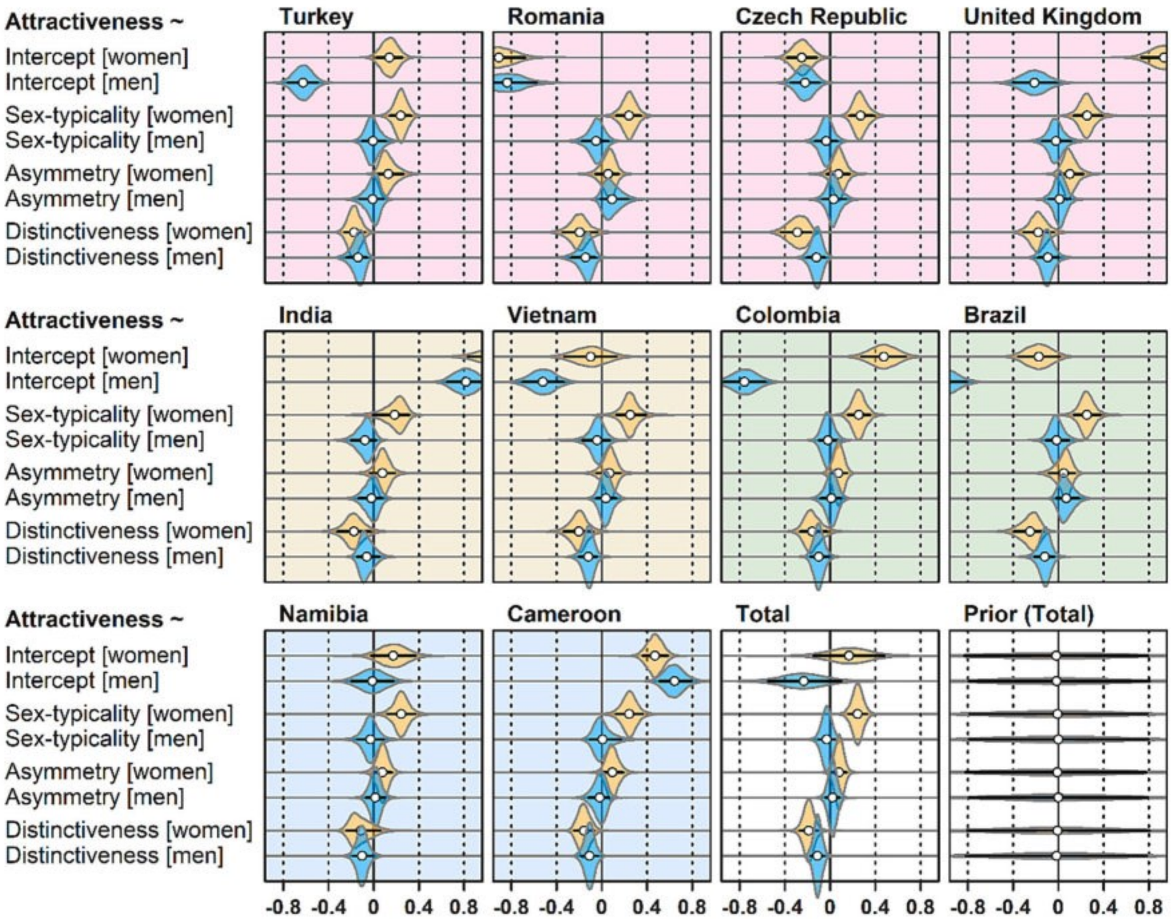

Fig. 1. Posterior distribution of parameter values in the model predicting facial attractiveness from Sex-typicality, Asymmetry, and Distinctiveness. Density diamonds outline distributions of plausible parameter values, white points mark means of these distributions, black lines span 89% percentile-based Compatibility Intervals. The panel of total estimates shows posterior distribution of means that characterize the multivariate normal distribution from which vectors of varying effects for population samples (background color indicates continent of data collection) are drawn.

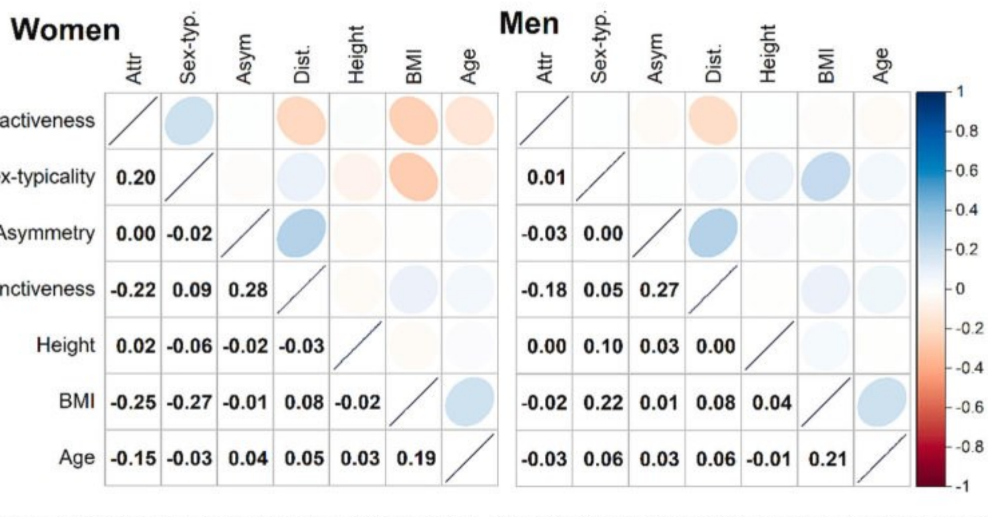

Fig. 2. Correlograms of morphometric/physical measurements and attractiveness. All variables were standardized within each nation and sex before the analysis.

with previous findings (Kleisner et al., 2021). The overall explained variance was 33% [89%CI : 29%37%] ($SD_{residuals}$ = 0.82 [89%CI : 0.80, 84]).

3.3. Differences in intercepts are large and meaningful

Women were rated as more attractive than men in most samples (see intercept estimations in Fig. 1). The difference was pronounced in South American samples, Turkey, and the United Kingdom. Interestingly, culture seems to have the capacity to influence how high or low ratings

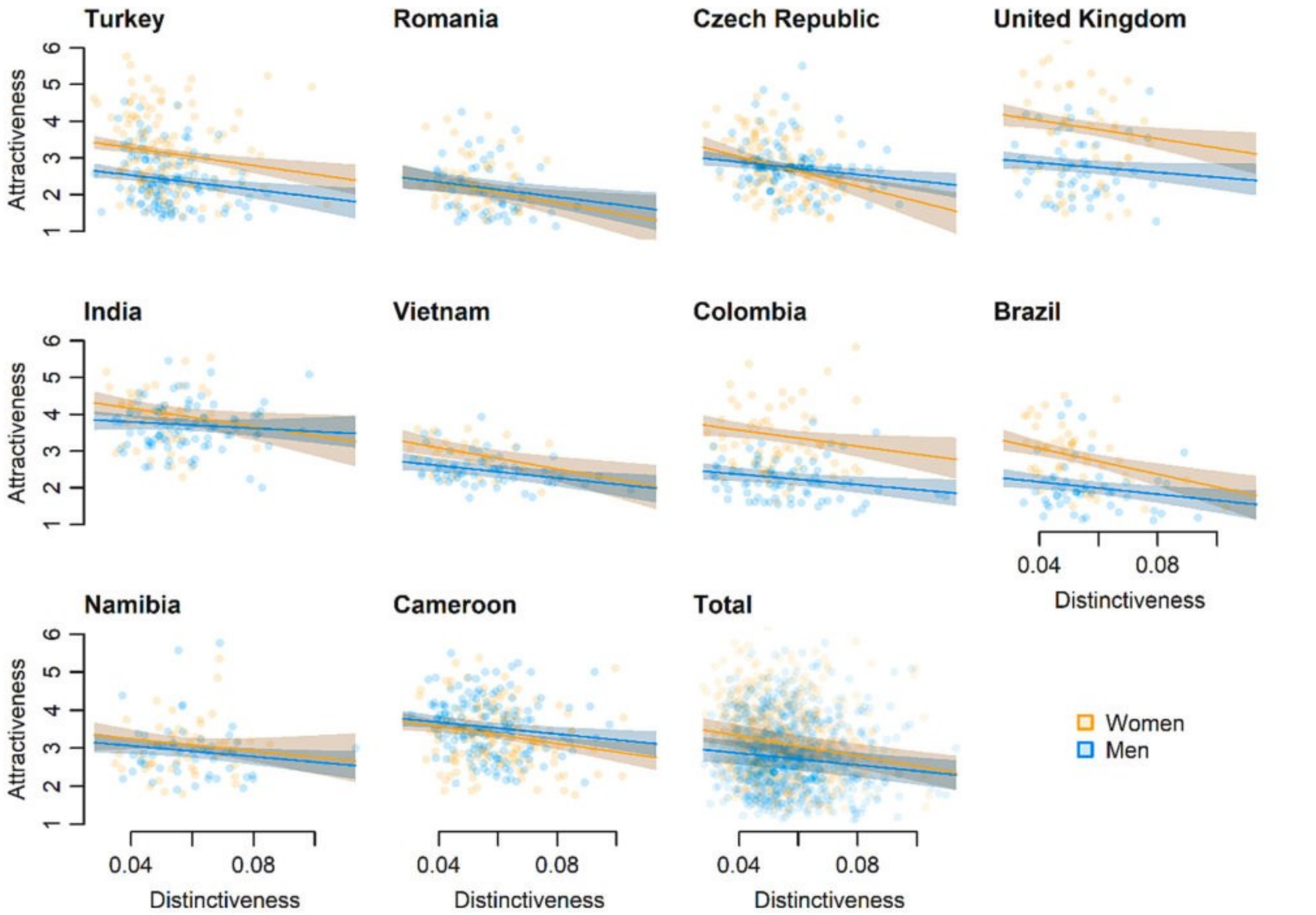

Fig. 3. Linear predictions with 89% compatibility corridors in the relationship between distinctiveness and attractiveness. Dots represent raw data, the slopes are based on parameter estimates from multiple regression in Fig. 1. The shaded corridors indicate 89% compatibility intervals. Predictions are based on a counterfactual situation, where Distinctiveness changes along the range of empirical values and all other independent variables are held at average (equivalent plots for other predictors can be found in Supplementary materials S8).

people grant to their conspecifics of the opposite sex (the standard deviation of female intercepts: $SD_{int\_F} = 0.65$ [89%CI : 0.44, 0.96], SD of male intercepts: $SD_{int\_M} = 0.69$ [89%CI : 0.46, 1.01]), but does not strongly modify the effects of facial features on the differences in ratings (largest SD in varying effects, the SD of the female face Distinctiveness slope, was $SD_{bD\_F} = 0.1$ [89%CI : 0.01, 0.21]); see Supplementary materials S3 for a complete overview of the standard deviation of varying intercepts and slopes and correlations between varying effects across nations.

3.4. BMI also predicts facial attractiveness

The model with body height and BMI showed a better than expected out-of-sample fit than the baseline model without these variables when fitted on the subsample of data where all measures were available (see Table 1). Nonetheless, we decided to report the model on the complete dataset in the main article because the inclusion of body height and BMI did not change any of the conclusions reported above. In fact, compared to the baseline model (without BMI and height), most parameter estimates—including varying intercepts and slopes—remain virtually unchanged in the extended model, fitted for comparison only on the restricted subsample of faces where body height and BMI were available (See Supplementary materials S5 and S6).

Lower BMI predicted higher facial attractiveness in women $bBMI_F = -0.18$ [89%CI : −0.29, −0.08] except for women from the African samples. In men from Namibia, higher BMI predicted higher facial attractiveness ($bBMI_{M,NAM} = 0.24$ [89%CI : 0.05, 0.44], see Supplementary materials S6 and S7). The model with body height and BMI explained 42% of the variance in the restricted sample [89%CI : 38%46%].

All findings hold when the direct effect of age is included in the model (Supplementary materials S7), which means that no reported effect is due to covariance between (omitted) age and the investigated morphological variable. The total effect of age may be higher because it influences BMI. Age did not covary with any other variables in our sample, but one should not—without due caution—extend this conclusion to samples that span wider age ranges, (see the age homogeneity of most of our samples in Table S2). In samples with more age diversity, the attractiveness of female faces tended to decline with age, and some of this effect could not be reduced to the investigated morphological variables (Fig. S7, Fig. S14).

Table 1
Model comparison on the subset of data where information on Body height and BMI was available.

Model	WAIC	SE	dWAIC	dSE	pWAIC	weight
mBMI	2573.53	54.24	0	NA	45.14	1
m1	2593.91	54.97	20.39	10.13	32.87	0

WAIC = Widely Applicable Information Criterion, SE = Standard Error of the WAIC estimation, dWAIC = distance from the best model, dSE = Standard Error of the distance estimation, pWAIC = penalty term.

3.5. More variance between individuals than between population samples

All conclusions from the main model hold when individual attractiveness rating (1,2,3…, or 7) is treated as the unit of analysis instead of mean rating (Supplementary materials S9). This model provides additional insight that ratings differ similarly between targets (SD_{target} = 11.75 [89% CI: 10.14, 13.46]; note that the effects are on the scale of log-odds in ordered-logit link function, see Supplementary materials S9 for details) and between raters (SD_{rater} = 12.24 [89% CI: 10.57, 14.11]) within population samples. Variance of intercepts between samples is lower than both sources of individual variation ($SD_{int.women}$ = 6.72 [89% CI: 4.68, 9.28], $SD_{int.men}$ = 7.14 [89% CI: 4.99, 9.62]).

4. Discussion

Using a large sample of facial portraits from ten different populations across the world, we investigated the effect of facial distinctiveness, sex-typicality, and symmetry on attractiveness assessment. In agreement with several recent studies (Jones & Jaeger, 2019; Kočnar et al., 2019; Phalane, Tribe, Steel, Cholo, & Coetzee, 2017), we found that the importance of facial symmetry for human mate choice might have been previously exaggerated. Facial symmetry does not seem to be a crucial component of facial attractiveness (Hume & Montgomerie, 2001). On the other hand, facial distinctiveness, measured as the distance of a face from its population mean, had a negative effect on facial attractiveness in all tested samples. Sex-typicality showed mixed results, with a moderate preference for feminine facial shape in female faces but an absence of preference for any sex-specific facial traits in male faces. All three components of facial morphology showed relatively consistent associations with attractiveness ratings across all ten researched populations.

4.1. Questioning the fitness indicator bases of human facial morphology

From an adaptationist perspective, perceivers in a mate choice context are expected to prefer facial characteristics that provide cues to aspects of potential partner quality. For instance, more average (prototypical) faces may indicate heterozygosity, and more symmetrical faces higher developmental stability, and both averageness and symmetry should thus be preferred in mate choice (Thornhill & Gangestad, 1993). However, the empirical evidence on the associations between given facial characteristics and proposed quality remains controversial (Davis & Arnocky, 2022; Prum, 2010).

Nevertheless, facial preferences can also be influenced by some more general cognitive processes (Bartlett & Tanaka, 1998; Tanaka & Corneille, 2007; Trujillo, Jankowitsch, & Langlois, 2014). Similarly, other preferences might not be specific to mate choice and may work across different contexts and be shared by different species. For instance, both human infants and three-month-old rhesus macaques (*Macaca mulatta*) attended more to prototypical faces of infants of their own species, suggesting an ancient and shared preference for protypicality in primates (Damon et al., 2017). Thus, preferences may reflect an array of historical evolutionary events, involving various secondary co-options of traits that may or may not reflect present evolutionary benefits.

4.2. Why isn't facial symmetry more important?

There are several possibilities to explain why facial symmetry—directly measured from standardized, unmanipulated faces—has no effect on the perception of facial attractiveness. A first possibility is that people do not regard symmetrical features as crucial for mate choice as theoretically predicted. Only serious departures from bilateral symmetry might be penalized in mate choice, while the average levels of asymmetry within populations might not be strong enough to decrease facial attractiveness. A second possibility is that facial symmetry remains an important cue to fitness but is concealed by noisy (yet natural) facial variation that prevents us from detecting the effect. A possible solution would be to control for individual variation by using manipulated facial images to disentangle the causative effects in facial morphology. However, if this solution is successful, studies using manipulated faces should converge in their results, which is not always the case (Lee, De La Mare, Moore, & Umeh, 2021).

Moreover, some previous investigations based on manipulated faces confounded asymmetry with averageness. To avoid such confusion, Swaddle & Cuthill (1995) manipulated faces so that the level of symmetry was changed, but the mean size of facial features remained unaltered. When faces manipulated in this way were rated on attractiveness, the less symmetrical faces were perceived as more attractive. Asymmetry may thus contribute to overall facial attractiveness. Faces that are too symmetrical likely look unnatural and emotionless and therefore less attractive (Swaddle & Cuthill, 1995). This brings us to another problem of facial manipulations: we never know what level of manipulation is optimal to compromise the variation while at the same time keeping the stimuli ecologically valid. Over-manipulation may provoke perception in unnaturally excessive ways and cause overreaction to abnormal or supernormal stimuli (Tucciarelli, Vehar, Chandaria, & Tsakiris, 2022).

Ultimately, human and non-human preferences for symmetric objects cannot be explained just by an evolutionarily shared, universal perceptual bias due to the computational ease of encoding and processing of symmetric information. If that were the case, both males and females of our species should possess the same encoding perceptual system. Although there is evidence that symmetry preferences can be extended to mate-irrelevant stimuli, it happens more in men than women (Shepherd & Bar, 2011).

4.3. Why prototypicality seems more important?

Like symmetry, prototypicality has been thought to be preferred due to its potential to signal a high level of genetic heterozygosity and the latter's benefits for immune function, parasite resistance, and overall health. While some studies of preferences for the faces of individuals with greater MHC heterozygosity brought supportive evidence (Roberts et al., 2005; Winternitz, Abbate, Huchard, Havlíček, & Garamszegi, 2017) other studies have failed to find any such connection (Coetzee et al., 2007; Thornhill et al., 2003). Either way, the assumption that facial averageness (not just attractiveness) is statistically associated with genetic heterozygosity, or any other genetic/developmental marker of biological quality, is mostly theory-driven (but see Lie, Rhodes, & Simmons, 2008). There is no reliable (i.e., repeatedly corroborated) empirical evidence of such a crucial link. In fact, the evidence often goes the other way around. For instance, Foo, Simmons, & Rhodes (2017) reported a negative relationship between semen quality and facial averageness. Studies focused on testing the relationship between paternal age in birth (the putative predictor of mutation load) and children's facial averageness did not produce any conclusive results of such a relationship either (Klimek, Marcinkowska, Fedurek, Kleisner, & Danel, 2022; Lee et al., 2016). Thus, the reason for the importance of prototypicality in facial judgments remains an open question.

4.4. Preference of BMI

A preference for facial adiposity is likely influenced by ecological and cultural factors, including the impact of environmental harshness (Batres, Kannan, & Perrett, 2017), exposure to societal beauty standards through the media (Batres & Perrett, 2014), and the familiarity that individuals have with their own ethnicity (Batres et al., 2017; Coetzee, Greeff, Stephen, & Perrett, 2014). At the same time, people of various ethnic backgrounds converge in the ability to reliably estimate BMI from facial cues (de Jager, Coetzee, & Coetzee, 2018).

Based on our results, a lower BMI, as reflected by facial appearance, was preferred in women across almost all populations, except for women of Namibian and Cameroonian origin. The preference for a larger body size in women within specific African communities has been consistently reported in previous studies (Coetzee et al., 2012; Coetzee & Perrett, 2011; Naigaga et al., 2018; Pradeilles et al., 2022). This effect is often interpreted as an evolutionary advantage linked to the frequent food shortages in the preindustrial era or as an adaptation to local survival and reproductive optima in harsher environments (Pradeilles et al., 2022; Tovée, Swami, Furnham, & Mangalparsad, 2006).

In the case of men, facial attractiveness was associated with higher BMI only in Namibian male faces (a similar trend was also present in Cameroonian men). In all the other populations outside Africa, BMI had either no effect on facial attractiveness or lower BMI tended to be preferred. In total, lower BMI tended to be preferred in women across most of the studied populations, but there was no effect, on average, on male facial attractiveness.

4.5. Limitations

Our study has several limitations. Although we managed to sample the majority of continents (i.e., Africa, America, Asia, and Europe), we did not sample Oceania or a more diverse set of countries in each continent. Conditions when taking the pictures for facial stimuli and collecting the attractiveness evaluations were not fully standardized among each country due to local infrastructure restrictions. We also did not collect perceived health evaluations so we cannot explore how symmetry, distinctiveness, and sex-typicality relate to this critical facet of individual quality. Future studies should try to overcome these limitations and expand this cross-cultural and multicomponent approach to facial attractiveness. Nonetheless, we hope to have offered a more global and ecologically valid approach to pin down the relative importance of each biologically based standard of facial attractiveness in humans.

5. Conclusions

Two main conclusions may be derived from our study. First, preferences for facial prototypicality, symmetry, and sex-typicality do not substantially vary across geographically and culturally diverse populations. Second, facial attractiveness is robustly predicted by only two shape characteristics. It is negatively associated with distinctiveness (the opposite of averageness) and positively with morphological femininity. Notably, and perhaps surprisingly, facial symmetry has no robust effect. Our results thus clearly show that facial prototypicality (population-specific distance from the mean) and female sex-typicality (morphological femininity) are universally preferred across the world. Previous research has provided evidence on possible adaptive roles of feminine traits in the faces of women, such as revealing underlying levels of steroid hormones and fertility (Law Smith et al., 2005; but see Puts et al., 2013); therefore, its universal preference is neither problematic nor surprising (e.g., Fiala et al., 2021; Fraccaro et al., 2010; Kleisner et al., 2017, 2021). However, the exact reasons why prototypical faces tend to be preferred across the world are less clear and remain to be discovered.

Declaration of Competing Interest

None.

Data availability

The code and data can be found at https://github.com/costlysignalling/Distinctiveness.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.evolhumbehav.2023.10.001.

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He performed the data collection, edited the manuscript draft and worked on the manuscript revisions.

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Abstract:	Sex-typicality displayed as sexual dimorphism of the human face is a key feature enabling sex recognition. It is also believed to be a cue for perceiving biological quality and it plays an important role in the perception of attractiveness. Sexual dimorphism of human faces has two main components: sexual shape dimorphism of various facial features and sexual color dimorphism, generally manifested as dimorphism of skin luminance, where men tend to be darker than women. However, very little is known about the mutual relationship of these two facets. We explored the interconnection between the dimorphism of face shape and dimorphism of face color in three visually distinct populations (Cameroonian, Czech, and Vietnamese). Our results show that populations which showed a significant dimorphism in skin luminance (Cameroon, Vietnam) had low levels of sexual shape dimorphism, while a population with higher levels of sexual shape dimorphism (Czech Republic) did not exhibit a significant dimorphism of skin luminance. These findings suggest a possible compensatory mechanism between various domains of sexual dimorphism in populations differing in the levels of shape and color dimorphism.

Cover Page

Sexual dimorphism: The interrelation of shape and color

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Declarations

Conflict of interest
The authors have no competing interests to declare that are relevant to the content of this article.

Ethical Approval
This study was performed in line with the principles of the Declaration of Helsinki. All procedures mentioned and followed were approved by the Institutional Review Board of the Faculty of Science of Charles University (protocol ref. number 2020/04). This study does not include information or images that could lead to the identification of a study participant. Informed consent was obtained from all individual participants included in the study.

Sexual dimorphism: The interrelation of shape and color

Abstract

Sex-typicality displayed as sexual dimorphism of the human face is a key feature enabling sex recognition. It is also believed to be a cue for perceiving biological quality and it plays an important role in the perception of attractiveness. Sexual dimorphism of human faces has two main components: sexual shape dimorphism of various facial features and sexual color dimorphism, generally manifested as dimorphism of skin luminance, where men tend to be darker than women. However, very little is known about the mutual relationship of these two facets. We explored the interconnection between the dimorphism of face shape and dimorphism of face color in three visually distinct populations (Cameroonian, Czech, and Vietnamese). Our results show that populations which showed a significant dimorphism in skin luminance (Cameroon, Vietnam) had low levels of sexual shape dimorphism, while a population with higher levels of sexual shape dimorphism (Czech Republic) did not exhibit a significant dimorphism of skin luminance. These findings suggest a possible compensatory mechanism between various domains of sexual dimorphism in populations differing in the levels of shape and color dimorphism.

Keywords

sex typicality, sexual shape dimorphism, skin color, facial contrast

Introduction

The face is usually the most frequently displayed part of the human body. It presents visual cues for age (Porcheron et al., 2017), attractiveness (Rhodes, 2006), health (Henderson et al., 2016), individual identity (Sheehan & Nachman, 2014), as well as sexual identity (Roberts & Bruce, 1988; Bruce & Langton, 1994). The perception of such cues is fast and accurate (Bruce & Young, 1986; O'Toole et al., 1998), enabling us to form first impressions about the unknown person. Although sexual identity can also be assessed from a range of other cues, ranging from visible primary sexual features and overall body shape to cultural features such as clothing, hairstyle, and jewelry, facial sexual dimorphism is by itself sufficient for sex classification (Cellerino, Borghetti & Sartucci, 2004).

Reported accuracy of sex recognition by human raters varies depending on study design but is overall very high, ranging from 96% (Burton, Bruce, & Dench, 1993) to 100% (Bruce & Young, 1986) in adult participants. Infants and children tend to be less accurate (Wild et al., 2000), which indicates that this ability is acquired and honed throughout development. Still, the core of this process is as yet not well understood. It has been reported that some particular features (eyes, nose) facilitate sex recognition (Roberts & Bruce, 1988), but by themselves they do not suffice for classification (Brown & Perrett 1993; Bruce et al 1993). Dupuis-Roy et al. (2009) have identified some areas important for sex classification, such as the eye area and mouth area, but in the absence of clear cues, such as red lips, the participants compensated by relying on different areas. This shows that this process combines information from multiple sexually dimorphic features.

Male and female faces differ in their overall shape and composition of features. The sum of these differences is measured as sex-typicality, usually quantified as Sexual Shape Dimorphism (SShD). Sexual dimorphism has been thoroughly studied in terms of femininity and masculinity of the human face (Kleisner et al., 2021; Komori, Kawamura & Ishihara., 2011; Mitteroecker et al., 2015; O'Toole et al., 1998). SShD can be partly explained by allometry (Kleisner et al., 2021) because men are overall taller and heavier than women. Other features are directly influenced by hormone levels and could therefore serve as "honest" signals of sexual identity (Fink et al., 2005; Johnston et al., 2001; Thornhill & Gangestad, 1999). These morphological differences are believed to be further enhanced by sexual selection (Marcinkowska et al., 2019), where more sex-typical faces are perceived as more attractive. Nevertheless, the relationship between SShD and perceived attractiveness is not straightforward (Kleisner et al., 2021). Rated attractiveness of women's faces seems to be generally positively associated with by their femininity (Perrett et al., 1998; Rhodes, 2006), but female preference for masculine male faces is at best inconsistent. Some studies have reported no effect of masculine appearance (Rhodes et al., 2003) or even preference for feminine male faces (Perrett et al., 1998). Other research suggests that preference for facial masculinity varies depending on changes in hormone levels during the menstrual cycle (Penton-Voak & Perrett, 2000; Jones et al., 2005), but that was recently challenged by studies which reported no effect of women's monthly hormonal fluctuations on their preference for male faces (Jones et al., 2018; Marcinkowska et al., 2018). Furthermore, while masculinity (maleness) as measured by geometric morphometrics does express facial sex-typicality, facial masculinity as perceived by human observers is associated with sexual dimorphism only in part (Mitteroecker et al., 2015).

The role of masculine and feminine appearance in attractiveness rating and mate choice thus remains a topic of discussion. Sex-typicality could, however, have an adaptive value on its own through the process of sex recognition. In a study by Hoss et al. (2005), sex classification of male faces was facilitated by masculinity in both adult and child raters. Sex classification of female faces, on the other hand, was facilitated by attractiveness, not by femininity.

Femininity and masculinity are not two sides of the same coin: femininity is closely linked to attractiveness and serves as a cue to biological quality, while masculinity could be an adaptive cue for sex recognition but is not directly associated with attractiveness.

Apart from shape, male and female faces also vary in skin color: women have in general lighter skin than men do (Jablonski & Chaplin, 2000; van den Berghe & Frost, 1986; Wee et al., 2013). This type of sexual dimorphism has been attributed either to sexual selection (van den Berghe & Frost, 1986), with a prevalence of preference for lighter females among men, or to different needs for vitamin D_3 (Jablonski & Chaplin, 2013). Other studies described sexual differences in the luminance contrast between certain facial features (eyes, eyebrows, lips) and the surrounding skin: women have a generally higher facial contrast in the eye and mouth regions and, consequently, faces with a higher contrast are perceived as more feminine (Russell, 2003; 2009). In our previous study, we argued that facial contrast is a cue to perceiving facial skin color, which is why this effect could be a by-product of the overall dimorphism in skin color (citation hidden for masked review). Some recent studies moreover explored not only skin lightness (or darkness) but also various color hues. In a study including multiple ethnic groups, Wee et al. (2013) reported a sex difference in skin yellowness: they found that are yellower than women. Men are also believed to be on average redder than women (Nestor & Tarr, 2008), although this is not supported by the results of Wee et al. (2013).

In the current study, we decided to investigate skin luminance and color through direct measurement as well as computation of facial contrast, which enables an identification of even small differences. Measurable differences in skin luminance, color, and facial contrast in both luminance and color then all contribute to the overall Sexual Color Dimorphism (SCoD).

Recently, it started to emerge that sexually dimorphic traits are not universal across human populations. Kleisner et al. (2021) described the range and pattern of SShD in a number of visually distinct populations and concluded that it varies dramatically in populations from Africa, Europe, and South America. In our previous study, we found differences in facial contrast dimorphism in populations from Africa and Europe (citation hidden for masked review). Furthermore, a study by Fiala et al. (2022) found no set of universal sexually dimorphic cues that would predict perceived sex-typicality in both Africans and Europeans. These findings have direct consequences for the study of sex recognition, because the levels and types of sexual dimorphism differ among populations.

Differences in color and contrast can facilitate sex recognition (Russell, 2009) but on their own, they are not sufficient for effective classification. The same applies to facial dimorphism: Burton, Bruce, and Dench (1993) have shown that sex classification using only shape is possible but far less accurate than when information about texture is also available. Although certain traits tend to facilitate sex recognition under normal conditions, human raters can effectively use other sex differences when information from these primary traits is unavailable. In a study conducted by Hill, Bruce, and Akamatsu (1995), participants relied more on color information in a frontal view and on shape information in a lateral view. Yip and Sinha (2002) observed that when shape information is degraded, color cues become useful in identity recognition. In sex recognition, raters rely on the mouth area as long as it was informative, but when that information is insufficient, they switch to the eye area (Dupuis-Roy et al., 2009). This polymodal focus on face perception is key to understanding how human populations can vary so much in sexual dimorphism yet perform well on cross-cultural sex recognition.

Our aim here is to expand these conclusions and describe the relationship between the shape component (SShD) and the color component (SCoD) in samples of Asian (Vietnam), European (Czech Republic), and African (Cameroon) populations. Although in particular populations, sexual dimorphism can be more pronounced in either the shape or the color component, we expect to find similar overall levels of sexual dimorphism in each of the studied samples.

Materials & methods

Photograph acquisition

Facial portraits were acquired using a standardized procedure (Třebický et al. 2016). Participants' portraits were taken in front of a white background with color camera Canon 60D using a studio electronic flash. For Vietnamese participants, we used the Canon RF 50mm STM lens and the focus point was set to the left eye. Exposure was set to ISO 100, shutter speed to 1/160s, aperture f/8, and strobe was set to 2/3 power. Photographs were taken from a tripod set to match the sitting height of each participant, so that the target's face was in the middle of the frame. Distance between the lens and the target's tip of the nose was set for each individual to 125cm to preserve the natural variability in facial size in each image and to obtain the sharpest possible result with the 50mm lens. Participants sat on a chair with no backrest and were instructed to sit straight, adopt a neutral facial expression, and look directly into the camera. They were also asked to refrain from any facial makeup, glasses, jewelry, or other decorations. To eliminate the effect of varying clothing, all participants were dressed in plain black T-shirts.

Photographs were shot into uncompressed raw files (*.CR2 format), and later processed into JPEG files in sRGB color space in Adobe Photoshop Lightroom 4. At the beginning of each session, a white balance patch was photographed, and color calibration, exposure, and white balance performed using X-Rite Color Checker targets. The photographs were post-processed in Photoshop CS6: images were cropped so that participants' faces were in all images in the same absolute position.

Participants

Participants were recruited via social networks, flyers, or personally. All individuals involved in this study provided informed consent. Cameroonian participants were mostly students from the University of Buea, Czech participants were from Charles University in Prague, and Vietnamese participants were students at the University of Science and Technology in Hanoi. Participants who did not follow through the entire process of data collection were removed from the study.

The final dataset consisted of facial photographs of 91 Vietnamese participants (60 men, 31 women, mean age ± SD = 21.42 ± 3.08), 98 Czechs (50 men, 48 women, mean age ± SD = 23.93 ± 4.11), and 113 Cameroonians (50 men, 63 women, mean age ± SD = 21.74 ± 3.09).

Color and contrast measurements

In the next step, we applied the Color Transformer 2 plugin in ImageJ. Eye, lips, brows, and surrounding skin areas were selected using the freehand selection tool (Figure 1), while skin patches from the forehead and the right cheek were selected using the oval selection tool. Mean luminance and color of the selected areas were measured in CIE L*a*b* color space. We used five measured skin areas (eye area, brow area, lips area, cheek, and forehead) to calculate mean lightness (L*), redness (a*), and yellowness (b*) of the skin.

Facial contrast in luminance, red, and yellow was calculated using adapted Michelson contrast (Russell, 2009) calculated as $C_f = (L_s - L_f)/(L_f + L_s)$, where L_f stands for the mean feature (eye, brow, lips) color, L_s stands for mean skin color, and C_f is the feature/skin contrast. Resulting values can range between -1 and 1: 0 indicates no contrast, values above 0 indicate that the feature is darker/greener/bluer than the skin, while values below 0 indicate that the feature is lighter/redder/yellower than the skin.

redder/yellower than the skin.

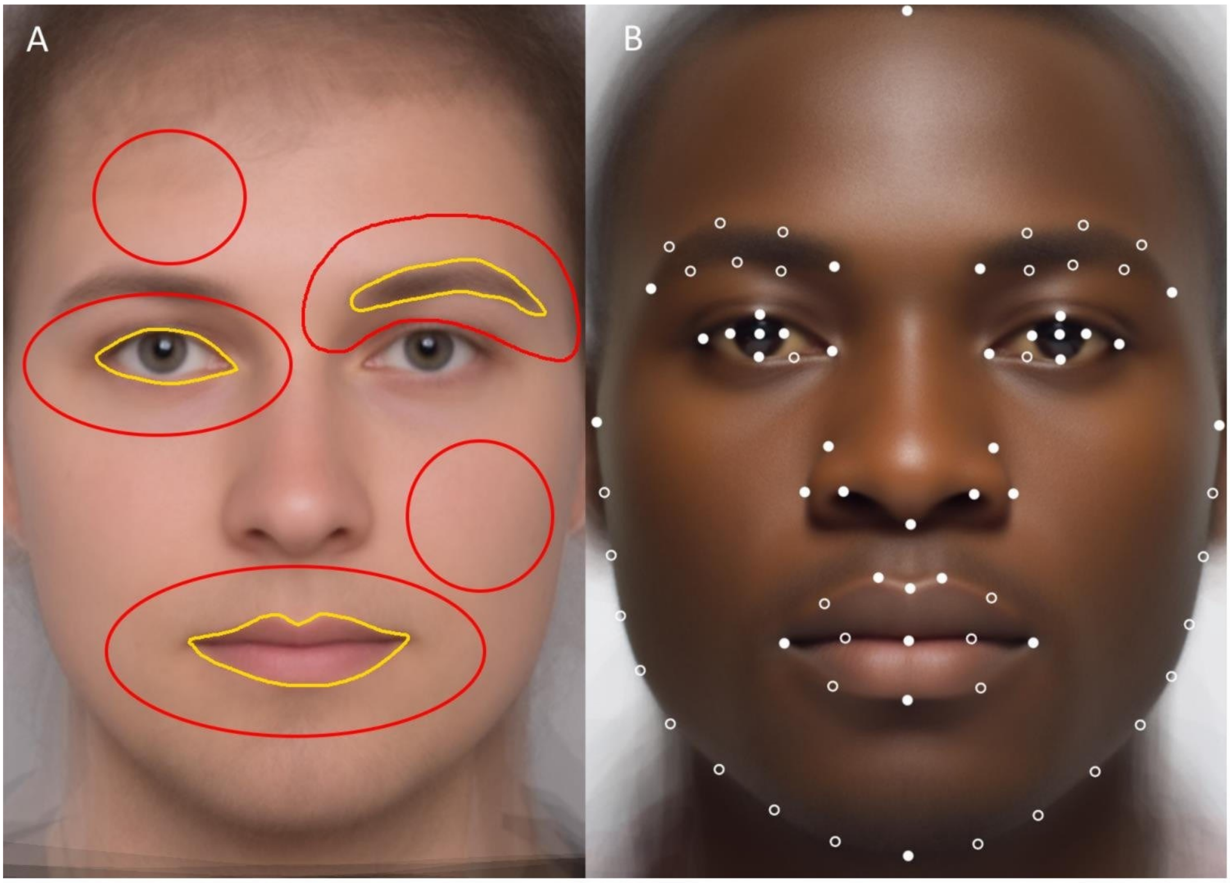

Figure 1: Facial color and shape measurements. A) Feature and skin area selection: yellow lines show how features (lips, eyes, and brows) were selected, while the red lines show how the areas of surrounding skin, cheek, and forehead were selected. B) Locations of 36 landmarks (full dots) and 36 semi-landmarks (circles). This image presents artificial faces.

Geometric morphometrics

Facial shape was digitized using tpsDig2 version 2.30 (Rohlf, 2015). We used a standard set of 72 landmarks (36 true landmarks, 36 semilandmarks) placed on a frontal facial image (Kleisner et al., 2010; Kleisner, Pokorný & Saribay, 2019). Landmark configuration was symmetrized and subjected to Procrustes superimposition (GPA) using the *gpagen* function of the geomorph package in R (Adams & Otárola-Castillo, 2013; Adams et al., 2019).

Calculating Sexual Shape Dimorphism (SShD) and Sexual Color Dimorphism (ScoD)

SShD was computed as a projection of individual facial configurations in the facial shape space onto a vector between the male and female means. This vector method, i.e., the use of group averages to define an axis of morphological differences between men and women, has been applied in numerous previous studies on human sexual dimorphism (Kleisner et al., 2021; Komori et al., 2011; Mitteroecker et al., 2015; Valenzano et al., 2006).

SCoD was calculated in the same way as SShD, except that instead of using shape coordinates, we used a matrix of skin color measurements. First, we defined the values of male and female means and then projected the color measurement of each individual on an axis defined by the sex difference.

The position of an individual's face (A) along an axis connecting male (MM) and female mean (FM) shape/color characteristics can be expressed as a dot product of a vector from the origin to the shape coordinates/color values of A and a vector from FM to MM.

Ratings of facial images

The stimuli were assessed for attractiveness by an unrelated sample of raters, whereby each rater rated a set of portraits of the opposite sex. Participants were recruited mostly via the internet (social media) and then redirected to an online survey platform (Qualtrics.com). Raters viewed each portrait on a computer using a full-screen browser with a survey session. They saw always only one photograph at a time and assessed attractiveness on a 7-point scale (ranging from 1 – very unattractive to 7 – very attractive). There was no time limit for exposure to each portrait and the order of photographs was randomized for each session.

Facial photographs of Vietnamese men were rated by 124 Vietnamese women (mean age=22.96; SD=4.26; range=18–48) and portraits of Vietnamese women were rated by 86 Vietnamese men (mean age=22.2; SD=3.76; range=18–47). Cameroonian men were rated by 51 Cameroonian women (mean age=23.37; SD=4.25; range=18–45) and Cameroonian women were rated by 49 Cameroonian men (mean age=22.96; SD=3.23; range=19–33). Czech men were rated by 80 Czech women (mean age=20.36; SD=1.70; range=19–27) and Czech women were rated by 32 Czech men (mean age=21.72; SD=2.76; range=19–31).

Excluded from further analysis were the results of raters younger than 18, older than 50, and (self-reported) non-heterosexuals. All participants provided their informed consent by clicking on the "I agree" button to consent with their participation in the study. Interrater agreement using intraclass correlation (ICC, 3k; see Shrout & Fleiss, 1976) was generally high (ICC for all rater datasets > 0.95).

Statistical analysis

An exploratory analysis of color dimorphism was conducted in SPSS Statistics 20. Color and contrast measurements were compared by a one-way ANOVA. Mean facial values for each color channel (L*a*b*) were tested separately. To account for minor differences in sexual dimorphism, further tests were conducted separately for each measured facial area (forehead, eyebrow area, eye area, cheek, and mouth area). The relationship between perceived attractiveness and components of SCoD was investigated using the Pearson correlation.

We used the *permudist* function from the Morpho package in R (Schlager, 2017) to compare the distances between sex-specific group means in facial shape and color. This was done separately for each of our population samples with a permutation test based on 10,000 replications.

Limitations

Several minor issues arose during data acquisition. They led to slight differences between the samples but the photograph acquisition process in each culture was fully standardized. The levels of sexual dimorphism compared in our study were measured separately for each culture by an intracultural analysis of male and female facial images. It is thus safe to assume that the abovementioned slight differences between the samples had no significant effect on the results.

Some participants had visible scars, shave marks, or lipstick residue, which made it impossible to take certain measurements (e.g., lips region contrast). These individuals were excluded from the relevant parts of the analysis, resulting in varying sample sizes in the correlation table (Table 2 in supplementary materials). Additionally, there is a slight variation in rater counts for the Vietnamese portraits due to the randomization of photos for each rating session coupled with a high rater attrition.

Results

In the Cameroonian sample, we found a significant dimorphism in skin lightness ($F_{1, 112}$=13.964, p<0.001, R^2=0.104, Figure 2) but no dimorphism in skin redness ($F_{1, 112}$=1.412, p=0.237, R^2=0.004, Figure 3) or skin yellowness ($F_{1, 112}$=1.113, p=0.294, R^2=0.001, Figure 4). In the Czech sample, sexual dimorphism in skin lightness was insignificant ($F_{1, 97}$=0.360, p=0.550, R^2=0.007, Figure 2), we found no sex differences in skin redness ($F_{1, 97}$=1.543, p=0.217, R^2=0.006, Figure 3), but skin yellowness differed significantly between the sexes ($F_{1, 97}$=16.627, p<0.001, R^2=0.139, Figure 4). In the Vietnamese sample, our results show significant sexual dimorphism in skin lightness ($F_{1, 90}$=6.667, p=0. 011, R^2=0.059, Figure 2) but no significant sexual dimorphism in skin redness ($F_{1, 90}$=1.736, p=0.191, R^2=0.008, Figure 3) or skin yellowness ($F_{1, 90}$=0.001, p=0.976, R^2<0.001, Figure 4).

Our findings on facial contrast dimorphism in Cameroonians and Czechs are mostly in line with previous results (citation hidden for masked review), except for the luminance contrast in the eye area, which was in our current Czech sample not statistically significant. The Vietnamese sample showed a pattern similar to the Cameroonian sample, with significant sexual dimorphism in the luminance contrast in the eyebrow ($F_{1, 83}$=24.782, p<0.001, R^2=0.223) and eye regions ($F_{1, 88}$=9.201, p=0.003, R^2=0.085) but no significant difference in the lips region ($F_{1, 71}$=0.009, p=0.924, R^2<0.001, see Table S1 in supplementary materials for full results). For full results on the effect of skin color on perceived attractiveness, see Table S2 in supplementary materials.

A permutation test based on a random assignment of observations to sex groups showed that sex differences in facial shape expressed by Euclidean distance between male and female means were statistically significant in all three compared populations: Cameroonians (p < 0.001, mean distance = 0.029), Czechs (p < 0.001, mean distance = 0.043), and Vietnamese (p < 0.001, mean distance = 0.028). Levels of SShD varied considerably (Figure 6): The Czech sample showed a much higher level of SShD than the Cameroonians and Vietnamese samples, which displayed comparable degrees of sex differences in facial morphology.

An analogical comparison of SCoD revealed rather the opposite pattern. The lowest level of SCoD was observed in the Czech sample (p < 0.005, mean distance = 1.742), Cameroonians displayed much higher sex differences in color (p < 0.001, mean distance = 2.646), and the highest levels of SCoD were found in the Vietnamese sample (p < 0.001, mean distance = 3.285); see also Figure 6. All in all, this suggests a mild pattern of substitution between the levels of SShD and SCoD, where, on average, lower levels of SShD tend to be compensated by higher levels of sex differences in color (SCoD).

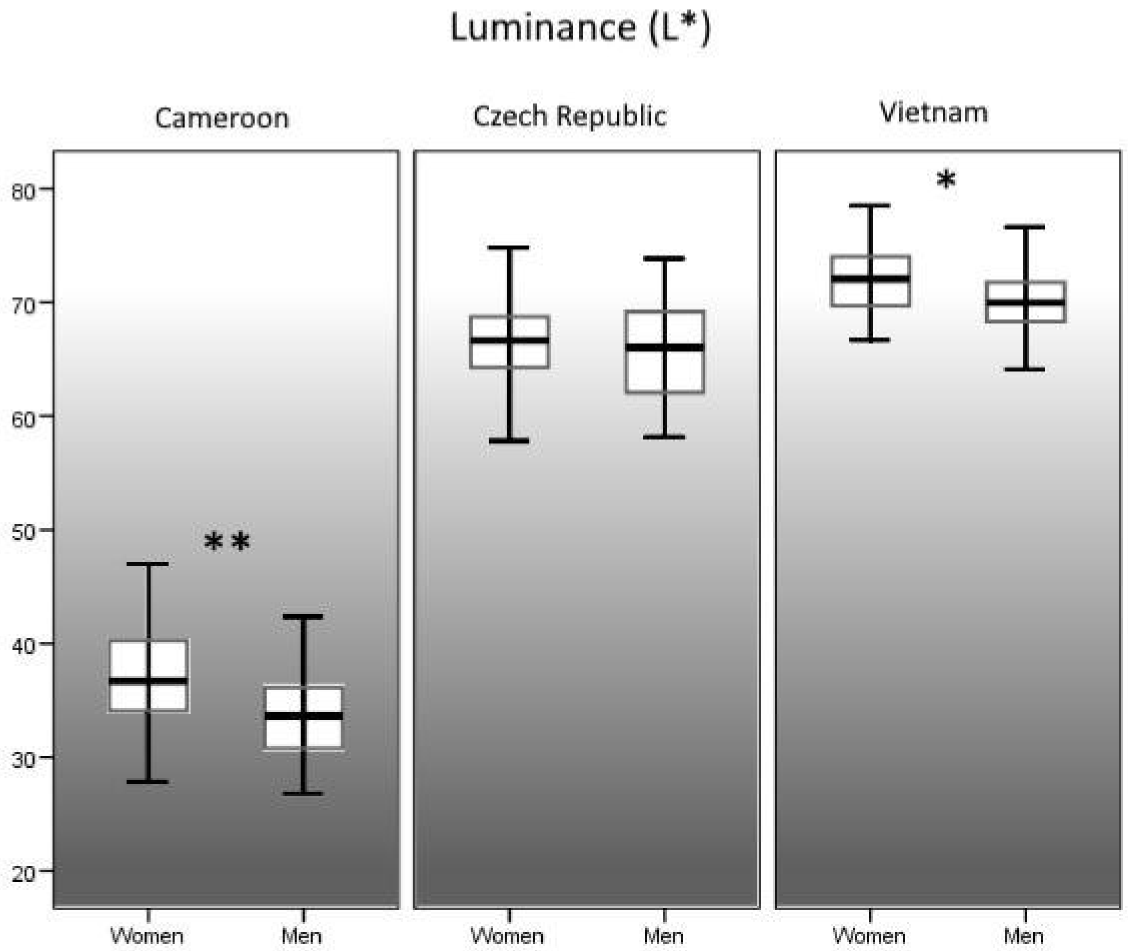

Figure 2: Sexual dimorphism in overall skin luminance (L*).

*p<0.05 **p<0.01

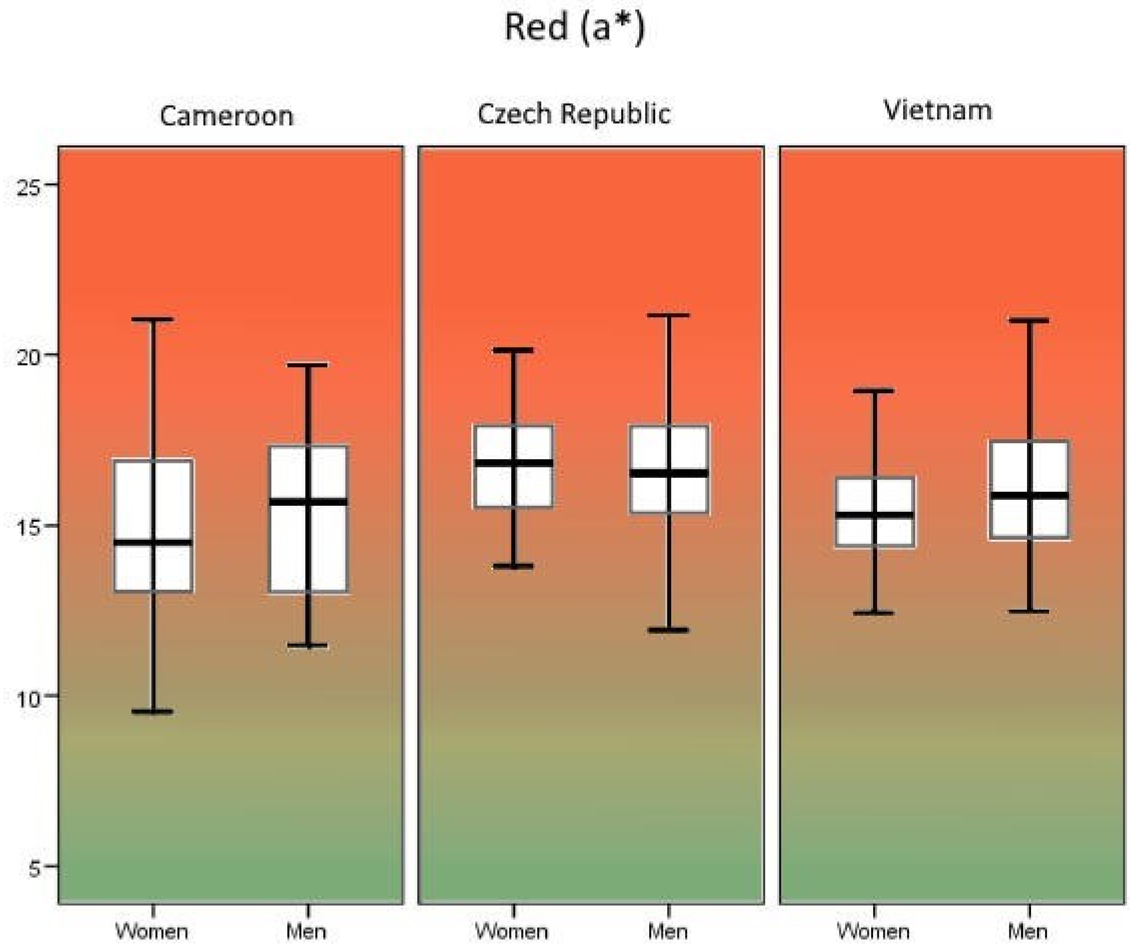

Figure 3: Sexual dimorphism in overall skin redness (a*).

*p<0.05 **p<0.01

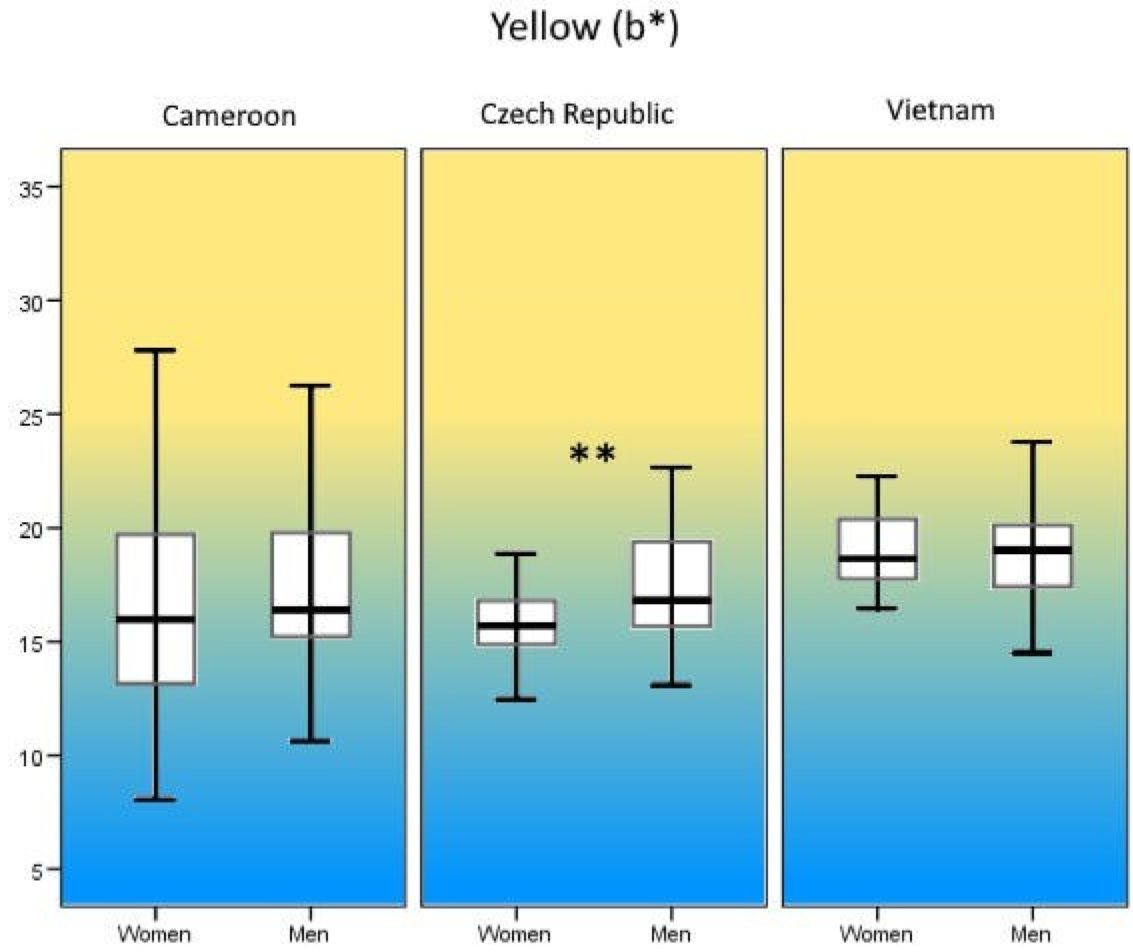

Figure 4: Sexual dimorphism in overall skin yellowness (b*).

*p<0.05 **p<0.01

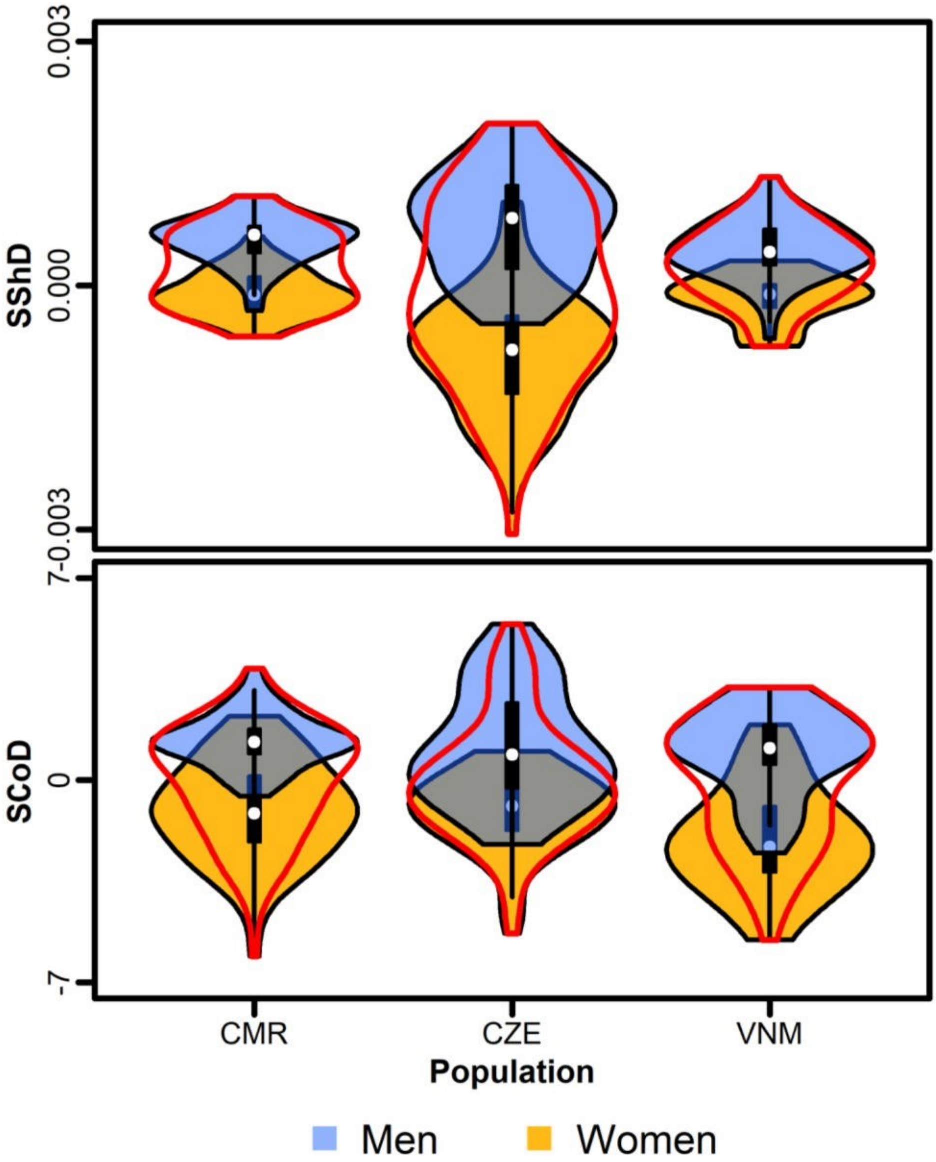

Figure 6: Violin plots showing the levels of sexual dimorphism in shape (SShD) and color (SCoD) in three cultures (CMR – Cameroon, CZE – Czech Republic, VNM – Vietnam). White points indicate medians, black rectangles represent interquartile ranges.

Discussion

Our results bring certain novel insights into the patterns of sexual color dimorphism. The Cameroonian and Vietnamese samples exhibited significant sexual dimorphism in skin luminance: men were on average darker than women, which is assumed to be a universal sexually dimorphic trait (van den Berghe & Frost, 1986; Jablonski & Chaplin, 2000). Conversely, we found in these samples no significant sex differences in skin redness or yellowness. Europeans, represented by a sample of Czechs, did not manifest the expected sex difference in skin luminance. Instead, we observed a significant difference in the yellow-blue channel of the CIELab color space: men were on average yellower than women. Moreover, the level of SShD was in the Czech sample also higher than in the other two studied populations. These aspects of sex-typicality might compensate for the lack of dimorphism in skin luminance and substitute it in the processes of sex recognition and biological quality assessment.

In human populations where the parts of the face which bear sex-specific traits have been subject to some other selective force, sex recognition can be facilitated by other facial regions or types of dimorphism. Furthermore, these secondary sexually dimorphic traits are likely to become exaggerated, because the need for sex recognition creates a constant pressure on maintaining a certain level of sexual dimorphism. Over time, these secondary cues can take on the role of the primary means of sex recognition. In the course of this process, the shape component of sexual dimorphism can expand to compensate for the limited color component – and vice versa. This can lead to different degrees and types of sexual dimorphism among human populations, populations which developed under different selective pressures and constraints. Such mechanism might explain our recent findings, particularly the pattern of sexual dimorphism in the sample from the Czech Republic: European populations have been under a strong selective pressure to maintain the rate of vitamin D_3 synthesis in an environment with low UVB radiation (Jablonski & Chaplin, 2010). This led to a decrease of eumelanin levels in the skin and a lighter complexion in modern-day individuals of European descent. The potential for sex differences in skin lightness is thus smaller in populations where eumelanin is maintained at certain levels by the abovementioned constraints. As a result, we would expect to find higher levels of sexual dimorphism in areas unrelated to eumelanin content, for instance in the blue and yellow hues, that is b* in the CIEL*a*b* color space, typically associated with pheomelanin and carotenoids (Ito & Wakamatsu, 2003), or in facial shape (SShD). In the studied European sample (Czech Republic), we have indeed found no sex differences in skin lightness (L*) but observed a significant level of dimorphism in skin yellowness (b*) in favor of males and a higher SShD than in either the African (Cameroon) or the Asian (Vietnam) sample. This interpretation, however, is challenged by our findings from the Vietnamese population, which is also very light-skinned but shows significant skin luminance dimorphism and no dimorphism in the yellow-blue channel. This might be due to cross-populational differences in the pheomelanin content and blood perfusion, but it was not within the scope of this study to compare absolute skin color measurements between the populations.

If human populations differ in the type and range of sexual dimorphism, as our results suggest, one would expect similar differences in mate choice and attractiveness perception among various populations. Yet although there is a general cross-cultural agreement in attractiveness ratings (Rhodes, 2006; Stephen et al., 2012), certain specific differences seem to support our claim: for instance, Coetzee et al. (2014) have shown that African raters (South Africa) tend to assess female attractiveness based on color cues, while European raters (Scotland) tend to rely more on shape cues. Kleisner et al. (2017) reached a similar result: attractiveness of African women rated by African participants (Cameroon, Namibia) was predicted by color cues (light skin), but when Europeans (Czechs) rated the attractiveness of African women it was not. More recently, Fiala et al. (2022) have shown that color cues affected also perceived sex-typicality in Africans (Cameroon) but not in Europeans (Czech Republic), with the sole exception of skin yellowness: men with yellower skin were perceived as more masculine. Lu et al. (2022) compared various aspects of skin color in Caucasian and Chinese populations and reported a preference for lighter skin among the Chinese but not among Caucasian raters, and a preference for yellower skin in Caucasian but not the Chinese raters. These findings are fully in line with our current observation regarding sexual dimorphism in the shape and color of African and European faces. Perhaps other instances of disagreement in attractiveness ratings (e.g., Jones & Hill, 1993; Zebrowitz et al., 2012) could be explained similarly after a multi-level analysis of sexual dimorphism in the studied samples.

Our results contribute to a growing body of evidence which indicates that human sexual dimorphism is a complex and multidimensional phenomenon. The extent and character of sex differences vary widely among human populations and, as our results also indicate, there does not seem to exist any single aspect of sexual dimorphism in human faces that would be universal across all human populations. Nevertheless, a certain level of overall dimorphism is always present and it enables sex recognition. If we were to study sex-typicality based on any single modality, for instance, if we reduced masculinity and femininity to shape measurements alone, we might exclude other, equally important, aspects of sexual differences in another population. Future studies on sexual dimorphism should consider the type and level of dimorphism in both shape (SShD) and color (SCoD), as well as possible natural constraints in the studied populations.

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Appendix

Additionally, two studies in appendix focus on femininity and masculinity viewed in broader spectrum of modes. However, these studies are not related to Vietnamese populations and cross-cultural research, so for this reason are not part of this thesis per se.

The first study in appendix (Pereira et al., 2019a) showed that men's self-reported rating and third-party rating of masculinity and attractiveness correlate with one another, whereas women's self-reported ratings of femininity/masculinity and attractiveness does not correlate with either third party rating or objective measurements. Women possibly utilize different mechanisms and cues in self-perception, than when rated by others, resulting in discrepancies between the two judgements.

The second study (Pereira et al., 2019b) illustrates association between modalities of sexual dimorphic traits, particularly the facial shape, dance and the voice pitch. There was positive correlation of facial and vocal femininity/masculinity in women, but not in men. Femininity/masculinity of dance was not associated with either facial or vocal femininity/masculinity in both men and women and as such may convey different messages about masculinity or femininity, possibly making use of other mechanisms and cues.

Pereira, K. J., Silva, C. S. A. da, Havlíček, J., Kleisner, K., Varella, M. A. C., Pavlovič, O., & Valentova, J. V. (2019). Femininity-masculinity and attractiveness – Associations between self-ratings, third-party ratings and objective measures. *Personality and Individual Differences*, *147*(April), 166–171.

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Femininity-masculinity and attractiveness – Associations between self-ratings, third-party ratings and objective measures

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A R T I C L E I N F O

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A B S T R A C T

Femininity-masculinity affects perceived attractiveness and indicates biosocial qualities. Physiological and morphological femininity-masculinity is primarily influenced by reproductive hormones; however, its perception is mediated biopsychosocially, and it is not clear if self- and other-rated femininity-masculinity is associated. We examined possible associations between self-rated, other-rated, and measured femininity-masculinity and attractiveness of faces, voices, and behavior (dance) in a target sample of 41 women and 38 men, aged 18–35 years, from Brazil. We took their facial photos, recorded voices and dancing behavior, and we measured sexual dimorphism of facial shape, vocal fundamental frequency, and performed behavioral analysis of the videos. These participants self-rated their facial, vocal, and behavioral femininity-masculinity and attractiveness. Sixty-four (43 women) and 51 (28 women) Brazilian students, aged 18–35 years, independently rated facial, vocal and behavioral femininity-masculinity and attractiveness, respectively, of the target sample. In general, men's self-rated femininity-masculinity and attractiveness correlated with third-party ratings. Male voice pitch correlated with self- and other-rated femininity-masculinity. In women, there was no association between self-ratings and third-party ratings, or between self-ratings and objective measures of femininity-masculinity. Women's subjective perceptions thus do not reflect perceptions of others or objective measures. Studies using different measures of attractiveness or femininity-masculinity should thus reflect upon this discrepancy.

1. Introduction

Perception of human attractiveness has been shaped by both culture and evolution. Attractiveness thus provides cues to both social and reproductive qualities of possible mates (Cunningham, Barbee, & Philhower, 2002). Alexander (1979) suggested that self-awareness in humans evolved as a way to compare ourselves with potential reproductive rivals. The accurate assessment of a potential mate's quality and one's self-perceived mate value would help avoid wasting resources on valuable mates one could not attain, or on less valuable mates who would reduce one's reproductive success (Miller, 2000; Regan, 1998). Thus, potential reproductive success depends on accurate calibration of self- and other-perception. In line with this reasoning, we can expect that people perceive their own attractiveness and other evolutionary relevant characteristics in accordance with other people's judgments.

Previous research mostly used either self-rated or other-rated attractiveness, but studies rarely examined the association between self-perceptions and third-party perceptions. For example, in women, some research found that self-rated and other-rated attractiveness correlate positively (Weeden & Sabini, 2007), but other studies reported a negative (Clark, 2004) or non-significant correlation (Mulford, Orbell, Shatto, & Stockard, 1998). Further, some studies showed that self-rated and other-rated attractiveness are differently related to objective predictors of attractiveness. For example, female self-perceived facial attractiveness was predicted by BMI and fluctuating asymmetry, while female facial attractiveness rated by men was predicted more by maturity (Muñoz-Reyes, Iglesias-Julios, Pita, & Turiegano, 2015). Thus, both measurements of attractiveness are, at least to some degree, dissociated, and more studies are needed to investigate these associations. Further, studies have mostly examined the association between self-ratings and other-ratings of facial appearance (e.g., Muñoz-Reyes et al., 2015), overlooking other domains, e.g. voice, body, or behavior.

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Similarly, associations between self- and other-perceived evolutionary relevant characteristics other than attractiveness, such as femininity-masculinity, health, or social status, should be explored more.

In particular, feminine and masculine (FM) characteristics influence preferences for potential mates. Physical traits indicating exposure to sex hormones cue to fertility, reproductive value, and health and are thus relevant for assessing mate qualities (Jasieńska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004; O'Connor, Fraccaro, Pisanski, Tigue, & Feinberg, 2013). Indeed, women's femininity is usually perceived as attractive (Rhodes, 2006). In contrast, there appears to be a trade-off between benefits associated with male masculinity and costs related to perceived aggression (Carré & McCormick, 2008) and lower parental investment (Mascaro, Hackett, & Rilling, 2013). This can explain the mixed results for preferences of men's masculinity (e.g., DeBruine et al., 2006; Valentova, Roberts, & Havlíček, 2013).

However, studies use different methods to measure FM, including objective measurements (e.g., facial morphology, voice pitch, and body circumferences), ratings by others, or self-ratings. Thus, to analyze whether others accurately assess self-evaluations and whether perceived appraisals accurately reflect objective measures, it is important to test the association between self-rated, other-rated, and objectively measured FM in both men and women.

1.1. Aims

In this study, we examined possible associations between subjective perceptions (i.e., self-ratings and other-ratings) and measures of facial, vocal, and behavioral attractiveness and femininity-masculinity. We tested whether self-reports correlated with third-party ratings and whether subjective perceptions of faces, voices, and dance videos correlated respectively with: (a) facial sexual shape dimorphism, (b) vocal fundamental frequency, and (c) dance movements.

We expected that subjective perceptions of faces, voices and behavior would be at least partly positively associated with other-ratings and objective measures.

2. Material and methods

2.1. Target participants

The target sample consisted of 41 women (mean age = 24.0 years, SD = 5.05, range 18–35) and 38 men (mean age = 23.6 years, SD = 3.28, range 19–32). Participants were Brazilian heterosexual students, comprising undergraduates (76.0%), postgraduates (20.2%), and postdocs (3.8%); 74.7% rated themselves as white, 17.7% as mixed race, 5.1% as black, with no response from 2.5%.

2.2. Procedure

Participants were approached and invited to the laboratory, or came after reading information sheet spread around the Sao Paulo campus of the University of Sao Paulo. They read and signed a consent form and then had their faces photographed, voices recorded and spontaneous dance movements videotaped. Volunteers wore standardized white T–shirts and light grey trousers. Makeup and accessories were removed, and hair-bands were provided when needed. No financial reward was given. The IRB of the Institute of Psychology at the University of Sao Paulo (Nr 53719416.5.0000.5561) approved the experiment.

2.2.1. Objective measures

Photographs and recordings were taken under standardized conditions, for details, see (Valentova, Varella, Havlíček, & Kleisner, 2017). For the rating session, images consisted of frontal facial photographs placed on a neutral grey background using Photoshop, and voices consisted of the following sentence read by participants in Portuguese "Hi, my name is Ana/Pedro and I am from Belo Horizonte" – "Ana" for all women, and "Pedro" for all men.

Behavior recordings consisted of participants spontaneously dancing to a 4/4 standard rhythm (130 beats per minute), which was generated using an automatic random rhythmic generator in Max/Msp. Participants danced for around 40 s in a 1 m^2 space in front of a standardized grey background. Videos were recorded on a JVC Everio digital camera placed on a 1.5 m high tripod located 2.5 m in front of the participants.

Each video was digitally edited using Videomux software. Firstly, any sound was excluded, videos were converted to black and white, and contrast was increased. For the rating session, we extracted a 10 second-video from the original 40 second-footage using the middle part to avoid some confounding variables (e.g. standstill, anxiety in the beginning, and tiredness in the end). Finally, Adobe Premiere Pro CC was used to cover participants' faces, but leaving head movements and position still recognizable. Part of pixelated layer (i.e. mask) with Mosaic effect was inserted on top of original video layer and mask tracking and frame-by-frame manual correction was carefully positioned, so that the whole face and a majority of hair was pixelated and indistinguishable. Mask feather (i.e. the strength of the effect) was set on value 16. By using this mosaic density, participants' faces were blurred.

2.2.2. Subjective perceptions

The subjective perceptions consisted of self-ratings and other-ratings of attractiveness and femininity-masculinity (FM). Target participants were asked to rate FM and attractiveness of their own faces, voices, and behavior on two 7-point scales (1 = very feminine/not at all attractive; 7 = very masculine/very attractive, respectively).

Then, targets' photographs, vocal recordings, and dance videos were assessed on a 100-point scale (0 = very feminine; 100 = very masculine) by 43 women (mean age = 24.1 years, SD = 4.56, range 18–34) and 21 men (23.9 years, SD = 4.62, range 18–34). Further, 28 women (mean age = 23.8 years, SD = 3.8, range 18–34) and 23 men (mean age = 23.6 years, SD = 3.56, range 18–30) rated attractiveness of the opposite-sex stimuli on a 7-point scale (0 = not at all attractive; 7 = very attractive).

Third-party raters were unrelated to the target participants. Raters of FM were mostly students of the University of Sao Paulo recruited by email. Data were collected online via Qualtrics software, version 2017. Raters of attractiveness were recruited personally at the University of Brasilia, and they completed their ratings in the lab. In both cases, the stimuli were shown in three blocks (i.e., blocks of faces, voices, and dances separately). Each block and the stimuli were presented randomly.

Raters of FM assessed stimuli of both sexes. Spearman test indicated a strong correlation between women's and men's ratings of all stimuli (all ρ's ≥ 0.85, all p's < 0.001), and thus the mean scores of FM for each target across all raters were used for analysis. Finally, Cronbach's alphas of FM ratings were high for facial ($\alpha = 0.78$), vocal ($\alpha = 0.83$) and behavioral ($\alpha = 0.89$) ratings. Similarly, Cronbach's alphas of attractiveness ratings were high for facial (female raters' $\alpha = 0.93$, male raters' $\alpha = 0.96$), vocal (female raters' $\alpha = 0.94$, male raters' $\alpha = 0.87$) and behavioral (female raters' $\alpha = 0.90$, male raters' $\alpha = 0.96$) ratings.

3. Analyses

3.1. Bivariate correlations

Data were analyzed with SPSS 21.0 (IBM Corp). A Shapiro-Wilks test indicated that some variables violated the normality assumption of distribution and thus Kendall rank correlation was chosen. First, we analyzed the association between age and all the variables. We only found a positive correlation between women's age and femininity of dance ($\tau b = 0.246$, p = .04) and thus age did not enter into the subsequent analyses.

3.2. Geometric morphometric analysis

We defined 72 landmarks on each facial portrait using tpsDig2 software (Version 2.31). The definition of landmarks (including 36 semilandmarks) was adopted from our previous studies (Danel, Dziedzic-Danel, & Kleisner, 2016; Danel et al., 2018). Landmark configurations were subsequently superimposed by Generalized Procrustes Analysis (GPA) using the "gpagen" function within Geomorph package in R (Adams & Otárola-Castillo, 2013). The positions of semilandmarks were optimized by an algorithm based on minimizing the bending energy. To measure the individual degree of development of sexually dimorphic traits in the human face, i.e. Facial Sexual Shape Dimorphism (FSShD), we calculated average facial configuration separately for faces of men and women. Subsequently, we projected all individual faces on an axis connecting male and female average facial shape. The projections of all faces on this axis are represented as one-dimensional scores and used as an objective measure of individual degree of facial sexual dimorphism (Komori, Kawamura, & Ishihara, 2011; Mitteroecker, Windhager, Müller, & Schaefer, 2015; Valenzano, Mennucci, Tartarelli, & Cellerino, 2006). Higher positive FSShD scores indicate increasing maleness whereas higher negative scores imply increasing femaleness.

3.3. Vocal analyses

All voice samples were analyzed using Praat software. The average fundamental frequency (F0) was measured using Praat's autocorrelation algorithm with parameters set to a pitch floor of 75 Hz and a pitch ceiling of 300 Hz for men, and a pitch floor of 100 Hz and a pitch ceiling of 500 Hz for women, with all other values set to default. The F0 ranged from 92 to 177 Hz in men (mean 125 Hz), and from 177 to 253 Hz in women (mean 209 Hz).

3.4. Behavioral analysis

Shoulders and hip movements were analyzed through Interact software (Version 16.0.0), because higher hip movements are associated with female sex-typicality, and higher shoulders movements to male sex-typicality (Johnson, Gill, Reichman, & Tassinary, 2007). Video analysis was performed in two stages using an ethogram composed of two types of body movements, and three levels of intensity (see Table 1).

First, two evaluators of both sexes observed eight videos (four videos of women dancing) according to the ethogram. The duration of shoulders and hip movements was computed separately in seconds, and the intensity of body movements was computed on a 3-point scale (0 = low; 3 = high). Then, duration was multiplied by intensity to generate one single score, and the results were analyzed through Lin's Concordance correlation coefficient. After reaching a moderate agreement (hip's $\rho c = 0.68$; shoulders' $\rho c = 0.73$) between the evaluators' responses, the male evaluator observed and coded the remaining videos. Finally, for each participant, the final score of hip movement was subtracted from the final score of shoulders movements and thus positive results indicate a masculine pattern of dance, while negative results suggest a feminine pattern of dance.

4. Results

As shown in Tables 2, 3, and 4, men's self-rated facial and vocal masculinity are positively correlated with other-rated masculinity, while no such association is found in women. In women, facial, vocal, and behavioral other-rated femininity were correlated with other-rated attractiveness and only other-rated femininity was correlated with feminine facial and vocal measures. Moreover, women's self-reports of vocal femininity were associated with self-reported attractiveness. In men, self- and other-ratings of vocal masculinity were associated with low fundamental frequency and other-rated attractiveness, and only other-ratings of vocal masculinity were correlated with self-rated attractiveness. Finally, vocal and behavioral self-rated attractiveness were associated with other-rated attractiveness.

5. Discussion

The current study examined the association between self-rated and other-rated attractiveness and femininity-masculinity (FM), and objectively measured FM in three domains: faces, voices, and non-verbal behavior (dance). Other-ratings of women's facial and vocal femininity were associated with facial sexual shape dimorphism and higher fundamental frequency, respectively. Further, in women other- and self-rated femininity in all three domains were mostly associated with other- and self-rated attractiveness. However, no women's self-ratings correlated with other-ratings or measured FM in any of the domains. In contrast, men's self-ratings and other-ratings were mostly in accordance. Moreover, self-rated vocal masculinity in men was associated with low voice pitch and with other-rated attractiveness.

Self-rated attractiveness and sex typicality significantly influence decision making in several contexts, including mate preferences (e.g. Vukovic et al., 2008). Such self-concepts are susceptible to social pressures and comparisons, particularly among women (Ben Hamida, Mineka, & Bailey, 1998; Little & Mannion, 2006). Indeed, we did not find any statistically significant correlation between self- and other-rated FM and attractiveness among women, while in men self- and other-rated facial and vocal FM were correlated. Moreover, self- and other-rated attractiveness was not associated either in men or women; the exception being men's voices.

In line with previous studies, we showed that women's self-perceived and third-party rated attractiveness are, at least in part, independent variables (Feingold, 1992; Muñoz-Reyes et al., 2015), and we expanded these findings to the ratings of FM and vocal and behavioral (dance) stimuli. This finding has implications for theoretical concepts and research on attractiveness and FM in women. Studies systematically show that people agree on what is attractive and what is not, in particular when judging facial appearance (e.g. Chatterjee, Thomas, Smith, & Aguirre, 2009). As we showed, women's FM rated by others is more connected to objective measures, but self-ratings seem to be independent. It was shown that attractiveness applied to self is flexible and can be altered rapidly by context (e.g. Little & Mannion,

Table 1
Ethogram of hip and shoulders movements.

		Body movements	
		Shoulders	Hip
Intensity	Low	Little lateral motion, and little or no front-back motion combined with up-down motion	Little or no lateral motion combined with no up-down motion or front-back motion
	Medium	Higher degree of lateral motion, and a medium degree of front-back motion combined with up-down motion	Lateral motion combined with up-down motion, but no front-back motion
	High	Higher degree of lateral motion, and a high degree of front-back motion combined with up-down motion	Three-dimensional motion

Table 2
Kendall correlations between self-rated, other-rated, and measured facial femininity-masculinity and attractiveness. Correlations for women's subsample are reported above diagonal and for men's subsample below diagonal.

	Self–rated FM	Other–rated FM	Facial shape FM	Self–rated ATTR	Other–rated ATTR
Self–rated FM		.143	.049	−.250	−.143
Other–rated FM	.481**		.255*	−.016	−.590**
Facial shape FM	.073	0.70		−.003	−.210
Self–rated ATTR	−.097	−.051	.091		.041
Other–rated ATTR	−.064	.029	.069	.162	

Note. FM = femininity-masculinity. ATTR = attractiveness. * = $p < .05$. ** = $p < .01$.

Table 3
Kendall correlations between self-rated, other-rated and measured vocal femininity-masculinity and attractiveness. Correlations for women's subsample are reported above diagonal and for men's subsample below diagonal.

	Self–rated FM	Other–rated FM	F0	Self–rated ATTR	Other–rated ATTR
Self–rated FM		.194	−.168	−.289*	.028
Other–rated FM	.343**		−.380**	.074	−.393**
F0	−.436**	−.280*		.030	−.023
Self–rated ATTR	.051	.312*	.151		−.102
Other–rated ATTR	.244*	.676**	−.184	.308*	

Note. FM = femininity-masculinity. ATTR = attractiveness. F0 = vocal fundamental frequency. * = $p < .05$. ** = $p < .01$.

Table 4
Kendall correlations between self-rated, other-rated and measured behavioral femininity-masculinity and attractiveness. Correlations for women's subsample are reported above diagonal and for men's subsample below diagonal.

	Self–rated FM	Other–rated FM	Dance FM	Self–rated ATTR	Other–rated ATTR
Self–rated FM		.080	−.140	−.086	−.066
Other–rated FM	.110		.049	−.024	−.482**
Dance FM	−.125	−.208		.000	−.076
Self–rated ATTR	.200	−.030	.021		−.003
Other–rated ATTR	−.032	.128	.039	.261*	

Note. FM = femininity-masculinity. ATTR = attractiveness. Dance FM = femininity-masculinity obtained from ethogram of dance videos. * = $p < .05$. ** = $p < .01$.

2006). The influence of social environment on women's self-image (Ben Hamida et al., 1998; Little & Mannion, 2006) can explain the lack of association between self-assessments and objective physical measures of faces and voices. Therefore, female self- and other-perceived attractiveness or FM should not be used interchangeably in research.

In contrast, other-ratings of women's facial and vocal FM were associated with objective measures and other-ratings of attractiveness. This is in line with previous research (Rhodes, 2006), suggesting that feminine physical traits can provide cues to reproductive value and current health (Jasieńska et al., 2004; O'Connor et al., 2013, although see Cai et al., 2019 for null results). Interestingly, we found no correlation between other-ratings of female attractiveness and objective measures of FM, which is in line with Cai et al. (2019). Thus, although perceived female femininity is associated with attractiveness and with objective measures of femininity, attractiveness is not linked to objective measures of femininity. It seems that components, e.g. skin quality, eye color, maturity, adiposity, voice timber, or any other trait that is not directly connected to femininity can contribute to female attractiveness. Unfortunately, these were not explored in this study.

In men, despite self- and other-rated FM of faces and voices being positively associated, only voice pitch was positively correlated with both subjective perceptions of vocal masculinity. First, other factors, such as symmetry (Mogilski & Welling, 2017) or the amount of facial hair (e.g. Valentova, Varella, Bártová, Štěrbová, & Dixson, 2017), could have influenced third-party ratings of male faces. This could explain the lack of association between subjective perceptions of facial FM and facial shape. On the other hand, previous studies suggested that men's voices provide cues to dominance (Rezlescu et al., 2015), which is relevant for men's mate value (Ben Hamida et al., 1998) and it thus explains the association between subjective perceptions of masculinity and masculine (i.e. low) voice pitch. Further, compared to women ancestral men faced stronger intrasexual competition (Puts, 2010), and they would thus benefit from having a more realistic self-perception regarding masculinity in order to avoid disadvantageous conflicts.

Interestingly, although men with lower voice pitch were perceived as more masculine, men's attractiveness did not correlate with voice pitch (see Namibian sample in Šebesta et al., 2017). Male masculinity is associated with indirect investments into reproduction (health, genetic quality), but also with aggressiveness (Carré & McCormick, 2008). Therefore, women face a trade-off between masculine and feminine male traits (Buss & Schmitt, 2019), which could explain the lack of association between masculinity and attractiveness.

For dance movements, subjective perceptions of FM and attractiveness did not correlate with the behavioral analysis of hip and shoulders movements, and we were thus not able to corroborate the association between body movements and the perception of FM reported earlier (Troje, 2003). Nevertheless, previous studies showed that static measures of bodies are correlated with the subjective perception of FM, such as the BMI, waist-to-hip ratio, and breast size (Brooks, Shelly, Jordan, & Dixson, 2015; Havlíček et al., 2017; Swami & Tovée, 2005). Moreover, dance is a complex and universal set of rhythmic body movements influenced by culture (Niemitz, 2010; Weege, Lange, & Fink, 2012). We can speculate that behavior develops via distinct processes than facial and vocal physiology and morphology. Dance and other movements are subject to higher self-control, experience, learning, and training. Therefore, other dance features not examined in the current study, such as head/arm/legs movements, movements coordination, could have influenced subjective perceptions and explain the association between men's self- and other-rated attractiveness.

The present study had some limitations. First, dances were recorded in an unnatural situation, which could have influenced participants' spontaneous behavior. Moreover, we did not test for variables which might have influenced self-ratings of FM or attractiveness, such as relationship context or experimental design (Chen, Jiang, Fan, Yang, & Ren, 2018). Finally, our samples were not diverse (Henrich, Heine, & Norenzayan, 2010), as most of our participants were students from a middle economic class who considered themselves white and thus a more representative Brazilian sample should be explored to support the existing results. However, recruiting a Brazilian sample of men and women to examine FM and attractiveness through distinct channels of information (faces, voices, and dance movements) are novelties that broaden the scope of the existing literature. Future studies might also include new objective measures, e.g., breast size, BMI, waist-to-hip ratio and leg-to-torso ratio, to investigate the associations with perceptions of dance movements.

To sum up, in general men and third-party raters assessed men's femininity-masculinity and attractiveness concordantly, and voice pitch was associated with subjective perceptions of vocal FM. In women, there was no association between self-ratings and ratings by others, or between self-ratings and objective measures of femininity-masculinity. Thus, self-perception and other-ratings probably follow different cues in women and different methods used to measure female attractiveness should reflect upon this discrepancy.

Declaration of interest

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He performed the data preparation, commented on the manuscript draft and contributed to further manuscript revisions.

The co-author signed below agrees with submitting this article as part of his Ph.D. thesis.

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Positive association between facial and vocal femininity/masculinity in women but not in men

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ABSTRACT

Multicomponent stimuli improve information reception. In women, perceived facial and vocal femininity-masculinity (FM) are concordant; however, mixed results are found for men. Some feminine and masculine traits are related to sex hormone action and can indicate reproductive qualities. However, most of the current research about human mate choice focuses on isolated indicators, especially visual assessment of faces. We therefore examined the cross-modal concordance hypothesis by testing correlations between perceptions of FM based on facial, vocal, and behavioral stimuli. Standardized facial pictures, vocal recordings and dance videos of 38 men and 41 women, aged 18–35 years, were rated by 21 male and 43 female students, aged 18–35 years, on 100-point scale (0 = very feminine; 100 = very masculine). All participants were Brazilian students from University of Sao Paulo. In women, facial and vocal FM correlated positively, suggesting concordant information about mate quality. Such results were not found in men, indicating multiple messages, which agree with women's multifaceted preference for male FM. In both sexes, FM of dance did not correlate with voices or faces, indicating different information and distinct process of development. We thus partially supported the cross-modal concordance hypothesis.

1. Introduction

Animals communicate with intraspecific and interspecific individuals in distinct contexts, such as parental care (e.g., Redondo and Castro, 1992), predator deterrence (e.g., Zuberbühler et al., 1999), and mate choice (e.g., Lardner and Bin Lakim, 2002; Sweeney et al., 2003). Some characteristics, such as sex dimorphic traits, can cue to the producers' health, fertility, hormonal status and/or other qualities (Gallup and Frederick, 2010). Humans are sexually dimorphic in several aspects (see, Puts, 2016), such as in facial and vocal characteristics (Puts et al., 2012), and behavior (Berenbaum and Beltz, 2011). Among other factors, levels of reproductive hormones influence development of feminine and masculine traits (e.g., Feinberg, 2008), thus affecting communication. For instance, estrogen is associated with higher vocal pitch (Raj et al., 2010), facial feminine features (Law Smith et al., 2006), and maternal behavior (Law Smith et al., 2012), although see Jones et al. (2018) for no association between sex hormones and facial attractiveness in women. Testosterone is linked to lower vocal fundamental frequency (Evans et al., 2008), masculine facial characteristics (Penton-Voak and Chen, 2004), and aggressive behavior (Batrinos, 2012).

Masculine and feminine traits that coevolved with perceptual propensities of potential mates are important cues in the mate choice process. Indeed, men find more attractive sex hormone-dependent characteristics of female body and behavior, such as feminine faces (Moore et al., 2011; Perrett et al., 1998; Rhodes et al., 2003), voices (Apicella and Feinberg, 2009; Puts et al., 2011; Re et al., 2012), and dance (Röder et al, 2016). However, studies are inconsistent about women's preferences for male masculinity (e.g., DeBruine et al., 2006; Fink and Penton-Voak, 2002; Re et al., 2012; Rhodes et al., 2000; Stephen et al., 2012).

In real life context, usually the traits are not evaluated separately, but rather holistically using multimodal information that can improve information exchange. In women, perception of distinct sensory cues (e.g. faces and voices) is intercorrelated, thus, different modalities seem to carry concordant information about fertility and genetic quality (e.g., Collins and Missing, 2003; Fraccaro et al., 2010; Wheatley et al., 2014). Again, mixed results were found for intercorrelation of perception of male stimuli (Feinberg et al., 2008; Little et al., 2011; Valentova et al.,

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2017). Despite the multimodal nature of masculinity and femininity in humans, most of the current research still focuses on isolated cues, e.g., either faces or voices (for a review, see Wells et al., 2009). Thus, more research on perceptions from multiple channels of information is needed.

Further, most research has studied facial traits, neglecting other channels of information, such as voice and odor (for further discussion, see Groyecka et al., 2017). Moreover, body movements, such as dance or gait, have been rarely studied in the mate choice context (Fink et al., 2015), despite dance behavior being an important part of courtship in many human societies. To the best of our knowledge, no study yet has tested a possible correlation between perception of faces, voices and dance movements. Finally, studies have usually analyzed samples from the USA and Europe. However, some cultural differences have been found regarding the sensory preference (e.g., Havlíček et al., 2008; Marcinkowska et al., 2014; Scott et al., 2014), thus showing the necessity of studies from different localities and cross-cultural research.

1.1. Aims

In the current study, we tested whether femininity-masculinity (FM) is concordantly perceived from faces, voices, and dance behavior in a sample of Brazilian women and men. We hypothesized that, at least in women, perceived FM of faces, voices and behavior would be intercorrelated.

2. Material and methods

Sixty women and 56 men were recruited at the University of Sao Paulo, Brazil. Those who identified themselves as bisexual and homosexual (3–6 on Kinsey scale) were excluded as they possess slightly distinct morphology and behavior (Johnson et al., 2007; Valentova et al., 2011, 2014; Wang and Kosinski, 2018). Moreover, one foreign student, and participants who did not complete the survey were also excluded. The final sample consisted of 38 men (age $M = 23.55$, $SD = 3.28$) and 41 women (age $M = 24.00$, $SD = 5.05$). Self-reports indicated that most participants were undergraduates (70.9%) and white (74.7%). Mann-Whitney U test showed no significant age difference between sexes ($U = 790$, $p = 0.76$).

2.1. Procedure

Participants were informed about general aims of the study and invited to the laboratory. Subsequently, they read and signed a consent form. The procedure was part of a larger intercultural study on human mating strategies (for other details, see Havlíček et al., 2017; Valentova et al., 2017; Varella et al., 2014), and lasted 40–60 min. The experiment consisted of a set of questionnaires, basic body measurements, standardized facial photographs, and vocal and dance recordings. Participants were asked to wear standardized white T–shirt and grey trousers in three sizes, and were given privacy to change their clothes. Makeup was removed, and hair band was provided when needed. No financial reward was given. The IRB of University of Sao Paulo (Nr. 53719416.5.0000.5561) and Charles University (Nr. 2011/7) approved the experiment.

2.2. Photographs and recordings

A standardized photographic equipment, camera distance, light, background, and clothes were used for facial photographs and video recordings. Participants were instructed to adopt a neutral facial expression for the facial pictures. Subsequently, using Photoshop software each photograph was placed on a neutral grey background (Valentova et al., 2017). For videos, participants were instructed to dance as naturally as possible under a standard simple rhythm (130 beats per minute) that was synthesized using an automatic random rhythmic generator in Max/Msp. Each video comprised 40 s, but only ten seconds of the middle part of the recordings were used for the rating session. Each video was cut and digitally edited using Videomux software, so that black and white videos with higher contrast were obtained. Finally, faces were covered (blurred) using Adobe Premiere Pro CC. Voices were recorded in a quiet room and participants were instructed to repeat the following sentence in Portuguese "Hi, my name is Pedro/Ana and I am from Belo Horizonte" – "Pedro" for all men, and "Ana" for all women (for details see, Valentova et al., 2017).

2.3. Facial, vocal, and behavior ratings

The stimuli were presented to a distinct and unrelated sample of 30 men and 58 women to assess FM on a 100-point scale ranging from 0 (very feminine) to 100 (very masculine). Participants were recruited online from students of University of Sao Paulo and were directed to Qualtrics platform (https://www.qualtrics.com). Non-heterosexuals (scoring 3–6 on Kinsey scale), one pregnant woman, and individuals older than 35 years were excluded, leaving a sample comparable to the target sample. The final sample comprised 21 men (age $M = 23.86$, $SD = 4.62$) and 43 women (age $M = 24.14$, $SD = 4.56$), composed mostly of undergraduate (57.8%) and white (71.9%) students. The sexes did not differ significantly in age ($U = 470$, $p = 0.79$).

Participants completed a basic demographic questionnaire and assessed the stimuli of both sexes in three randomized blocks (ratings of facial, vocal and behavioral stimuli). Within each block, the individual stimuli were also randomized. Thus, participants judged each stimulus in a randomized order and only once. There was a strong correlation between males' and females' ratings in all rated stimuli (all ρ's ≥ 0.85, all p's < 0.001) and the Cronbach's alphas of FM ratings were reasonably high for facial ($\alpha = 0.78$), vocal ($\alpha = 0.83$) and behavioral ($\alpha = 0.89$) ratings.

2.4. Analyses

Shapiro-Wilks test was used to check the normality of data. Since some variables departed from normality, Spearman rank correlation was used to examine the relation between all modalities ratings. All data were analyzed via SPSS 21.0 (IBM Corp.). Data were transformed into Z-Scores to perform a figure using OriginPro 9.5 (OriginLab).

3. Results and discussion

As shown in Fig. 1, in women, we found a significant correlation between the mean perceived facial and vocal femininity-masculinity (FM) ($N = 41$, $\rho = 0.33$, $p = 0.03$). However, there was no significant correlation between behavioral FM and facial ($N = 41$, $\rho = 0.09$, $p = 0.59$) or vocal FM ($N = 41$, $\rho = 0.08$, $p = 0.62$).

In men, there was no significant correlation between facial and vocal FM ($N = 38$, $\rho = -0.02$, $p = 0.89$), behavioral and facial ($N = 38$, $\rho = 0.14$, $p = 0.40$), or behavioral and vocal FM ($N = 38$, $\rho = 0.02$, $p = 0.93$).

In women, we have replicated the positive association between perceived FM of faces and voices (Fraccaro et al., 2010; Feinberg et al., 2005; Smith et al., 2016). Although weak in its effect, the current results indicate that female facial and vocal FM can offer concordant underlying information. Rowe (1999) argues that multicomponent stimuli increase information reception. Studies suggest that women's femininity indicates health, fertility, and parenting skills (Feinberg, 2008; Jasieńska et al., 2004; Law Smith et al., 2012). Accordingly, feminine traits are assessed as more attractive (Moore et al., 2011; Perrett et al., 1998; Valentova et al., 2017; although see Jones et al., 2018 for no association between sex hormones and perceived attractiveness in faces), and are preferred by men (Re et al., 2012). Additionally, facial and vocal attractiveness predicted the overall attractiveness ratings of women (Wells et al., 2013), and attractiveness

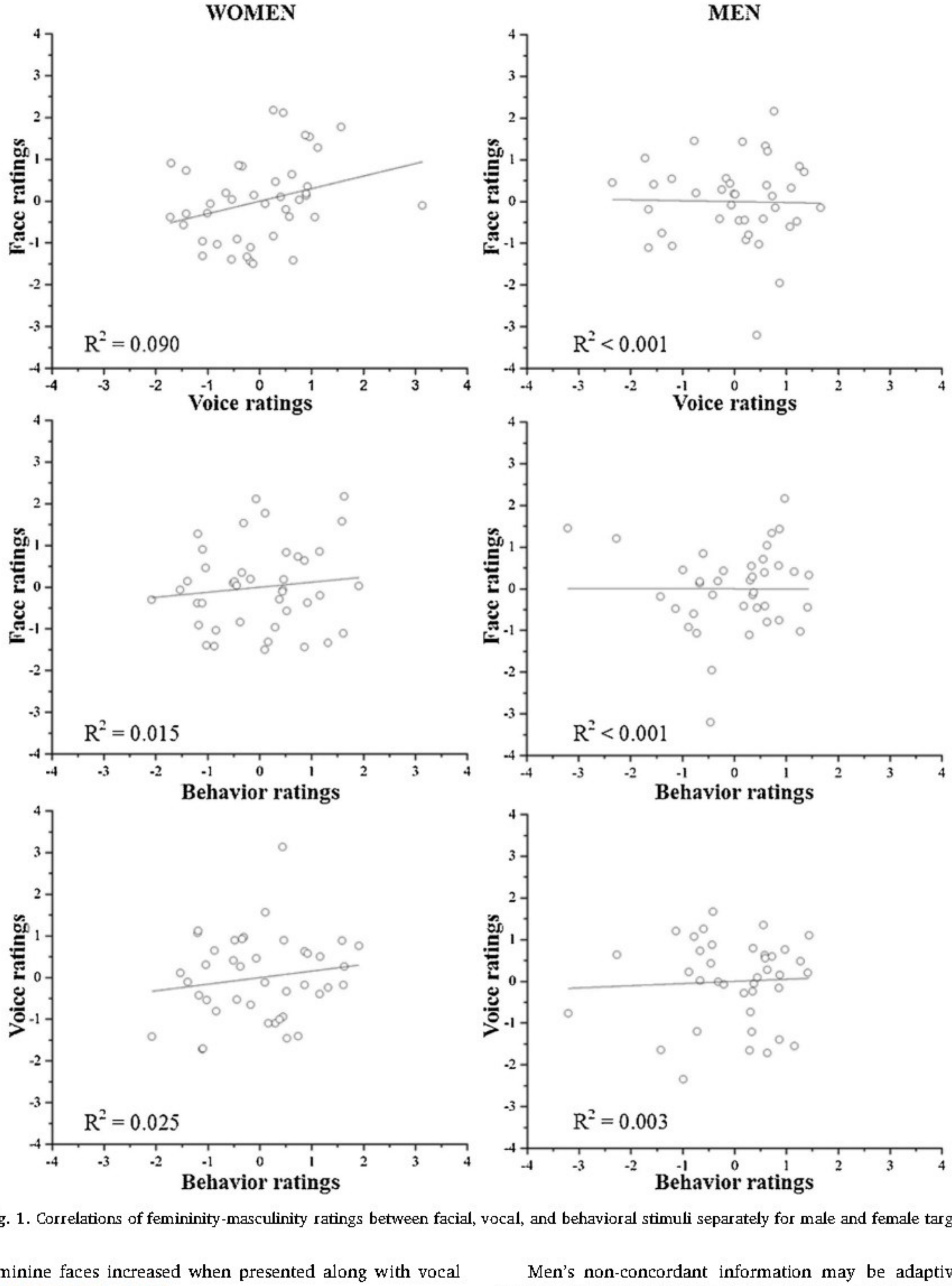

Fig. 1. Correlations of femininity-masculinity ratings between facial, vocal, and behavioral stimuli separately for male and female targets.

ratings of feminine faces increased when presented along with vocal femininity (O'Connor et al., 2013).

In men, faces and voices show no concordance and can, thus, indicate different qualities of the individual. Wells et al. (2013) showed that men's faces and voices contribute independently to attractiveness. Accordingly, Varella et al. (2014) found that women preferred men with a mosaic of masculine and feminine traits. In the same line, women's ratings of male attractiveness increased with a negative covariance between girth, and facial and vocal masculinity (Hill et al., 2013). Thus, testosterone synthesis and mechanisms of tissue response in different parts of the body and behavior may have evolved independently (Hau, 2007).

Men's non-concordant information may be adaptive and reflect women's highly flexible preferences for FM. Previous studies show that women's mate choice varies according to stage of menstrual cycle, resource and pathogen exposure, relationship status, or women's own mate quality (Brooks et al., 2010; Gildersleeve et al., 2014; Little et al., 2011; Lyons et al., 2016; Moore et al., 2013), indicating a variable preference for indirect (e.g. genetic quality) and direct (e.g. parental care) paternal investment according to the context (Gray et al., 2002; Kruger and Fitzgerald, 2011).

We found no correlation between ratings of FM of dance videos and FM rated from voices and faces, either in men or women. Thus, dance has no concordance with the other variables, and may thus convey different messages. We can speculate that complex behavior, such as dance, which is aerobically costly, represents and develops via distinct process than facial and vocal display. Indeed, FM of behavior is emergent already during early childhood, while vocal and facial FM develops largely through exposure to sex hormone during puberty (Hines, 2011; Puts et al., 2012; Rieger et al., 2008).

In summary, we found a positive correlation between perception of women's facial and vocal FM, but that did not occur in men. Furthermore, dance was not associated with either vocal or facial FM in either men or women. The current study thus advanced the discussion concerning the use of multiple sensory modalities in the context of assessing masculinity-femininity. Differently from previous research, besides studying facial and vocal perception, we also focused on complex behavior, dancing (for further discussion, see Groyecka et al., 2017). As our study sample was relatively small and conducted on a specific population (Brazilian men and women), further studies are needed. Different populations can show distinct results in perception of faces, voices, and other sensory modalities, as shown by previous studies (e.g., Havlíček et al., 2008; Marcinkowska et al., 2014). Further, we collected samples in artificial environment, and recruited mostly university students. Future studies, thus, should investigate higher diversity of indicators, ideally in cross-cultural and more realistic mate choice settings.

Declaration of interest

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